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Factors Affecting Collision & Grounding Losses in the UK Fishing Fleet

FINDLAY, MALCOLM

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Factors Affecting Collision & Grounding Losses in the UK Fishing Fleet

A thesis submitted to the University of Plymouth in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

by

MALCOLM FINDLAY
B.Sc.(honours), M.Sc.(distinction), MIFM
Fishing Skipper

Institute of Marine Studies
Faculty of Science
University of Plymouth

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ABSTRACT

Examination of the literature reveals a paucity of dedicated research into collisions and groundings involving UK fishing vessels. The aim of this research was to provide answers to fundamental questions regarding the factors that contribute to fishing vessel traffic losses. Data for this study were gathered from a broad range of sources and an eclectic range of techniques employed in their analysis.

The recent development of the UK fishing fleet and the pattern of losses from all causes is investigated for the period 1975 to 1994. Fishing vessel collision and grounding losses are then set in relative perspective by comparison with those arising from other causes.

Aspects of the macro-environment in which the UK fishing fleet has operated since 1975 are examined and the results interpreted in the form of a comparative regional analysis. The micro-environment prevailing in the fishing fleet is exemplified through combining an array of observations made at sea on board working fishing vessels with questionnaire responses drawn from representative samples of British fishermen in 22 fishing ports around the country.

A previously unattempted composite analysis of the circumstances of fishing vessel collision and grounding losses is presented and this allows for a number of conclusions to be drawn. A causal analysis technique is applied to fishing vessel casualties for the first time and leads to the identification of human factors as a more significant contributor to traffic losses than either technical or environmental factors.

A novel programme of cross-validated observations of fishing vessel watchkeepers in their working environment was pursued, providing data on how attention is allocated, workload levels at different stages in the fishing cycle and also on the watchkeeper's cognitive state while on duty.

The thesis concludes with a wide ranging discussion and recommendations based on the research that could contribute to reducing loss of life and vessels in traffic events, made with due consideration for the physical and fiscal constraints that impinge upon the UK fishing fleet.

LIST OF CONTENTS

Page no.

Chapter 2

The UK fishing fleet and UK fishing vessel losses: An overview, 1975-1995

Chapter 3

The operational macro environment of UK fishing vessels

Page no.

Chapter 5

Circumstances of fishing vessel grounding & collision losses

Chapter 6

Causal analysis:
The aetiology of fishing vessel collision & grounding losses

LIST OF FIGURES

page no.

Chapter 4

page no.

Chapter 6

Chapter 7

page no.

page no.

Chapter 8

LIST OF TABLES

Page no.

Chapter 5

Chapter 6

Page no.

Chapter 7

LIST OF PLATES

Chapter 3

Chapter 7

LIST OF ABBREVIATIONS

ARPA..........	Automatic Radar Plotting Aid
BIM............	An Bord Iscaigh Mara (The Irish Sea Fisheries Board)
BOT...........	Board of Trade
DDR..........	Deep Draught Routes
DOT..........	Department of Trade
DANI........	Department of Agriculture for Northern Ireland
DTp..........	Department of Transport
EPIRB......	Electronic Position Indicator Rescue Beacon
FSA..........	Formal Safety Assessment
HSE.........	UK Health and Safety Executive
IMO.........	International Maritime Organisation
ISO..........	International Organisation for Standardisation
ITZ..........	Inshore Traffic Zone
M Notice...	UK Merchant Shipping Notice
MAFF.......	Ministry of Agriculture, Fisheries and Food
MAIB.......	Marine Accident Investigation Branch
MSA........	Marine Safety Agency
MSC.........	Maritime Safety Committee (of the IMO)
NFFO......	National Federation of Fishermen's Organisations
SFIA........	Sea Fish Industry Authority
SFO.........	Scottish Fishermens' Organisation
SOAFD....	Scottish Office Agriculture and Fisheries Department
TSS..........	Traffic Separation Scheme
UKHO.....	United Kingdom Hydrographic Office
VDU........	Video Display Unit
WBGT.....	Wet Bulb Globe Temperature
WFA.......	White Fish Authority
WHO.......	World Health Organisation

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AUTHOR'S DECLARATION

I declare that the content of this thesis is the result of my own investigations and has not been submitted in support of a candidature for any other academic degree and at no time during registration for the degree of Philosophiae Doctor was I registered for any other university award.

Signed ....

Date 14th March 1998

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Presentations given on aspects of this work

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'The need for research into fishing vessel watchkeeping'
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'A technique forcausal analysis of fishing vessel collision and grounding'
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External contacts

- Captain P.B. Marriott, Head of *UK Marine Accident Investigation Branch*
- Mr. K. Dickson, Principal Investigator, *UK Marine Accident Investigation Branch*
- Captain D.C. Thompson, Principal Surveyor, *UK Marine Safety Agency.*
- Captain A. Starling-Lark, Chairman, *Sea Safety Group, UK.*
- Mr K. Cormack, Head of Policy and Economics Unit, *Sea Fish Industry Authority*
- Mr K. Waind, Head of Training Unit, *Sea Fish Industry Authority*
- Mr A. Dean, Senior Technical Advisor, Seafish Technology, *Sea Fish Industry Authority*
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Chapter 1

RATIONALE & METHODOLOGY

"Crafty men condemn studies; simple men admire them; and wise men use them"

(Francis Bacon, 1561-1626)

1.1 Introduction

The above quote epitomises the problem with research in the sphere of fishing boat safety. There are many people involved directly in and on the periphery of the UK fishing industry who because of obscure vested interest or from inexplicable, deep-rooted cynicism would dismiss any safety-related analysis emanating from an academic source. There are also those who glibly praise any work, the content of which exceeds their threshold of ability (or willingness) to absorb and comprehend then proceed to ignore the findings. Both these attitudes have by default made substantive contributions to affirming commercial sea fishing's place as the most dangerous of occupations in the UK (HSE 1989). In the three years prior to the end of 1993, an average of one British fisherman was killed every eight days (SEA SAFETY GROUP, UK 1994).

During the research and compilation of this thesis, the author nevertheless encountered numerous "moments of delight" which were brought about by dealing with individuals who were perceptive enough to understand that while research studies cannot purport to offer instant and complete solutions to problems, they nevertheless have an important role to play. In many cases this role will amount to no more than the synthesising of information to confirm or deny by virtue of sound scientific process, concepts and principles that are already anecdotally taken as fact. These are Bacon's 'wise men' and it is they who will hopefully be astute enough to use the information contained in this thesis to work towards creating a safer environment within the British fishing industry.

1.2 Why pursue this study?

Most seafarers have an opinion, verging on dogma in some instances, on the main reasons why fishing vessels have been lost in collisions and groundings. Those involved in merchant shipping tend to have a particular set of beliefs, recreational and military sailors hold others and the fishermen themselves quite naturally have theirs. Many of the reasons cited are common to all of these parties but any trust invested in this apparent concensus may be misplaced. The much vaunted "common knowledge" on this subject seems to be largely based upon a thin slice of often biased personal observation supplemented by a large helping of hearsay and media reporting. Thus far, dedicated research into losses of fishing vessels in traffic events, their main collective causes and watchkeeping systems on board UK fishing vessels has been at best piecemeal and from a survey of the available literature it appears that no systematic and comprehensive study of these features ever been carried out. The goal of this thesis is to address this shortcoming in the corpus of human knowledge through quantification and analysis. In the frequently quoted words of Lord Kelvin;

> "*I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is a meagre and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of science, whatever the matter may be*"
>
> (Quoted by CANTER, 1997)

It is not within the remit of the thesis to apportion blame, nor is it intended to condemn fishermen in general and existing watchkeeping systems on fishing vessels around the coasts of the UK specifically. Using scientific method to gain insight into the origin of fishing vessel loss is the prime tool of this research and in the same way that a microbiologist might use this to pursue greater cognisance of disease, it is used to explore the total fishing vessel environment, observe the process of watchkeeping and highlight the pathogenic factors. Ultimately, where the results are sufficiently unequivocal this allows for remedial action to be proposed. HAIGHT (1988), commenting upon public attitudes towards road traffic safety says;

> *"Many of us have heard demands that we should 'do something', but it is only recently that there have been suggestions that we should 'know what we are doing' before we do it"*.

1.3 Thesis outline

Chapter One is aimed at introducing the reader to the general approach taken in this research, including an outline of the basic concepts and terminology.

By drawing on a range of information sources, the Second Chapter of this work presents an overview as a current "snapshot" of a British fishing fleet which has changed dramatically over the last twenty-five years. So far as providing an illustration of the size and composition of the fleet is concerned, this is probably the best that one might hope to achieve since the fishing industry has recently been undergoing a process of metamorphosis. Ideally, it will emerge in an as yet undefined end-state where catching capacity is perfectly matched to available fish resources, but it is yet to be seen whether this is realistically attainable. A time series review of the general situation regarding fishing vessel losses then serves to set collision and grounding losses in relative perspective.

Chapter Three sets out to describe the "macro-environment" in which British fishing vessels operate. This includes national and regional analysis of climate, coastal topography, locations of fishing activity. The Fourth Chapter is an examination of the "micro-environment", including physical conditions on board vessels (movement, noise, temperature, vibration, etc), the composition and *modus operandi* of watchkeeping systems, and the watchkeepers themselves, including the ways in which they are trained.

Chapter Five explores the circumstances of fishing vessel traffic losses using information derived from many institutional and private sources. Processed data arising from questionnaire studies are presented and the concept of comparing responses to questionnaires with answers to the same questions asked in an interview situation - a recurrent theme in the thesis - is introduced.

The Sixth chapter is aetiological, devoted to a causal analysis, using a representative sample of collision and grounding losses upon which detailed information relating to each individual event was available. In view of the heavy implication of one group of factors in this analysis, the results provide direction for the remainder of the thesis.

Chapter Seven describes a dedicated programme of observation pursued on board three British fishing vessels, designed to address fundamental human factors questions relating to allocation of the watchkeeper's attention, workload, boredom, aspects of fatigue and vigilance in watchkeepers. The reader is acquainted with each of the "tools" employed by way of a series of brief reviews preceding an outline of the results. The validation process employed in support of the experimental measures is also explained.

The ultimate Chapter is a concluding discussion in which points raised in the earlier Chapters are general considered in the broader context. The picture of watchkeeping behaviour derived from "field" observations is compared with that arising from interviews and written questionnaire responses. Where disparity is clear, the factors responsible for the manipulation of the perceptions of fishermen and their attitudes and approach to the watchkeeping task are discussed.

The thesis concludes with a series of recommendations that are made with due sensitivity for technological, fiscal and personnel limitations in the British fishing industry. The recommendations highlight areas of further research that are deemed to hold most potential for reducing the likelihood of fishing vessels being lost in collision and grounding events.

1.4 Comments on methodology

In some branches of scientific study, practitioners are endowed with the luxury of being able to adjust input variables, observe the results and then repeat this process until reliability can be verified. In the present study, with its broad remit, there is no single research approach available which is capable of providing the full range of information necessary. Accordingly, a methodology which can best be described as "eclectic" has been adopted with a range of doctrines and systems having been freely borrowed to supplement the research methods that were specially conceived.

Unlike many other types of scientific labour, a study in marine traffic safety often relies on information coming from sources that seem paradoxically unscientific. It would be quite difficult for example, to design an empirical experiment to show that it actually is safer for the watchkeeper to frequently look out of the wheelhouse windows than for him not to do so. Rationalism and intellect however dictate that even in the absence of such scientific "proof", frequent observation of the external navigational environment is a cornerstone of good watchkeeping practice. Clearly it would be folly to suspend the principles embodied in UK Admiralty M Notice No. 1020 (DOT, 1982), which implores watchkeepers on fishing vessels to keep a good lookout, until a rigorous scientific study could be pursued. So although it is accepted that *ceteris paribus* statements supported by scientific evidence will inevitably find favour over anecdote, rational discourse does have a place in this type of study provided that its basis is explained.

While is accepted that the "Kelvinian" goal of science is the quantification of factors that produce a certain result, there must also be room in a thesis dealing with maritime safety for what might best be called, "suggestive data". These arise where observations are made but drawing conclusions from them requires assumptions that make more than one interpretation of the situation possible. This situation frequently arises where data are scarce and with only limited numbers of observations possible to support some aspects of this study, has been unavoidable.

1.4.1. Why study only losses?

Fishermen are not renowned for being sedulous in their approach to reporting minor incidents and "close-calls". This probably arises from their intimate familiarity with hazardous situations and is exemplified in questionnaire responses from 239 fishermen operating from 19 different ports around the coast of the UK, which showed that more than half of them (52%) had been on board some vessel when it had either run aground or been involved in a collision. Fortunately most of these events pass with no loss of life and only slight to moderate damage to the vessels concerned - a glancing blow or re-floating on a later high tide. Although little more than the grace of God often prevents these relatively inocuous incidents from becoming tragedies and undoubtedly much could be learned from analysing what went on in the run-up to seemingly inconsequential collision and grounding events there is seldom any reliable record of this in existence. This is why only information from losses and not from all casualties and near misses has been used.

1.4.2 Statistical techniques and graphics used

A range of techniques has been used in this thesis to analyse data. These are outlined in Table 1.4.1.

	statistical techniques	*graphics*
chapter 2	absolute comparisons, loss ratios,	double axes histograms/line charts
chapter 3	correlations, chi-squared test	histograms, pie charts, flow charts
chapter 4	correlations, chi-squared test	histograms, pie charts
chapter 5	percentage comparisons, loss ratios, chi-squared test, goodness of fit test, 2 period moving average	pie charts, area charts, radar charts,
chapter 6	factor analysis, involving expert ratings, weighting, effect level calculation	histograms, line charts, event trees, block scheme
chapter 7	correlations, t-tests, Time Line Analysis,	histograms, line charts
chapter 8		flow diagrams,

Table 1.4.1. Statistical techniques and graphics used in this thesis.

Unless otherwise stated the results of statistical tests in this work are assumed to be significant if the 5% level is not exceeded, i.e. $p < 0.05$. Wherever a result is declared to be significant however, the potential for what is known in the statistical literature as a "Type 1" error (HEYES *et al.* 1986) is accepted. That is to say that even where an appropriate test indicates a result to be less than 5% likely to have happened by chance, there is always the possibility that this unlikely event could have happened.

Where statistical tests, such as chi-squared (χ^2) are used, only the test statistic and the resulting level of significance are given since illustration of the full table of calculations would serve no meaningful purpose. The reader is referred to any standard statistical text book (e.g. HEYES *et al.* 1986) for explanation of statistical techniques not explained in the text.

Where information is represented graphically, if no alternative source is indicated the reader may assume that this has arisen from the author's own researches in the course of this study.

1.4.3 Sources of information

Gathering the information required for this study was an onerous task in many ways. The data collection phase brought home to the author the anecdotal truth that research is as much a detective task as anything else and that the tact and diplomacy needed to unlock the door to data gathering can ultimately be as important as the techniques used in its analysis. A further complication is that much of the general information on the UK fishing fleet is incomplete and important features such as the number of operational vessels that constitute it, have varied in accord with legislative changes.

Three main types of data were used in this study; those gained from official and unofficial records; those that were derived from questionnaires and interviews; and those that were recorded during field observations. These are shown with detail of their sources in Table 1.4.2.

data type	*source*
official and unofficial records	Marine Accident Investigation Branch; Marine Safety Agency; Sea Fish Industry Authority; Ministry of Agriculture Fisheries and Food; Register of Shipping and Seamen; Sunderland Mutual Marine Insurance Co Ltd; Lloyd's Casualty Week
questionnaires and interviews	2 questionnaires, both with responses from 22 UK fishing ports (see Appendix 1 for list of ports with map). Questionnaire I achieving 239 responses, questionnaire II achieving 139 responses. (Details in Appendix 2) 20 structured interviews replicating questionnaire 2
field observations	trips on fishing vessels recording data relating to watchkeeping practises and environmental data.

Table 1.4.2. Data types used in this study and their sources.

1.5 Comments on terminology

LANGLEY (1988) provides a compelling argument for avoiding the term, "accident" in any technical analysis of safety. Even though the word is in general use regarding events where injury or damage to property has occurred, it is shrouded in conceptual ambiguity and suggests an element of chance which must accordingly erode the possibility of assigning causes. Indeed some fishing vessel losses can be traced to single acts that are so conspicuous that even in common parlance, the use of the word, "accident" becomes inappropriate. In this thesis there is therefore no reference to marine traffic "accidents";

rather to "events" and "incidents" when talking in general terms and to "collisions" and "groundings" when specifically dealing with these. Where both published and unpublished figures are used these is referred to as "data" or "information", rather than "statistics" since the latter, as EVANS (1991) points out, is the branch of mathematics dealing with hypothesis testing and confidence limits and thus using it to mean "data" invites needless ambiguity.

So far as fishing vessels are concerned it is only where a vessel has actually been lost that a concerted effort is made to piece together a comprehensive account of events. In the UK, this is usually done by government bodies, primarily the Marine Accident Investigation Branch (MAIB) since 1989 (the Department of Transport or Board of Trade previously) and insurance companies. For this reason, the events analysed in this thesis invariably relate to either; "actual total losses" - where damage reached a point that the vessel is unable to be recovered physically; or "constructive total losses" - where the damage exceeded the point where it was economically feasible to attempt to repair the vessel. Thus wherever the term, "loss" is used in this work it may be taken to mean either of the above.

Throughout this thesis, the terms, "skipper", " mate" and "crewman" are used. These relate to the various ranks that compose the crews of UK fishing vessels and are likely to have watchkeeping duties. The International Maritime Organisation defines the first two of these roles as follows (IMO, 1988);

"skipper"	- *any person having command or charge of a fishing vessel*
"mate"	- *any person exercising subordinate command of a fishing vessel, including any person, other than a pilot, liable at any time to be in charge of the navigation of such a vessel.*

In some cases, this being to some extent a function of the size of the vessel, the skipper will not possess a Class I or Class II Skipper's (fishing) Certificate of Competence and the mate will not always hold a Class II Certificate. This information is seldom explicit in the casualty information sources so where the need arises, the ranks are accepted as they are stated in the reports that have been used. The term, "crewmen" in this thesis relates to all members of the complement of a fishing vessel except the skipper and mate. Where a watchkeeper had a supplementary role, such as being the vessel's engineer or cook, they were included with crewmen. The exception to this principle within the thesis is in Chapter 7, where accurate information was available on the qualifications and experience of the respective subjects used in field observations.

The term, "loss ratio" is used to describe the relationship between the number of vessels lost in any given year from a specified cause and the total number of vessels that could have been lost. Throughout the thesis, this ratio indicates the number of losses per 100 vessels in the UK fleet at the beginning of the stated year. The loss ratio is therefore a measure of risk during the period, although it will not necessarily be entirely accurate because some vessels will be sold out of the fleet, laid up or lost prior to the next census date.

As might be expected in a study of marine traffic losses, the term, "visibility" appears from time to time throughout this work. McINTOSH (1972) defines visibility as, "*the greatest distance at which an object can be seen and identified with the naked eye in any particular circumstance.*" Features or objects at known distances from the reference point are used in assessing visibility from land stations but these are not available on the open sea so a much coarser scale has to be employed (BURGESS *et al.*, 1988).

In the UK it is customary in marine accident reporting to refer to the visibility at the time of an event using the general terms, "good", "moderate" or "poor" though this is not the case in some other countries, for example Korea, where the Korean Marine Accident Inquiry Agency uses the additional term, "fog" (PARK, 1994). In its public information literature the United Kingdom Meteorological Office attaches the classification shown in Table 1.5.1 to these terms (UK METEOROLOGICAL OFFICE, 1995). In the present work, although reference is specifically made to fog where this is appropriate, the term, "poor visibility" may be taken to encompass fog.

term	visible distance
fog	**less than 1 km**
poor	**1 to 5 km**
moderate	**5 to 10 km**
good	**more than 10 km**

Table 1.5.1. UK Meteorological Office visibility classification.

From the author's personal experience as a fishing skipper, it is known that there are females employed on board fishing boats in the UK, indeed one very successful fishing boat operated from Stornoway on the Isle of Lewis for many years with a female skipper. While tradition might dictate otherwise there is also no logical reason why women should not in the future play a much greater part in catching sector of the industry. No female "fisherpersons" were encountered or observed during this research however and given the necessarily anonymous nature of the questionnaires, it is impossible to ascertain whether any female subjects were included in the questionnaire study. For these reasons and because the term, "fisherperson" is rather awkward, the terms, fisherman, crewman, mate and skipper may be taken to encompass both male and female genders.

1.6 Definition of the study area

The area covered in this study is that within which the British fishing fleet has operated since the mid 1970's and currently continues to operate in, with the exception of a relatively minor number of excursions made by a handful of vessel owners to exploit extremely limited distant water fishing opportunities. This operational area (Figure1.6.1) is approximately enclosed within the range of latitudes 49°North, (the Brest Peninsula) to 62° North (where the water deepens to the north-east of the Shetland Isles) and between the continental mainland and longitude 14° West (the Rockall Bank), (*pers. comms.*, Mr. G. Quelch, Assistant Chief Executive, National Federation of Fishermen's Associations, 1995 and Mr R. Allan, Chief Executive, Scottish Fishermen's Federation, 1995).

Figure 1.6.1 Area within which most UK fishing activity takes place.

Where analysis of any factor is pursued according to area in this study, the waters around the UK have been delineated in broad accord with two sources which themselves show mutual, though unrelated general agreement in this respect. Firstly the UK Admiralty

Hydrographic Office, which publishes *Admiralty Sailing Directions* (UK Hydrographic Department, 1989) for clearly defined areas (Figure 1.6.1) and secondly the International Council for the Exploration of the Sea (ICES), based in Copenhagen, Denmark, which has divided the fishing grounds of North West Europe into *ICES Fishing Areas* for the purpose of providing fisheries management advice to nations with an interest in exploiting fish stocks in the region (Figure 1.6.2).

Both of these bodies see merit in differentiating between the Northern and the Central North Sea zones, the Scottish West Coast and the English Channel. Division of the Western Approaches is more fraught however, with the Admiralty Hydrographic Office opting for three numbered zones while ICES attributes an umbrella numbering , Area VII, with ten sub- divisions, a, b, c, d, e, f, g, h, j and k. For the sake of simplification, all of these ICES sub-divisions and corresponding Admiralty sailing areas 27, 37 and 40 are included in the area referred to in this study as, Western Approaches, with the exception of ICES area VIId which forms part of the English Channel area. This latter exception provides a delineation which concurs with the Admiralty Hydrographic Office's concept of the English Channel, defining the extent of 'Sailing Directions', volume number 28. The resulting map, outlining the five areas referred to in this study is shown in Figure 1.6.3.

For the rest of this work then, five areas are referred to:

Area 1 - Northern North Sea (including the waters around the Northern Isles)

Area 2 - Central North Sea

Area 3 - English Channel (incorporating the southernmost part of the North Sea and the Dover Strait)

Area 4 - Western Approaches and Irish Sea (including the area to the west of Ireland0

Area 5 - Scottish West Coast (including the Minches)

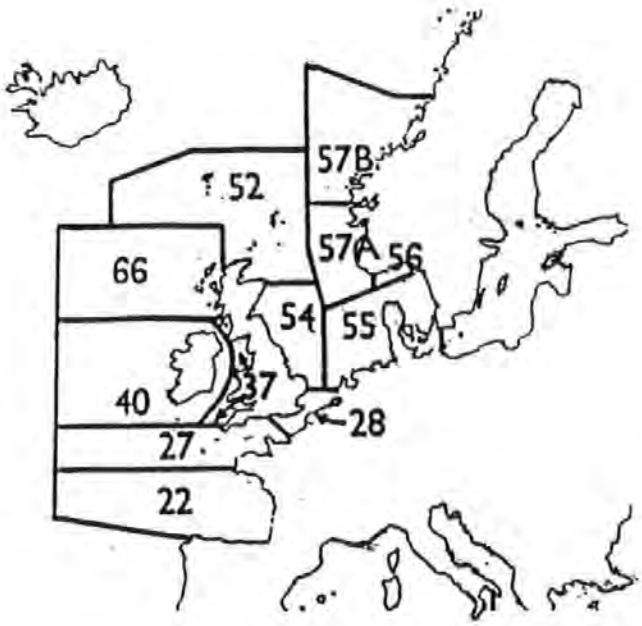

Figure 1.6.1 Delineation of sea areas around the UK used in compilation of Admiralty Sailing Directions. (Source: UK HYDROGRAPHIC DEPT., 1989).

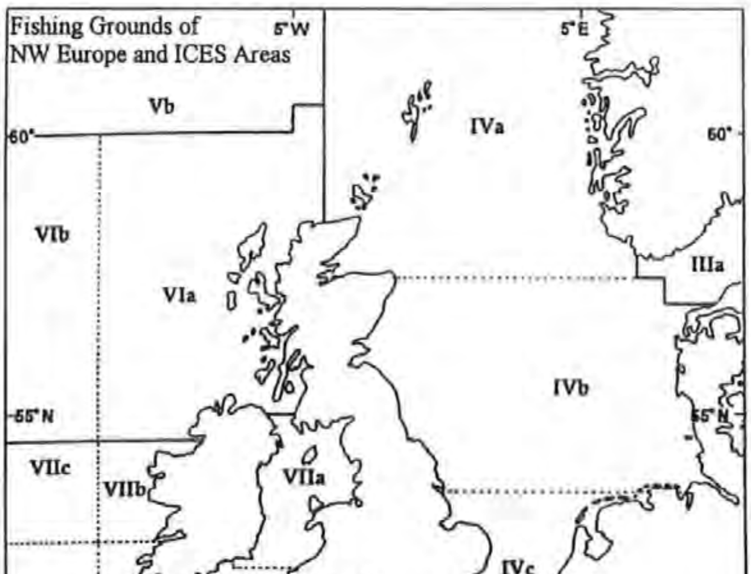

Figure 1.6.2 ICES delineation of the sea around the UK into fishing areas. (Source: SFIA, 1996)

Figure 1.6.3 Delineation of waters around the UK for the purposes of the present study.

1.7 The concept of risk

Some of the scenarios considered in the course of this thesis include actions by watchkeepers that might be classified by behavioural psychologists as "risk-taking". The use of the word, "risk" is a semantic matter of importance in the present study and warrants some clarification.

Certain activities which are accepted by society as being necessary, carry an inherent level of risk that is higher than that which exists in others. Marine commercial fishing is one of those activities. In the UK, as in all other maritime nations, the collective dependence upon fish as an important food source has led to general endorsement of the relatively high chance of loss of life and property in fishing operations. As a concept, risk is perceived through the fundamental human instinct of fear of the unknown and accordingly where the sources of the risk (collision and grounding as examples) are well known and have existed for many centuries it is quite natural that the degree of aversion to these risks will be diminished.

A basic difference normally exists between the acceptable levels of risk for the individual and for the state. For the former, a more cogitative approach is normal, where the likelihood of a catastrophic event and its consequences are considered in the light of their potential effects on the individual's own lifestyle. In the case of the individual, where benefits (financial, social, status) are in some way linked to the level of risk, there will exist an optimum level up to which the risk of fatality and loss of property is acceptable. KINCHIN (1978) suggested that a notional risk of accidental death amounting to 1 in 10^6 is generally acceptable in the UK although this would probably be regarded as conservative for many other countries.

Governments on the other hand, often with the backing of international organisations, tend to favour a less polemic approach based mainly upon some form of cost-benefit study. For the state, trading the cost of vessel losses and deaths against the benefits that may accrue from preventing them, provides an alternative though not necessarily corresponding optimum. KINCHIN (1982) proposes that by applying appropriate discount rates to the future net income of a worker, the "present worth" of the remainder of his career can be assessed and this can be used as a measure of the value of his life. This method has been commonly used by the courts in the UK since the leading case of *EDWARDS -V- NATIONAL COAL BOARD* in 1949. Attempting to assess the future income of a fisherman whose livelihood is dependent upon fish stocks that are currently overexploited may nevertheless be an exigent task for even the most skilled of actuaries!

SPIRO (1992) advocates the collation of information on government legislative action following some fatal accident and consequent expenditure by industry in compliance as a means of valuing life in marine accidents. None of these approaches however can allow for any valuation by the victims so these concepts of risk, with their pecuniary base, do not really provide for analysis of the factors that reconcile fishermen to whatever level of traffic accident risk they are prepared to accept. Perhaps more interesting still, they do not shed light on how fishermen "weigh-up" the various factors. Given the lack of opportunity cost attached to fishing for those who live in isolated fishing comunities and the rather unconventional career base the fishing industry involves (discussed in Section 4.2.11, below), non-monetary aspects in particular are likely to play a major part in the psyche of the fisherman.

The concept of "objective risk" and its perception amongst groups such as fishing vessel watchkeepers suffers from the fact that it has no generally agreed definition. Most research literature refers to risk using abstract terms such as probability, but in many ways this is unlikely to be helpful since the abstruse aspects of collisions and groundings are difficult to measure in any credible way and have to be dealt with on the subjective basis of expert judgement. Decision-making by fishing vessel watchkeepers may have little to do with probability theory where complacency, boredom or fatigue have made inroads. Even where the watchkeeper is alert and motivated, if he has little idea about what he is doing he may reduce his cognitive input to a simple process of assessing the consequences of alternative courses of action and ranking these.

Because many of the analyses in this research involve fishermen themselves defining and quantifying the situations in which they consider navigational danger to exist, the concept of subjective risk is more relevant. A large body of research work in this area accrued in the early 1980's, in which measurement of individual attitudes and responses to danger was the focus (eg. FISCHOFF *et al.*, 1981; VLEK AND STALLEN, 1981; COVELLO, 1983; HALE, 1984). HALE (1987) describes this type of research as the "expressed preference" approach since the outcome is a measure of the way in which individuals think about, classify or rate potentially dangerous situations.

The use of the word "risk" *per se*, carries with it connotations which may hamper the present study. Used in the context of the contribution of individuals to fishing vessel losses, it suggests that some conscious decision has been made to act in a manner that increases the likelihood of an undesirable event and while this does indeed feature in loss analyses (where a watchkeeper has left the wheelhouse unattended for example) it is not uniquely the case. Applied to the watchkeeping system aboard fishing vessels, a component of the system that is customary in any particular segment of the fleet is unlikely to be perceived as risky even though under scrutiny it may prove to be so.

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Chapter 2

THE UK FISHING FLEET AND UK FISHING VESSEL LOSSES:

AN OVERVIEW, 1975-1995.

"The brave! that are no more:
All sunk beneath the wave,
Fast by their native shore"

William Cowper (1731-1800)

2.1 Fleet Structure and Composition

The structure and mode of operation of the UK fishing fleet changed quite dramatically over the twenty year period, 1975 - 1995. Prime movers in this process were the accession of the UK to the (then) European Community in 1973, and the assertion of jurisdiction over living resources of the sea in areas up to 200 miles from baselines by the UK and other countries following the lead given by Iceland in 1972. Figure 2.1.1, drawn from one of the Annexes to the Final Report of the Committee of Inquiry into Trawler Safety, presented to the UK government in 1969 (HOLLAND-MARTIN, 1969), shows the range of the deep sea fishing fleet at that time while figure 2.1.2 shows the ICES (International Council for the Exploration of the Sea) areas within which virtually all UK fishing has taken place since 1977.

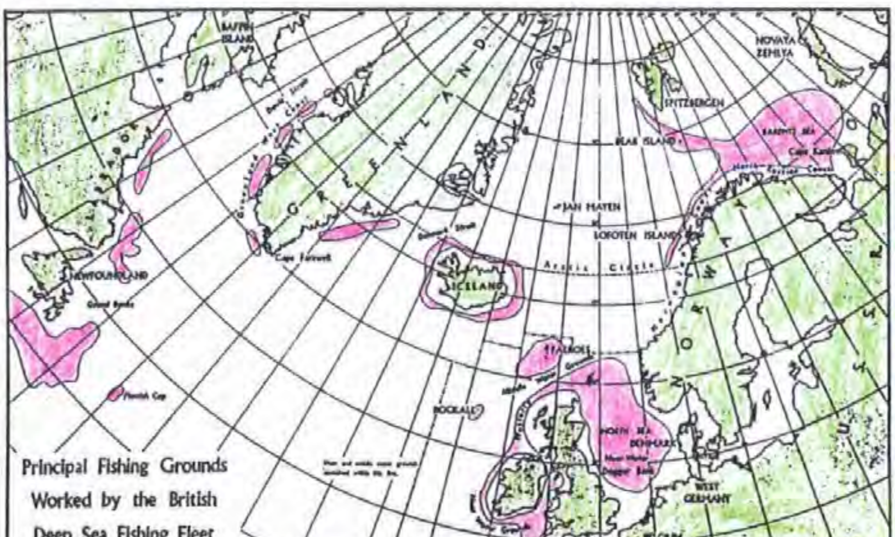

Figure 2.1.1 Principal fishing grounds worked by the UK fishing fleet in 1968. (Source: HOLLAND-MARTIN, 1969)

This closure of productive distant waters led to a severe reduction in viable fishing opportunities for a large proportion of ageing UK vessels which had been primarily designed to fish there. Whether by ecologically-aware policy design or the operation of market forces (see GARROD & WHITMARSH, 1994, for elaboration of this point), the resultant overcapacity was mainly addressed by the withdrawal from the fleet of those vessels which could not be readily adapted to fish nearer home. Between 1978 and 1986, the UK fishing fleet size fell by 43% in tonnage although this loss was counterbalanced by a trend towards an increase in number of vessels in smaller length categories, (Figure 2.1.3).

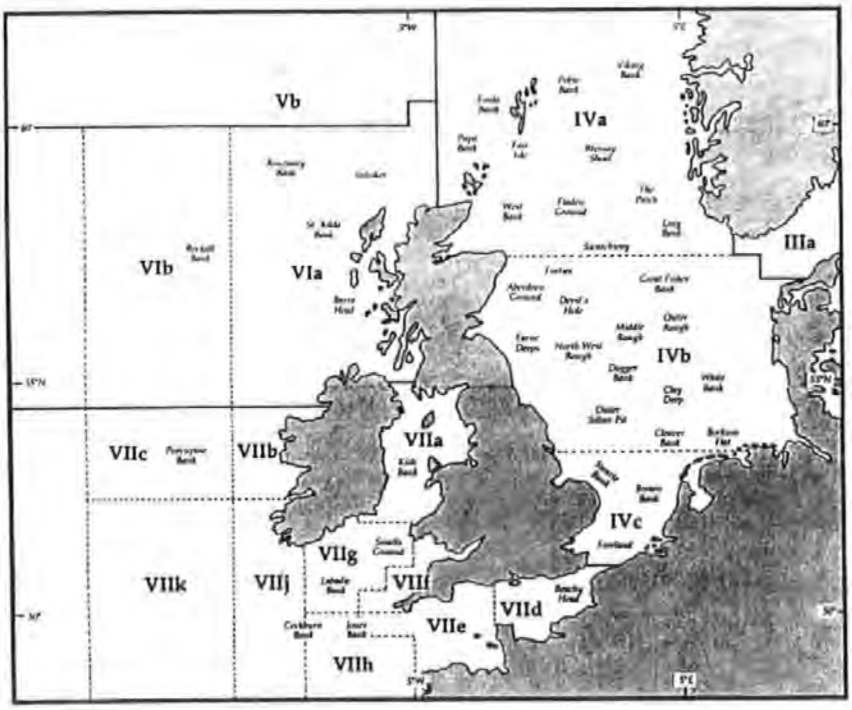

Figure 2.1.2 ICES areas within which almost all UK fishing activity has taken place since 1977. (source: SFIA, 1995)

Fleet size then accelerated rapidly until 1990, when effective implementation of successive European Union, "Multi-Annual-Guidance-Plans" (MAGP I to III) (EC Regulation 3699/83, 1983) which required reductions in both tonnage and engine power to prevent catching capacity outstripping fishing opportunities, (Table 2.1.1) appears to have intervened to stabilise the situation. The most recent version of the plan, MAGP IV, sets re-structuring targets for each fleet segment for 1997 to the end of 2002. Unlike its predecessors, this version of the plan will be accompanied by structural support measures under the EU Financial Instrument for Fisheries Guidance (FIFG). Its measures are designed to ensure significant reductions in fishing capacity in the fleets of EU nations, in the light of a definitive recent report from scientific advisers. The 'Lassen Report' (LASSEN, 1996) indicated that the general situation of fish stocks in Community and international waters has worsened recently, and for many commercial species, urgent steps are required to prevent their total collapse.

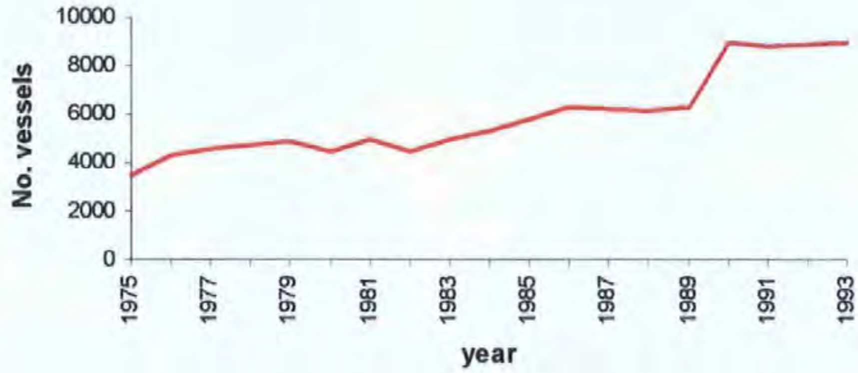

Figure 2.1.3 Total numbers of vessels in the UK fishing fleet, 1975 - 1993. (Source of data: Ministry of Agriculture, Food and Fisheries.

The dramatic increase in vessel numbers between 1989 and 1990, shown in Figure 2.1.3, arose largely because of new fisheries conservation regulations requiring the registration and licensing of vessels of under 10 metres.

Aside from this general picture of decline and later rise in tonnage, there exists a picture of radical change in prevalent mode of operation within the fleet and this is clearly evidenced in changes in the format used for fishing vessel casualty returns. In 1974, UK fishing fleet casualties were clearly categorised by the UK Department of Trade under two main groupings; "Deep Sea Trawlers" and "Fishing Vessels other than Deep Sea Trawlers". The former mainly comprised very large demersal stern and side trawlers while the latter was a mixture of demersal and pelagic trawlers, demersal seine-netters and boats operating static fishing gear (drift-netters, gill-netters, crab-potters, etc).

	VESSEL TONNAGE TARGET	PERCENTAGE REDUCTION NEEDED	ENGINE POWER (HP) TARGET	PERCENTAGE REDUCTION NEEDED
December 1989	**161 231**	**9%**	**1 115 337**	**6%**
December 1990	**150 336**	**15%**	**1 068 062**	**11%**
December 1991	**141 620**	**20%**	**1 017 863**	**15%**

Table 2.1.1. MAGP targets for UK fishing fleet reduction. (source: SFIA European and parliamentary briefs)

In 1979, the format of fishing vessel casualty returns, published by the Department of Transport, was revised to consist of three sections, "over 80 feet", "40 to 79.9 feet" and "under 40 feet". This move was significant in that it was as much a reflection of the changing composition of the fleet as it was relevant to the length categories used in the Fishing Vessels (Safety Provisions) Rules, 1975.

By the mid 1980's, the number of large distant water demersal trawlers had declined by 67% while numbers of smaller inshore vessels operating mainly within the UK Fishing Zone and pursuing various types of fishing, remained roughly constant, before rising from 1987 on. In 1983, fishing vessel size groupings were metricated to become, "over 24metres", "12 - 24 metres" and "less than 12 metres".

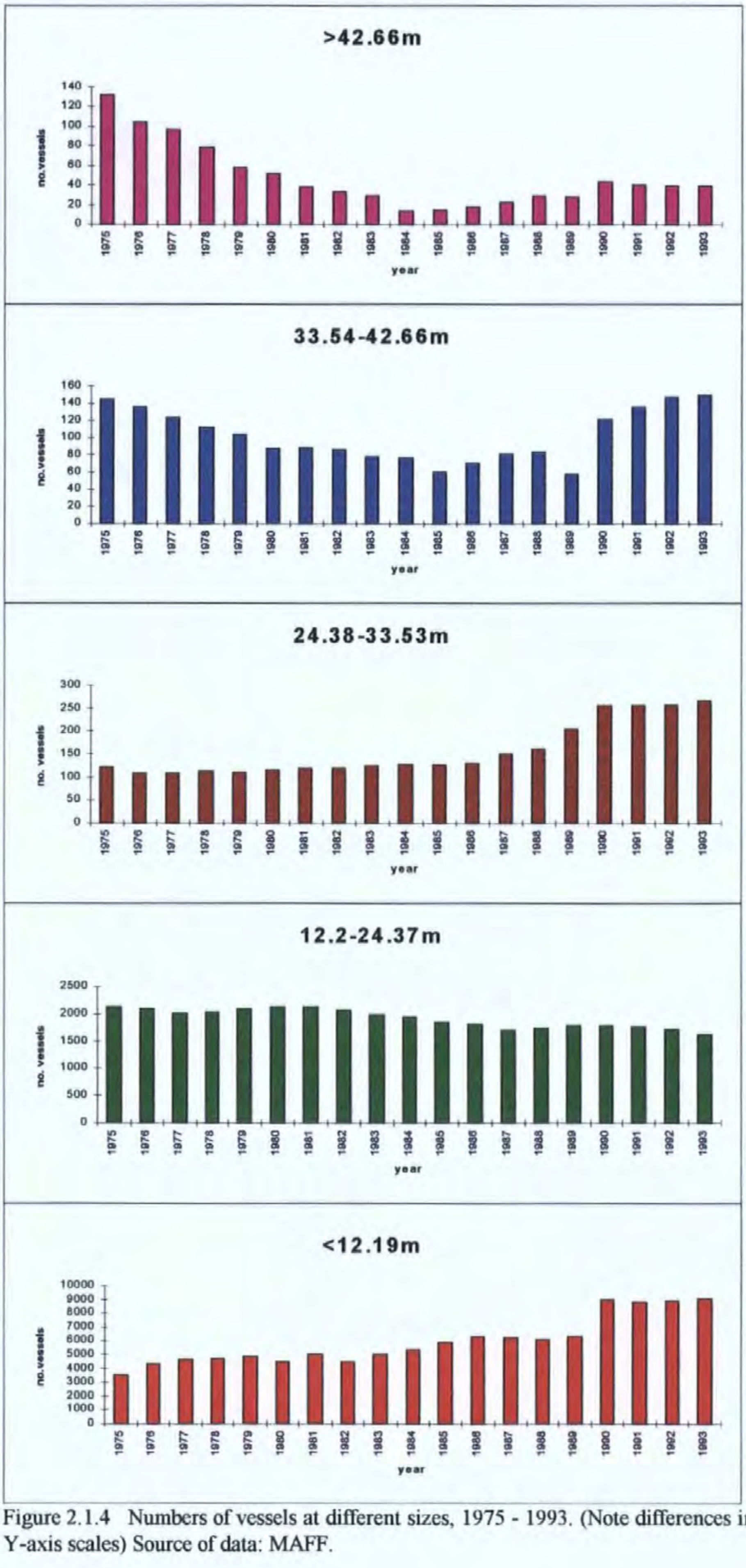

Figure 2.1.4 Numbers of vessels at different sizes, 1975 - 1993. (Note differences in Y-axis scales) Source of data: MAFF.

From January 1st, 1998, the system of describing fishing vessels will be harmonised within the European Union by being divided into the following categories; "large" (>24 metres), "medium" (10 - 24 metres) and "small" (<10 metres), (EUROPEAN INFO FLASH, 1994).

Changes in the numbers and types of vessel in operation during the period are evidenced in the figures published by the Ministry of Agriculture, Fisheries and Food (MAFF) which were used to compile Figure 2.1.4. From 1984 onwards, these data indicate a gradual trend towards the re-introduction of very large (over 40 metre) fishing vessels. These are however very different to the previous generation of boats of this class, being mainly engaged in pelagic purse-seining and pelagic trawling and equipped with full watertight shelterdecks, refrigerated seawater tank fish preservation systems and an exhaustive inventory of navigational, fishfinding and safety equipment. These vessels tend to fish within fifty miles of the UK coastline and spend as much time in port, unloading their large catches and laid up during closed fishing seasons, as they do at sea.

1985 also appears to have been a watershed year for the medium size classes of fishing boats. From that time, numbers of 24 - 33 metre and 33 - 42 metre vessels have expanded. The most likely reason for this is that, as coastal waters have come under increasing fishing pressure and become "fished-out", vessel owners previously operating smaller craft have invested in vessels that are better capable of fishing further out to sea and in less favourable weather conditions. It may be that the fleet will gradually revert to a structure similar to that in existence prior to the demise of the distant water fleet of the 1970's as an increasing number of UK operators begin to pursue what are currently lightly fished stocks on the continental shelf edge to the west of the British Isles. BRADY (1993) proposes that fishing in these waters is not suited to vessels of anything smaller than 35m in length. The economics of fishing also dictate that where longer steaming distances are concerned, it is preferable to make fewer journeys with larger loads, so as fishing moves further offshore, fish-hold capacities must increase. In accordance with this operational remit, significant advances in the design and manning of this class of vessel began to show from the mid 1980's onwards. For example, full length, watertight shelterdecks and advanced electronic navigational equipment became *de rigeur* and because of the increase in vessel length, Skippers and Mates have been required to gain appropriate Certificates of Competency.

From reviewing the fishing trade press (eg. "Fishing News"; "Fishing News International"; "Commercial Fishing"; "Scottish Fishing Weekly"; etc.) it is clear that a great number of those involved in capture fisheries in the UK are currently under quite severe financial pressure, yet many who would like to do so are finding it impossible to leave the industry. Although the EU Common Fisheries Policy (CFP) allows for member states to operate a system of decommissioning grants aimed at providing a financial incentive for owners to remove their vessels from the fleet, this was not a popular strategy with the UK government through the late 1980's and early 1990's. In addition to this, with the exception of replacement of vessels lost at sea, financial aid for newbuilding has been withdrawn and only improvements which do not result in an increase in vessel power or GRT have been eligible for grant assistance from the British government. Since the EU will usually only match a national grant once it has been arranged, and also because of the UK's general failure to meet MAGP targets (Table 2.1.1), British fishermen have found it almost impossible to access European money for replacing and improving their vessels.

In 1992, the British government did announce a decommissioning scheme which was backed by some £25 million. This support was offered only on the condition that the industry agreed to an effort reduction scheme based upon a system of permanently limiting the number of days that UK fishing vessels could spend at sea in each year. This condition, which has become known as the "days at sea issue" was vehemently attacked by fishermen's organisations on the premise that safety would be compromised because fishermen would be forced to go to sea in weather conditions that were unsuitable, simply to make up their time allocation. The National Federation of Fishermens Organisations (NFFO) has gone on to challenge the legality of the bill enabling this legislation in the European Courts and the "days at sea" regime has never been introduced.

2.2 Fishing vessel losses

This element of the research is mainly based on analysis of data collected by public bodies and insurance companies, frequently for purposes other than addressing the specific questions the author had in mind. While these data provide indisputable knowledge of numbers of vessels lost and associated fatalities, the difficulty in contriving a credible a measure of exposure to risk so far as fishing vessels are concerned, is problematic.

To illustrate this point; it is well known that world wide, more people die as a result of being stung by bees than in shark attacks. Most people however would rather spend time in a garden where bees abound, than swim at a beach where even one shark has been sighted. To further complicate matters, while "number of fatalities per species" would appear to be a superior measure to a simple count of fatalities, it must be borne in mind that bees tend to be close to people much more frequently than sharks. Even if a process of normalisation for proximity was carried out, it would still be difficult to answer the question, "do bees pose a greater threat than sharks?" since people tend to exercise greater care in the presence of sharks.

It would be conceptually possible to derive some figure for the mean amount of time, say days spent at sea per year, by each vessel. This could then be multiplied by the number of vessels in the fleet during the year in question and finally related to the number of vessels lost and cause of loss to arrive at a figure for the percentage chance that a vessel will be lost to any given cause, on any given day. Paucity of the necessary information in this case however would render such analysis so imprecise that it would not constitute a meaningful component of a scientific study. While EVANS (1984), talking of road traffic safety, expounds the view that there can be no all purpose definition of exposure, it is accepted for the purpose of this Chapter that a general measure of a fishing vessel's exposure to the risk of loss does exist and that this lies in normalisation of the annual number of vessels lost by reference to the number of vessels in the fleet during that year. Albeit it retrospective, this tactic provides a more accurate indicator of the relative level of loss risk within the fleet but it cannot of course detract from the fact that a greater overall number of vessels lost, regardless of fleet size, must inevitably lead to higher economic and human cost.

ROMER *et al.* (1995) broadly describe this approach to comparing maritime loss frequencies as being "empirical" and cite an alternative method, "ship domain theory" (eg FUJII, 1974) as having application in assessing collision and grounding frequencies. This latter proposition is based upon the traffic density and number of loss events in a given sea area and arrives at some probability that a vessel will fail to avoid an obstacle. The present author did in fact attempt to gain some idea of the rate of encounter with other vessels experienced by fishing boats by distributing standard forms for completion by willing fishing boat watchkeepers. Unfortunately, the forms were returned with a paucity of useful information since the encounter rate, defined as when either their own vessel or a give-way vessel had to change course in a meeting situation, was so low that it became meaningless. ROMER *et al.* conclude that for highly specific studies, for instance the development of a new bridge, ship domain theory may be appropriate but for more general studies, empirical analyses seem more advantageous.

The use of losses in the present study, rather than accidents, incidents or casualties also reinforces the use of empirical analyses rather than the ship domain approach in the present study because of confidence in the completeness of the database. All losses of fishing boats in the UK fleet have been recorded during the study period and therefore the empirical results must be conclusive. If data relating to incidents were being used however, this would not necessarily be the case since only a proportion of these are actually reported and even then the reports are only occassionally accompanied by the level of information required to make further analysis possible.

2.3 Losses from all causes

Absolute numbers of losses of UK fishing vessels from all causes reached a peak of 52 in 1981, falling to a low of 14 in 1987. The loss ratio for UK fishing vessels broadly mimics this pattern although the trend of rising losses through the most recent years is less pronounced. (Figure 2.3.1).

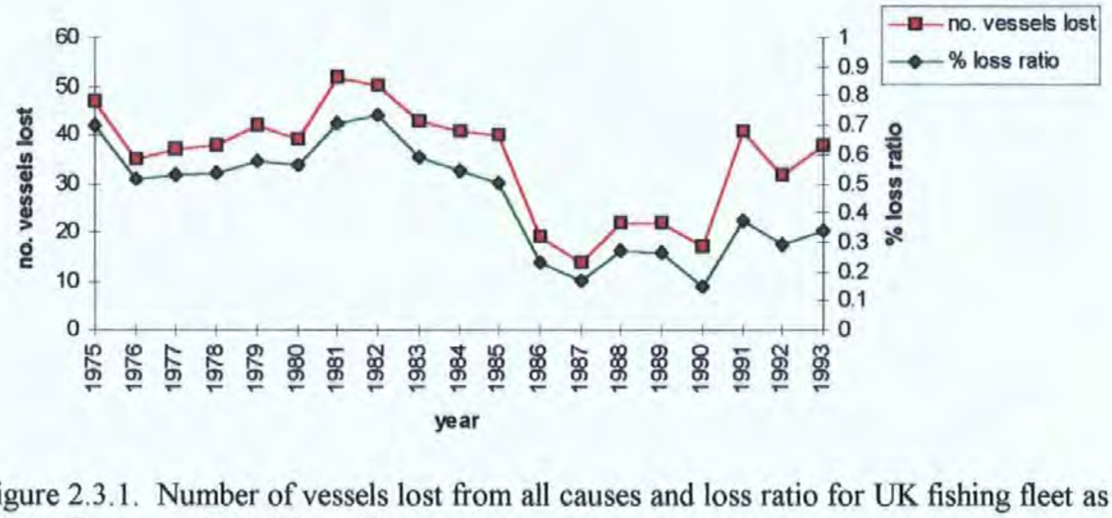

Figure 2.3.1. Number of vessels lost from all causes and loss ratio for UK fishing fleet as a whole, for the period, 1975-1993.

2.4 Losses by cause

Since July, 1989, the Marine Accident Investigation Branch (MAIB) has assumed responsibility for the compilation and publishing of fishing vessel loss statistics. Established under Section 33 of the Merchant Shipping Act (1988), the MAIB operates under the Merchant Shipping (Accident Investigation) Regulations (1989) with powers to investigate accidents involving or occurring aboard all types of UK vessels and submits reports of inquiries to the Secretary of State. The MAIB categorises fishing vessel losses in broadly similar fashion to its predecessor, according to the nature of the loss, under the following headings;

- ***Capsize***
- ***Collision***
- ***Fire***
- ***Flooding***
- ***Foundering***
- ***Grounding***
- ***Heavy weather***
- ***Machinery damage***
- ***Missing***

Prior to the advent of the MAIB, "heavy weather" and "machinery damage" did not appear in official statistics as loss categories. For purposes of the analyses presented in this study, the convention adopted by MAIB in presenting statistics relating to fishing vessel accidents in general has been adopted; that is to say, figures for losses resulting from foundering and flooding are combined, and also the inclusion of those resulting from heavy weather damage and machinery damage under the heading, "other causes".

UK fishing vessel losses over the period 1974 - 1994 were examined under these individual headings to investigate how the significance of each, as a cause of loss, altered during that time.

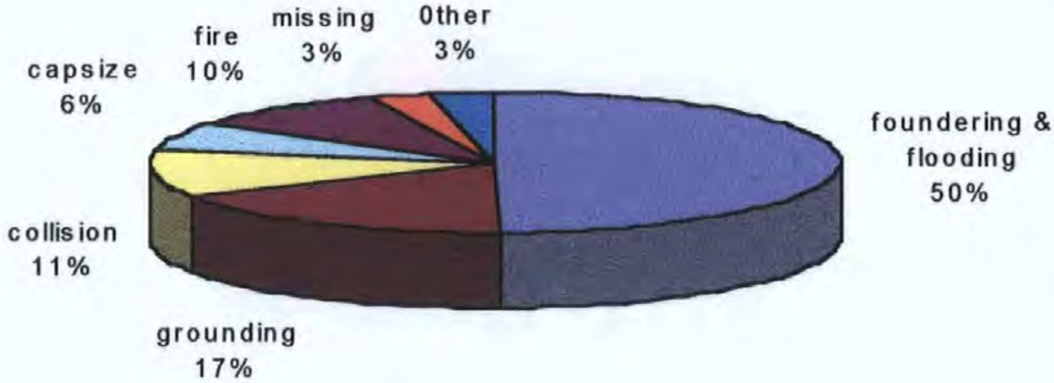

Figure 2.4.1 Causes of all fishing vessel losses, 1975 - 1993.

Figure 2.4.1 shows that during the whole of the period, 1975 - 1993, exactly half of all fishing vessels that were lost came to grief in foundering and flooding events. A further 28% were lost in collision and grounding incidents and the remaining 22% were the result of fires, capsize, disappearance and other miscellaneous causes respectively.

Using the high and low points of the annual distribution of losses over the study period as markers allows the somewhat arbitary delineation of three discrete time bands within the loss ratio time series: Period A (1975 - 1981) when the percentage ratio of losses increased slowly (regression coefficient = 0.005542; $r^2 = 0.0199$); period B (1982 - 1987) when this ratio fell dramatically (regression coefficient = -0.11331; $r^2 = 0.9329$); and period C (1988 - 1993) when it rose once again (regression coefficient = 0.018742; $r^2 = 0.2939$), (Figure 2.4.2).

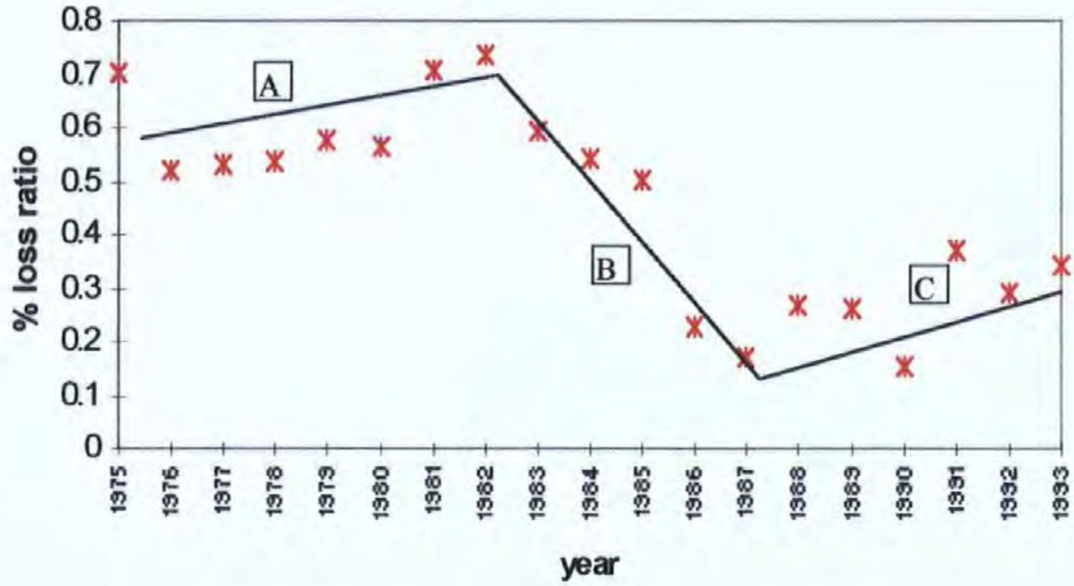

Figure 2.4.2 Regression lines plotted on loss ratios for UK fishing fleet, 1975 - 1993.

Analysis of the distribution of causes of loss within each of these time bands provides a more tangible picture of the causal situation over the study period. Figures 2.4.3 (a), (b) and (c), show how the proportion of losses attributable to various causes has changed in these three periods, with collisions, groundings and fires diminishing in significance while the gravity of foundering & flooding and capsize increases substantially. Losses classified under the umbrella term, "other causes" (heavy weather, machinery damage, etc.) are of little consequence in the first two time periods, but become more important in the most recent. The number of vessels that disappear without trace, leaving the cause unknown remains variable throughout.

Figure 2.4.3 a. Proportion of losses attributable to various causes, 1975 - 1981, when overall % loss ratio rose

Figure 2.4.3 b. Proportion of losses attributable to various causes, 1982 - 1987, when overall % loss ratio fell.

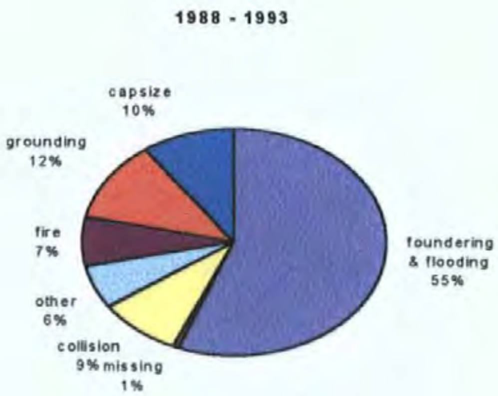

Figure 2.4.3 c. Proportion of losses attributable to various causes, 1988 - 1993, when overall % loss ratio began to rise once again.

2.5 Analysis of Loss Categories

While this study is primarily concerned with fishing vessel losses arising from collisions and groundings, it serves to set these in perspective to give some general consideration to loss categories.

2.5.1 Foundering & Flooding

Foundering and flooding events account for exactly half of the total number of fishing vessel losses over the entire study period. Figures 2.4.3 a, b and c shows that it has assumed increasing consequence over the three time periods, 1975-81; 1982-87 and 1988-93, when it was the cause of 45%, 49% and 55% of losses respectively. This trend is reiterated in figure 2.5.1 where the loss ratio for foundering and flooding is superimposed upon the actual number of vessels lost due to this cause. From a fluctuating situation in the late 1970's and early 1980's, an increase in both absolute numbers of vessels lost in this way and in the proportion of the total number of vessels at risk, which succumbed to foundering and flooding, is clearly evident from 1987 onwards.

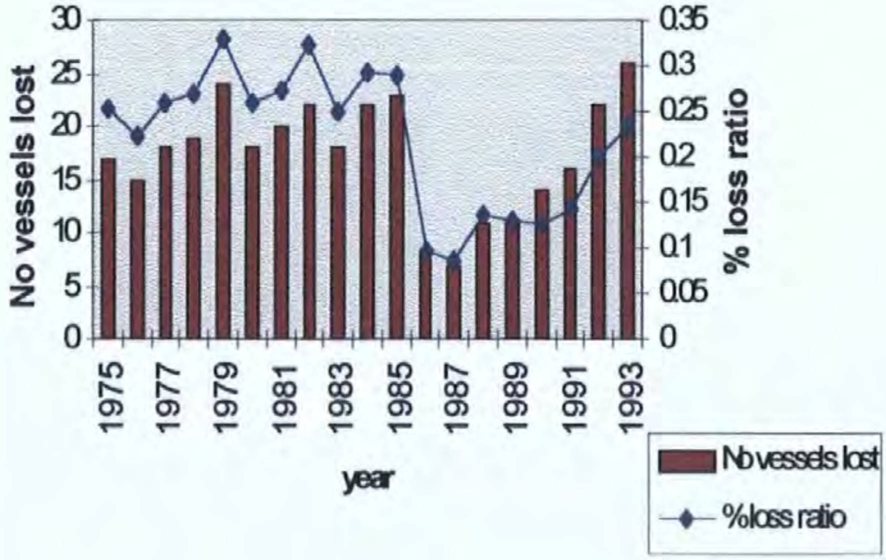

Figure 2.5.1 Numbers of fishing vessels lost and percentage loss ratio as a result of foundering and flooding 1975-1993.

2.5.2 Capsize

Although the actual number of events is small, a maximum of four losses in 1980, the nine year period from 1980 to 1988 showed a clear downward trend in capsize losses.

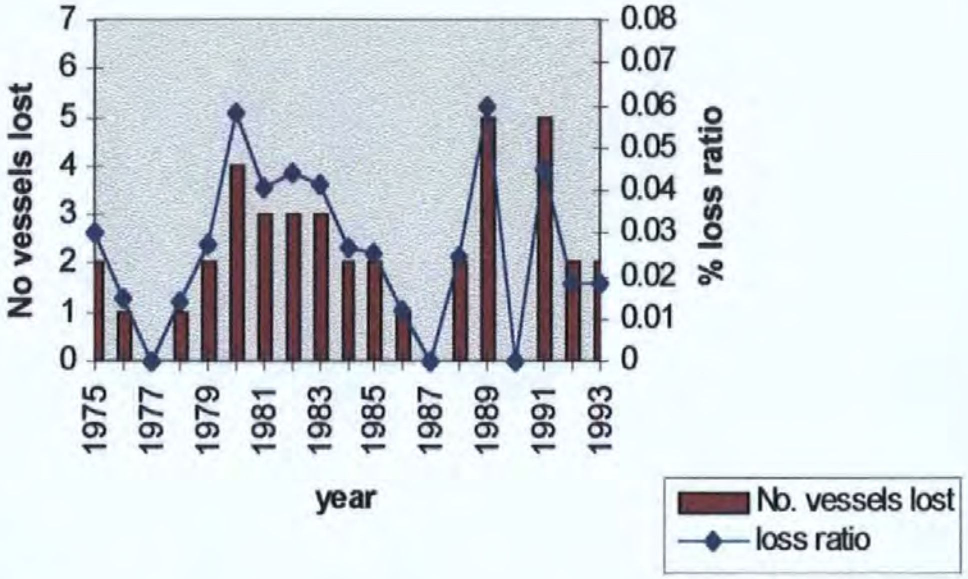

Figure 2.5.2 Number of fishing vessels lost and percentage loss ratio resulting from capsize, 1975-1993.

2.5.3 Fire

The trend in fishing vessel losses resulting from fires between 1975 and 1993 has been uneven, with a maximum of 10 vessels being lost in 1981 and none lost at all in 1990. The three years 1981 through to 1983 were notably bleak in respect of fire losses with 23 vessels succumbing to this hazard while only 21 were lost in the same manner in the subsequent ten years.

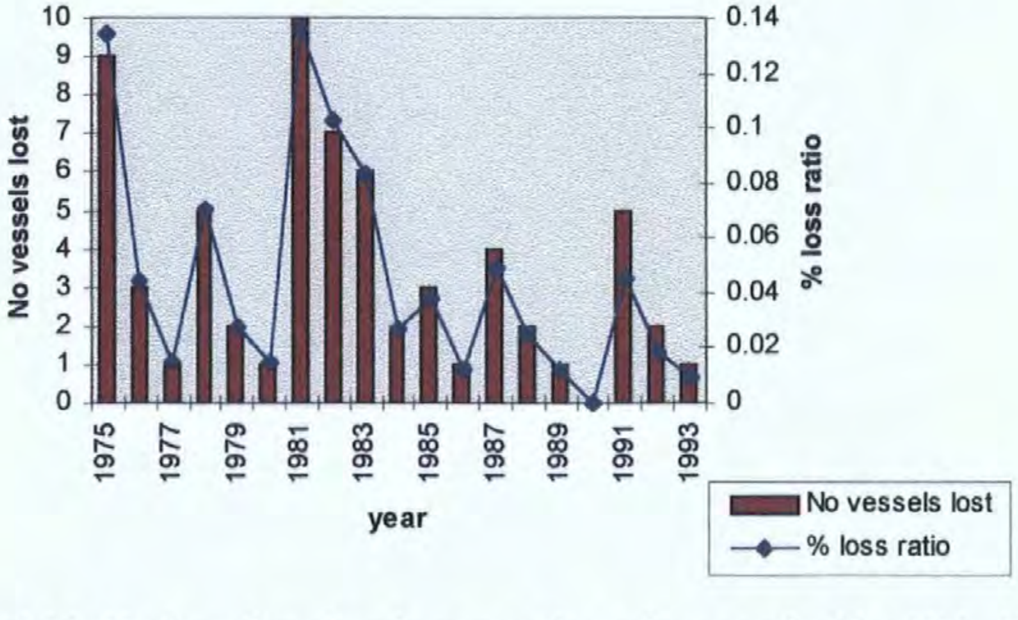

Figure 2.5.3 Numbers of vessels and percentage loss ratio as a result of fire, 1975 - 1993.

2.5.4 Missing

The total number of fishing vessels presumed lost after going missing may of course include those which in reality went down for any of the other reasons. Mercifully, since 1985 only one loss has had to be recorded under this heading.

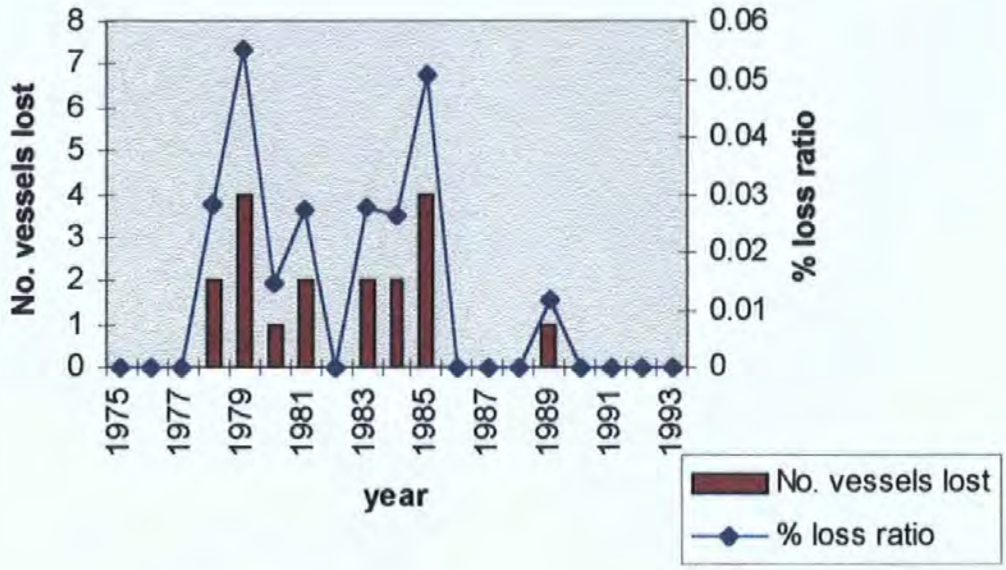

Figure 2.5.4 Numbers of fishing vessels assumed to be lost after going missing and resulting percentage loss ratio, 1975-1993.

2.5.5 Collision

1979 was an extremely grim year with regard to fishing vessel collision losses with nine being recorded, giving a loss ratio of 0.12%. This would mean that roughly one in every 800 vessels in the UK fleet that year was lost in collisions. Put in these terms, 1979 offers a stark comparison with the years, 1987 1988 and 1990, when only around one in 10000 fishing boats was lost in this way. In the early part of the 1990's a disturbing trend towards a return to higher annual rates of collision losses was evident.

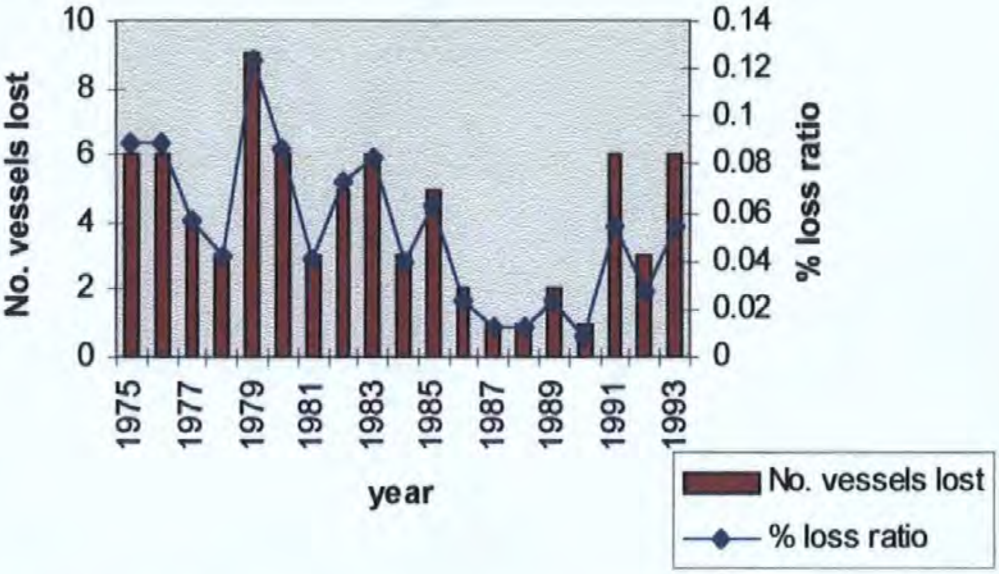

Figure 2.5.5 Number of fishing vessels lost and percentage loss ratio resulting from collision incidents.

2.5.6 Grounding

The very nature of some types of fishing activity involves fishing boats being presented with the risk of running aground. Some vessel types, those fishing for crabs and lobsters for example, tend to work near reefs and headlands where their target species are more plentiful. Many boats discharge their catches daily, or at other intervals during the fishing trip with the aim of achieving a price premium for freshness but each of these landings carries with it the risk of running aground. It is not surprising therefore that grounding has been the second most common cause of fishing vessel loss after foundering and flooding.

With the exception of 1979, when only one fishing boat was lost in a grounding event, the ten years from 1975 to 1985 saw substantially more grounding losses than the subsequent period. The risk of a UK fishing boat being lost as a result of grounding in 1975 was marginally better than one in five hundred while in 1993, it was about one in a thousand.

The trend in grounding losses, although declining on average, has been erratic since the mid 1980's.

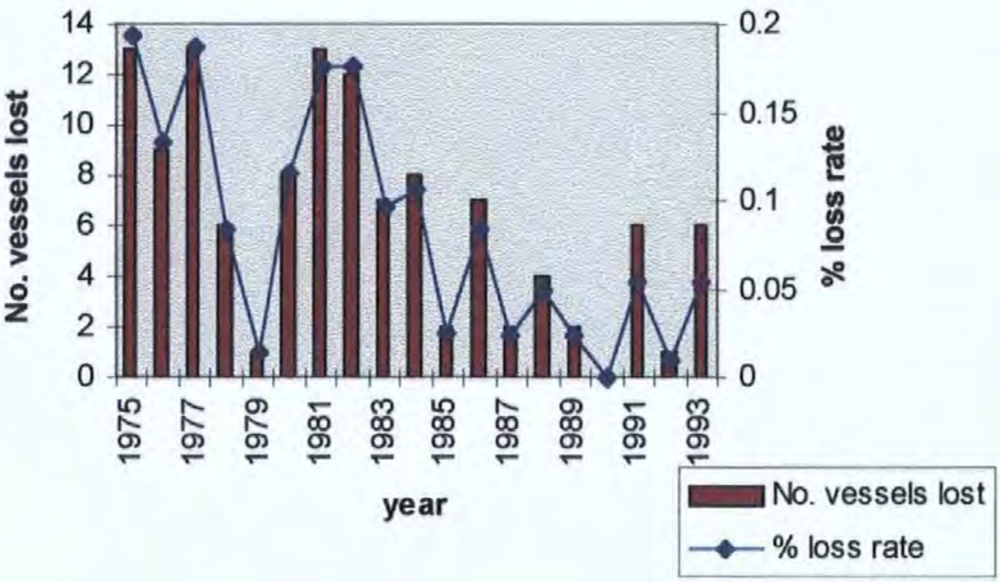

Figure 2.5.6 Numbers of fishing vessels lost and percentage loss ratio resulting from groundings, 1975-1993.

2.6 Chapter discussion

The UK fleet has undergone considerable change in size and structure since the mid 1970's. This was driven firstly by the imposition of firstly, 50 mile fishing limits which were subsequently pushed out to 200 miles. This, coupled with the oil price rises of that era, led to the demise of the British distant water fleet.

While the present fleet structure has been more or less stable for a number of years, the effect of MAGP IV, in particular since it is accompanied by structural support measures, may well lead to noticeable change in the the early part of the next century. Already a trend towards a fleet composed of a small number of bigger, newer, more sophisticated vessels and a currently large but decreasing number of small, much older boats is becoming apparent. This would suggest that a study of the relative importance of vessel length and age in traffic losses might be worthwhile. This is pursued in Chapter Four.

Legislation proposed for the purpose of conservation of fish resources could also have an effect on the safety of the fleet. One of the arguments proposed by the NFFO to counter the UK government's plan to introduce a "days at sea" regime was that safety would be compromised since fishermen would be forced to go to sea in bad weather and work harder while they were out at sea to make sure they derived full benefit from their fishing time allowance. Indeed, VEENSTRA & STOOP (1992) cite "restricted fishing days" as being a potential source of extra workload in a safety integration matrix for Dutch beam trawlers. It might equally be argued however that if the average amount of time vessels were spending at sea was compulsorily reduced, they would be at risk for a correspondingly reduced period and thus the fleet will become safer.

The measure of exposure to risk embodied in the loss ratio is weakened from 1989 because of vessels of under 10 metres being forced on to the register of shipping from that time on and thus into the risk normalisation process. Many of these small craft are operated on a part-time or seasonal basis, for instance by crofters in the Scottish Hebridean islands and owners of summer guest houses in Cornwall and Wales. Additionally, most of them spend considerable amounts of time in port because of bad weather. The result is that the calculated loss ratio may be, since this influx of small boats into the figures, biased towards making the fishing fleet look much safer than it actually is.

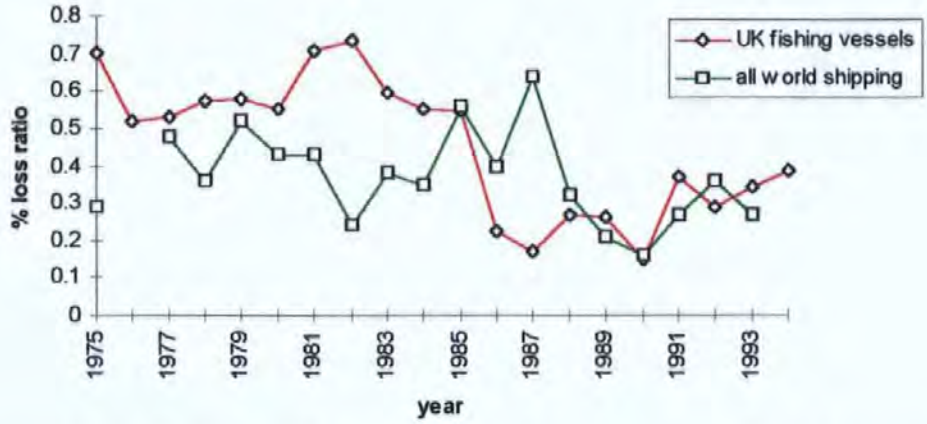

Figure 2.6.1 Ratio for all UK fishing vessel losses compared with loss ratio for all world shipping, 1975-1994. (Source: JAMRI, 1993).

Comparison of the loss ratio for UK fishing vessels with the same for all world shipping (Figure 2.6.1) shows that up until 1989, the former was, on average higher. Since 1989 however, there has been little difference between the two. With the under 10m vessels removed from the fishing vessel loss ratio however, the same analysis shows considerable disparity with that for over 12 metre fishing boats rising above 1% in 1994 while its counterpart remains below 0.4%, (Figure 2.6.2).

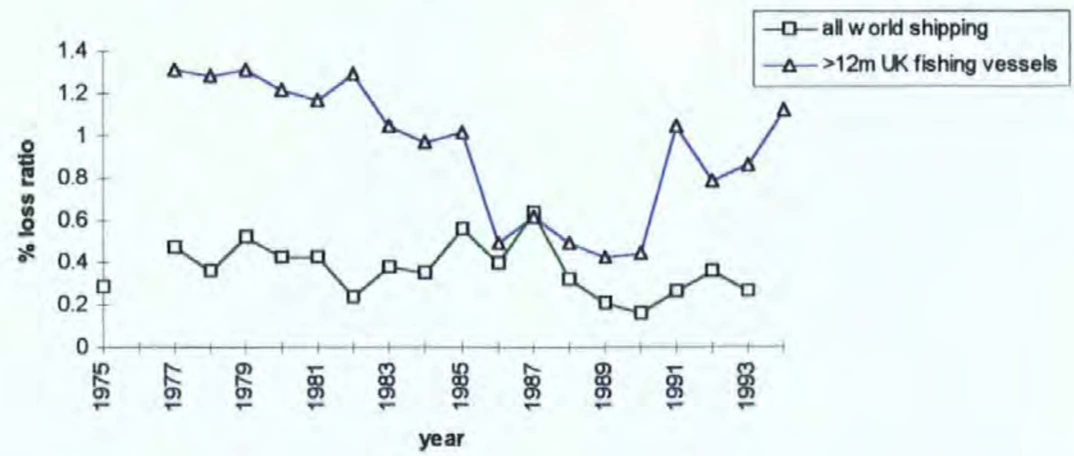

Figure 2.6.2. Loss ratio for all world shipping compared with same for UK fishing vessels of over 12m.

Albeit without corroborating evidence, BOURNE (1992) contradicts the reasoning in the previous paragraph, saying that since 1975 the number of accidents involving small fishing vessels has made up an increasing proportion of the total. That he uses the term, "accident" rather than "loss" may however have more than mere semantic significance. Figure 2.6.3 shows the level of search and rescue activity related to fishing boats between the years 1978 and 1990. A sharp increase can be seen from 1986 onwards - possibly the result of the introduction of much improved distress and communications systems. One might readily hypothesise that had this level of search and rescue not been available, there might have been many more "accidents" that would have turned into "losses". Review of the level of "search and rescue' activity related to fishing vessels during the study period (Figure 2.6.3) tends to confirm that this is likely to be the case.

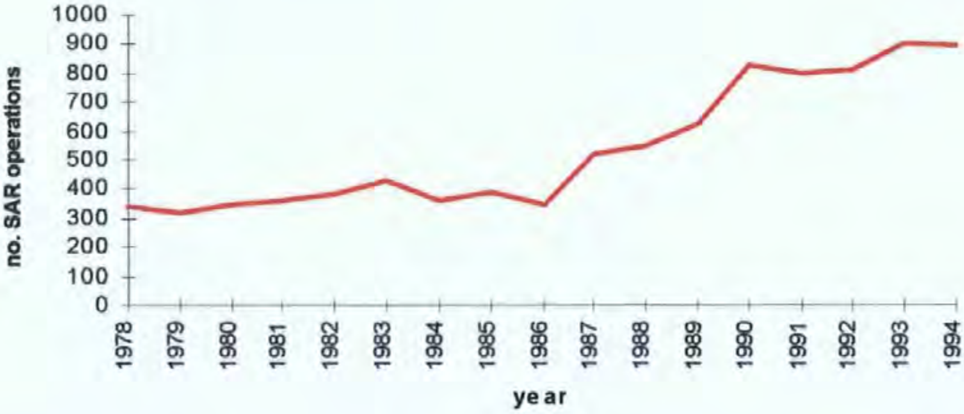

Figure 2.6.3. Annual numbers of search and rescue operations concerning fishing vessels around the UK coastline, 1978-1994. (Source: Royal National Lifeboat Institution, Public Relations Office, 1997)

While perhaps rather difficult to substantiate, it is nevertheless a peripherally interesting hypothesis that period 'B' in Figure 2.4.2 i.e. falling losses from all causes, corresponds with a relatively buoyant phase in the UK national economy, during which finance for vessel improvement programmes was readily available. This is an argument often tendered by UK fishermen eager to see the level of grants and low interest finance for vessel improvement raised and it is not necessarily without foundation. JOKSCH, (1984) for example, proposed that the index of industrial production is an effective explainer of the number of road traffic fatalities in the USA between 1930 and 1982.

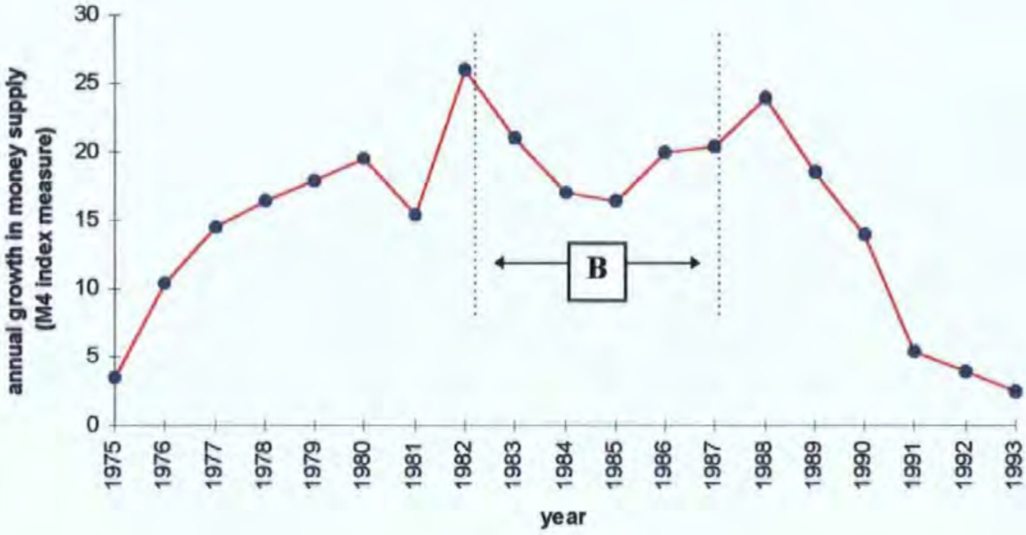

Figure 2.6.4 Trend in annual growth in lending by UK banks (M4 measure).
(source: JOHNSON & BRISCOE, 1995).

Figure 2.6.4 illustrates the annual growth in UK money supply which is a surrogate for the level of bank lending between 1975 and 1993. From this it can be seen that it is probably true to say that it was generally easier for vessel operators to access finance during this period than either before or after, although it would be more accurate to incorporate the numbers of applications for vessel improvement grants into the analysis.

Improvements to vessels must be planned and take time to complete so it is necessary to introduce a time lag into the analysis to test whether this availability of funding made any difference to the safety of the fleet. A range of different "time lags" from one to five years were tried to see whether the two variables provided any significant correlations however none gave an R^2 value of more than 0.2, completely undermining the fishermen's anecdotal reasoning. Figure 2.6.5 illustrates this by plotting vessel losses against the M4 money supply index from two years prior to give virtually no correlation at all. Had there been a relationship of significance in this respect it would have been a useful guide to the time it takes for new measures, possible including legislation, to be translated into improved safety levels.

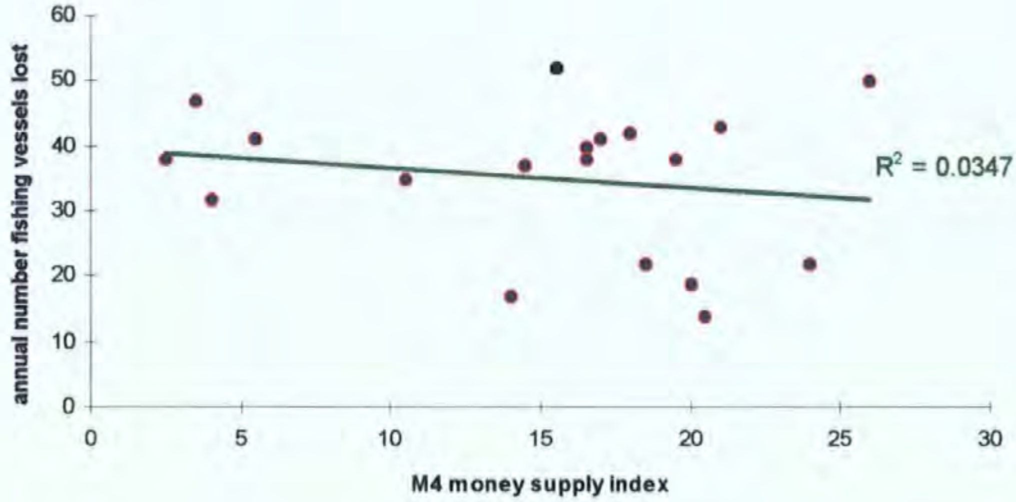

Figure 2.6.5. M4 money supply index correlated with numbers of fishing vessels lost where a two year time lag is included.

The fact that since 1985, only one vessel was lost under the category, "missing" is probably due to a number of factors. The introduction of EPIRB (Electronic Position Indicator Rescue Beacon) devices which are installed to float free when a vessel goes down will undoubtedly have contributed to this, but other less obvious developments, for example better hydro-acoustic systems for locating wrecks and ROV (Remotely Operated Vehicle) camera systems for their positive identification and determination of cause of loss have also played their part.

The decline in capsize losses through the 1980's may well be have been due to the widespread introduction of shelterdecks in the fishing fleet at this time since these tend to delay the point at which stability is lost, thus reducing the chance of capsizing. Additionally, the application of new Fishing Vessel Safety Rules since 1977 which include regular surveys may have helped to identify stability problems before they led to catastrophe. There is no simple explanation however for the irregular pattern of capsize losses post 1988.

The rest of this thesis is focused upon losses due to collision and grounding and it is hoped that the data presented in this chapter have served to set these in perspective. Considered in tandem, collisions and groundings account for 28% of all fishing boat losses during the study period compared with foundering and flooding which accounts for 50% (Figure 2.4.1). This is contradictory to the findings of ROMER *et al* (1995) who state that, for all types of merchant shipping, founderings are on the decrease while collisions are increasing. Nevertheless, the reader could be excused for begging the question - why study these losses and the factors which surround them when they are not the most significant contributors to the overall loss rate?

The answer lies in the fact that collisions and groundings are "traffic" events, rather than "material" ones and are likely to have common causes rooted in navigation and watchkeeping systems. Recent moves by competent authorities to improve levels of safety in the UK fishing fleet have tended to concentrate on material aspects, for example, the proposed MSA "under 12 metre code of safe practice", currently in its consultation stage, which is aimed at ensuring small fishing boats meet essential stability and equipment criteria. This is understandable and correct given the high and apparently increasing role of foundering and flooding as a vector of vessel loss.

At a time when fish resources appear to be overstretched and fishermen face the prospect of having to accept reduced earning opportunities in order to allow stocks to recover, safety measures that can be effected cheaply are likely to be more readily acceptable than those involving major expense. Meeting onerous technical criteria usually involves installation of equipment or fittings and can be a very costly matter. Improving the effectiveness of fishing watchkeepers and changing watchkeeping systems for the better may, on the other hand, be a simple and cheap matter if shortcomings in the present regimes can be identified using reliable methods. If the 28% of losses that are attributable to traffic events can then be reduced through informed yet inexpensive changes in attitude and approach, then research in this area must be justified.

2.7 Chapter summary

- The size and structure of the UK fishing fleet changed markedly during the period, 1975-1993. It is likely that even more pronounced changes in these respects will occur in the future, this being accelerated by fisheries management measures aimed at aligning fishing effort with available resources

- Legislation introduced for fisheries management may have an effect on the safety of the fishing fleet, but it is a matter of debate whether this will be positive or negative.

- A large number of small vessels became reckonable in calculation of loss ratios in 1989. This may have the effect of making the fishing fleet as a whole, look safer than it really was over the ensuing years.

- No correlation could be found between the availability of funding for vessel improvements and the number of fishing vessels lost to all causes.

- The most common cause of fishing vessel loss between 1975 and 1993 was foundering and flooding though traffic events - collisions and groundings - together accounted for 28% of all fishing vessel losses.

- Most safety measures introduced in recent years have been of a technical nature, often involving significant cost for operators; nevertheless the number of founderings and floodings continues to increase.

- Reducing the number of traffic losses might be possible with relatively little expense if improvements in the standard of watchkeeping, based on appropriate research, could be effected.

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Chapter 3

THE UK FISHING VESSEL MACRO-ENVIRONMENT

"In a bowl to sea went wise men three,
On a brilliant night in June,
They carried a net, and their hearts were set
On fishing up the moon."

Thomas Love Peacock (1785-1866)

3.0 Introduction

Although some aspects of the environment in which fishermen and their vessels operate are anecdotally well known, too little has been published to allow for a comprehensive resumé based upon literature searching. Some relevant material does exist, for example data on noise on fishing vessels published by the Sea Fish Industry Authority, but this type of information is fragmented and no composite study has been attempted. The work in this chapter is accordingly based upon a wide range of sources - structured and unstructured interviews by telephone and in person, questionnaire responses, observation and data recording at sea, and reference to relevant publications which are not necessarily fishing-related.

In this chapter, the operating macro-environment of UK fishing vessels is described. This deals with factors such as marine traffic density, meteorological conditions, main fishing ports and the types and ages of vessels operating around the UK. The approach taken is that of offering a broad comparitive analysis of five fishing vessel operating areas which have been identified in this study and to use this to provide a general description of the operational macro-environment.

3.1 Geographical areas

With the exception of only a very small number of boats licensed to fish seasonally in various distant water locations, the UK fishing fleet has tended to operate well within 200 miles of the British coastline over the last twenty years. Recent technological developments in deep water fishing have led some operators to mount forays to fish the continental slope off the west coast of Scotland for non-quota controlled species. However, the contour of the shelf edge means that even if this type of activity expands, the fleet's range of operation is unlikely to extend beyond 250 miles. Since 1991, a small number of vessels from SW England have pursued a high seas drift-net fishery for albacore tuna in the Bay of Biscay, but the increasingly precarious economics of this operation and pressure from the environmental lobby in connection with alleged high levels of cetacean by-catches (FINDLAY & SEARLE, *in press*) mean that the future of this fishery is uncertain.

For the purposes of this study, the fishing waters around the UK have been divided into the five areas outlined in Figure 1.6.3. A brief description of each of these areas, highlighting the main navigational hazards is given in the sections to follow. For more complete information on any particular area, the reader is referred to the relevant volume of "UK Admiralty Sailing Directions", published by The UK Admiralty Hydrographic Office (UKHO), Taunton, England and also the "Atlas of the Seas Around the British Isles", (first edition, 1981) available in printed form or as a computer package known as the "United Kingdom Digital Marine Atlas", both compiled by the MAFF Directorate of Fisheries Research.

Figure 3.1.1 is drawn from the Atlas of the Seas Around the British Isles and although slightly dated, is still nevertheless valid as an indication of the likely presence of merchant ships in the various areas, based upon recorded data for merchant marine traffic flow

(*pers. comm.* Mr J Ramster, 1996; responsible for compilation of "The Atlas of the the Seas Around the British Isles")

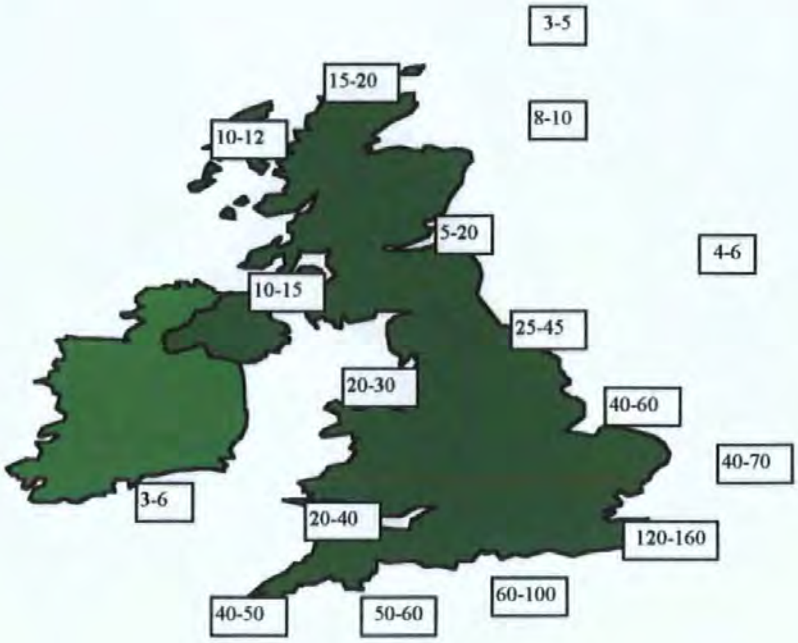

Figure 3.1.1. Traffic flow of merchant shipping. Figures in boxes represent average numbers of merchant ships per day. (Source: MAFF, 1981)

3.2 Area 1: Northern North Sea

This area encompasses the Shetland and Orkney Isles both of which present challenging navigational conditions for mariners because of their ragged and fragmented nature and also the notoriously strong currents associated with the inter-island passages and the Pentland Firth. The East coast of mainland Scotland is less hazardous however with few off-lying islands and numerous fishing harbours with good access. Questionnaire responses from fishermen operating in this area indicate that 96% are of the opinion that their vessels are in a potential running aground situation fewer than once in every six months (Figure 3.2.1).

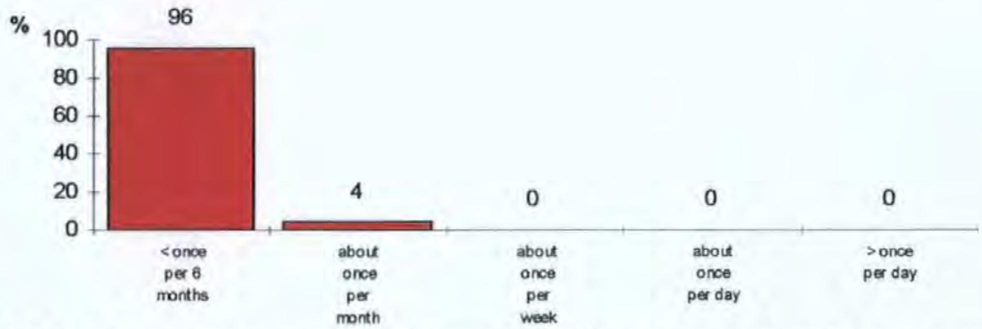

Figure 3.2.1. Percentage estimates of frequency of being in a potential running aground situation for fishermen operating in the Northern North Sea.

Winds in the Northern North Sea are variable in both speed and direction during all seasons and are likely to exceed Beaufort force 5 for 60% to 65% of the time in winter and 20% to 30% during the summer months. While the coastal waters are sheltered from south to south-west winds, very rough seas indeed can develop in gales from other directions. The area is notorious for the confused seas of hazardous proportions that can result from the combining of wind, swell and current in particular areas. Poor visibility resulting from fog is most prevalent between April and September although heavy snow showers in winter can induce very sudden decreases in visibility. Throughout the year, visibility in excess of 5 miles will occur for around 72 - 83% of the time (UKHO., 1994a).

Marine traffic related to the oil industry is heavy in this area, with supply and standby vessels supporting dense concentrations of oil and gas rigs in particular areas and significant numbers of oil tankers calling at the Sullom Voe oil terminal in Shetland. Marine Safety Agency data on port entry (MSA, 1996a) suggest that for every port entry by a merchant vessel in this area, there are over thirty fishing vessel entries. In questionnaire replies, 12% of fishermen operating in this area reported that they faced very close quarters situations with other vessels more than once a day while at the other end of the range of possible questionnaire responses, 58% felt that such situations arose fewer than once every six months (Figure 3.2.2).

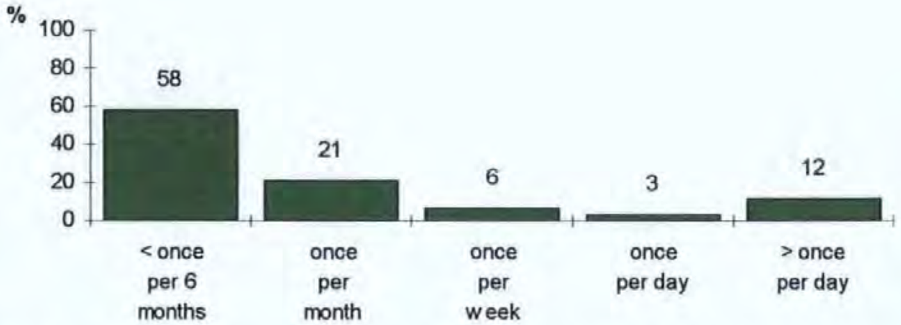

Figure 3.2.2. Percentage estimates of frequency of being in a very close quarters situation for fishermen operating in the Northern North Sea.

The main fishing ports in this area are Lerwick, Kirkwall, Scalloway, Scrabster, Wick, Lossiemouth, Buckie, Macduff, Fraserburgh. The area sees probably the most eclectic range of fishing activity with all seven categories of fishing method illustrated in Section 3.8 in evidence, although otter trawling and pair-trawling are the most prevalent with beam trawling by British boats in this area being a relatively recent development.. The Northern North Sea also supports the most modern sub-population of fishing vessels in the UK fleet with more than a third of vessels based in the port of Fraserburgh and over half of those based in Shetland having been built since 1980. Ports in this area are home to the largest vessels in the UK fleet, these being modern pelagic fishers, capable of switching between purse-seining and midwater trawling and able to carry up to 1000 tonnes of fish in refrigerated seawater tanks or in the most modern boats as frozen blocks.

3.3 Area 2: Central North Sea

The Central North Sea area covers a stretch of coastline with relatively few topographical navigation hazards. Save for the Firths of Tay and Forth and the Tees and Humber estuaries, there are few major indentations in the coastline pertaining to this area and only a small number of islands, all of which are within close proximity of the coast. Away from the estuaries, there are very few areas subject to particularly strong tides and currents and there are many fishing harbours to which access is generally good and well documented.

No fishermen operating in this area gave questionnaire responses indicating that their vessels are in situations where the potentiual for running aground exists any more frequently than once a month, the great majority (87%) being of the opinion that this happens less than twice a year (Figure 3.3.1).

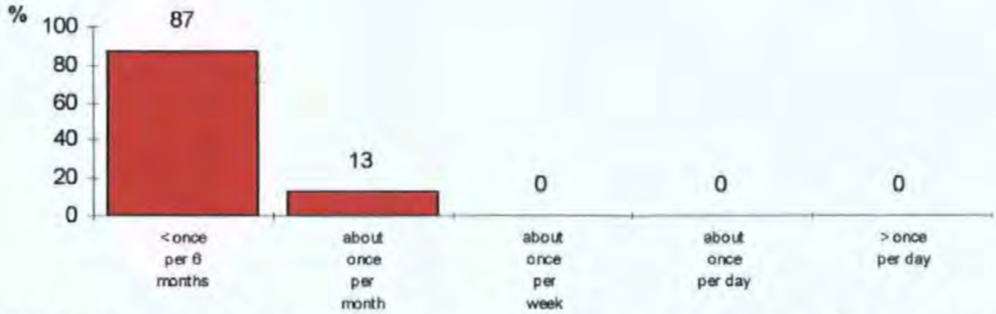

Figure 3.3.1. Percentage estimates of frequency of being in a potential running aground situation for fishermen operating in the Central North Sea.

From October to March, gales from between NW and SW tend to occur quite frequently in the Central North Sea but during the summer months, the few gales that do occur are mainly from the north. Gales from a northerly or easterly direction can lead to the development of heavy swell and winds from the south or south-west produce steep choppy seas. There is a high incidence of poor visibility in the region, especially south of latitude 55° N, this being mainly due to both radiation fog and sea fog, although precipitation may also be a factor. Visibility in excess of 5 miles can be expected in the area for 70 - 80% of the time during the summer months and 60 - 75% of the time in winter, (UKHO, 1995a). Sea fog is a common hazard in the late spring to the north of latitude 55° N.

Merchant traffic is fairly dense, especially along the coastal zone (Figure 3.1.1) with around twelve fishing boats entering port for every merchant vessel (MSA, 1996a). In spite of this, none of the fishermen operating in the Central North Sea could recount involvement in very close quarters situations with any greater frequency than once per month (Figure

3.3.2). This was the lowest of all the areas and as a corollary, the same area had the highest proportion (65%) of fishermen reporting the lowest frequency of such situations.

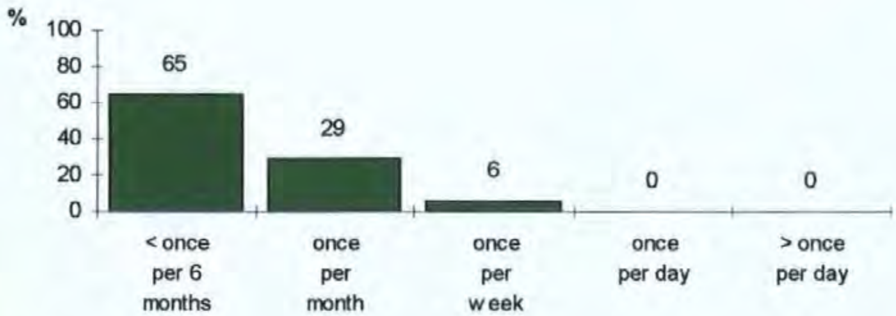

Figure 3.3.2. Percentage estimates of frequency of being in a very close quarters situation for fishermen operating in the Central North Sea.

Within this area, covering the east coast from Rattray Head south to The Wash, the main fishing harbours are Peterhead, Aberdeen, Arbroath, Pittemweem, Eyemouth, North and South Shields, Whitby, Scarborough, Bridlington and Grimsby. Although up until the late 1960's this area was intensively fished for herring using drift nets, this fishery is now extinct with very little other types of pelagic fishing pursued by UK vessels. Otter and beam trawling are the most popular fishing methods although numerous smaller static netters and crabbers (also targeting lobster) operate along the coastal fringe. The few British distant water vessels that are licensed to fish are based in the Humber port of Hull and although they do not in fish in the Central North Sea, they inevitably pass through in transit from their home port. A third of vessels operating from Peterhead and the same proportion operating from Grimsby have been built since 1980.

3.4 Area 3: English Channel (including the Southernmost part of the North Sea and Dover Strait)

The coastline of this area is indented in places with numerous small estuaries, but there are few offshore islands. The tidal stream accounts for the most of the current effect encountered in the area although persistent west or south-west gales can induce a flow through the Dover Strait. In the Strait itself, a strong tidal stream running into the wind can induce steep choppy seas while to the west of the Strait, longer swells can occur in south-west or westerly gales. In anticyclonic weather conditions, mist and haze can be extensive. In January, visibility will be in excess of five miles for 65% of the time on average and for around 80% of the time in July (UKHO, 1994b).

Asking fishermen who operate in this area how often they felt their vessels were in potential running aground situations produced an interesting result. A high proportion, 33%, answered that they were in this situation about once each day and it was only after examination of the returned questionnaires that it became clear that a great many of these were 'beach-boats' - smaller day boats which are dragged up on to beaches such as at Hastings rather than kept in harbour overnight. The fishermen had answered the question quite literally! Notwithstanding this anomaly however, responses from fishermen in this area suggest the highest incidence of exposure to the immediate risk of running aground of all the five areas (Figure 3.4.1).

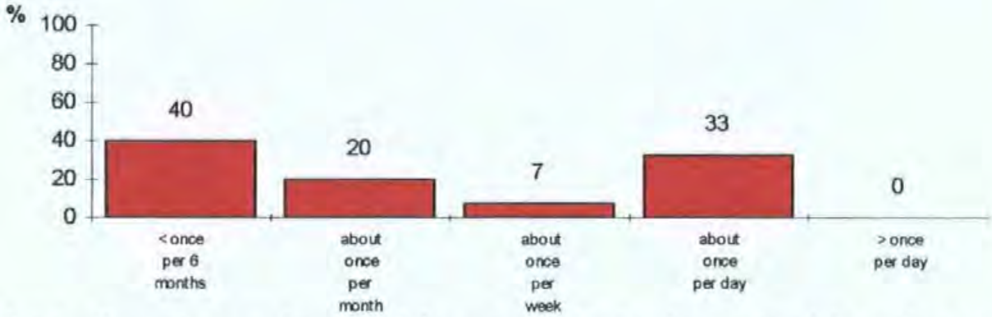

Figure 3.4.1. Percentage estimates of frequency of being in a potential running aground situation for fishermen operating in the English Channel and Dover Strait.

The most notable feature of this area is the density of marine traffic. The Dover Straits are anecdotally credited with being the busiest shipping zone in the world and there are only three fishing vessel port entries for every one merchant vessel entry. Overall, this area showed the most platykurtic distribution of frequency of close quarters situations occurring (Figure 3.4.2). Three-quarters of fishermen in the English Channel/Dover Strait area said they experience very close quarters situations with other vessels more frequently than once per month, with 13% proposing that they faced this hazard about once per day on average.

Figure 3.4.2. Percentage estimates of frequency of being in a very close quarters situation for fishermen operating in the English Channel and Dover Strait.

Because of the comparitively short distance between Britain and the European continent in this area, much of this traffic is composed of ferries although numerous other vessel types pass through en route to ports such as Rotterdam, Bremen, Hamburg and those on the Baltic Sea. The Straits are subject to a "Traffic Separation Scheme" (TSS) which includes special deep draught routes and which has "Inshore Traffic Zones" (ITZ) established on either side. Rule 10 of the 1972 International Regulations for the Prevention of Collisions at Sea notes that vessels using the traffic lanes do not enjoy any privilege that they do not have elsewhere and this has been interpreted by some fishermen as signalling that it is acceptable to fish within the TSS. Rule 10 (e) (i) supports this approach by stating that fishing vessels may enter separation zones or cross separation lines to engage in fishing within the zone, but Rule 10 (i) goes on to undermine this reasoning by saying, "*a vessel engaged in fishing shall not impede the passage of any vessel following a traffic lane*", (MSA, 1996b).

The legal situation in this respect is unclear and an action was brought by the dependents of the crew of the Brixham registered beam trawler, Ocean Hound which was run down by an unidentified merchant vessel and lost with all hands in the northbound shipping lane in 1991, against the estate of the skipper (also the owner) on the grounds that it was reckless to fish there in the uncertain visibility conditions pertaining at the time. This may have set a legal precedent were the action not abandoned when doubt was cast over whether the Ocean Hound was actually fishing at the time of her loss. Fishing does go on in the ITZ's with the blessing of Rule 10(d)(i) which unequivocally states, "*.....vessels engaged in fishing may use the inshore traffic zone.*", (MSA, 1996b).

Most important fishing ports in the southern North Sea, Dover Strait and English Channel area are; Lowestoft, Hastings, Newhaven and Poole. Almost 60% of vessels operating from the port of Lowestoft were built prior to 1980 and exactly half of the vessels operating from Poole are of the same genre.

3.5 Area 4: Western Approaches and Irish Sea

This area encompasses the Celtic Sea and the ragged coastline of the south of Ireland. The relevant coastline of the British mainland is indented by numerous estuaries, many of which have fishing harbours within, and has a wide range of coast types, ranging from precipitous cliffs to mud flats and long sandy beaches. A very small proportion (4%) of fishermen operating in this area felt their vessels faced potential running aground situations more than once per day and these were mainly small crabbers. Most fishermen (85%) thought their vessel faced a potential running aground situation fewer than once every six months (Figure 3.5.1).

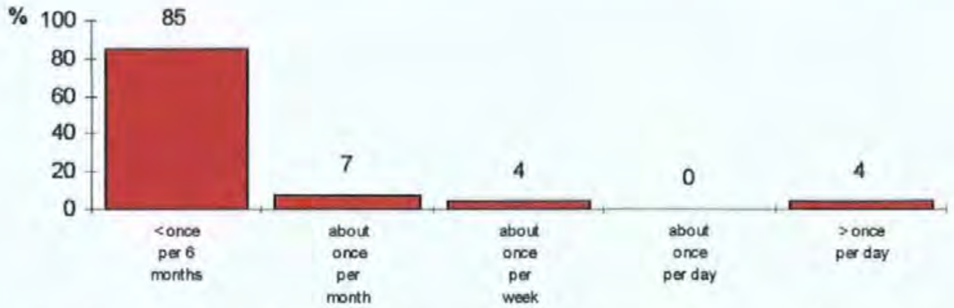

Figure 3.5.1. Percentage estimates of frequency of being in a potential running aground situation for fishermen operating in the Western Approaches and Irish Sea.

The sea state in the Western Approaches may be rough to very high during south-west gales. Such rough seas are to be expected in the area on 2 - 3 days per month during the summer and 6 - 7 days in winter. To the west of the Isles of Scilly, swells from between SW and NW may exceed 4 metres for as much as 10 days a month during the winter (UKHO, 1984; UKHO, 1996c). Strong currents are associated with many of the headlands along the relevant coast, such as Start Point, Trevose Head and Hartland Point and the greatest tidal range around the UK occurs in the Bristol Channel. Sea fog often occurs in the area in spring and summer as a result of warm winds from the south-west blowing over relatively cold water and usually disperses only when there is a change of air mass, such as the passage of a cold front. Visibility in excess of 5 miles can be expected for 75 - 85% of the time in winter and 80 - 85% of the time in summer, (UKHO, 1984; UKHO, 1996c). Merchant marine traffic density is high with eight fishing vessel port entries for every one merchant vessel entry, coming second only to the English Channel area where the ratio is 3:1. Questionnaire responses from fishermen operating in this area indicate that 8% feel their vessels are involved in very close quarters situations at least once per day (Figure 3.5.2). Three quarters of them however report this situation occurring once per month at most.

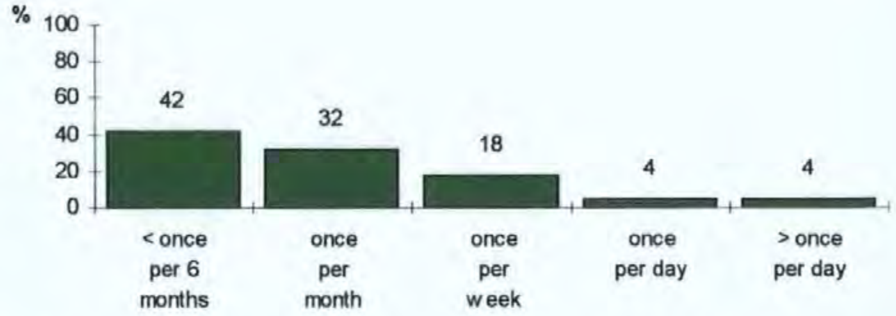

Figure 3.5.2. Percentage estimates of frequency of being in a very close quarters situation for fishermen operating in the Western Approaches and Irish Sea.

Main fishing harbours are Brixham, Salcombe, Plymouth, Mevagissey, Newlyn, Padstow, Bideford, Milford Haven and Fleetwood. 80% of the fishing vessels operating from Newlyn, the largest fishing port in the area, were built prior to 1980, making this sub-population the oldest in any one major port in the UK. Both Brixham and Milford Haven have slightly younger fleets with 26% and 33% respectively being built since 1980. Beam trawling is particularly prevalent in this area although there are also significant numbers of otter trawlers and static gear boats. Pelagic fishing methods have been periodically popular, for hake (*Merluccius merluccius*) in the Irish Sea in the 1970's, mackerel (*Scomber scombrus*) around the SW peninsula during the late 1970's and 80's, and in recent years, for scad (*Caranx trachurus*) and pilchards (*Clupea pilchardus*).

3.6 Area 5: Scottish West Coast

The Scottish west coast area probably holds more potential for grounding events than any of the other areas. The Inner and Outer Hebrides consist of many hundreds of islands and the coastline of the mainland is deeply indented by sea lochs with numerous offlying reefs, headlands and islands. The coastline is sparsely populated a feature carrying safety implications exemplified in the tragic case of the fishing boat, "Loch Erisort" which ran aground, apparently at full speed, on the Stour peninsula in 1981. Four days passed before the wreck was noticed and it was realised that all four crew had perished. In spite of the hazardous coastline, 89% of fishermen feel that their vessels are in a situation where there is potential for running aground less than once every six months and only 4% felt that this potential existed as often as once per week (Figure 3.6.1).

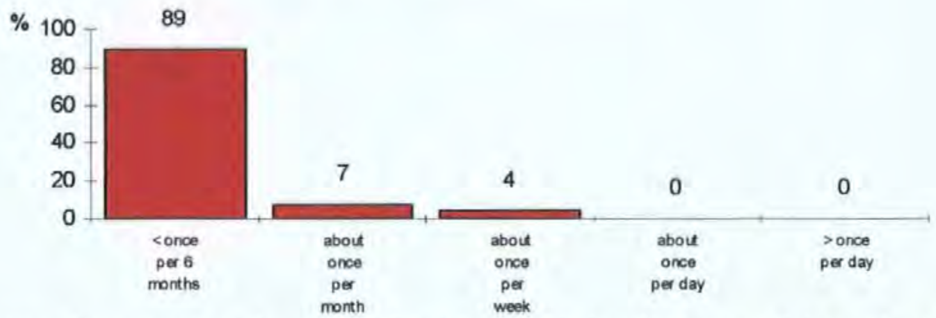

Figure 3.6.1. Percentage estimates of frequency of being in a potential running aground situation for fishermen operating in the Scottish West Coast area.

Open ocean currents in the area average 0.5 knots but the tidal stream in the sea lochs and firths can be very unpredictable due to the effect of persistent winds in any direction or the draining effect of heavy rain or melting snow (UKHO, 1995b). The area has a diverse range of possible swell conditions. In the NW, long Atlantic swells are prevalent and during winter between 30% and 40% of observations record waves of over 4m (UKHO, 1995b). Even the sounds and lochs of the Inner Hebrides exhibit rough seas and moderate swells from time to time, particularly in the winter months. Relatively mild airflow from the south-west over the cold waters can cause prolonged periods of reduced visibility, especially in springtime. The incidence of visibility in excess of 5 miles can be expected to be of the order of 79 - 88% during winter and 77 - 82% in summer, (UKHO, 1995b). Merchant traffic density is the lowest around the UK with 37 fishing vessels entering pertinent ports for every one merchant vessel entry. The distribution of frequencies of very close quarters situation occurring in this area was very similar to that derived from responses to the same questionnaire by fishermen in the South West Approaches and Irish Sea area (Figure 3.6.2).

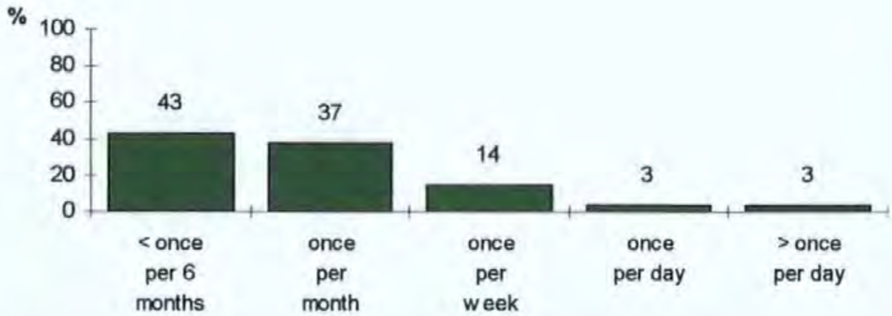

Figure 3.6.2. Percentage estimates of frequency of being in a very close quarters situation for fishermen operating off the Scottish West Coast.

Most important fishing ports are Annalong, Kilkeel, Portavogie, Girvan, Cambletown, Mallaig, Oban, Stornoway, Ullapool, Lochinver and Kinlochbervie. Main fishing method is otter trawling, with large numbers of vessels from ports in Northern Ireland targeting Norway lobster (*Nephrops norvegicus*) using this method. 87% of this Northern Ireland fleet as a whole, was built before 1980. There are also many smaller static gear boats operating within the Hebrides and an increasing fleet of large new vessels which, although registered in Scottish east coast ports, are operating from the northern ports of Lochinver and Kinlochbervie and fishing on the continental slope.

The salient points covered in the above section are summarised in a table and composite graphs in Appendix 4.

3.7 Measures of the presence of fishing vessels in the areas

A very broad idea of the proportions of the fishing fleet based in different areas can be gained from reviewing the numbers of vessels by licensing district (Table 3.7.1). Vessel numbers in this table relate to numbers of vessels registered in the licensing districts but this is not an accurate guide to the numbers of vessels actually operating in the numbered sea areas at any given time. Many vessels registered in areas 1 and 2 actually spend the greater part of the year fishing in Area 5, the Scottish West Coast for example, and a sizeable proportion of those registered in the Peterhead District (in Area 2) will fish in the Northern North Sea (Area 1). For the purposes of this study it is clear therefore that assigning levels of fishing activity on the basis of licensing district or port of registry is not a sound approach for assessing the relative risk of loss in traffic events in the areas.

area	licensing district	no. vessels
1. Northern North Sea	Buckie	68
	Fraserburgh	130
	Lossiemouth	65
	Macduff	92
	Orkney	66
	Shetland	82
2. Central North Sea	Peterhead	112
	Eyemouth	80
	North Sheilds	159
	Grimsby	193
3. English Channel	Lowestoft	231
	Hastings	89
	Poole	95
4. Western Approaches	Brixham	101
	Plymouth	100
	Newlyn	212
	Milford Haven	130
5. Scottish West Coast	Northern Ireland	196
	Ayr	108
	Campbletown	60
	Mallaig	42
	Stornoway	73

Table 3.7.1. UK over 10 metre fleet by licensing district, at 31/12/94. (Source, SFIA Policy and Economics Department.)

Deriving a reliable idea of the amount of fishing going on in the five areas and using this as a surrogate for the number of vessels likely to be 'at risk' at a given time is preferable. Comparing the intensity of fishing activity in these areas is not however an easy matter since responsibility for policing fisheries rests with three discrete authorities (MAFF, SOAFD and DANI) and mis-reporting of fishing locations by skippers is rife (from *Pers. Comm*. with many fishermen, 1996).

To overcome this, the percentage proportion of the fishing fleet regularly operating in each of the five areas was assessed on the basis of questionnaire responses from 239 fishermen in 22 British fishing ports in 1994. Figure 3.7.1 illustrates the distribution that arose when fishing skippers were asked to roughly estimate which of the five areas they fished in and for what proportion of the year.

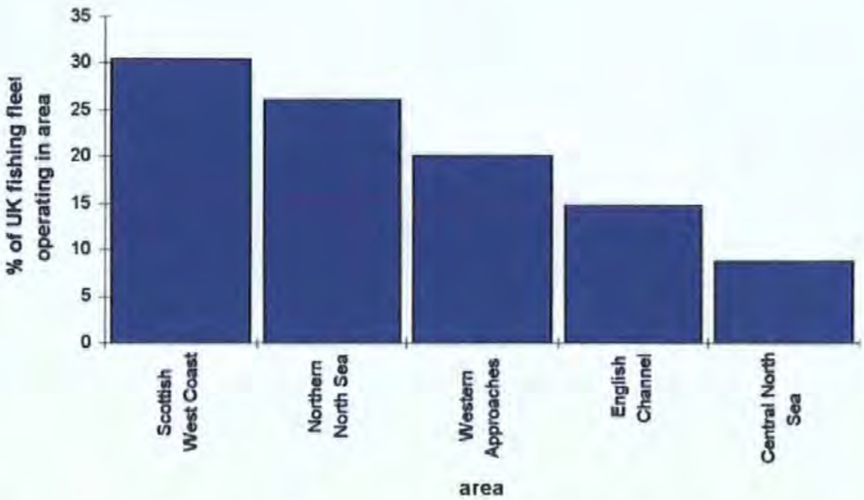

Figure 3.7.1. Questionnaire derived percentage proportions of UK fleet regularly operating in the different areas identified for this study.

Figure 3.7.1 indicates that over the course of one year, just under one third of the UK's fishing fleet operates in the Scottish West Coast area. A further 26% operate in the northern part of the North Sea and 20% work in the Western Approaches. Just under 15% of the fleet operate in the English Channel and a surprisingly low 9% in the central part of the North Sea. These areas differ in size of course, and this needs to be considered in any analysis in which the density of fishing traffic per unit of area is an important factor. Nevertheless, where the salient factor is the proportion of the UK fleet operating in a given area, the above figures are adequate since the data allowed for these proportions to be "fine tuned" to acount for seasonal distributions of vessels in the areas. The weakness of the approach taken to arrive at these proportions however is that the excellent response to questionnaires by fishermen in the ports of North West Scotland may have produced a slight overestimate of the amount of activity in Area 5. Conversely, a relatively poor response from fishermen based on the English East Coast ports may have induced a slight underestimate of activity in the adjacent sea area.

3.8 Main fishing methods and phases of the 'fishing cycle'

The fishing methods employed by the UK fishing fleet can be fitted into one of seven categories, according to gear type (FAO, 1977). The categories are - *pelagic purse-seiner*; *demersal or pelagic otter trawler*; *beam trawler* (always demersal); *demersal seine-netter*; *static netter*; *crabber*; *longliner*. Prior to 1989, information on the numbers of vessels in different fishing categories in each port was recorded in official statistics but this is no longer done. The figures in Appendix 1. illustrate the fishing method associated with each of these categories. There are often variations on these themes, for example demersal otter trawlers may also operate as part of a "pair team". While this is not technically the same as "otter trawling", the general fishing principle is similar with the exception that one large net is held open between two boats rather than each vessel having its own net held open by "otter boards". Since the mid 1980's, British demersal seine-net vessels have also commonly operated in pair teams.

The operation of fishing vessels in the UK is characterised by a fairly regular cycle of activity, the main features of which are dependent upon the type of fishing method employed, rather than other aspects, such as length of trip, vessel size, area of operation, etc. The cycle of phases that occur during the fishing trip can be generalised into two types; one applying collectively to crabbers, long-liners and static netters (Figure 3.8.1) and the other applying to otter trawlers, beam trawlers, demersal seine-netters and purse-seiners (Figure 3.8.2). In addition to the "action" stages of the cycle, the points at which strategic decisions need to be made by the skipper are indicated on these figures.

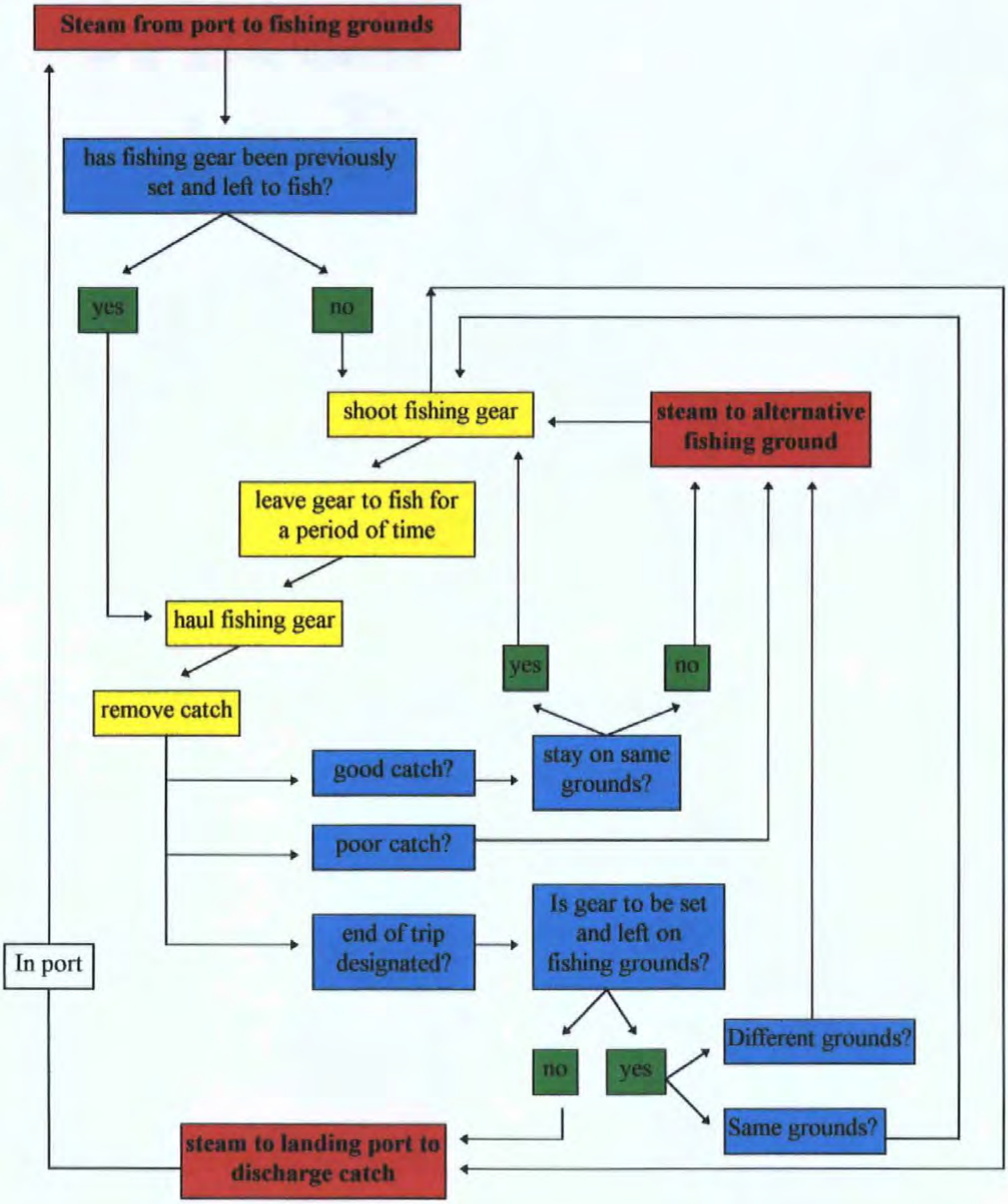

Figure 3.8.1 Phases of the fishing cycle within each fishing trip for crabbing, long-lining and static netting fishing vessels in the UK fishing fleet

(Key: = steaming phases; = fishing phases; = decision points)

Figure 3.8.2. Phases of the fishing cycle within each fishing trip for otter trawling, beam-trawling, seine-netting and purse-seining fishing vessels in the UK fishing fleet.

(Key: = steaming phases; = fishing phases; = decision points)

3.9 Types of vessel, designs and equipment

A fishing vessel may be required to fulfil any or all of a number of vital requirements during the course of operations. These will include;

- *safely and efficiently travel to and from fishing grounds*
- *trace and identify target fish species*
- *handle often complex fishing gear*
- *provide means of loading the catch aboard during operations*
- *provide a base for the primary processing of the catch*
- *offer storage and preservation facilities for the catch*
- *allow for the efficient discharge of the catch in port*
- *provide suitable living accomodation for the crew*

The ways in which these criteria have been satisfied have changed over time, in accord with changes in target species, fishing gears, technological innovation, social norms and statutory requirements.

Although there are essentially only seven prevalent fishing methods in the UK fishing fleet, the manner in which these may be pursued and the environmental circumstances in which vessels operate are manifold. The result is that an almost infinite range of vessel designs and layouts have arisen. Large otter trawlers operating in the deep water at the edge of the continental shelf west of Scotland are very different to small vessels using the same method to catch flatfish along the coastal fringe of the English Channel. The reader is directed to BRADY (1993) and the fishing trade press, particularly "Fishing News" and "Fishing News International", both published by EMAP Heighway Ltd., for more detailed descriptions of individual vessels as required.

Certain design features do have bearing on the ability of the watchkeeper to perform his duty effectively. One of these is the quality of visibility from the wheelhouse windows. Department of Transport M Notice No. 1111 (1984), "Visibility from the wheelhouse of fishing vessels", implores fishing vessel owners and skippers to ensure unobstructed visibility from their wheelhouses. Questionnaire responses in 1994, ten years after this notice was issued, indicate that around 18% of fishing vessels have whalebacks or deck shelters which restrict visibility from the wheelhouse, as on the vessel shown in Plate 3.9.1. In most of these cases, the whaleback/deckshelter had been retro-fitted to an older vessel and although some innovative interim solutions to this impediment have been tried, for example the "periscope" shown in Plate 3.9.2, it is likely that these vessels will gradually be phased out of the fishing fleet. A matter of greater concern is that questionnaire responses revealed that there were even instances where visibility was impeded in newbuildings. Another aspect mentioned in the same M Notice, (No. 1111) is the additional installation of electronic equipment in positions which deleteriously affect visibility. While the extent of this problem was not assessed, anecdote suggests that it is a very common feature of older fishing boats, especially those with small wheelhouses.

Whichever permutation of operational criteria applies to any one vessel, the fact that the vessel must remain functional, even under extreme conditions (bad weather, loading, etc), has direct bearing upon the approach taken at the initial design stage. VEENSTRA & STOOP (1992) suggested that this requirement has led to the installation of massive and oversized equipment in the Dutch beam trawling fleet Within the UK, the same trend is evident aboard purse-seiners and trawlers where, for example selection of main winches by vessel owners appears to be done on the basis of an arbitary doubling of the centre-barrel pull that is known to be required at the time of building. (*pers. comm.* Mr A. Kennedy, Manager, Dauntless Trawl Winch Co. Macduff, Scotland. 1995).

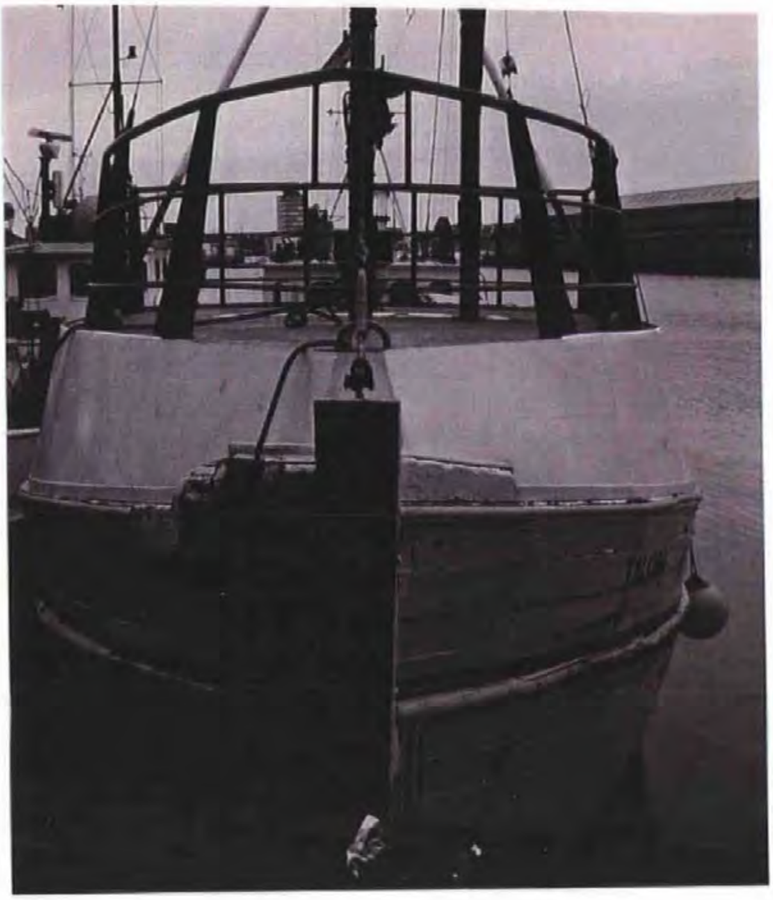

Plate 3.9.1. Retro-fitted whaleback impeding forward vision from a fishing vessel's wheelhouse

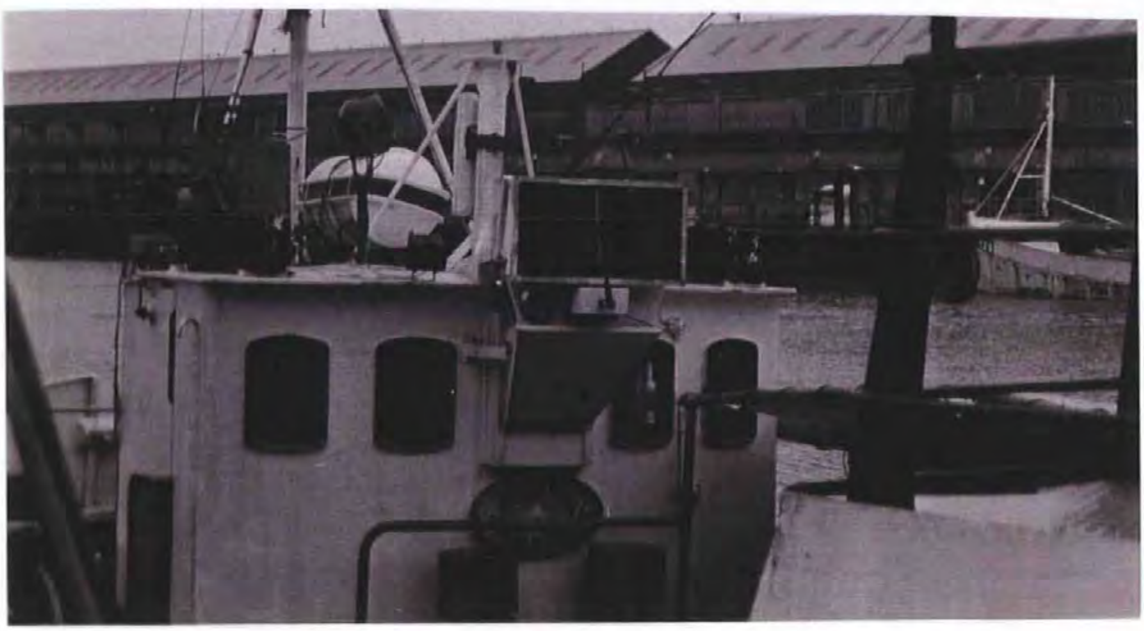

Plate 3.9.2. "Periscope" installed to allow better forward vision from the wheelhouse of a fishing boat over a retro-fitted whaleback.

3.10 Chapter Discussion

In a perfect world, where human error and technical failure would never occur, the probability of a fishing vessel being lost in a collision or grounding event would be equal in each of the five operational areas identified in this study. Reality however dictates that differences in the geographical, oceanographical and meteorological conditions that pertain in each area moderate and adjust the risk of losses due to these causes. It would be possible to construct "hazard gradients" running through the areas, based on criteria such as, number of offlying reefs, ruggedness of the coastline, traffic density, number of days of poor visibility per year, but it is difficult to see what useful contribution this would make to the present study since the macro-environment is composed of elements which either cannot be varied or change only very slowly over time. The mobile nature of the fishing fleet and the national system of training mean that special vessel types and training schemes designed for certain areas are, in the main, unfeasible propositions. The analysis must therefore move on to description of the micro-environment, over which control is more easily exerted.

3.11 Chapter summary

- The salient features of the macro-environment in which UK fishing vessels operate are summarised in Table 3.11.1.

- Most fishing by UK vessels takes place within 200 miles of the UK coastline. Within this general region, five areas of operation are identified, each with different geographical, meteorological and traffic situations.

- The northern North Sea area sees the most eclectic range of fishing activity and ports there are the base for the most modern, and the largest fishing vessels in the UK fleet.

- The central North Sea has the least hazardous coastline of the five areas and supports the least amount of fishing activity.

- The English Channel has the greatest density of merchant traffic of the five areas and fishing operations there are complicated by the existence of a Traffic Seperation Scheme.

- The ragged coastline and the numerous islands and reefs in the Scottish West Coast area make it the most likely venue for groundings. This areas also supports the highest level of fishing activity of the five areas.

- Assigning levels of fishing activity in the five areas on the basis of Licensing District for fisheries management purposes is not a sound method of arriving at a figure for numbers of vessels 'at risk' in these areas.

3.12 References

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Chapter 4

THE UK FISHING VESSEL MICRO-ENVIRONMENT

"Its fine to hae the skipper's job
If luck signs on as mate,
For then ye're called a clivver chiel.
But should that mate desert ye well,
The job's nae just so great,
For ye're called an eesliss feel."

Peter Buchan, 'Stormy Bank'
(*clivver chiel* = clever fellow; *eesliss feel* = useless fool)

4.0 Introduction

In this Chapter, conditions on board fishing vessels are examined with particular attention being given to features of watchkeeping systems and the stressors that may impinge on the efficiency of watchkeepers. Findings are presented for British fishing boats in general and also on a UK regional basis where this is appropriate. Unlike the merchant shipping industry, where the working conditions have been observed, measured and fairly well documented (e.g. MOREBY, 1975; SAGER, 1995; SCHAEDEL, 1995) little comprehensive information is available on the conditions fishing vessel watchkeepers typically operate in. STRANKS (1994) lists physical environmental sources of stress in the workplace as; inadequate temperature control, poor workplace layout, poor illumination, excessive noise levels, inadequate ventilation, inappropriate work patterns and long hours. To these can be added the physical stress of performing a job of work on a platform that is constantly moving, often quite violently. There are also the psychological stresses specific to the fishing industry cited by HEINRICH (1988) in a Dutch study, which result from quotas and other fishing restrictions, financial pressures, awareness of risks, manning problems and problems in domestic life.

Monitoring the the onshore working environment, in factories, shops, construction sites etc. is the concern of the UK Health and Safety Executive (HSE) but at present its mandate ends "at the quayside" with respect to fishing vessels. The MSA has assumed responsibility for drawing up a *Code of Safe Working Practice* for the merchant shipping industry, which embodies the relevant European Union Directives and takes account of the 1978 *International Convention on Standards of Training, Certification and Watchkeeping* (STCW). A similar Code for the fishing industry has been mooted by the MSA and this would include, amongst a range of other matters, reference to the 1995 STCW-F (a variation on the 1978 STCW convention specifically for fishing personnel) and the relevant EU Directives (*pers. comm.* Mr A. Dean, SFIA Technology, Hull, 1997). There are now 16 EU Directives, of which 11 have application in the shipping industry where workers are employed - the European Court of Justice having decided that share fishermen, unless they are joint owners of the vessel, are such (FISG, 1996). In addition to these main Directives, there are "daughter" Directives, one of which is 93/103/EEC *Fishing Vessels*, but little in this has any direct relevance to watchkeeping. The implementation of a Code of Practice for fishing boats is probably unlikely for many years since an extensive process of consultation with the fishing industry would need to take place and this could lead to protracted discussion, particularly over its financial cost to fishermen and how it might be effectively enforced.

4.1 Crew size and delineation of labour

Table 4.1.1, which is based upon a combination of questionnaire response data, interview data and articles in the primary UK fishing trade publication, "Fishing News", gives an indication of the numbers of crew sailing on different types of British fishing vessels in the mid-1990's.

A broad relationship between fishing method and vessel size exists and both of these factors, along with the level of mechanisation and automation present on individual vessels, influences the number of crew carried.

type of vessel	vessel length (metres)	total crew
purse-seiner / pelagic trawler	35 - 80	10 - 18
demersal otter trawler	10 - 50	2 - 12
beam trawler	10 - 45	3 - 9
demersal seine-netter	18 - 30	5 - 8
static netter	5 - 25	1 - 7
crabber	5 - 20	1 - 6
long liner	5 - 25	1 - 12

Table 4.1.1. Crew sizes on different types of fishing vessels in the UK fleet.

A common feature is that every vessel has a designated skipper even though, particularly on some of the larger pelagic fishing boats, there may be a number of holders of "skippers tickets" in the complement. Excepting of course, small single-handed vessels, it is usual for the second and additional crew members to assume some role to complement that of the skipper, for example as engineer or cook. When the crew exceeds four, one of the crew members, who may or may not actually hold the appropriate formal qualification, will normally assume the position of mate.

On smaller boats with up to three crew, the delineation of labour is blurred but the respective roles and responsibilities become much more clearly defined as vessel size increases. Responsibility for safe navigation, selecting fishing grounds, administration and overseeing the deployment and recovery of gear invariably rests with the skipper. With the enginerooms on fishing boats being unmanned, he will also monitor and control a number of systems from the wheelhouse. The mate tends to be responsible for overseeing the work on deck, including maintenance of fishing gear, primary processing and stowage of catches. While at sea, the engineer (often referred to in the UK fishing fleet as the "driver") carries out routine inspection and maintenance work on the engine(s), winches and hydraulics, but also works on deck during shooting, hauling and catch processing. He will usually operate the winches where these are not controlled by the skipper from the wheelhouse. The cook will obviously attend to the preparation of meals and snacks and, like the engineer will also work on deck during shooting and hauling and dealing with the catch.

The regime outlined above is a general description of the respective roles and will vary, for example on some of the larger pelagic purse-seine fishing vessels, the cook will do little more than prepare food, his only duty beyond this being arranging the float line as it comes through the hydraulic hauling system. At the other extreme, a skipper may also act as the engineer or cook on a small 2 or 3 man vessel.

4.2 Working hours

The *raison d'être* for a fishing vessel is catching as much fish as possible in the shortest time, and return them to port to be sold. To this end, hours of work regimes on UK fishing boats are infinitely variable and impossible to generalise. At the one extreme, some beam trawlers operating from ports on the English east coast have a fairly well ordered system within which each member of the crew has an unbroken off-duty interval of six hours during each 24 period, excepting where some major problem requiring all hands arises. At the other extreme, demersal seine-net boats operating from ports in north-east Scotland spend long periods steaming to fishing grounds, perhaps the Bergen Bank in the northernmost reaches of the North Sea or the Rockall Bank, one and a half days steaming time west of the

Scottish mainland, but once fishing starts the entire crew is likely to be working round the clock with sleep only available in brief cat-naps.

The advent of new fishing techniques can have a remarkable effect on working hours. The introduction of "twin-rig" demersal otter trawling for Norway lobster (*Nephrops norvegicus*) since the late 1980's for example, changed what was once regarded as one of the most sedentary modes of mobile fishery in the UK into one of the most demanding. Previously, crews on *Nephrops* boats had the luxury of six hour hauls producing catches which would take, on average about 2 hours to sort, clean and stow, giving four hour rest periods for all except those keeping watch, each haul. Twin-rig trawling has increased catches rates by more than double (*pers. comm*. various fishermen, 1994/95) with the result that catches from the same haul length are taking five hours to deal with, leaving very little time for rest once fishing has started.

At present, those employed in sea fishing are excluded from the European Union *Working Time Directive*, along with junior doctors and others involved in work at sea, i.e. offshore oil workers. This situation may change however, a recent written answer to a question in the UK Parliament (SFIA, EPB 1997) indicating that the British Government is about to enter into consultation in this regard. While the opinion of fishermen on this matter was not tested in the course of this study, there can be little doubt that any attempt at legislation would be met with strong opposition from the industry. It would also be virtually impossible to effectively enforce legislation in this area.

4.3 Fishermen's training and qualifications

Traditionally, British fishermen went to sea at a young age and after a specified minumum length of time working on board approporiate vessels, became eligible to attempt the oral and written examinations leading to Department of Transport (fishing) Certificates of Competency. This is known as the "ticket" system and has (along with raising the financial collateral to invest in fishing boats) formed a career progression route for fishermen through the award of mate's, skipper's and more recently, engineer's tickets.

Enquiries to the MSA and the UK Register of Shipping and Seamen revealed that no data currently exists regarding the number of practising fishermen in the UK who hold tickets although the former has invested £20 000 in researching this very point (*Pers. Comm.* UK Register of Shipping and Seamen, Cardiff, 1996).

Resulting from international legislation which evolved over thirty years (Figure 4.3.1), October 1995 saw a new regime of qualifications for fishermen launched in the UK, based upon nationally recognised Vocational Qualifications (VQ's). The VQ system is planned to eventually replace the ticket system but the main training colleges are unwilling to embrace this change so the two are currently running alongside each other. Rather than being based upon oral and written examination, VQ's are assessed by the candidate presenting evidence of consistent competence in a variety of simulated navigational situations and to demonstrate understanding of the basis for their actions. The rationale for the introduction of the VQ system is that it is more flexible than its counterpart and can thus thus adapt better to new technologies as they are introduced and preparation for assessments can be more readily fitted around the fisherman's work schedule. The VQ also represents a move away from what is perceived as a test of academic ability towards a demonstration of practical skills.

The introduction of the VQ programme is regarded by some sectors of the British fishing industry as being a 'knee-jerk' reaction to the *International Convention on Standards for Training, Certification and Watchkeeping for Fishing Vessels* (STCW-F) which was published in draft form by the International Maritime Organisation (IMO) in 1995. This convention is the end result of around thirty years of work at international level to develop appropriate minimum levels of knowledge required for certification of fishing personnel at given levels (Figure 4.3.1). Indeed M Notice No. 1634 (MSA, 1995) actually states, "*VQ's have been introduced in compliance with the STCW-F (95)*". Those responsible for compiling the VQ programme and its associated "units of competence" however, contend that these were in place before the STCW-F requirements were agreed, (*pers. Comm.* Mr S. Potten, SFIA, 1996). The argument is largely academic however since both the British VQ training material and the STCW-F seem to be founded upon the *Guidance Document on Fishermen's Training and Certification*, published by IMO in 1988.

Fishermen's responses in a questionnaire study show that at the time of taking their first navigational watch, 13% of fishermen had received no training at all and a further 24% had previously shared watches but had not been formally trained in any way, (Figure 4.3.2). Less than one quarter of British fishermen have received any shore-based training in watchkeeping at the time of taking their first watch.

1966

General Conference of the International Labour Organisation (ILO) adopts Fishermen's Competency Certificate Convention, 1966 (No.125) in order to establish standards of qualifications for certificates of competency entitling persons to perform the duties of skipper, mate or engineer on board a fishing vessel.

1974

International Convention for the Safety of Life at Sea (SOLAS) 1974 (Regulation 13, Chapter V) requires contracting governments to adopt measures for the purpose of ensuring that all fishing vessels are sufficiently and efficiently manned.

1977

International Conference on Safety of Fishing Vessels, 1977 notes Regulation 13 of the 1974 SOLAS Convention and adopted Resolution 8. This invites the International Maritime Organisation (IMO) to consider the problem of training and certification of the crews of fishing vessels (outlined in the Torremolinos International Conference for the Safety of Fishing Vessels, 1977) in collaboration with the Food and Agriculture Organisation (FAO) of the United Nations.

1978 -1980

IMO prepares and adopts a number of resolutions - A484(XII); A539(XII); A622(XV); A623(XV) .

1981

Sixth Session of Joint IMO/ILO Committee on Training considers proposal to prepare document for guidance on fishermen's training. A Joint Working Group, including representatives of FAO, ILO and IMO produce a Guidance Document which is approved by the Maritime Safety Committee of the IMO.

1988

Document for guidance on Fishermen's Training and Certification is published by IMO.

1995

Draft Convention on Standards of Training, Certification and Watchkeeping for fishing vessels (STCW-F) is published by IMO.

Figure 4.3.1. Recent evolution of international protocol that has driven watchkeeping training for fishermen.

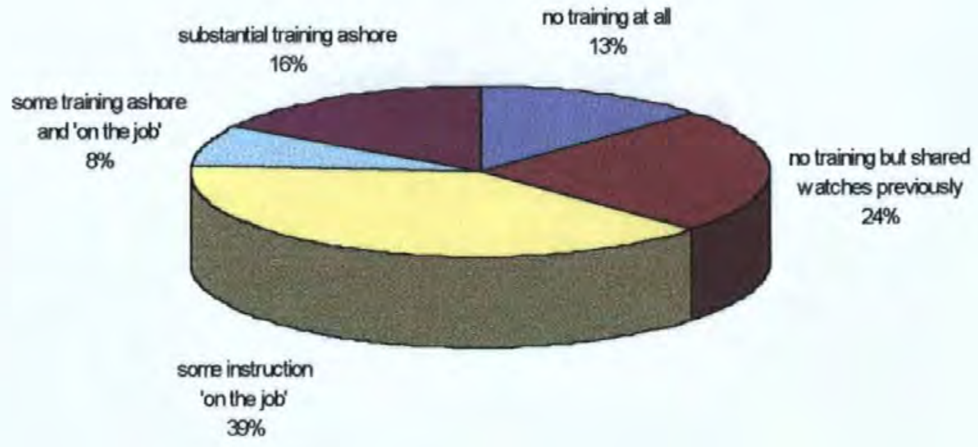

Figure 4.3.2. Type of training in navigation and 'Rules of the Road at Sea' previously received at the time of taking a first navigational watch.

Regional analysis of type of training prior to taking a first watch indicates that watchkeepers on vessels operating primarily in the Northern North Sea have the lowest level of training while those on vessels fishing off the Scottish West Coast and in the Central North Sea are best prepared through training, (Figure 4.3.3).

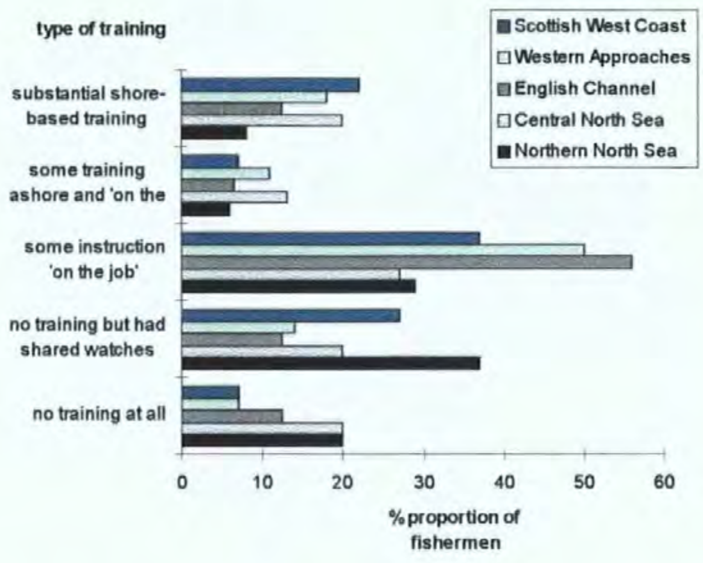

Figure 4.3.3. Regional analysis of previous training undertaken by watchkeepers on fishing vessels in navigation and 'Rules of the Road' at the time of taking a first navigational watch.

As a 'follow-up' to this section, fishermen were asked in an anonymous questionnaire study to respond honestly to the question;

> *"While on watch, do you ever find yourself in situations where you are unclear of the appropriate course of action? Examples might be when encountering a tug towing a barge on a long tow and being unsure about which way to alter course, or being faced with a large vessel which should give way but shows no sign of doing so, leaving you to make a decision?"*

Figure 4.3.4 illustrates the proportions of different responses to this question given by fishermen operating in the five areas. A roughly similar pattern emerges; around half of all British fishermen admit to sometimes being unclear about what action they should take in a traffic situation. An average of 17% of them said they are unsure of themselves either often or very often and only 8% intimate that they always have a clear idea of what action they should be taking.

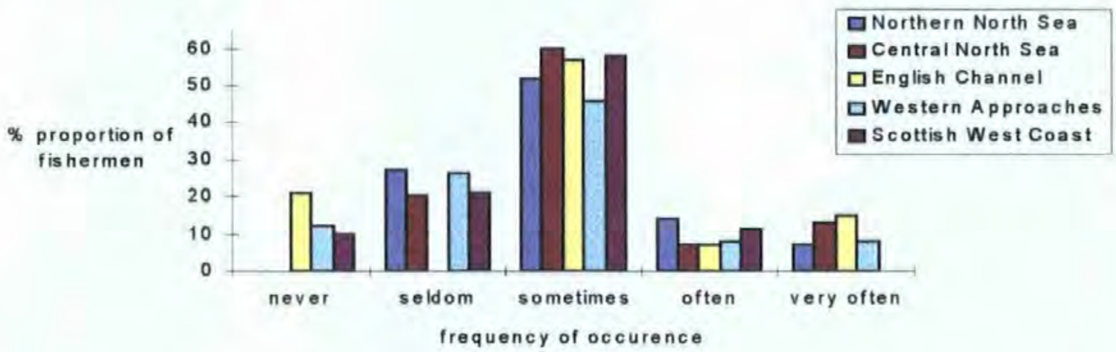

Figure 4.3.4. Frequency of being unclear of the appropriate action in a traffic situation.

4.4 Watchkeeping schedules and hours of work

Watchkeeping schedules on UK fishing boats are not standardised and tend to vary according to a number of factors including vessel size, length of fishing trip, type of fishery, size of crew and the general ethos of the operator. Questionnaire responses from fishermen in 22 UK fishing ports were the main source of the information presented in this section.

Where more than one completed questionnaire related to the same vessel, only one was actually used.

On 79% of British fishing boats, the watchkeeper will be on duty alone. 63% of vessels operate watchkeeping rota systems in which most of the crew will be included, (Figure 4.4.1).

Regional analysis of the situation (Figure 4.4.2) reveals that it is far more likely that the skipper or the skipper and mate between them will take all of the navigational watches in the English Channel and the Western Approaches/Irish Sea areas. In the waters around both the east and west coasts of Scotland, the prevalent system is for all or most of the crew to be included in a watchkeeping rota.

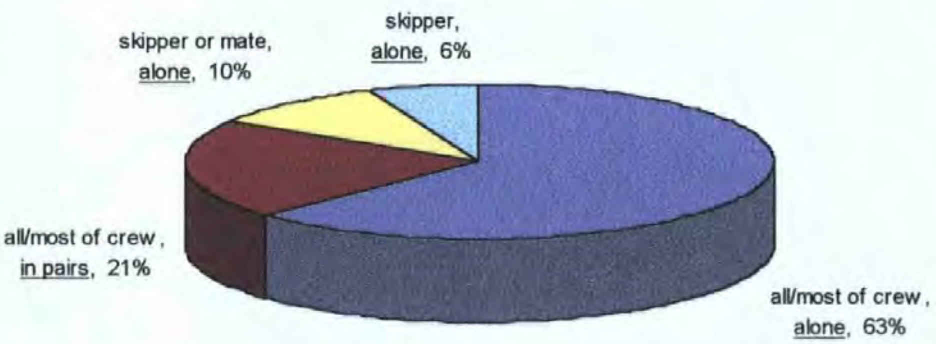

Figure 4.4.1. Number and rank of personnel taking navigational watches on UK fishing vessels.

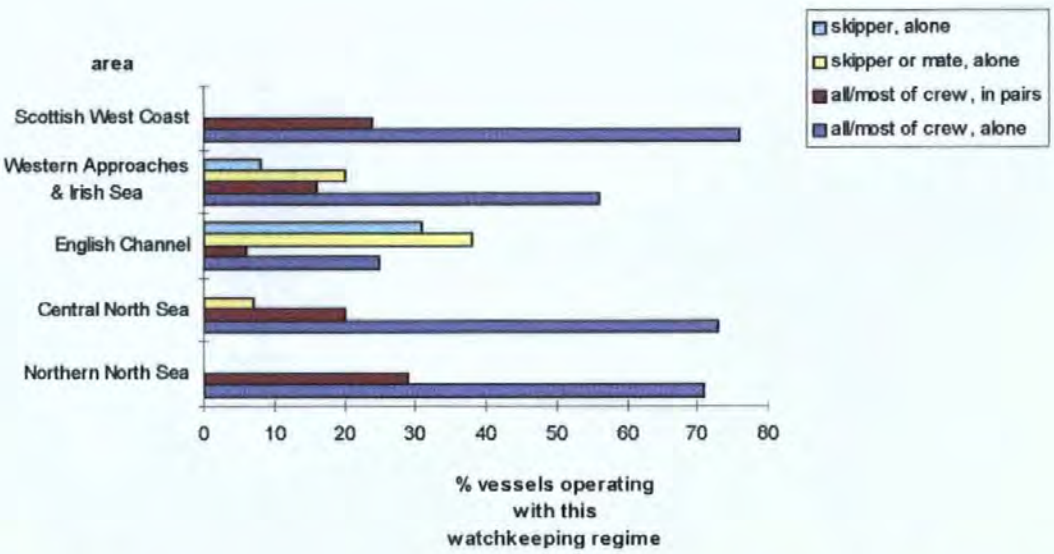

Figure 4.4.2. Regional distribution of rank and number of persons taking watches on UK fishing vessels.

Based upon questionnaire responses from a representative sample, it was calculated that almost half (48%) of the boats in the UK fishing fleet employ 2 hour steaming watches. A further 32% use 3 hour spells of duty while the remaining 20% use either longer or shorter periods (Figure 4.4.3). A very small proportion (3%) employ watches of 6 hours duration.

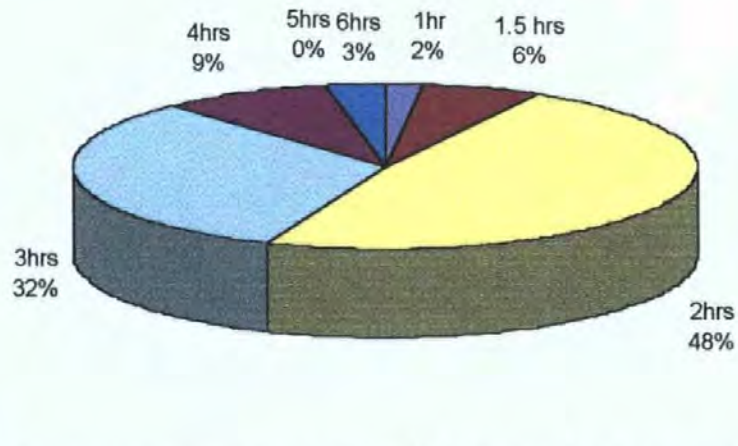

Figure 4.4.3. Percentage proportions of the UK fishing fleet employing different watch durations while steaming to, from and between fishing grounds.

Figure 4.4.4 shows that while fishing, no vessels employ watches of less than 2 hours and 89% of the fleet uses 2, 3 or 4 hour durations (38%, 21% and 30% respectively). Double the proportion of vessels employ 6 hour watches while fishing than do while steaming, 6% *cf* 3%.

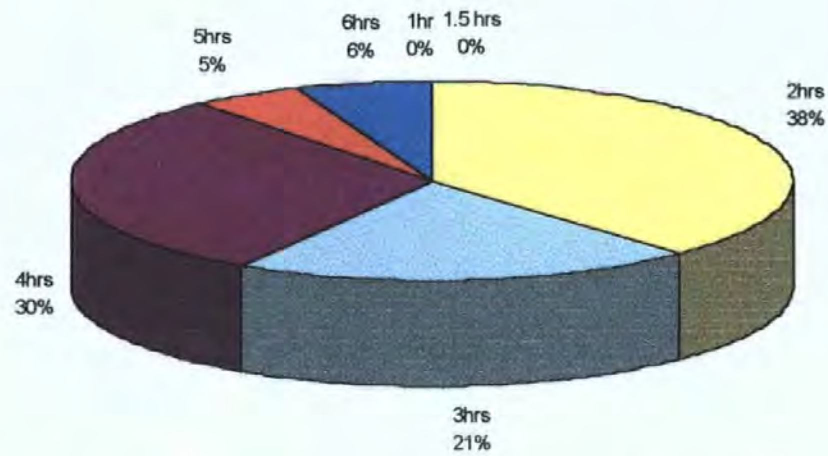

Figure 4.4.4. Percentage proportions of the UK fishing fleet employing different watch durations while towing fishing gear.

Throughout the whole of the UK fishing fleet, the mean lengths of watches are; 2.5 hours while the vessel is steaming and 3.1 hours while fishing mobile gear. The modal watch duration in both conditions is 2.0 hours with watches ranging in duration from 1 to 6 hours while steaming and 1.5 to 6 hours while fishing. Table 4.4.1 gives a breakdown of regional variation within these overall figures. From this it is clear that watchkeepers on fishing vessels operating in the English Channel tend to spend longer on watchkeeping duty than those on vessels in other areas. The shortest average watch duration occurs on vessels operating off the west coast of Scotland. Those vessels operating in the Northern North Sea showed the most uniformity in watch length with 61% using 2 hour watches while steaming although this was not carried into fishing watches where, as in the other areas, there was no discernible pattern.

area	steaming (hours)	*range*	fishing (hours)	*range*
Northern North Sea	2.28	1-4	3.03	1.5-5
Central North Sea	2.5	1-3	2.98	1.5-6
English Channel	3.71	2-6	4.0	2-6
Western Approaches	3.08	2-6	3.83	2-6
Scottish West Coast	2.21	1.5-3	2.72	1.5-4

Table 4.4.1. Mean duration in hours, of steaming and fishing watches in different areas of operation.

Figure 4.4.5 offers a graphic inter-regional comparison of mean watch durations in both fishing and steaming modes and clearly shows the proclivity for longer watches in the southern half of the UK.

Later in the questionnaire study, fishermen were asked whether on their boats, there were clear guidelines regarding a number of important points. These are listed in Table 4.4.2, along with the percentages of yes and no responses. Fishermen were asked, "*On your vessel, are there clear guidelines regarding the following?*"

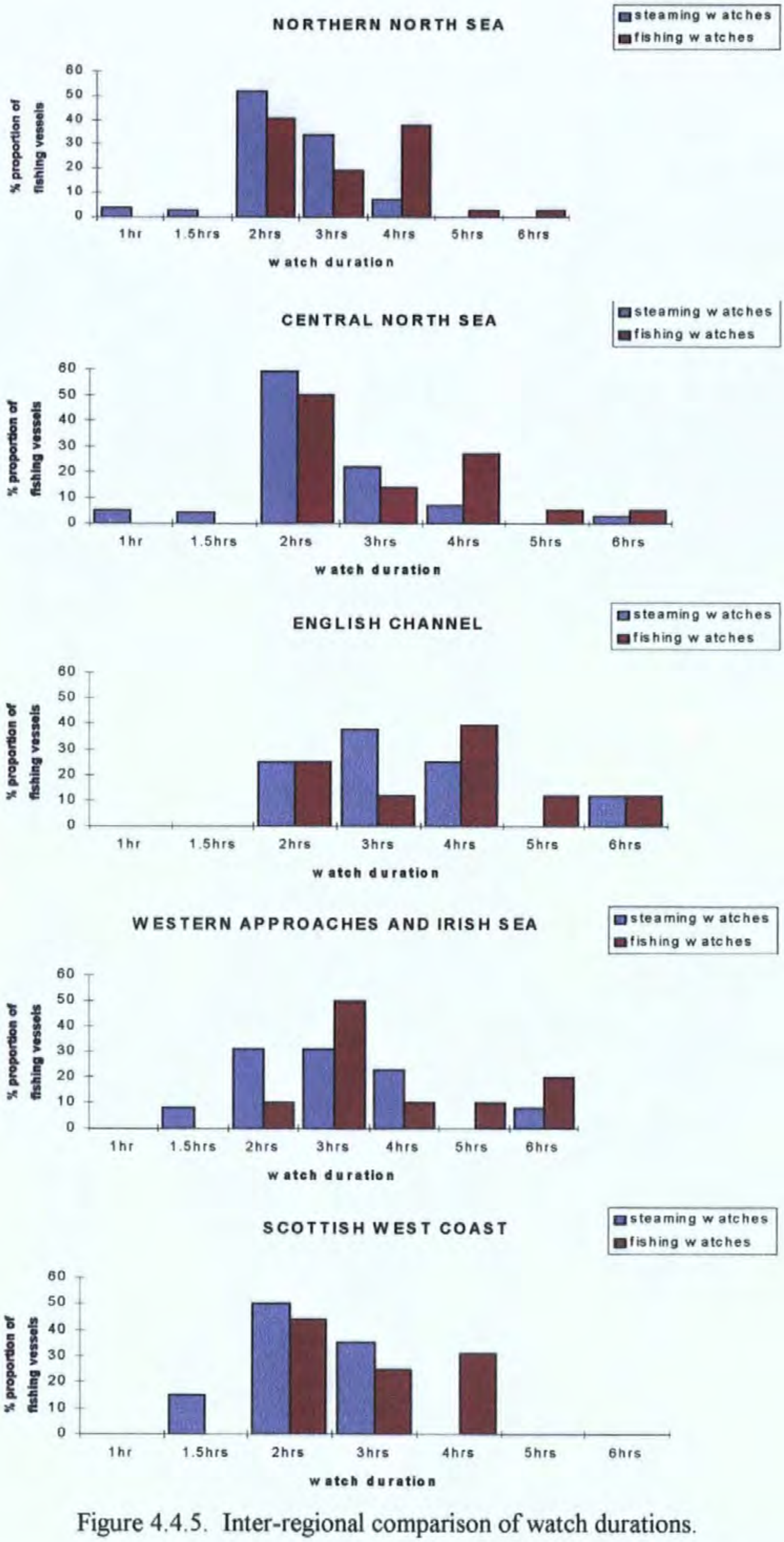

Figure 4.4.5. Inter-regional comparison of watch durations.

	yes (%)	no (%)
• procedure for taking over the watch	76	24
• using electronic navigation equipment	77	23
• keeping an effective lookout	87	13
• circumstances in which the skipper should be called	89	11
• using the autopilot	81	19
• using the engine controls	82	18
• procedure for when visibility becomes reduced	76	24
• procedure in the event of an emergency	75	25

Table 4.4.2. Percentage responses to questions regarding watchkeeping guidelines in a questionnaire study. (n = 78).

The author's personal experience in the UK fishing industry gave cause to question the precision of these responses so a representative sample of twenty fishermen working on different boats was asked exactly the same questions during personal interviews. The interview responses are shown in Table 4.4.3.

	yes (%)	no (%)
• procedure for taking over the watch	60	40
• using electronic navigation equipment	45	55
• keeping an effective lookout	35	65
• circumstances in which the skipper should be called	75	25
• using the autopilot	70	30
• using the engine controls	25	75
• procedure for when visibility becomes reduced	70	30
• procedure in the event of an emergency	50	50

Table 4.4.3. Percentage responses to questions regarding watchkeeping guidelines in personal interviews. (n = 20).

A Chi-squared (χ^2) test was applied to the two sets of results to test whether the diferences between the proportions were the result of chance. The resulting χ^2 statistic of 20.85

suggests that the two results are significantly different at the 1% level (p = 18.47). One may therefore assume that in the questionnaire study, where the fishermen had time to consider their answers, a number of them were simply providing the answer that they felt conformed with what was expected. In the interview situation, this time for consideration of the response was not available.

4.5 Exposure to noise

Industrial research into the stress effects of loud and continuous noise tend to fall into three categories; monitoring, motor skills and cognition and each of these has some bearing on watchkeeping (*see* JONES, 1983 for a competent review). Previous work has not thrown up any clear principle that can be generalised and it would appear that loud, continuous noise can have positive, negative or even no discernable effect on performance in each category.

An SFIA Technical Information Service pamphlet (SFIA, 1988) states,

> *"Modern fishing vessels are highly mechanised, relatively small and have all the necessary conditions to produce high noise levels. This is not the case with all vessels but there are frequent serious cases of this growing problem."*

Noise in the wheelhouse of a fishing boat is invariably a combination of sounds of different frequencies that, for the purpose of measurement, may be summed together into one value. The sources of this noise are varied and while some will be constant, others will emit different frequencies and sound levels at different stages of the fishing cycle. As an example of the former, one of the vessels monitored in this study had a rotary converter housed in a cupboard at the rear of the wheelhouse to provide the appropriate level of electrical power for some of the electronic equipment. This gave out a constant high pitched whine throughout the duration of the fishing trip. More variable sounds were provided by hydraulic systems while they were in use and by the main engines where the engine revolutions needed to be altered.

Noise levels were measured on board four working fishing boats using a sound level meter with an octave band filter set incorporated, manufactured by CEL Instruments (UK) Ltd. (Figure 4.5.1). This piece of equipment is capable of approximating the auditory response of the human ear by automatically applying a frequency-determined weighting (A) to the sound level measured in decibels (dB) to give readings in dB(A). When assessing a watchkeeper's exposure to noise, it is the dose that is important, i.e. the duration of exposure in relation to the noise intensity. To address this point, the unit of L_{eq} has been used to express the noise dose experienced by the watchkeeper. The L_{eq} is the equivalent continuous noise level which would give the same total amount of sound enegy as fluctuating noise. For most industrial workers, an L_{eq} period of 8 hours is appropriate but the SFIA declared that in the case of fishermen, a 24 hour L_{eq} would be more meaningful in a general study of the working environment on fishing boats (ANON., 1988). Table 4.5.1 shows the L_{eq} results that were obtained.

Fig 4.5.1. C.E.L. Soundmeter.

	wheelhouse	mess deck	accommodation	engine room	working deck	fishroom
18 m beam trawler	72 (87)	72 (76)	72 (72)	114 (120)	72 (82)	58 (82)
22 m otter trawler	71 (80)	72 (78)	76 (78)	99 (112)	68 (96)	nvr
24 m pair-seiner	75 (83)	73 (80)	76 (79)	100 (105)	72 (82)	nvr
12 m crabber	87 (90)	nvr	82 (83)	95 (97)	62 (70)	nvr

Table 4.5.1. L_{eq} noise values for various compartments on board different vessels. Figures in brackets are maximum dB(A) values (nvr = no value recorded).

Monitoring in addition to finding the L_{eq} values showed that the maximum dB(A) values , shown in brackets in Table 4.5.1, were achieved in the larger vessels while extremely noisy hydraulic systems were in operation during gear retrieval. Very high dB(A) readings were also made in the wheelhouses during hauling when VHF radios were on high volume settings. In the smallest vessel, which was 36 years old, the engine compartment was separated from the wheelhouse by only a thin wooden bulkhead with a door which the skipper, for no apparent reason, insisted upon keeping tied open for much of the time. The result was that normal conversation was virtually impossible at the steering position.

In January 1990, regulations regarding noise at work came into force for industry in the UK (SI No. 1790, 1989). In these, three "action levels" are defined, the first two relating to daily personal noise exposure and the third to exposure in a single event. The maximum noise dosages for given time durations at the second action level are shown in Table 4.5.2. Comparing values in Tables 4.5.1 and 4.5.2 indicates that on the 18 metre beam trawler, any random 2 minutes spent in the engineroom without hearing protection would equal the maximum noise dose while any more than 30 seconds in the engineroom at the peak noise level would mean the second action level would be exceeded.

The L_{eq} values shown in the first column of Table 4.5.1 are of greatest relevance to this study since these relate the level of noise to which watchkeepers would be subject during the course of watches.

limiting dB(A)	maximum duration of exposure
90	8 hours
93	4 hours
96	2 hours
99	1 hour
102	30 mins
105	15 mins
108	7 mins
111	4 mins
114	2 mins
117	1 min
120	30 secs

Table 4.5.2. Statutory UK maximum noise dosages for given time durations. (Source: HSE, 1990).

4.6 Vibration

Accurate specification of the effects of vibration on watchkeepers would be a very onerous task, largely because of the complex manner in which vibration impinges upon the body. SHOENBERGER & HARRIS summarised the problems very succinctly and survey of the ergonomics literature suggests that their early hypothesis still holds;

> *"Quantification of vibration responses will never reach the accuracy achieved in acoustics, due to factors such as the lack of a unique receptor for vibration, and the multiplicity of vibration transmission paths and the fact that vibration transmission to the body may be greatly altered by changes in body position and muscle tone"*

(SHOENBERGER & HARRIS, 1971)

While vibration levels were not formally measured on the vessels used in this study, this is nevertheless a clear potential source of stress and ultimately fatigue in watchkeepers. In the larger vessels there was some vibration, emanating from the main engine, felt through the wheelhouse floors, but this was not pronounced. On all three of these bigger boats, when the watchkeeper was seated in the deeply upholstered wheelhouse chair, little more than a faint throb could be felt while the vessel was either steaming, or towing the fishing gear. The conning position of the smaller crabber was a different matter however, and when either seated on the small bare wooden shelf seat or standing in the wheelhouse, the watchkeeper was subject to considerable vibration.

In the mess areas on the larger boats, slightly more vibration could be felt than in the wheelhouses but again this was not at a disconcerting level. In the accommodation cabins however, vibration was quite pronounced in some of the bunks, especially those near the engineroom bulkhead and those very close to the propeller shafting and stern tube. The vibration emanating from the propulsion system became irregular and at times exaggerated while the vessels were towing fishing gear before a seaway. While not directly affecting the watchkeeping environment, vibration in bunks could well be a source of weariness and fatigue, but it was not possible to test this hypothesis during this research work.

4.7 Temperature and ventilation

Many studies have been made on the effects of heat and cold on mental and physical performance and several general reviews have been done (e.g., McCORMICK & SANDERS, 1983). The physiological relationship between an individual and his thermal environment is well established but the psychological equivalent is much less so. Heat appears to have a more adverse effect on mental performance than cold, RAMSEY & MORRISSEY (1978) providing a comprehensive review of the effects of heat in tracking and vigilance tasks and summarising that exposure to higher temperatures over longer periods are likely to yield greater performance decrements.

The common index for evaluating exposure to different (particularly hot) temperature environments is the Wet Bulb Globe Temperature (WBGT) value (ISO, 1982; WHO, 1969). This incorporates air temperature, humidity, radiant heat and air movement into one single value. For practical reasons, it was not possible to use this measurement in the present study but air temperatures were measured in the workspaces of four vessels using a mercury thermometer. The results are shown in Table 4.7.1 which gives an L_{50} value, corresponding with the mid point of the cumulative frequency of air temperature readings, and in brackets, the high and low values. It should be noted that these data were derived from measurements made over full 24 hour cycles during the months of April and August and may not be representative of temperatures that might prevail at other times of the year.

	wheelhouse	mess deck	accomm.	engine room	working deck	fishroom
18 m beam trawler	21 (27-11)	23 (28-11)	18 (20-14)	32 (34-15)	9 (11-4)	-2 (-1- -2)
22 m otter trawler	17 (23-7)	21 (25-19)	20 (22-20)	34 (37-28)	17 (21-11)	nvr
24 m pair-seiner	19 (22-18)	21 (24-20)	19 (20-17)	32 (32-33)	19 (24-15)	1 (1-0)
12 m crabber	26 (28-25)	nvr	18 (19-17)	nvr	17 (20-16)	nvr

Table 4.7.1. L_{50} air temperature values for various compartments on board different vessels, recorded in degrees Celsius. Figures in brackets are maximum and minimum values (nvr = no value recorded).

On the assumption that keeping watch on a fishing boat lies somewhere between "office work" and "light work" in terms of physical effort, then with the exception of the small crab-potting vessel, the wheelhouse temperature values recorded compare favourably with the working temperatures recommended by the UK Health and Safety Executive, listed in

Table 4.7.2. Although temperatures in the mess areas were on average within acceptable limits, heat from cooking appliances meant that the "highs" were attained just before and during mealtimes when these areas were most used. Most main meals were thus consumed in relatively high temperatures, up to 28°C. On all three of the larger boats, the temperature in the shared sleeping space was quite steady, rising only gently as the fishing trip progressed.

type of work	**'comfort' temperature range (°C)**
sedentary/office work	19.4 - 22.8
light work	15.5 - 20
heavy work	12.8 - 15.6

Table 4.7.2. HSE recommended working temperatures. (source: HSE, 1989)

In general, watchkeepers were observed to open windows as a cooling mechanism whenever wheelhouse temperatures rose markedly and most seemed quite keen to have the space well ventilated. This may not be the case during winter however when much lower outside temperatures might lead this action to produce temperatures too low for the watchkeeper's comfort. The accommodation spaces on the larger vessels were ventilated by open hatches or fans while their machinery spaces were ventilated by powerful fans. Mess areas all had windows which were permanently open except where spray was possible. The most useful measure of ventilation is the number of "air changes" in one hour but it was not possible to assess this for the vessels in this study.

4.8 Lighting

During the day, strong sunlight may result in glare which reduces the quality of watchkeeper vigilance because radar and echosounder VDU screens are difficult to view and other craft or navigational hazards missed in visual scanning. The watchkeeping task is complicated during the hours of darkness since the person on duty not only needs to be acclimated to the dark to visually detect the lights of other ships and navigation signals but also needs some lighting system that allows him to refer to charts and other paperwork without losing his night vision.

Using a photoelectric photometer, manufactured by Salford Electrical Instruments Ltd. (Figure 4.8.1), illuminance during daylight was measured in lux at the top of the backrest of the watchkeeper's chair. Lux levels clearly depended upon the external lighting environment and varied between 320 lux on a dull and overcast day and 1250 lux when the sun was shining. These are acceptable values given that the HSE Guidance Note, HS(G)38 'Lighting at Work' (ANON. 1987) specifies an average illuminance of 200 lux as being adequate for 'work requiring perception of detail'. This approach does not deal very well with the question of glare however which in this case can only rely on a visual assessment.

Figure 4.8.1 Photoelectric photometer.

During daylight, the skippers and mates of the vessels observed used "brilliance" and "contrast" controls on the VDU displays to counter the effect of bright sunlight, resetting these appropriately as darkness set in. Crewmen on watch were not observed to make similar adjustments at any time. On at least two occassions, it was noted that where bright evening sun faded into darkness over the course of a crewman's watch, the VDU displays became un-necessarily bright to the extent of appearing "fuzzy" and possibly interfering with all round vision through wheelhouse windows.

The working deck lighting on one of the vessels observed seriously impacted upon the watchkeeper's ability to visually scan the external navigational environment. Floodlights on the foremast were aimed back towards the three quarter length deck shelter so that the winch operator, who stood forward at the winch, could see the length marks on the warps which paid out over the shelter. The result was that the watchkeeper would have had great difficulty in seeing any other vessel approaching from a head-on direction. The lights were sometimes extinguished when the gear had been shot away but were more usually left on until the fish from the previous haul had been dealt with and stowed, this taking up to three hours where a good catch had been obtained. When the skipper was asked about this at the end of the trip, he said that he was aware of the problem but relied on the radar display while these lights were in use.

During darkness, only one of the three vessels had an operational red night light in the wheelhouse. Of the other two, a low power chart table lamp burned permanently in one wheelhouse, while in the other, the watchkeeper had to switch on the full wheelhouse lighting whenever it was required and then re-adapt his night vision when the lights were switched off. This latter situation may prevail in as many as 47% of British fishing boats since, in a questionnaire study, only 53% of fishermen said that their vessels were provided with separate wheelhouse lighting system for use during darkness.

4.9 Fishermen's attitude to working conditions

It is widely recognised that fishermen worldwide are a hardy breed who are reticent when it comes to commenting adversely about their working conditions. UK fishermen are no exception to this adage and the culture of fishing communities bears evidence to the manner in which they have lived for centuries with tragedy and death. In Shetland for example, up until fairly recently, the womenfolk would knit jumpers for their men in unique "Fairisle" patterns, so that if the men were lost at sea, the bodies could be identified by the women when they washed ashore. In North-East Scotland, fishermen wore gold ear-rings so that if they were lost at sea and their bodies subsequently washed ashore, the ear-rings could be sold to pay for their burial. Although they are vociferous in their complaining about fish prices, quotas and other legislation (for examples of this, the reader is referred to any edition of the UK fishing trade publication, "Fishing News" published by EMAP Heighway Ltd.) fishermen are hesitant to challenge their working conditions and are often fatalistic or devoutly religious and happy to devolve responsibility for safe passage to an omnipotent power.

During interviews and in conversations in the course of this research, the only aspects of their immediate environment that fishermen complained about were respectively, fellow members of their crews failing to "pull their weight" and food that was not to their taste. Little negative comment was made concerning working hours, noise and vibration levels or the general element of danger that prevails during fishing operations.

Defining the causes of this stoical approach is in many ways a matter of conjecture. There is undoubtedly an underlying element of "machismo". While it very difficult to measure, and no attempt has has been made to do so, is is nevertheless clear that many fishermen appear to derive considerable satisfaction from their ability to cope with arduous conditions. Younger fishermen in particular appear to revel in this "work hard" ethos and tend to carry it ashore during their leaves to create a "play hard" culture in which heavy drinking and fast cars often figure. Another factor may be the remuneration regime that almost all UK fishermen are subject to. Except where repairing damaged gear is the cause, long spells working hard on deck are generally associated with big catches and given the share system of payment that prevails, these mean greater rewards at the end of the trip. Prolonged periods of duty may therefore be viewed in a positive light with the negative effects, possible fatigue during watchkeeping duty for example, being ignored.

In personal interviews, 20 individual fishermen were asked whether they had ever refused to take a navigational watch on the grounds that they were dangerously tired after spending a very long time working on deck or (in the case of skippers) in the wheelhouse. None said they had, and all commented that this was something that simply was not done since this would be seen as weak and "letting down" the rest of the crew.

4.10 Fishermens' perceptions

It is of interest to know how fishermen themselves perceive the inherent risk attached to their work, for example, how they might rank the various causes of fishing vessel loss. Although no reference to fishermen could be found, much of the work in this general field has been aimed at determining the operating principles of the mind (known as "heuristics") since they act to reduce the complex task of making probablistic judgements to something that the individual can comfortably deal with. In this respect, and in particular with regard to the rather emotive subject of vessel loss, one of the heuristics - "availability" - is of special interest.

According to TVERSKY & KAHNEMAN (1973), individuals base their judgements of the likelihood of some given occurrence upon the ease with which that particular subject comes to mind. Things that come to mind easily are judged to be quite likely and *vice versa*. Thus when individuals are asked to make a judgement concerning the safety of fishing vessels with regard to collisions, they will tend to attribute a high rating if they cannot readily remember any such incidents, and a low rating where they are able to think of a collision incident very quickly. This is arguably a useful way of making judgements, since one of the factors aiding recall is the frequency in the past experience of the person concerned, of that particular type of event. Recall however, is also influenced by vividness. Thus a graphic description of an incident makes recall easier than a brief entry on the inner pages of a newspaper. Consequently, the availability heuristic, although generally useful, may introduce bias and more discussion of the risk of collision is likely to raise the "subjective" risk simply because it makes it easier to think of the risks.

Throughout 1991 and 1992, nine British fishing vessels were lost in collision events, a number of which were vividly reported in the media and had widely publicised repercussions lasting over many months - the *Ocean Hound*, the *Wilhelmina J* and the *Margaret and William II* in 1991, the *Suromaa*, the *Active* and the *Supreme* in 1992. In the same period, seven vessels were lost in grounding events. In a survey in early 1993, fishermen were asked to estimate what percentages of fishing vessels were lost in collisions and what percentage was lost in groundings. Figure 4.10.1 shows that the difference between the perceived and real situations was not far from being perfectly mirrored.

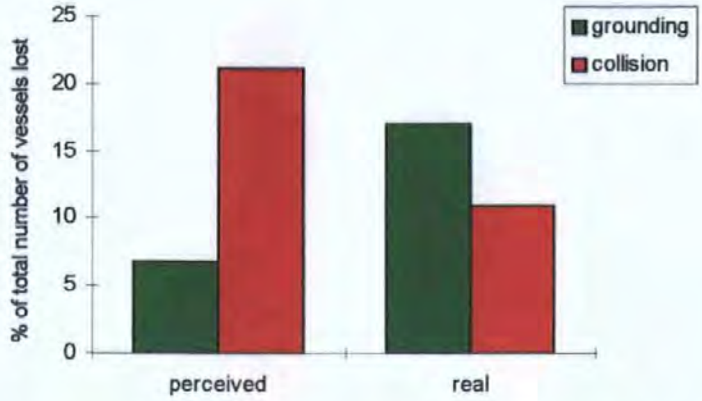

Figure 4.10.1. Differences between real and perceived percentage of fishing vessel losses in collision and grounding events.

Through the subsequent three years, 1993, 1994 and 1995, four vessels were lost in collisions, none of which events commanded a particularly high media profile and eighteen were lost in groundings. The previous question was again asked of a similarly representative group of fishermen in early 1996. Figure 4.10.2 indicates a stark difference in subjects' perception of the relative risk.

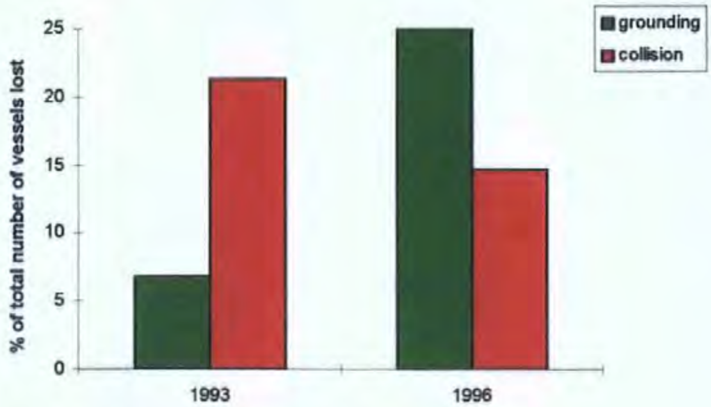

Figure 4.10.2. Differences in fishermen's perception of relative percentages of collision and grounding losses between 1993 and 1996.

In a similar vein, it was proposed in this research to compare the questionnaire results shown in Figure 4.10.3 with a second set taken immediately after a high-profile collision or grounding loss, should one occur during the work. Fortunately for those who might have been involved, but unfortunately for this research, no such event happened during the time alloted.

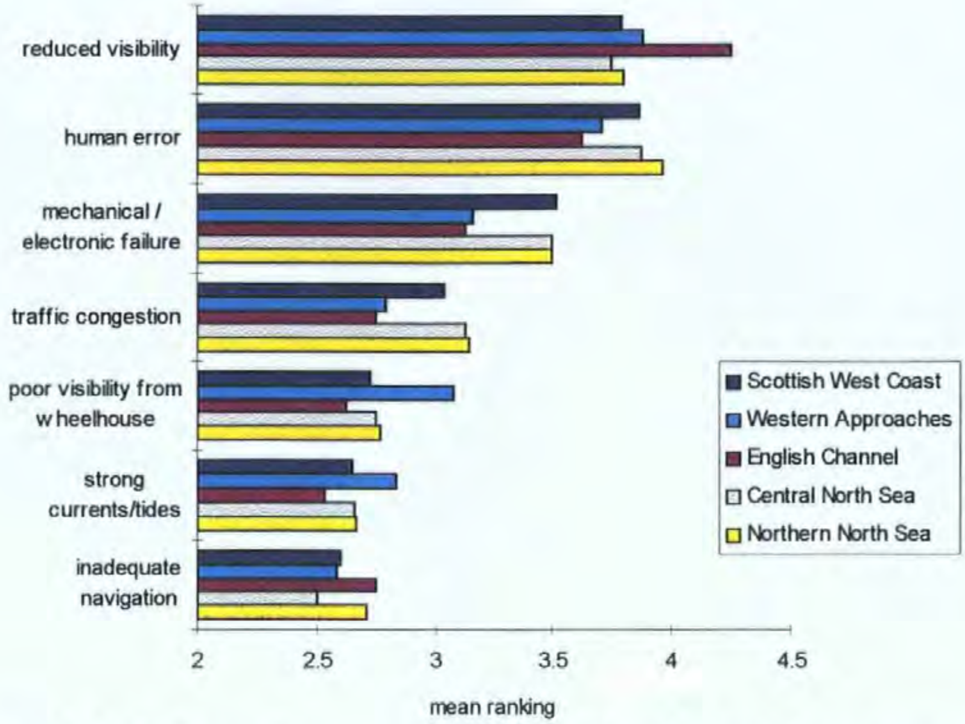

Figure 4.10.3. Fishermen's mean rankings, on a scale of 1-5, of the most common causes of fishing vessel traffic loss, by area (mean values are shown to allow for different size samples in each area).

The availability heuristic has another side. JOB (1990) suggests a number of mechanisms which induce false perception of superior skill and safe operation in motor car drivers. One of these is that accidents and fatalities reported as occuring elsewhere, rather than impelling drivers to be more circumspect and safety-conscious, simply confirm feelings of driving superiority. FULLER (1988) agrees with this hypothesis, writing:

> *"From behavioural theory, we can predict that every time a driver takes risks, either knowingly or otherwise, and "gets away with it", without any undesirable consequence, then that behaviour will be reinforced; that is; made more probable in similar circumstances in the future."*

WOGALTER *et al.* (1987) found that the subjective assessment of risk decreases as familiarity with the hazard increases. If this is indeed the case, it could for example mean that many of the losses that have occurred while no-one was at the helm may be the result of the watchkeeper having left the wheelhouse on a number of previous occassions with no adverse result, and so on for other risky behaviours.

4.11 Aspects of the careers of UK fishermen

The great majority of British fishermen come from fishing communities. In many cases, sons will follow fathers into fishing, often sailing on the same vessel as part-owners but equally likely to sail on board vessels owned by others. The reasons given by fishermen for entering the industry fall broadly into two categories - some see it as a "calling" while for others the alternative employment opportunities are extremely limited and lack the perceived excitement attached to fishing. The reality in a great many cases, is that it is ultimately difficult to separate the two since what may start off as a calling leads individuals inexorably into a lifestyle that is very difficuly to break out of. To illustrate, a sixteen year-old who goes to sea to fish because his father did the same before him will find it difficult to retrain and re-orient himself to work ashore if twenty years on, at the age of 36 he decides that the job is not for him. This is borne out in the towns of Hull and Grimsby where after the decline of the British distant water fleet many former fishermen remained unemployed and to all intents and purposes, "unemployable" for decades (*pers. comm.* Skipper T. Thresh, Fishing Manager, J. Marr & Sons, Hull, 1995). The manner in which income tax is levied on British fishermen also makes it difficult for fishermen to leave the industry. They are taxed under the "Schedule 4" pattern and are thus classed as self employed, paying their income tax in arrears rather than on a "pay as you earn" basis. In interviews, the majority of fishermen, particularly those with no financial interest in the vessels they sailed on, admitted to having had income tax problems at some point and said that tax arrears would make it difficult for them to leave the industry.

While no study has been done on the longevity of British fishermen anecdotal evidence suggests that it is rare for them to reach the statutory retirement age for men in the UK of 65 years, while still working on fishing vessels of over 10 metres. In the course of research for this thesis, only two fishermen over the age of 65 years old were encountered. One of these operated a very small crabber single-handed and the other sailed as cook on board a 24 metre long pair-seiner. Where fishermen have become owners or part-owners of vessels, the norm appears to be for them to phase themselves out of seagoing work during their late 50's, often gradually assuming the role of ship's husband and making and repairing fishing gear. Increasingly, share fishermen in the UK are investing in private pension provision within which they have the right to retire at age 55 under government regulations.

4.12 Chapter discussion

The way in which crewing systems are composed on larger fishing boats, including the duties attached to each rank has evolved over time and very broadly emulates that employed on merchant vessels. On vessels carrying five men or more, the role of each crew member seems to be fairly well defined and the structure appears to work quite efficiently. Although it was not observed during this study, the imprecise delineation of labour on many smaller vessels could easily lead to individual crew members, particularly the skipper, trying to attend to too many tasks, for too much of the time. The introduction of some requirement formalising the role of each member of the crew, this being related to time spent at sea and type of fishing done, would be a simple means of ensuring this is less likely to happen.

Fishermen working long hours is a feature that is not easily addressed. The prescription of *per se* maximum work durations and minimum rest periods prior to watchkeeping duty would be difficult to justify since a regime that leaves one person dangerously fatigued will not necessarily have the same effect on another. This is recognised in M. Notice No. 1020

'Keeping a safe navigational watch on board fishing vessels' which is based upon Inter-Governmental Maritime Consultative Organisation (IMCO) *Resolution A.484*(XII). This uses the phrase, "*.....sufficiently rested and otherwise fit for duty*", rather than suggesting a *per se* rest period. Although intuitively one can of course say that a rested watchkeeper is preferable to an unrested one, fatigue presents a complex problem for research and the literature relating to maritime safety is festooned with glib references unaccompanied by supporting scientific evidence. Chapters 7 and 8 of this thesis deal respectively with the role of fatigue-related factors by measuring the extent to which they alter the points at which watchkeepers become cognitively overloaded and underloaded

The fact that no record exists of the number of practising fishermen who hold qualifications in navigation and watchkeeping prevents the conceptual possibility of comparing rises or falls in the number of "ticketed" fishermen against rises and falls in the loss ratio resulting from traffic events. The MSA initiative aimed at forming such a record may make this type of analysis feasible at some later date.

While 37% of fishermen have had no training at all when they take their first navigational watch, two thirds of these say they have previously shared watches. This is probably an effective means of learning where the other watchkeeper is competent and clearly displays good practise but will probably have the opposite effect where this is not so. There is therefore a compelling argument for the implementation of some requirement for any instruction "on the job" to be done by personnel who themselves are properly trained and indeed, the data suggest that this is precisely how 39% of watchkeepers are trained before they take their first solo watch. The introduction of a formal VQ system of qualifications for fishermen, based on practical competence rather than academic ability, would therefore appear to dovetail well with this fairly prevalent informal system but only where the point of concern made above is addressed.

If the possession of at least an elementary level VQ in watchkeeping was made mandatory for all fishing personnel sailing on vessels over 10m, before they were allowed to take a watch on their own, the data in this study indicate that less than 13% of fishermen would be directly affected, provided that shared watches became training sessions. Instruction in watchkeeping practise on the job is particularly common on vessels operating in the English Channel and Western Approaches / Irish Sea and the VQ system would therefore seem to be particularly suitable in these areas.

Watchkeepers in the Northern North Sea seem to be relatively poorly trained, an ironic finding when it is noted that the area boasts the UK's two largest, best equipped fishermens' training centres - the Banff and Buchan College in Fraserburgh, Aberdeenshire and the North Atlantic Fisheries College in Scalloway, Shetland. When this is coupled with the finding in 3.2.4, that the most frequent situation in this area is for all of the crew to be included in the watchkeeping rota, a disconcerting picture emerges. M. Notice No. 1190 states,

> *" The need for competent watchkeepers is self evident when making a landfall or navigating close to the coast, or in dense traffic, restricted visibility or severe weather conditions; yet casualties still occur where the man in charge of the watch in such circumstances is seriously deficient in knowledge of navigation, "*

Given the geographical and meteorological circumstances that prevail in the fishing areas around the northern half of the UK, it is difficult to see how this could be complied with where much of the crew is untrained though still included in a watchkeeping rota that is strictly adhered to. If a proper training on the job approach was embraced in these areas, the situation could be dramatically improved. Information from the Training Division of the SFIA suggests that for financial reasons rather than in the interest of providing the most appropriate form of training, the bigger training colleges want to stay with the ticket system rather than moving to on the job training with VQ qualifications (*pers. comm.*, Mr Simon Potten, Training Coordinator, SFIA Training Division, 1996).

The question of when a watch duration becomes too long is one that is very difficult to answer. Although well over half of all UK vessels employ watches of two hours or less while they are steaming, watch lengths of up to six hours were noted in this study. Where the watchkeeper is well rested and not performing in a stressful environment, such as reduced visibility, heavy ship movement, excessive vibration, noise, heat or cold, this may not pose a problem. This research has shown that all of these factors may apply on fishing boats, often in concert and thus these "longer" watches may be a cause for some concern. Fishing boats operating around the southern half of the UK appear to display a proclivity for operating longer watch durations than those in the northern half. SCHMIDTKE (1976) tested the performance of naval cadets on a radar-based navigation and collision avoidance system while they were on watch alone for four hour periods. He found a decrease in performance in the second half of these watches that was evidenced in some of his subjects failing to detect collision courses and being unable to take effective avoiding manoeuvres in time. Similar instances of detection latency over time in maritime watchkeeping experiments are reported by CAILLE *et al* (1965) (cited by DAVIES & PARASURAMAN, 1982). Chapter 7 of this thesis presents research aimed at identifying the time points during various types of watches (steaming, fishing, shooting/hauling) on fishing boats where the cognitive ability of the watchkeeper is reduced and thus provides a foundation for suggesting the appropriate duration of watches.

The questionnaire responses to questions regarding watchkeeping guidelines were initially encouraging, with more than three quarters of fishermen indicating that they were supplied with clear guidelines on the eight important points noted. The set of responses to the same question posed during interviews and the statistically significant difference between the two is however a disquieting result. Although the sample used in interviews was much smaller, the fact that in this situation, only 35% of fishermen said they were given clear guidelines as to what constitutes the keeping of a good lookout whereas 87% had said they were in written questionnaires indicates that watchkeeping guidelines are a matter that demands some attention.

While the working environment on fishing vessels has been shown to be noisy, when viewed in the light of the statutory maximum noise dosages for shore-base workers, the noise levels recorded in wheelhouses are such that they are unlikely to pose any serious problem. It nevertheless be noted that the noise data recorded for this study were taken on board well found and maintained vessels and are not necessarily representative of the entire fleet. Wheelhouse temperatures were also within a range that would be unlikely to cause discomfort or stress. The temperature on the working deck of the largest vessel used in this study, a 24 metre pair-seiner, which was enclosed by a watertight shelter-deck was rather high for hard physical work and resulted in most of the crew working in oilskin dungarees and T-shirts and the engine room temperatures were as might be expected, also very high. While no convention was noted in the research, it would clearly be advisable for anyone who had been working in either of these two environments immediately prior to watchkeeping duty to be allowed some rest time in which to acclimate to the wheelhouse environment. As for the noise data, the temperature results presented must be qualified by saying that they were drawn from a small sample of vessels during the spring and summer months.

During the hours of daylight, lighting generally presents no problem for watchkeepers but in the dark, two factors were noted in this research the solutions to both of which are relatively simple. The first of these, inappropriately positioned deck floodlights, is a design problem which is apparently quite common, but easily solved by re-positioning or shielding the existing lights. This is a feature that is not currently checked during mandatory four-yearly fishing vessel surveys but could easily be. The second problem, glare from VDU screens, demands even simpler solution. As noted in 3.2.8, this problem tended to arise only with crewmen who were unwilling to adjust brilliance and contrast settings. The skipper should instruct crewmen on how to moderate the glare from video screens and let them know that is is acceptable for them to make the necessary adjustments as the need arises.

Perhaps the most important yet least tangible feature influencing safety in the fisherman's working environment is his attitude. It is a matter of debate whether it is possible to over-ride the fatalistic notion ingrained over generations, that "the sea gives and the sea takes" without a shift in cultural values. Given that British fishermen have relatively short careers, characterised by a phase of youthful exuberance giving way to a state of indifferent acceptance of the imperfect risk/reward balance the job offers, it is difficult to see how such a fundamental change could be engineered. Well designed training regimes are clearly a vital tool in replacing fatalism and its attendant risky behaviour with a "safety culture" approach but this will probably take considerable time before it shows beneficial effect.

In section 4.10, it was demonstrated that the availability heuristic can be useful in raising fishermens' awareness of certain risks and the publication and distribution of Summaries of Investigations by the MAIB is probably a worthwhile pursuit in this respect. This has to be tempered however with the possibility that this type of publication does no more than reinforce the notion that "accidents always happen to someone else" and encourage an attitude of complacent superiority in those who have managed to avoid such events. When this is coupled with the possibility that every time a watchkeeper does something risky and emerges unscathed, that action then becomes more likely in the future a frightening situation emerges.

4.13 Chapter summary

- A broad relationship has been identified between size of vessel and number of crew carried and although every vessel will have a designated skipper, delineation of labour is not always clear on smaller vessels.

- It is impossible to generalise on working hours on British fishing boats and the advent of new technologies and fishing techniques can cause dramatic changes to this. At present, fishermen are excluded from legislation on working hours but there may be attenpts to change this in the future.

- The system of training for fishermen is presently in a state of flux, between the traditional 'ticket' system and the new VQ system. Although there is resistance from some quarters, the latter is probably more suited to the fishing industry and complements the prevalent informal training system operated on board fishing boats.

- At the time of taking their first solo watch, fishermen operating in the Northern North Sea have least training and preparation while fishermen operating off the Scottish West Coast and in the Western Approaches are best prepared.

- Mean length of watches throughout the fishing fleet, while vessels are steaming to, from and between fishing grounds is 2.5 hours and while towing the fishing gear it is 3.1 hours. The longest and shortest watches, in both steaming and fishing modes, are kept in the English Channel and off the Scottish West Coast, respectively.

- A significant difference was found between written questionnaire responses and personal interview responses to the same set of questions regarding guidelines given to watchkeepers on fishing vessels.

- The working environment on the fishing vessels studied in this research was noisy, but not to the extent that it exceeded the maximum dosages that would be allowed in shore-based working environments in the UK.

- During research for this work, although high temperatures were recorded in the engine spaces and on mess areas when cooking equipment was in use, the temperatures in accommodation spaces and in the wheelhouses were unlikely to be stressful. It must however be borne in mind that this research work was done during spring and summer, in relatively fine weather.

- There are specific problems attached to lighting conditions in fishing vessels wheelhouses, but these are relatively simple solutions to these.

- Fishermen tend not to complain about their working conditions and accept risk and danger as being part and parcel of their profession. For various reasons, they also tend to find movement into other types of employment difficult.

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Chapter 5

THE CIRCUMSTANCES OF FISHING VESSEL GROUNDING & COLLISION LOSSES

"Some circumstantial evidence is very strong - as when you find a trout in the milk"

Henry Thoreau (1817-1862)

5.0 Introduction

The most recent published work dealing with the circumstances of UK fishing vessel losses was by M. J. Reilly, a researcher working in the Geography Department at the University of Dundee, (REILLY, 1984). The main thrust of his work was to compare the level of fishing vessel safety before and after the publication of the Holland-Martin Report (HOLLAND-MARTIN, 1969) which was commissioned following the consecutive loss of three British distant water trawlers in the space of eight days in 1968. Reilly found that the risk of loss or serious casualty was twice as great in 1981 than it had been at any time during the previous 20 years and identified vessel age as being an important factor. He did not however, give any specific consideration to fishing vessel traffic losses. Tvedt and Reese, in an unpublished report (TVEDT & REESE, *unpublished 1986*) attempted to identify interactions between different circumstances in fishing vessel losses from all causes but were hamstrung by the small number of records they had access to and could draw a limited number of tenuous conclusions. Beyond these references, no consolidated work on the circumstances of British fishing vessel collisions and groundings would appear to have been done. In the Netherlands, some research into the circumstances of traffic casualties has been pursued but this is limited to a specific sector (beam trawlers)of the Dutch fishing fleet (HEINRICH, 1988; VEENSTRA & STOOP, 1992).

The object of this chapter is to explore the collective circumstances in which fishing vessel traffic losses have occurred in recent years. Using information derived from a range of institutional and private sources, these circumstances are first presented descriptively and subsequently subjected to individual analyses. Processed data arising from questionnaire studies are also presented and the concept of comparing respondent's perceptions with reality is again implemented. The circumstances under scrutiny are, in the order of their presentation;

- *length of vessels lost* - comparison of traffic loss records of three vessel length categories
- *vessel age at time of loss* - analysis of the importance of vessel age as a factor in traffic losses
- *timing of losses* - identification of the weekday, month and season when traffic losses are most likely to occur
- *location of losses* - categorisation of the areas of operation of the UK fleet in terms of their importance as locations of traffic losses
- *operational status of vessel* - the relative importance of steaming and fishing modes in traffic losses
- *visibility at time of loss* - assessment of the importance of visibility as a factor in traffic losses
- *watchkeeper rank at time of loss* - analysis of the respective roles of skippers, mates and crewmen in traffic losses

In order that the relevant aspects of each of the circumstances dealt with in this chapter can be considered the layout of the chapter is unconventional in that the results of each section are specifically discussed before moving to the next. The chapter concludes with a general discussion of the findings.

5.1 Length of vessels lost in traffic events

A search of the existing relevant literature failed to produce any published opinion on the elementary question of whether big fishing boats were safer than small ones so far as collision and grounding are concerned. At the simplest level, the numbers of vessels lost from the three length categories, "under 12 metres", "12 to 24 metres" and "over 24 metres" can be reviewed using area charts for quick comparison of the relative scale of losses.

Figure 5.1.1 shows that the greatest numbers of traffic losses occur in the 12 - 24 metre length class with fewest in the over 24 metre class. Treating collision and grounding losses individually results in a broadly similar pattern emerging, (Figures 5.1.2 and 5.1.3).

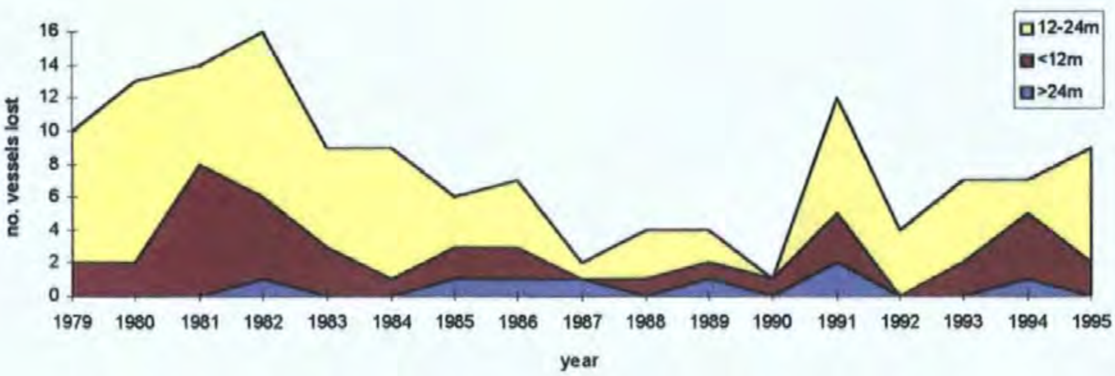

Figure 5.1.1. Numbers of UK fishing vessels lost in collision and grounding events by length class, 1979-1995.

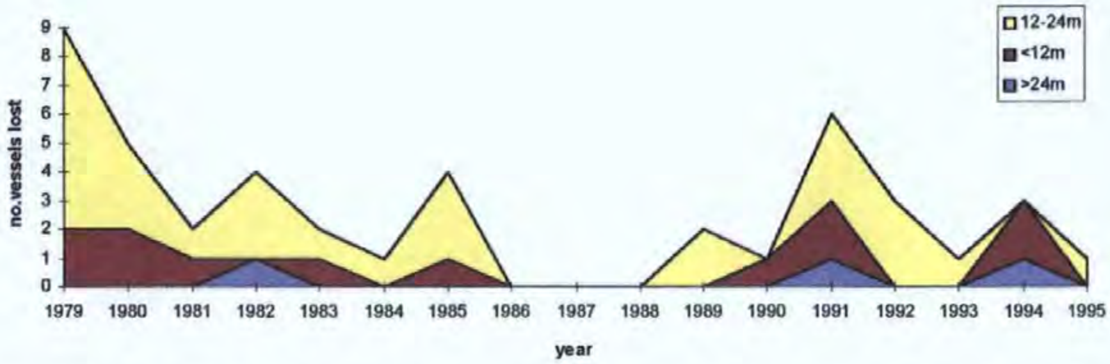

Figure 5.1.2. Numbers of UK fishing vessels lost in collision events by length class, 1979-1995

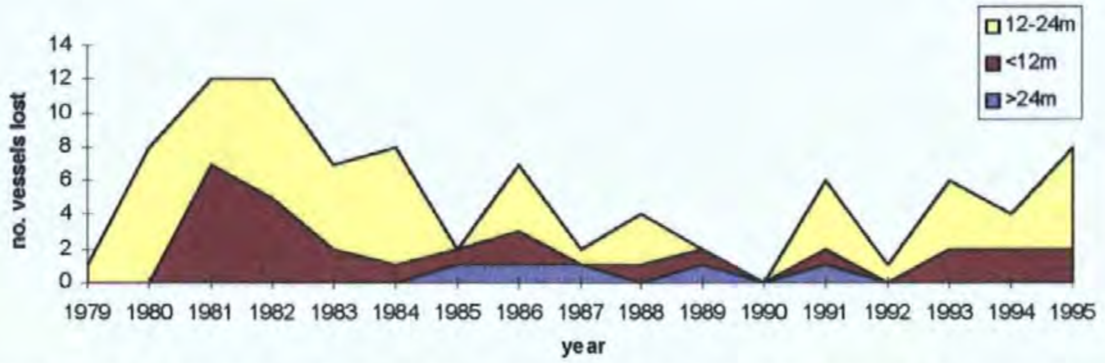

Figure 5.1.3. Numbers of UK fishing vessels lost in grounding events by length class, 1979-1995.

Providing an accurate answer to the original question of whether bigger fishing boats have a better traffic-safety record than small ones however requires the number of vessels lost in each length category to be reviewed in the light of the numbers of vessels in the UK fleet that are at risk in those categories. Figure 5.1.4 indicates the loss rate per 100 vessels in each length category for the period 1979 to 1995 for both groundings and collisions, as moving average trendlines.

This paints a very different picture to that arising from simple analysis of numbers of vessels lost. For the entire period under scrutiny, under 12 metre fishing boats are shown to have been proportionately less susceptible to loss in collision and grounding events than the other two length classes. The collision and grounding loss ratio for under 12 metre boats during the period was on average, 86% lower than for 12 - 24 metre vessels and 76%

lower than their over 24 metre counterparts. Over 24 metre boats were less likely to be lost in traffic events than 12 to 24 metre ones prior to 1985 but the situation reverted to its earlier state in 1991.

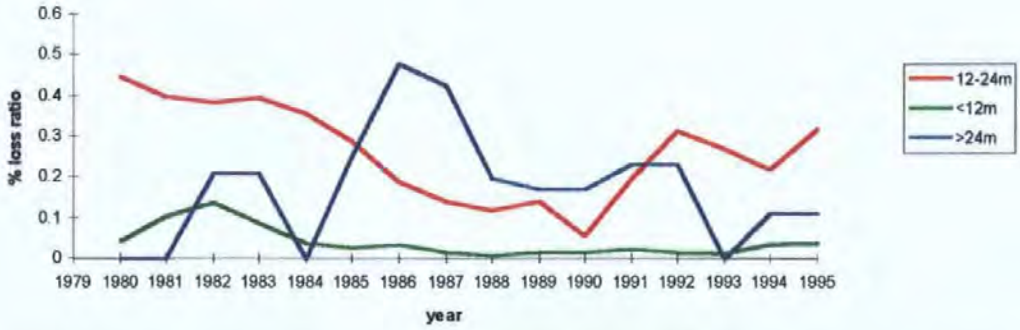

Figure 5.1.4. Percentage loss rate for UK fishing vessels lost in collision and grounding events by length class, presented as two period moving averages.

A similar analysis for collision losses only (Figure 5.1.5) results in a situation where both of the larger length categories vie for the highest loss ratio over the period, with the most recent trend being for over 24 metre vessels to be more prone to loss.

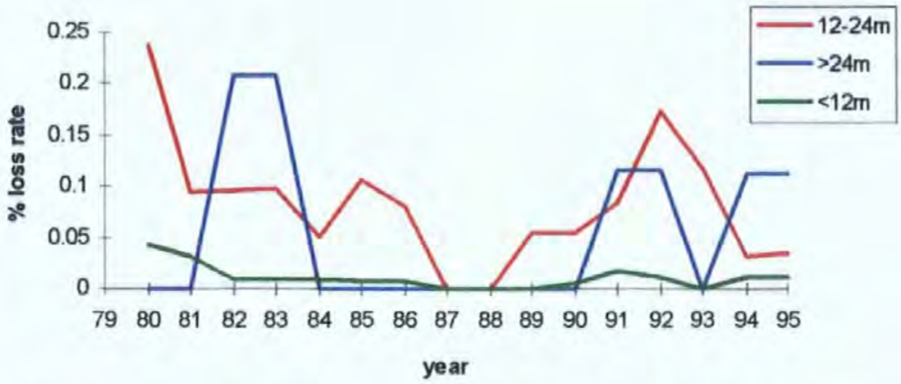

Figure 5.1.5. Percentage loss rate for UK fishing vessels lost in collision events only, by length class, presented as two period moving averages.

Figure 5.1.6 shows that the trends for grounding loss ratios are very different to those for collisions, the most recent being for vessels in the 12 - 24 metre class to be most at risk. In both collisions and groundings, under 12 metre fishing vessels appear to have substantially better safety records than either of their two length class counterparts.

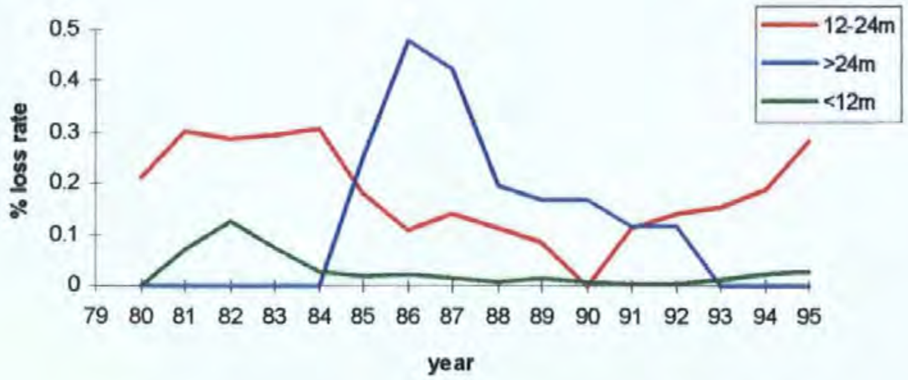

Figure 5.1.6. Percentage loss rate for UK fishing vessels lost in grounding events only, by length class, presented as two period moving averages.

5.2 Age of vessel at time of loss

A number of fairly recent commmentators on fishing vessel losses (REILLY, 1984; HOLLAND-MARTIN, 1969; HEDERSTROM & GYLDEN, 1992) have made reference to "age of vessel" as being a factor of some bearing. In this respect, it is easily conceivable that the increase in the proportion of vessels lost in foundering and flooding and capsize incidents over recent times may be partly an age-related phenomenon since more legislative attention has been focused on fundamental features of seaworthiness as time has progressed. Likewise, improved fire-prevention and fire-fighting technology has probably reduced over time the relative level of risk of loss due to fire. No specific reference to fishing vessel age at time of loss in traffic incidents could be found in the literature.

Figure 5.2.1, showing the recent trend in mean vessel age in the UK fishing fleet, provides a yardstick against which trends of age of vessels lost may be compared. The reader should note that an average age of 30 years has been assumed for vessels recorded in the official statistics as "over 25 years old". This has been done to negate the skewing effect that the few very old (up to 80 years) boats that are still registered and fishing would have on the data, so although not a truly accurate representation of the mean ages, this nevertheless offers a more realistic impression of the general vessel age situation.

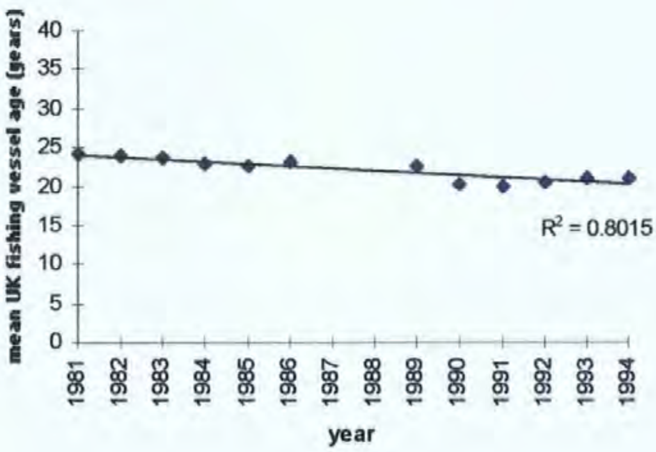

Figure 5.2.1. Mean age by year, of all vessels in the UK fishing fleet in recent years. *(Compiled from available data supplied by the Sea Fish Industry Authority, using mid-points of class intervals and assuming an average age of 30 years for vessels in the 'over 25 yrs' category)*

Figure 5.2.2 shows that so far as vessels lost in collisions between 1975 and 1993 are concerned a barely perceptable rising trend is indicated, although the relationship is particularly weak.

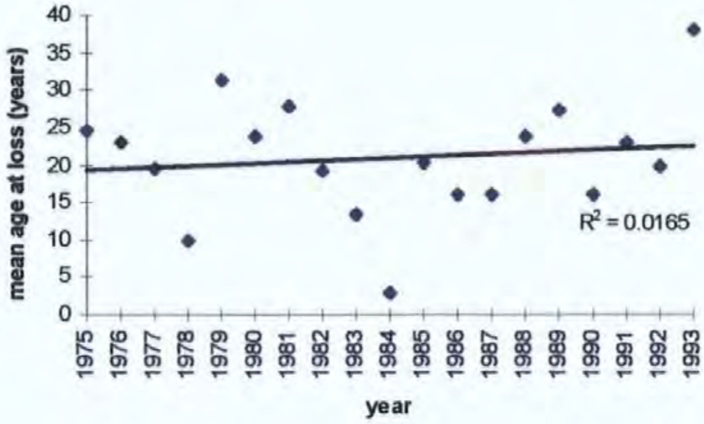

Figure 5.2.2. Mean age of fishing vessels lost in collisions, 1975 - 1993.

Plotting the mean age at time of loss of vessels lost in grounding events however, shows a more clearly defined relationship (Figure 5.2.3). Although far fewer vessels were lost annually in this way during the late 1980's and early 1990's (see Figure 2.5.6, *ibid.*), the mean age of victims has steadily increased. REILLY (1984) found the mean age at time of loss in fishing vessel groundings over the 8 year period, 1973 - 1980 to be 17.8 years. This increased between 1981 and 1993 to 22.7 years.

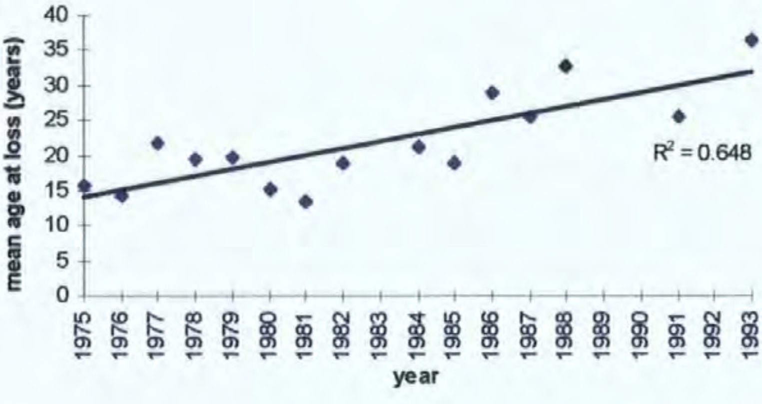

Figure 5.2.3. Mean age of fishing vessels lost in groundings, 1975 - 1983.

There are likely to be a number of tenable reasons for this, one of which is that the increased prevalence of more sophisticated electronic navigation equipment has been the precursor of both the general reduction in collision and grounding losses and of the reduced susceptibility of newer vessels to grounding loss.

To test this theory, an "index of navigational sophistication" was compiled for British fishing vessels in four different age groups.; 0-5 years old; 5-10 years old; 10-20 years old; over 20 years old. The index was compiled on the basis of whether vessels were fitted with the 16 items of navigational equipment and systems listed in Table 5.2.1.

The information used in this analysis was derived from questionnaires sent to fishing vessel owners in 19 fishing ports around the UK who were accessed through the 'Year Books' of the National Federation of Fishermen's Organisations, the Scottish Fishermen's Federation and the Secretary of the Northern Ireland Fishermen's Group Training Association.

- *Decca Navigator*
- *GPS*
- *other electronic position fixing system*
- *video track plotter*
- *paper echosounder*
- *video echosounder*
- *video echosounder with digital depth display*
- *sonar*
- *more than one VHF radio*
- *autopilot*
- *autopilot alarm*
- *magnetic compass*
- *gyro compass*
- *stabilised radar*
- *radar range ring alarm*
- *ARPA*

Table 5.2.1. Items of equipment incorporated in calculating "navigational sophistication".

Table 5.2.2. indicates, perhaps not unexpectedly, that older vessels were found to have, on average, a less sophisticated array of navigational equipment. The relationship between the four fishing vessels age groups and mean levels of navigational sophistication, in fact shows an almost linear correlation of -0.98.

vessel age	mean sophistication score
0 - 5 years	7.87
5 - 10 years	6.74
10 - 20 years	5.60
over 20 years	3.13

Table 5.2.2. Mean navigational sophistication index scores for fishing vessels, by age of vessel.

5.3 Operational status at time of loss

TVEDT and REESE (*unpublished 1986*) divide all fishing vessel casualties into two groups in their analysis; those which were lost at sea while on a fishing voyage and those which were lost while in port. Such a distinction has little useful application in the present study which is specifically concerned with traffic losses and watchkeeping practice. It is of course possible that a fishing boat could be rammed by another vessel while lying tied to the quayside and subsequently lost. So far as can be ascertained however, this type of event is extremely rare and did not figure in any of the casualty reports that relate to cases in the data set used.

Of the 34 traffic losses examined in detail during the course of this research, only three were lost while fishing. Further examination of Marine Accident Investigation Branch files made available to the Author in 1995 prompts the conclusion that relatively few (probably <10%) fishing vessels are lost in traffic accidents during the time that they are actually engaged in fishing operations. The vast majority of collision and grounding events that lead to the loss of fishing vessels happen during steaming to, from and between fishing grounds.

5.4 Timing of loss

Because there were an average of 35.4 fishing vessel losses each year between 1975 and 1995, it is tempting to state that 2.95 fishing boats are lost each month, or in extreme form, to say that one fishing vessel is lost every 10.3 days. Vessel losses do not however, necessarily occur with the regularity implicit in such comments. While analysis of the time distribution of events is common in road traffic and aviation safety studies, it appears less so in marine safety research. Work in this area has been done and data published for merchant marine accidents (e.g. APSLAND, 1995) but none could be found in the literature relating to fishing vessels.

5.4.1 Inter-annual

The inter-annual distribution of numbers of fishing vessels lost due to collision and grounding, and the respective loss ratios have been outlined in Chapter Two. The combined loss ratio for all fishing traffic losses is shown along with actual numbers of vessels lost in Figure 2.3.1. It must be borne in mind that, for the reasons explained in Section 2.6, the loss ratio measure for the fleet as a whole is undermined by the inclusion on the Shipping Register of under 10 metre boats from 1989 onward. Nevertheless, a generally decreasing trend through the 1980's is evident with both number of losses and the loss ratio showing signs of rising in the early 1990's.

5.4.2 Seasons and months

No clear trend is evidenced in overall analysis of the numbers of collision and grounding losses (Figure 5.4.1) beyond confirmation that relatively more traffic losses occur during the Winter, late Autumn and early Spring months (October to April) where the mean monthly number of losses for the period 1975 - 93 was 13.14, than in Summer when the mean was 12.6. This is as might be expected since there will be increased prevalence of adverse natural phenomena - fog, snow, gales, etc. - during Winter, early Spring and late Autumn. This effect should nevertheless be counterbalanced to some extent by the increase in fishing activity when the weather is favourable during the summer.

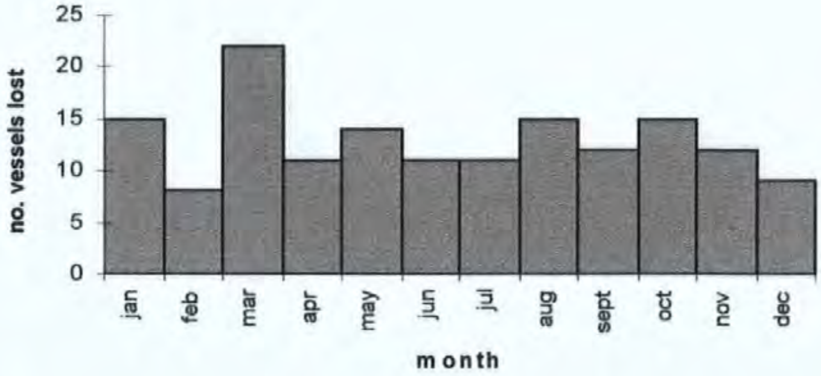

Figure 5.4.1. Numbers of fishing vessels lost in both collisions and groundings according to month, 1975 - 1993.

Although the total number of losses in the sample is small, Figure 5.4.2 indicates that more fishing boats have been lost in collisions during late Spring, Summer and early Autumn, (May - October) than during the rest of the year (64% *cf* 36%). Six collision losses have occurred in each of the months, March, August and October during the study period and no vessels at all were lost in a collision during the month of December between 1975 and 1993.

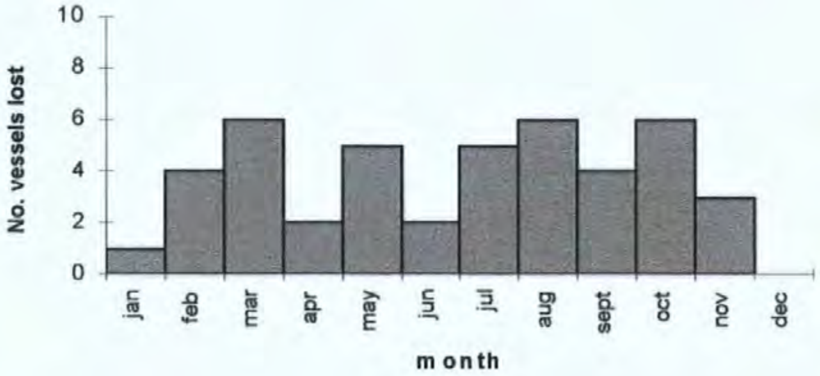

Figure 5.4.2. Numbers of fishing vessels lost in collisions according to month of loss, 1975-1993 (n = 44).

Save for the months of January, February and March, the monthly pattern of numbers of fishing vessels lost in grounding events was remarkably homogeneous between 1975 and 1993 (Figure 5.4.3). The greatest number of grounding losses (16) during the study period occurred in March with January showing the second highest (14). Curiously, during February - the month between these two - the least number of losses happened in this way.

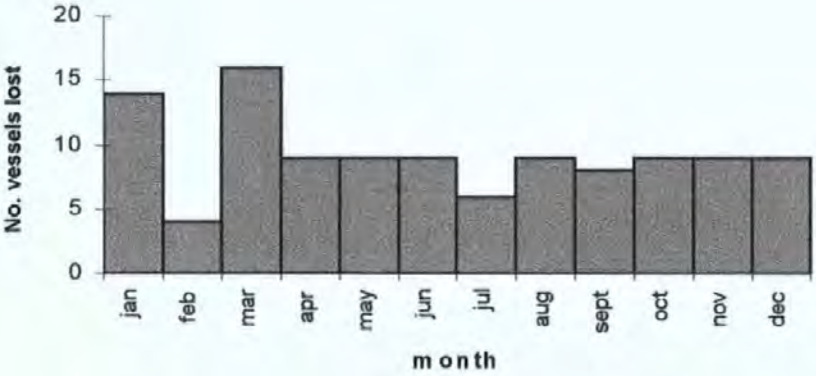

Figure 5.4.3. Numbers of fishing vessels lost in groundings according to month of loss, 1975-93.

4.5.3 Weekday

When taken together, analysis of the frequency of collision and grounding losses by day of the week indicates that these types of incidents have most commonly occurred towards the end of the week, with Friday being the "worst" day (Figure 5.4.4). A chi-squared statistical test for goodness of fit applied to these data gave a χ^2 statistic of 26.48, suggesting bias in the distribution of losses over the week that was significant beyond the 1% level.

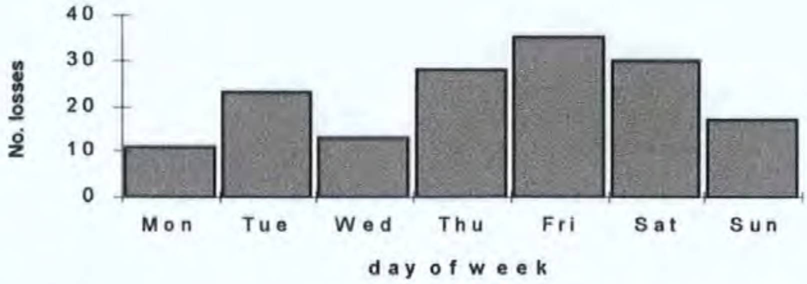

Figure 5.4.4. Number of fishing vessel losses in both collisions and groundings by day of the week, 1975 - 1993.

Figure 5.4.5 highlights Thursday and Sunday as the critical points in the week so far as numbers of fishing vessels that were lost in collisions between 1975 and 1993 are concerned. Numbers of collision victims are relatively low during Monday, Tuesday and Wednesday. During 1979, the worst year in the period for collision losses (see Figure 2.5.5) a total of seven fishing vessels were lost in collision events with six of these occurring on Saturday or Sunday.

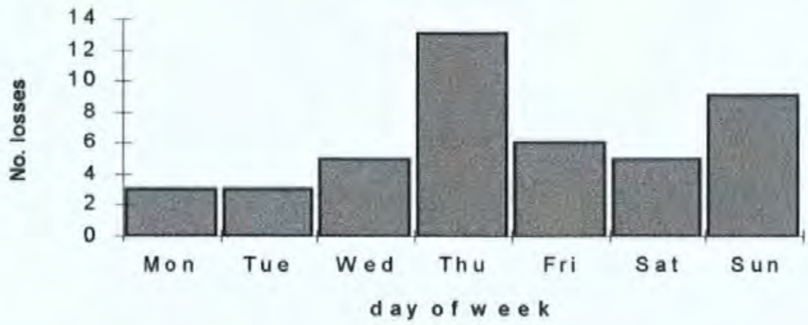

Figure 5.4.5. Number of fishing vessel losses due to collisions by day of the week, 1975 - 1993.

The daily pattern of number of vessels lost in grounding events has its peak on Friday but also indicates high values for Saturday and in contrast to the same for collision losses, Tuesday (Figure 5.4.6). Grounding losses also differ markedly from collisions in the number occurring on Sundays.

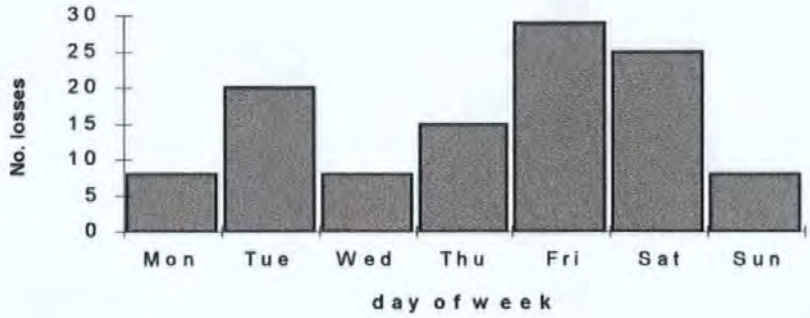

Figure 5.4.6. Number of fishing losses due to groundings by day of the week, 1975 - 1993.

The question of isolating the "worst" day of the week for traffic events leading to the loss of the vessel, can only be meaningfully addressed by relating the proportion of the fishing fleet at risk on each day of the week to the distribution of losses by weekday. Questionnaire responses from fishing skippers in 19 ports around the UK indicate that, on any given week, as much as 27% of the fleet, the greatest proportion on any one day, will be in transit between port and fishing grounds on Mondays (Figure 5.4.7).

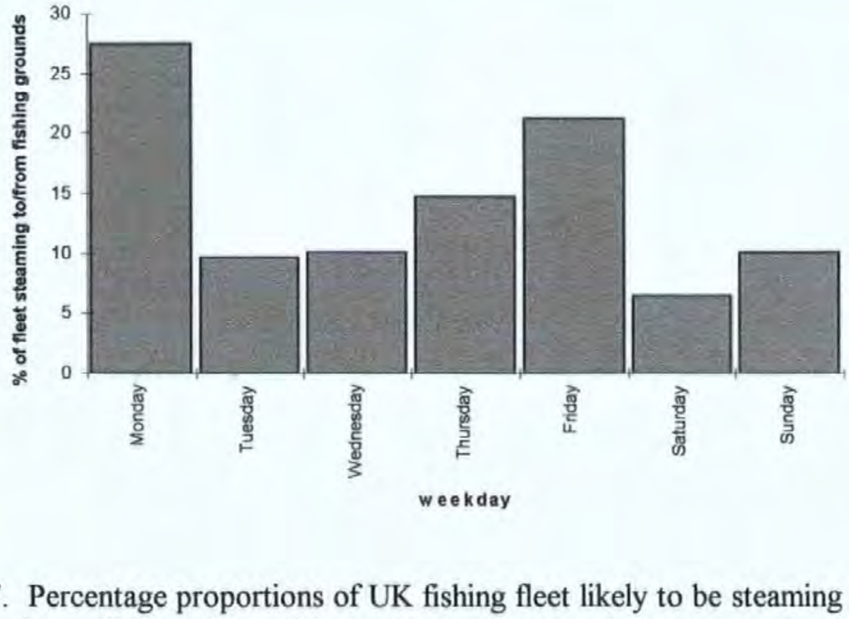

Figure 5.4.7. Percentage proportions of UK fishing fleet likely to be steaming to and from fishing grounds on different days of the week.

Over Tuesday and Wednesday, about 10% of the fleet will be steaming, rising to 15% on Thursday and 20% on Friday. Saturday sees the least fishing boat traffic (6%) and although about 10% of the fleet is on the move on Sundays, much of this tends to be from late afternoon onwards. During the Monday to Friday period, many vessels operate on a daily basis which entails steaming out to and back from local grounds on the same day. This is particularly the case during the winter months. Drawing upon supplementary data derived from questionnaire responses, the proportion operating in this mode is roughly 10 - 12%, so the inflated proportions of steaming vessels evident on Monday and Thursday/Friday respectively suggsts an exodus to the grounds at the start of the week and a more gradual return towards the end.

When broken down on a regional basis, it can be seen that this pattern is fairly consistent around the whole of the UK, with some minor variation (Figure 5.4.8). For example, more vessels are in transit and thus 'at risk' in the Western Approaches during Tuesday and Wednesday and this reflects the fact that a greater proportion of the South West, Welsh and Irish Sea fleets operate on a daily basis all year round. The Scottish fleets and those from ports on the east coast of England however tend to operate more within a weekly regime and the mass departure/return model is more prevalent.

Given the proposition that there are certain days when more vessels are likely to be at risk of being involved in traffic incidents is established, one might expect the pattern of actual losses to move in line with this. Figure 5.4.9 demonstrates that this is not the case. In this figure, each arm of the chart represents a different weekday with the red area showing the way in which all types of navigational loss are distributed over the week. Superimposed upon this is the blue area which shows the proportions of the fishing fleet which are likely to be at risk on given weekdays. Where red protrudes from under blue on any arm of the chart, disparity between these two proportions is indicated.

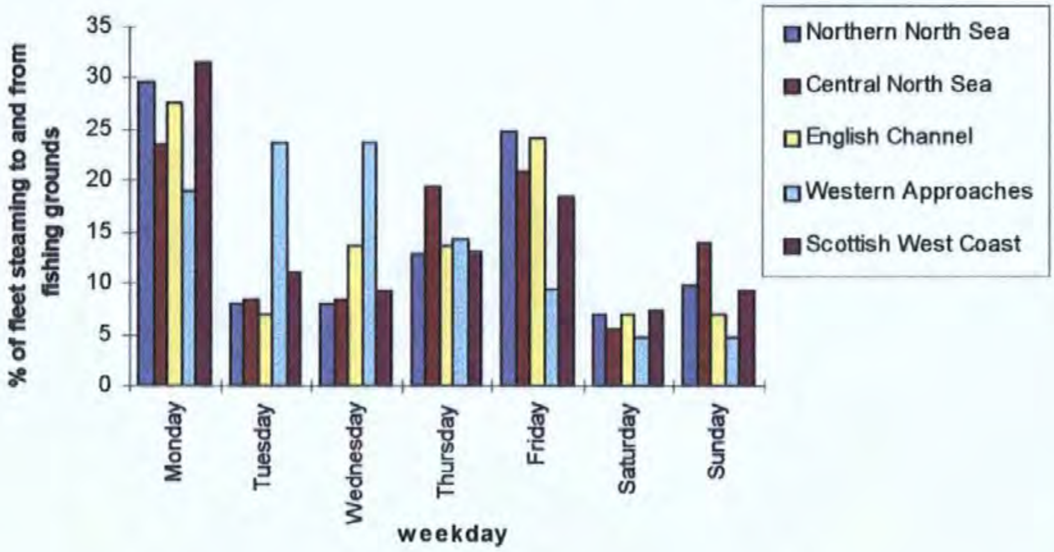

Figure 5.4.8. Regional variation in the proportions of the fishing fleet in transit to and from the fishing grounds according to day of the week.

For collisions and groundings taken together, there appears to be some minor inconsistency between the two proportions on Tuesdays and Thursdays, but a notable amount of red is visible at the end of the week, particularly on Saturday.

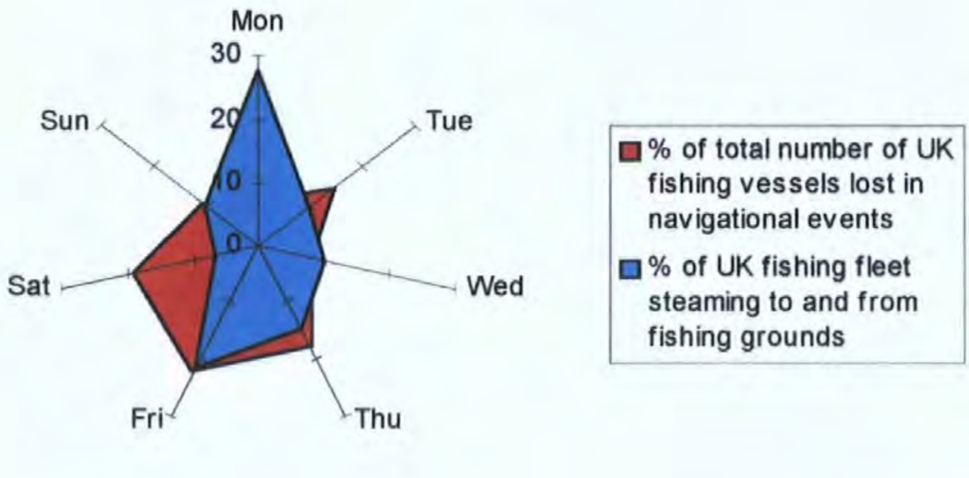

Figure 5.4.9. Radar chart comparing proportion of vessels steaming to and from fishing grounds on each weekday with proportion of total losses in navigational events.

To discern whether this effect was due to any inter-daily variation in either collision or grounding occurrences, similar displays were prepared for each of these causes of loss. Figure 5.4.10 shows that so far as collision is concerned, Sunday and Thursday are the days of greatest disparity. Scrutiny of the very limited available information on individual events does suggest that many of these Sunday and Thursday collisions occur during the second half of both days.

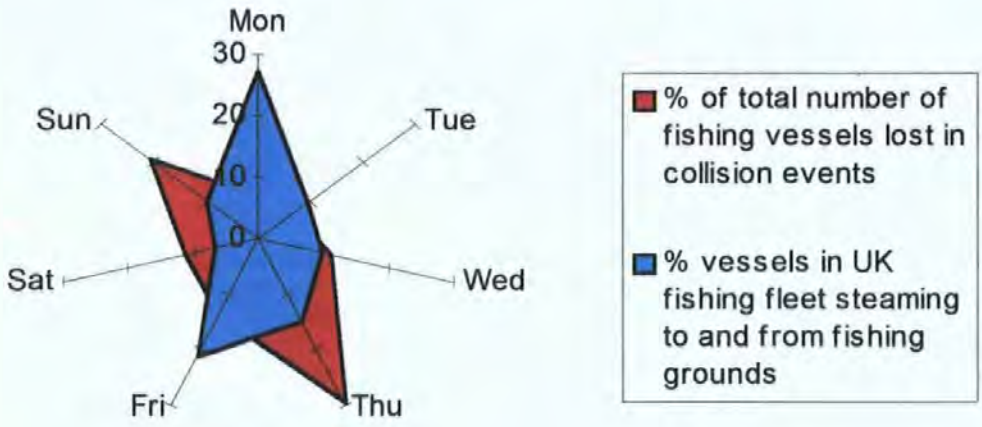

Figure 5.4.10. Radar chart comparing proportion of vessels steaming to and from fishing grounds on each weekday with proportion of losses due to collisions on those days.

When the same type of display is presented for grounding losses (Figure 5.4.11), a small area of red protrudes on Tuesday while a significant disparity is apparent on Friday leading in to Saturday. Scrutiny of the available loss accounts indicates that these loss events are fairly well distributed throughout the duration of both of these days.

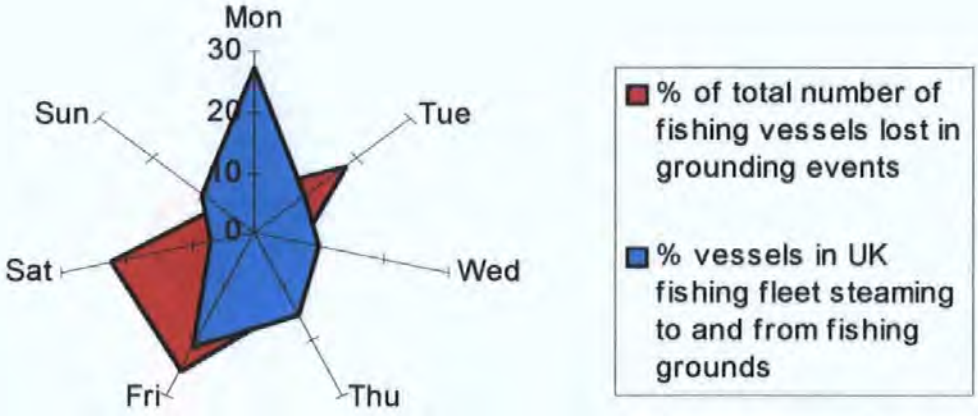

Figure 5.4.11. Radar chart comparing proportions of vessels steaming to and from fishing grounds on each weekday with proportion of grounding losses occuring on those days .

5.5 Location of loss

The macro-environment in which the UK fishing fleet operates, described in detail in Chapter 3 incorporates considerable topographic and oceanographic diversity and also significant inter-regional variation in the type and volume of marine traffic. It might reasonably be expected that the incidence and type of fishing vessel loss will reflect these differences. For example, one would intuitively expect relatively more grounding losses to occur off the West Coast of Scotland where the navigator is faced with picking a safe path round many headlands and through the hundreds of islands and reefs, than in the Central North Sea, where the coastline tends to run in long sweeps with few hazards outside its contiguous zone. Survey of relevant literature indicated that no analysis of the location of fishing vessel traffic losses had been previously attempted.

Information on the position at which fishing vessels were lost in traffic events was gathered from the sources noted in Section 1.4.2 for 112 collision and grounding events which occurred the period, 1975 - 1994 (this accounts for about two-thirds of relevant losses during the period). Analysis of the locations of both collision and grounding losses taken together suggests a fairly even distribution in all of the areas around the UK with the greatest proportion (24%) occurring in the Central North Sea and the least (14%) in the English Channel (Figure 5.5.1).

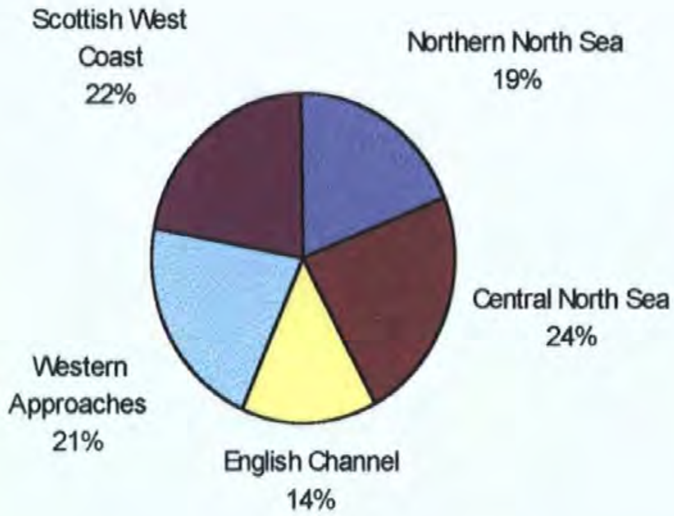

Figure 5.5.1. Locations of fishing vessel losses due to both collision and grounding, 1975-93.

When collision and grounding losses are taken separately (Figures 5.5.2 and 5.5.3), the picture changes quite dramatically. Only 11% of collision losses occurred on the Scottish West Coast while conversely, the same region accounted for 37% of grounding losses. The Central North Sea is the location of a relatively high proportion of collision losses (33%) but has no similar corollary, since only 17% of grounding loss events also happened there.

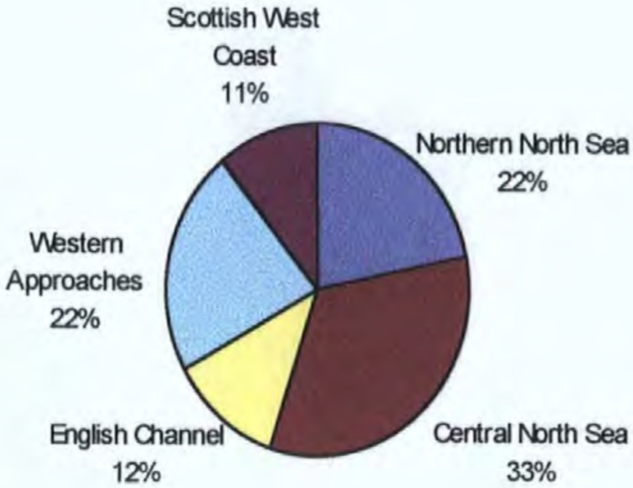

Figure 5.5.2. Locations of fishing vessel losses due to collision, 1975 - 1993.

Relating the observed percentage frequencies for traffic losses in the different sea areas to those that would be expected if there was no relationship between sea area and loss due to either collision or grounding in a chi-squared statistical test gave a test statistic of $\chi^2 =$ 24.81. This suggests that the difference in frequency of occurrence of the two types of loss is less than 1% likely to have happened by chance.

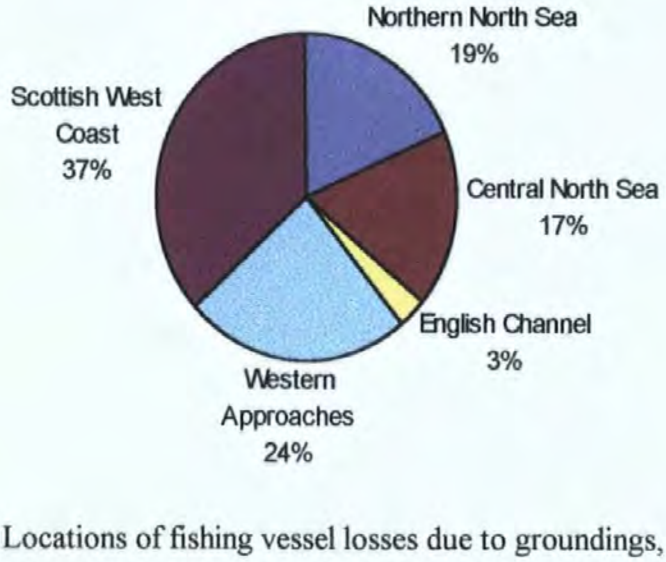

Figure 5.5.3. Locations of fishing vessel losses due to groundings, 1975 - 1993.

Unfortunately, this does not provide an *ipso facto* case for saying that vessels are more prone to either collision or grounding loss in any particular area since this requires some form of data normalisation. Figure 5.5.4 compares the proportions of the total number of UK fishing boats that are likely to be steaming to and from fishing grounds in each of five areas with the proportion of traffic losses that have occurrred in each of these areas. The levels to which the former agrees with the latter are tabulated in Table 5.5.1 and for clearer understanding of the principle, disparities for each cause are displayed graphically in Figures 5.5.4, 5.5.5 and 5.5.6 on page

	all traffic losses	collisions	groundings
Scottish West Coast	-6.4%	-19.4%	+6.6%
Northern North Sea	-6.4%	-4.1%	-7.1%
Western Approaches	+3.0%	+2.0%	+4.0%
English Channel	+1.3%	-2.7%	-11.7%
Central North Sea	+16.2%	+24.2%	+8.2%

Table 5.5.1. Proportions of UK fishing traffic losses related to the proportion of the UK fishing fleet likely to be at risk in particular areas.

While a degree of diversity between proportions is evident for the Scottish West Coast, the Northern North Sea and the Western Approaches, the English Channel provides a very close match. The respective proportions for the Central North Sea are relatively disparate however, in global terms (Figure 5.5.4) and for both collisions and groundings when these are considered independently (Figures 5.5..5 and 5.5.6 respectively).

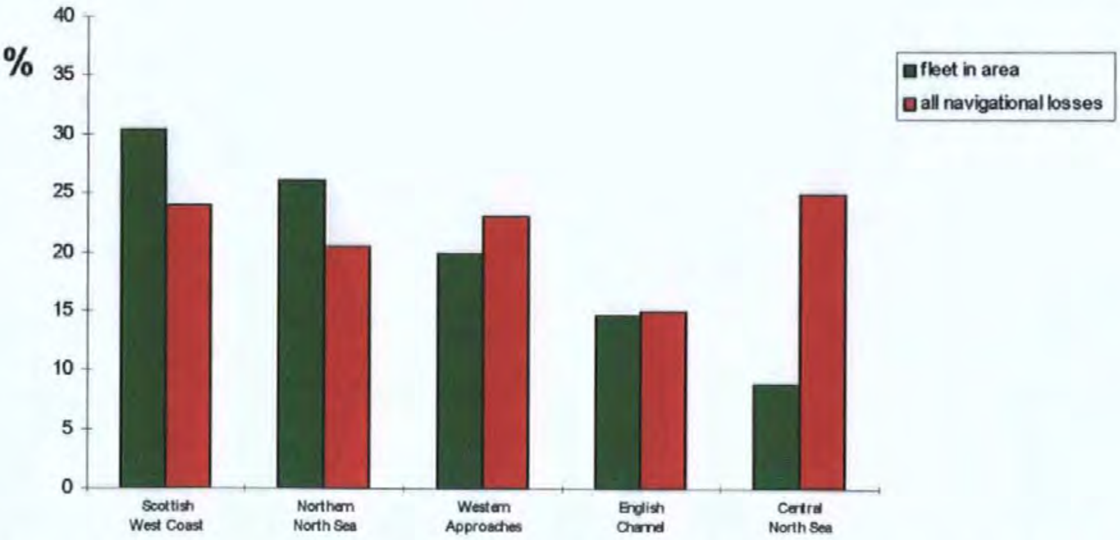

Figure 5.5.4. Percentage distribution of all fishing traffic losses according to area, compared with percentage distribution of UK fishing fleet regularly operating in those areas.

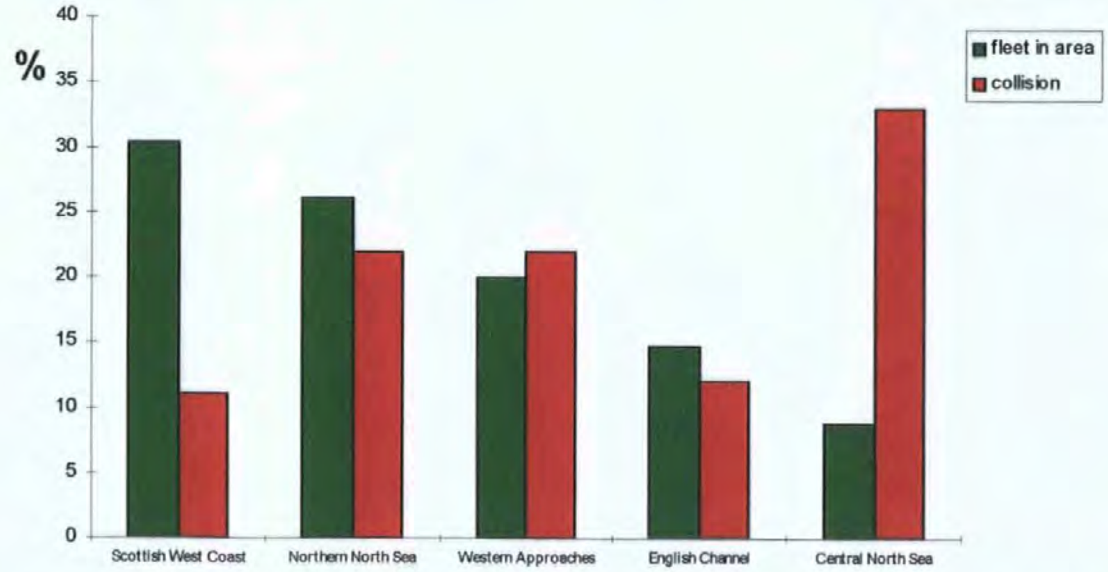

Figure 5.5.5. Percentage distribution of fishing vessel collision losses according to area, compared with percentage distribution of UK fishing fleet regularly operating in those areas.

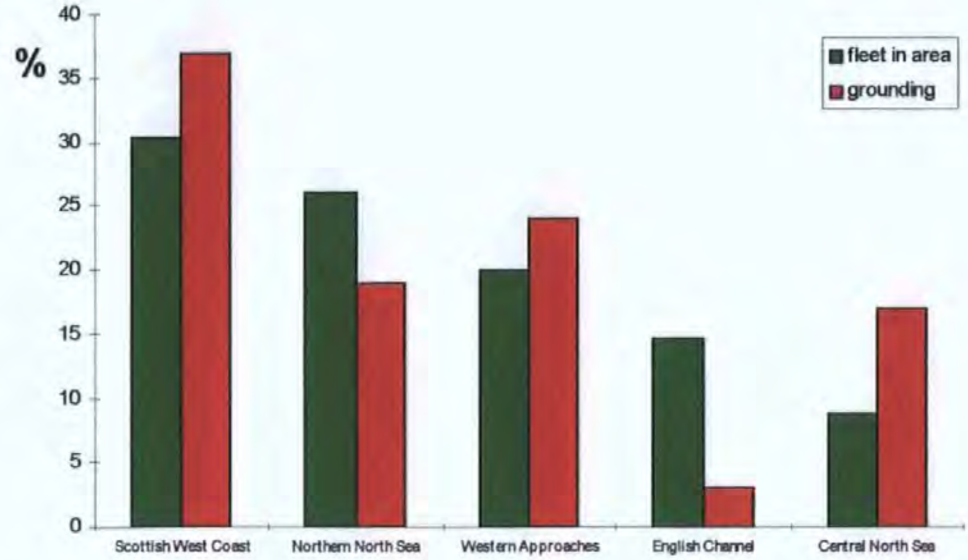

Figure 5.5.6. Percentage distribution of fishing vessel grounding losses according to area, compared with percentage distribution of UK fishing fleet regularly operating in those areas.

5.6 Visibility at the time of loss

One might naturally expect serious collision and grounding incidents to be more likely during periods of impaired visibility. Analysis of a sample of 39 traffic loss events during the period 1985 - 94, for which reliable information regarding the prevalent state of visibility just before and at the time of the event was available, suggests that this may not necessarily be the case. The same system for classifying visibility into three categories - "good", "moderate" and "poor" - as explained in Chapter One was used; poor incorporating fog where visibility is less than 5 km, moderate where visibility is between 5 and 10 km and good where visibility is in excess of 10 km. The sample of traffic loss events for which reliable information on visibility at the time was available was too small to be attributed to the different areas so only national figures are presented. Visibility was good in well over half (56%) of all collision and grounding events that led to the loss of a fishing vessel with moderate visibility at the time of 18% of all losses and poor visibility in 26% of cases, (Figure 5.6.1) .

Figure 5.6.1. Visibility at time of incident for all fishing vessel traffic losses. (n = 39).

When collision and grounding losses in the same global sample are separated, (Figures 5.6.2 & 5.6.3) a roughly similar pattern emerges. Although the collision sample includes only twelve loss events, this amounts to 44% of the 27 losses of this type during the period in question, good visibility prevailed in exactly half of these occassions. The remaining half was evenly split between moderate and poor visibility conditions.

For grounding losses the sample size was much larger (27 events) and although visibility may have a part to play, this would appear to be of a minor nature since 59% of these events occur in good visibility.

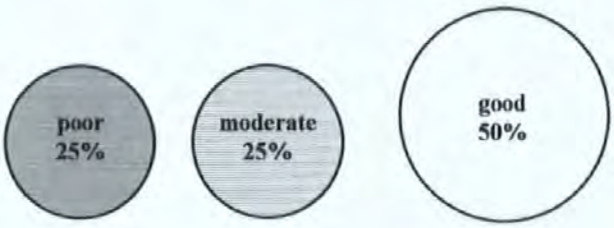

Figure 5.6.2. Visibility at time of incident for fishing vessel losses resulting from collisions (n = 12).

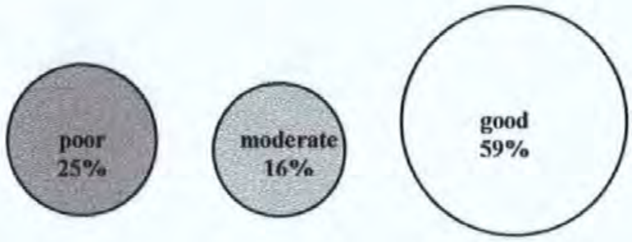

Figure 5.6.3. Visibility at time of incident for fishing vessel losses due to grounding (n = 27).

5.7 Rank of watchkeeper at the time of loss

Using a sample of 42 traffic loss events compiled from casualty data relating to the period, 1985 - 1994, for which reliable information on the status of the watchkeeper at the time of the event was available, the status of the watchkeeper at the time of the event was noted. When both collision and grounding losses are taken together, it can be seen that the skipper was on watch at the time of the event in almost half (47%) of all cases. Crewmen were on watch in 30% of the time, the Mate 8% of the time. A further and disquieting feature was that the wheelhouse was unmanned in 15% of these events (Figure 5.7.1).

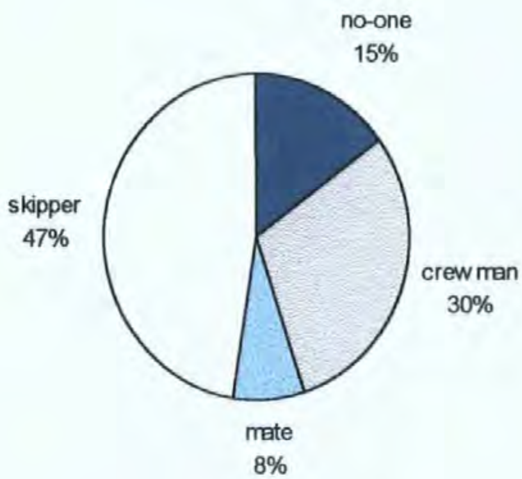

Figure 5.7.1. Rank of person on watch at time of event in all traffic losses. (n = 42)

When the overall situation is broken down into the constituent collisions and groundings, it can be seen that the Skipper was in charge of navigating the vessel in 53% of groundings and 36% of collisions (Figures 5.7.2 and 5.7.3). Mates were much more likely to be on watch when collisions occurred than groundings (14% *cf* 4%) while there was no great difference in the proportions of events in which Crewmen were in charge between collisions and groundings. Splitting collisions from groundings also shows that the proportion of occassions in which no-one at all was on watch was very high in the former (21%) and less so but still a cause for concern in groundings (12%).

Again it must be emphasised that only 12 incidents comprised the collision sample although this did amount to 55% of the total number of collision losses during the period in question and may therefore be construed as being an acceptable sample size in terms of reliability.

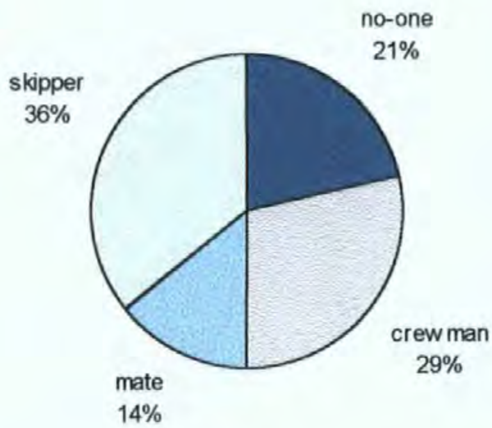

Figure 5.7.2. Rank of person on watch at time of event in collisions. (n = 12)

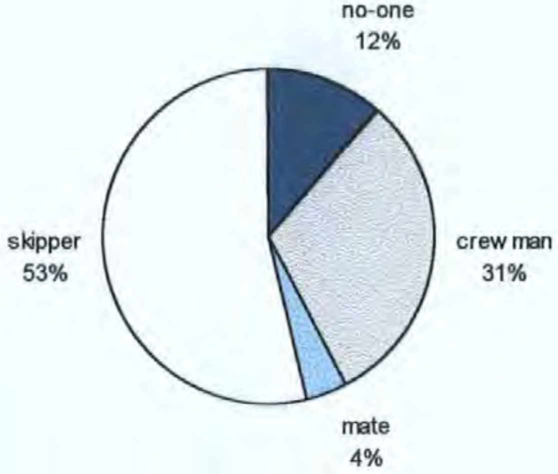

Figure 5.7.3. Rank of person on watch at time of event in groundings. (n = 30)

5.8 Visibility and watchkeeper rank considered in tandem

The previous two elements of this analysis of circumstances can be set against one another to examine how watchkeepers of differing rank perform in alternative states of visibility. Drawn from information in the sources noted in section 1.4.2, tables have been compiled which include a column headed "no-one". This relates to occasions where, although there may have been an individual accorded with watchkeeping duty, for whatever reason, there was no-one in the wheelhouse. The records from which information was drawn only occassionally refer to the rank of the watchkeeper who *should* have been present at the time of the event.

Table 5.8.1 relates the rank of the watchkeeper to visibility at the time of the event in both types of fishing traffic losses. The table strongly implicates skippers who, in 26% of the cases studies in detail were on watch in good visibility at the time the loss event occurred. Another 18% of traffic losses happened while crewmen were on watch in good visibility. 10% of these losses took place during poor visibility while crewmen were on watch.

	SKIPPER	MATE	CREWMAN	NO-ONE
good	26	5	18	8
moderate	15	0	2.5	0
poor	8	2.5	10	5

Table 5.8.1. Percentage occurrence of watchkeeper status at time of incident in fishing vessel losses due to both collision and grounding. ($n = 39$).

No collision losses occurred with the skipper on watch in good visibility and all of the collision losses which happened while a crewman was on watch took place in conditions of good visibility (Table 5.8.2). At the time of 17% of collision loss events in good visibility, there was no-one at all in the wheelhouse of the vessel.

	SKIPPER	MATE	CREWMAN	NO-ONE
good	0	8	25	17
moderate	25	0	0	0
poor	17	8	0	0

Table 5.8.2. Percentage occurrence of watchkeeper status at time of incident in fishing vessel losses due to collision. ($n = 12$).

The same analysis performed for grounding losses (Table 5.8.3) portrays skippers in an even gloomier light since 37% of these happened while the skipper was on watch in good visibility. 7% of vessels in the sample were lost after running aground in poor visibility while no-one was in the wheelhouse.

	SKIPPER	MATE	CREWMAN	NO-ONE
good	37	4	15	4
moderate	11	0	4	0
poor	4	0	15	7

Table 5.8.3. Percentage occurrence of watchkeeper status at time of incident in fishing vessel losses due to grounding. ($n = 27$).

5.9 Chapter discussion

The most interesting outcome of analysing the role of vessel length in both collision and grounding losses is the low rate of occurrence of under 12 metre boats when the resulting statistics are normalised to the numbers of vessels at risk (Figures 5.1.4, 5.1.5 and 5.1.6). Section 2.6 offers a number of reasons why this might be - many boats in this class being worked on a part-time basis, operated seasonally, and spending time in port during bad weather. It might also be argued that the under 12 metre class of vessel quite simply spends much less time at sea than bigger boats do, even in fair weather. When this point was put verbally to a sample of fifteen fishing skippers, some put forward a plausible additional reason - that small boats were "lighter on themselves" and were much more likely than larger ones to be successfully refloated with minimal damage following a grounding.

Attempting to forecast the susceptibility of a fishing vessel to collision and grounding risk on the basis of its age is complicated by the fact that there are essentially two different age based considerations: on the one hand, there is the genre of the boat - this encompasses the features that are typical of boats built at any particular time, and on the other, there is the ageing process itself. Relating navigational sophistication to age has shown that older fishing boats generally have less sophisticated navigational equipment than those built more recently and it is comforting to believe that more sophisticated wheelhouse equipment performs an effective "task offload" function, releasing more of the watchkeeper's available mental capacity to address the task of visual observation and processing of information from non-automated sources. While many items of navigational equipment that come on to the market can be retro-fitted, it would appear that there is a tendency for vessel owners to "make do with what they have" and thus, if one is to accept that better navigation equipment improves the performance of the system, the genre of the boat may indeed be a predictor of increased grounding risk. It must be borne in mind however that no direct evidence is presented in this thesis or elsewhere, to indicate that the watchkeepers themselves in new vessels perform any better than those in older ones.

The relevant aspects of the ageing process itself will most likely manifest themselves in greater incidence of breakdown and malfunction in wheelhouse equipment. This has not been explored in depth in this study because the number of loss events for which detailed information was available and in which equipment breakdown was implicated was too small to provide for any meaningful analysis. Questionnaire responses from a representative sample of fishermen in 19 ports around the UK refute the contention made by KNOX, (1994) that, "*skippers of fishing trawlers, despite all the advances (in navigation technology) will sadly miss the paper chart, parallel rule and dividers*". The vast majority of these fishermen were of the opinion that the safety of their vessels while in transit to and from the fishing grounds had been very much improved by the installation of GPS navigation system, adjustable alarm ring on the radar unit, and for those that had it, an automatic radar plotting aid (ARPA).

A peripheral question must be addressed at this point however. If both collisions and groundings are related to the navigational capability of vessel and crew then should it not follow that each would display the same relationship between age and likelihood of loss, rather than the differing ones illustrated in figures 5.2.2 and 5.2.3? Two possible answers to this question exist:

i) The relationship between vessel age and loss due to collision is less distinct than that for grounding because of the fact that the blame for the former, in a number of cases, lies with other (often non-fishing) vessels and these vessels do not select their stand-on targets according to their age. That is to say, the watchkeeper aboard a new fishing vessel is just as likely to have to make a rapid decision on whether to evoke Rule 17 (b), ("*When, from any cause, the vessel required to keep her course and speed finds herself so close that collision cannot be avoided by the action of the give way vessel alone, she shall take such action as will best aid to avoid collision*") as the watchkeeper aboard an older one.

ii) Although sophisticated technology may help in the initial identification of the existence of a collision course, the fact that a decision has to be made by a fallible human operator - even where sophisticated technology makes it abundantly clear that collision risk exists - puts newer vessels as much at risk of loss in collision situations as older ones.

The analysis is weakened however when one considers that older vessels are probably more likely to be declared by insurers to be constructive total losses than newer ones because of increased susceptiblility to damage in grounding events and the resultant cost of repairs.

In an "open" question forming part of a questionnaire study, many fishermen commented on technical measures that might help reduce the likelihood of collisions, for example, radar plotting aids. Few however had any suggestions for technical measures to reduce groundings and this type of response was consistent from questionnaire to interview. This may be a feature of the 'horror' aspect of being in a collision which far outweighs the same for involvement in a grounding. This may be a feature of the availability heuristic, briefly explored in Chapter 4.

A number of factors conspire to make fishing boats less vulnerable to invovlement in loss events while they are fishing, but one rather obvious reason stands out from the rest. The greatest number of fishing traffic losses occur in 12-24m length class. These, and the over

24 metre vessels will almost invariably be fishing far enough from shore to render the prospect of running aground while fishing highly unlikely. This is not to say that fishing boats are not vulnerable to collision and grounding while fishing, indeed the results of research into the workload of the watchkeeper, presented later in this thesis, shows that they are indeed more so at certain stages of fishing operations. This paradoxical situation is discussed in Chapter 7.

The inter-annual pattern in UK fishing traffic losses declined up until about 1990, since when it has shown signs of rising. While the fishermen themselves might well argue that this is a manifestation of a harsher economic environment, the information presented in Section 2.6 of this thesis would not be supportive of this opinion. Economic factors may however exert some influence over other aspects of the timing of traffic losses.

March is the month during which most traffic losses have occurred and a number of features attach to this particular month that may be relevant in this respect. The weather of course can be treacherous in March, with a high incidence of sudden gales and frequent poor visibility as a result of rain, snow and fog. Perhaps less obvious is the fact that the period of daylight begins to lengthen and thus boats which operate mainly in the daylight hours begin to increase their number of hours worked, increasing the exposure to risk and opening up the potential for increased levels of fatigue. March is also, for a biological reason, a difficult time for the British fisherman since the fish have recently spawned and tend to display a low "condition factor" meaning that their weight to length ratio is generally at its lowest point for the whole year. The result of this is poor quayside prices for catches, increasing financial stress and a resultant prompting of fishermen to work longer hours to compensate. This will accordingly tend to increase the likelihood of fatigue, especially towards the end of a fishing trip.

When collision losses are separated from groundings, the most notable feature of the resulting monthly pattern is that only one vessel was lost in a collision event during the month of December throughout the 18 year period studied. The introduction of annually calculated Total Allowable Catches (TAC's) in the late 1970's and the resulting quota management regime in the UK meant that British catch allowances for a number of species were frequently exhausted during the last few weeks of the year and numerous vessels had to temporarily stop fishing, including larger ones which would not normally have been greatly hampered by the established bad weather pattern prevalent at this time. This would have had the effect of dramatically reducing the number of vessels being exposed to collision risk during the month of December, when there were no collision losses, in these years. While a plausible scenario for December however, this hypothesis does not explain why only one vessel was lost in a January collision when the fleet would have been back in operation, though bad weather of course, seriously limits the number of vessels operating during January in most years.

Apart from the spike in the number of grounding losses that occurred during the month of March, which has already been discussed in a general context, and the trough in February, numbers of fishing vessels lost in this way display a remarkably homogeneous pattern throughout the rest of the year. Numbers of vessels lost in grounding events are higher during January, and it is tempting to suggest that this is because they are more likely to be declared as 'lost' where the incidence of powerful winter waves will cause greater damage to a grounded vessel more quickly than in the calmer seas of summer. This supposition would be confounded by the low number of vessels lost in February which, although a shorter month, would see wave action which might reasonably be expected to be as significant as during the preceding month.

The radar chart, based on normalised data for the daily incidence of collision losses shown as Figure 5.4.10, indicates that although many vessels will be steaming to and from fishing grounds on these days, Thursdays and Sundays harbour a disproportionately high incidence of losses of this type. Information on precise timing of these loss events was very limited but where this could be accessed, a tendency for the event to occur during between 15.00 and midnight was indicated. While it must be viewed in the light of this information being only available for a small number of the total number of vessels lost in this way over the last twenty years, it would nevertheless tend to suggest the influence of stressors of some form, perhaps fatigue and even disorientation as vessels leave port late on Sunday evenings.

So far as grounding losses are concerned, the amount of red showing on the Friday "arm" of Figure 5.4.11 might perhaps be explained by fatigue or cutting corners in eagerness to get back to port at the end of the week, but the relatively large red area for Saturday is both sinister and enigmatic. In addition to the obvious possibility of fatigue amongst watchkeepers returning to port, the general lack of fishing traffic on Saturdays may implicate the inter-related concepts of boredom, complacency and work underload.

The low proportion of fishing vessel collision losses (-19.4%) and higher proportion of grounding losses (+6.6%), relative to the level of fishing activity evident in the Scottish West Coast area are features that might be expected, given the lower density of traffic per unit area and the difficult coastline, respectively (Chapter 3). The most striking feature of the analysis of the location of traffic losses is the high proportions of both collisions and groundings, relative to the number of fishing vessels operating there, that have occurred in the Central North Sea. Notwithstanding the fact that the level of fishing operations may have been slightly underestimated in this area, the disparity in the two proportions is clearly a cause for concern.

The preponderance of collisions in the Central North Sea area is difficult to explain. It is a large expanse and although fishing effort is concentrated in certain zones, this will be no more so than in the other areas. Merchant traffic is heavy in the eastern part, near the continental mainland but only moderate in the western part of the area where most fishing by British boats would tend to take place (again Figure 3.4.1). Likewise the high level of grounding losses is difficult to rationalise, the coastline being the least navigationally challenging of all the areas (Section 3.10).

One possible explanation, certainly for the high collision rate, is that up until the late 1980's, a large fleet of "anchor-seiners" operated from the port of Grimsby. These vessels did not operate during the winter and put to sea for trips of up to twenty-one days with only three crew - a skipper, engineer and cook. It was customary for these vessels to fish during daylight only and to lie-to at night, during which time the whole crew would turn-in, leaving no-one in the wheelhouse on watch. With the information used in the present analysis stretching back to 1975, it may be that a number of the losses included came from the anchor-seining fleet but this cannot be ascertained since the fishing method of vessels lost is seldom recorded.

In discussing the concept of weather-routeing for merchant ships, MOTTE (1972) stated, "*poor visibility is the ship master's greatest enemy*". Questionnaire responses from over 300 fishermen showed that the fishermen themselves perceive bad visibility to be the the most significant causal factor in navigational losses, ranked even above human error, though only marginally so.

True consideration of the rôle of visibility at the time of fishing vessel loss events, requires that the proportions of the total number of traffic losses attached to good, moderate and poor visibility be set against the natural occurrence of these states in the study area, to assess whether any real effect is apparent. This presented some difficulty since the incidence of different states of visibility varies from area to area and only national figures for the visibility at the time of the loss events could be compiled in section 5.7. Reference to Table 3.11.1 shows that the lowest incidence of visibility in excess of 5 miles may be expected in the English Channel area during the Winter (55 - 75%). In none of the areas would visibility of more than 5 miles be expected to occur less than 70% of the time in Summer. This would therefore imply that over all of the five areas, throughout the year one might reasonably expect good visibility for more than roughly 65% of the time, with moderate and poor visibility prevailing for the rest. The finding that 56% of all fishing vessel traffic losses occur in good visibility and 44% in the other two options (Figure 5.6.1), suggests that reduced visibility is indeed a factor, though perhaps not to the extent the fishermen themselves perceive it to be. If the above reasoning is to be accepted, then the figures for collision losses, where 50% occurred in reduced visibility strongly implicate reduced visibility, as an influental factor.

It is clear that fishing in the English Channel, where merchant traffic is most dense and poor visibility is a frequent occurrence, may be a hazardous pursuit since the Collision Regulations extend no privilege to vessels engaged in fishing when they cannot be seen. By the same token, reduced visibility would appear to be much less important in grounding losses wherever it occurs, because with 59% occurring in good visibility, the distribution is much closer to that which transpires naturally. The greater influence of reduced visibility in collision events agrees with KOSTILAINEN and TUOVINEN, (1981) who found that for general merchant shipping in the Baltic Sea, higher proportions of collision losses (40%) than grounding losses (28%) occurred in poor visibility. COCKROFT (1976) however expressed the opinion that, on a worldwide basis, reduced visibility is a major factor in some 70% of collisions at sea.

At first sight, the high percentage of traffic loss events at the time of which the skipper was on watch (47%) could be construed as an indictment of the training and certification regime for fishermen. A number of points could be made to suggest that this is not necessarily the case and that it is to be expected that skippers will be on watch during the majority of losses. Firstly, on smaller vessels, operating on a daily basis, the skipper will be on watch for the entire trip from the point the boat leaves the quay to when she is tied up again, indeed where the vessel sails single-handed, this is inevitably the case. Secondly, a sound watchkeeping management system would dictate that the skipper *should* be on duty when navigating in a hazardous area or when there is a serious equipment malfunction. Thus it is actually to be expected that the skipper be on watch when some feature, or combination of features, of the navigational, natural or technical environments has been deemed to significantly increase the risk of collision or grounding. Furthermore, many skippers of smaller boats only nominally hold the rank, hold no qualifications and have not had any formal training.

Of far greater concern is the fact that crewmen were on watch at the time of 29% of collisions and 31% of groundings, despite the finding in Section 4.4 that crewmen only take watches on 63% of British fishing boats. This suggests that crewmen were on watch on almost half (30% of 63% = 48%) of the vessels on which they are required to take part in a watchkeeping rota when these vessels were involved in loss events. There is clearly a need to find out why this should be the case and this is pursued in later chapters of this work.

The "anchor-seiner theory" expounded earlier in this discussion may help to explain the high proportion (21%) of collision losses that occurred during the study period while no-one at all was on watch. Such a simple explanation is far from watertight however since even if the data were influenced by this particular section of the British fleet, it would not explain the 12% of grounding losses that occurred while the wheelhouses were empty. It is difficult to see any reason for an empty-wheelhouse collision or grounding other than poor watchkeeping management and bad seamanship.

Although the sample used was small, the number of collision losses that have happened while crewmen were on watch in good visibility probably indicates a lack of attention being given to keeping a good lookout (Table 5.8.2). This may well be a symptom of some deeper malaise, but whether this is obscure in nature or as simple as complacency is a debatable point. With the data going on to show that no-one was in the wheelhouse, in good visibility in a further 17% of collision losses, the latter is nevertheless strongly implicated. The skipper was on watch in 42% of collision losses that occurred in reduced visibility but as discussed earlier, this in itself may not necessarily be a matter of concern.

What is however, a source of unease is the fact that over a third of all groundings happen in good visibility, with the skipper on watch (Table 5.8.3). While the skipper is statistically more likely to be keeping watch than the other ranks, it is difficult to find a reason for such a high proportion other than complacency and lack of attention, due possibly to work underload or overload. Mates on the other hand, are likely to be on watch for much less of the time than skippers (though more than crewmen) but the low proportion of traffic losses in all conditions of visibility where mates are on watch portrays them in a favourable light so far as their giving attention to the job is concerned.

5.11 Chapter summary

- Under 12 metre vessels are relatively less likely to be lost in collision and grounding events than their longer counterparts.

- Vessels in the length range 12 - 24 metres have the poorest record of loss in traffic events over the study period although this situation temporarily changed during the period 1985 - 1991, when relatively more over 24 metre fishing boats were lost in this way.

- The mean age of fishing boats lost in grounding events has risen steadily since 1975 but the age of vessels lost in collisions has remained steady in the same period.

- Newer fishing vessels were found to be navigationally more sophisticated and this may be a reason for their reduced rate of loss in grounding events. If this is the case however, the same influence has not been exerted over collision risk.

- March is the month during which fishing traffic losses have been most prolific. There are environmental, biological and economic reasons for this.

- The number of vessels that were lost in groundings in the month of February during the study period is low. Other than the fact that less boats are at sea because of bad weather, this is difficult to explain.

- The analysis of the daily distribution of traffic losses implicates boredom, complacency, fatigue and disorientation after time ashore as major factors.

- Relative to the level of fishing activity, few fishing boats have been lost in the Scottish West Coast area in collisions but the proportion of groundings is relatively high.

- The Central North Sea has seen very high levels of losses due to both collision and grounding relative to the level of fishing operation in the area. The working system in the now defunct 'anchor-seiner' fleet is proposed as a possible factor in this respect.

- Reduced visibility appears to be a factor in fishing vessel collision losses, but not to the extent that the fishermen themselves perceive. It does not however seem to exert much influence over occurrence of grounding losses.

- A very high proportion of fishing vessel traffic losses occur while crewmen are on watch.

- Many fishing boats were lost in traffic events during the study period while no-one at all was in the wheelhouse. This is clearly contradictory to the principles of good seamanship.

- The high proportion of grounding losses that have occurred with the skipper on watch in good visibility suggst that factors such as cognitive overload or underload are detracting from the attention given to the job.

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Chapter 6

CAUSAL ANALYSIS:
The aetiology of fishing vessel collision & grounding losses

"Don't trust general impressions", said Holmes, "look for detail, Watson, detail!"

Sir Arthur Conan Doyle (1859-1930)

6.0 Introduction

The question,"why?" is notoriously ambiguous and can have many different types of answer. Some of these refer to motivation: "in order to....", some are causal: "because .... happened first", some are typological: "because it is an example of....", and some invoke the existence of a social rule: "because it is the custom to .....". The type of answer required will often depend upon the questioner's overall perception of the field in which he is operating and on what originally aroused his curiosity. Accordingly, there are very few general rules governing the manner in which an explanation - in itself merely a human construct - should be provided. In science however, explanations tend to form a particular subset of answers to the question, why? in that they usually demand some form of causal account.

Causes, distinct from explanations, are real and not simply human constructs designed to aid understanding. MACKIE (1974) refers to causes as the "cement of the universe" since they are processes that, once started lead to a particular outcome at a later point in time. Therefore, if it is to be accepted, for example that X causes Y, then the corollary, that a change in causal factor X must produce a change in outcome Y, must also be accepted.

The approach to this chapter, embodies two important principles:

1/ Cause cannot be defined in terms of statistical association.

The classic philosophical example quoted by MARSH (1977) to illustrate this conceptual discrepancy involves two wristwatches. Although different times may be showing on each, time can nevertheless be perfectly associated so long as both watches are running. In this state, time on one watch can be correctly predicted from the time displayed on the other, but not because the first causes the time on the other. Adjusting the time shown on the first watch will have no bearing on time given by the second.

2/ A number of different factors may combine to give rise to a certain event through the process of "multiple causality". This principle is fundamental to the reasoning offered in this chapter since the work outlined proceeds from the standpoint that it may be unrealistic to expect a perfect relationship between any one cause (amongst many) and effect.

6.1 Rationale

Anecdotally, human error is almost always noted as being the primary cause of collisions and groundings amongst all types of shipping (JAMRI, 1993; BOURNE, 1992). Although no study has to date been focused upon the fishing fleet, some general marine traffic accident researchers (e.g. WAGENAAR & GROENEWEG, 1987) have supported this idea with respect to fishing vessels, while others (TVEDT & REESE, *unpublished 1986*) have differed in opinion, citing technical factors as the dominant causal grouping. A third group of causal factors - environmental factors - is also commonly implicated in descriptions of marine traffic accidents although their influence is, in many instances questionable.

The work outlined in this chapter represents a detailed investigation into the causes of collision and grounding losses in the fishing fleet with the main analysis tool being quantification of the effect level of causal factors related to the casualties. Pursuing this type of analysis inevitably calls for a number of assumptions to be made and also what may appear in many instances to be arbitary qualification, grouping and quantification of factors. This might leave the reliability of the work open to challenge. To overcome any inconsistency that might arise in this respect if a single person were charged with scoring and allocation tasks, a team of experienced interraters has been used wherever appropriate and the strength of their agreement noted. The Author is deeply indebted to the experienced Fishing Skippers who so willingly gave up their time to make this contribution to the research, (see Acknowledgements) - and agreed not to open the *quid pro quo* bottle until their contribution was complete!

Dissecting relevant casualty reports for thirty-four recent fishing vessel collision and grounding losses allows for isolation of forty-nine causal factors which can in general be grouped under three main factor headings, environmental, technical, and human. Within these three main groupings, seven sub-groups are identified. Taking factors grouped in this way and then setting them in a block scheme which then serves as a symbolic model is not a new approach, having been first exemplified in general safety studies the 1960's (ARINC,1964). The technique has since been used with various adaptations to study merchant shipping casualties (DRAGER *et al.*, 1978; KARLSEN & KRISTIANSEN, 1980; KOSTILAINEN & TUOVINEN, 1981; QUINN & SCOTT (1982); TUOVINEN *et al.*, 1983; PARK, 1994). Table 6.1.1 offers a comparison of the results of these earlier studies with the present one, in terms of number of groups, sub-groups employed and factors identified.

	no. of groups	no. of sub-groups	no. of factors
PRESENT AUTHOR	3	7	49
KARLSEN & KRISTIANSEN (1980)	6	21	200
QUINN & SCOTT (1982)	4	-	27
TUOVINEN *et al* (1983)	3	4	60
PARK (1994)	3	12	82

Table 6.1.1. Comparison of numbers of causal groups, sub-groups and factors identified in earlier studies with the regime and findings of the present study.

The aim of this part of the study is to allow the research to be focused later in the thesis, on the critical components of collision and grounding events, as indicated by the tendencies of the casualty data. The block scheme compiled in this chapter allows the flow of factors in each of the cases in the sample data set to be traced to the top event (i.e. loss due to grounding or collision).

6.2 Casualty Data Sources

Totally comprehensive information on fishing vessel casualties is quite rare and tends to have been compiled only where substantial litigation has followed a particular event. Although the advent of the Marine Accident Investigation Branch (MAIB) in 1989 prompted an immediate improvement in the recording of this type of data, it is nevertheless still difficult in most cases to build a complete picture of events leading to the loss of a vessel. In this study, three sources of information were used;

i) *MAIB files*

ii) *Records of the Sunderland Marine Mutual Insurance Company*

iii) *Lloyd's Casualty Week*

6.2.1 MAIB files

The MAIB is responsible for investigating all marine accident events in the UK. Its remit is wide ranging and covers merchant vessels and fishing boats, both registered in the UK and foreign vessels operating in UK waters.

The main purpose of the Branch's investigations is to identify the causes of marine casualties and publicise these in the form of salutary summaries of investigations for dissemination amongst seafarers. An extract from one of these Summaries is given below.

Extract from MAIB Summary of Investigations (No. 1/94)

Collision between two fishing vessels and their subsequent loss

Narrative

Two steel-hulled purse-seine net fishing vessels of 23.8 and 21.3 metres length arrived at fishing grounds off the coast of Norway at about midday and prepared for fishing operations. The weather was good with a north-west wind, Force 4 - 5, a moderate sea and 3 -4 miles visibility.

Before fishing began the two vessels lay stopped starboard quarter to starboard quarter whilst fish baskets were transferred. When this operation was completed one vessel (B) remained stopped whilst the other (A) moved off intending to shoot her net.

Initially A went ahead until B was about 300 metres astern and then turned to port with the intention of passing down B's starboard side. When the turn was completed vessel A's skipper, who was alone in the wheelhouse whilst the rest of the crew were preparing the fishing gear, engaged the auto-pilot and set the engine to give a speed of about 9 knots. he monitored the auto-pilot, considered it was operating satisfactorily and turned his attention to setting up his plotting equipment. By this time vessel B was about three points (33 degrees) on his port bow distant about 1 cable (185 metres) and the skipper expected that he would pass her at a distance of about 80 metres.

Very shortly after this his vessel struck the bows of vessel B in way of her starboard side. Such was the force of the impact that the struck vessel sank within six minutes. Fortunately her crew were able to take to the liferaft and were pulled aboard vessel A without injury.

Unfortunately the collision had damaged vessel A so that 30 minutes after rescuing vessel B's crew she also sank. Before abandoning vessel A, her skipper broadcast a MAYDAY signal and was able to include an accurate position. The crews on vessel A then took to the liferafts and were quickly picked up, all uninjured by a Norwegian rescue helicopter.

Observations

1. The autopilot had a history of unreliable operation and was not fitted with an off-course alarm.
2. Vessel A had attained the intended speed of about 9 knots when the collision occurred.
3. The Skipper of vessel B was also engaged in the setting up of fishing gear and his first indication of the collision was when he looked through the wheelhouse window and saw the bows of A coming towards him.

Comment

1. The most probable cause of this accident was malfunction of the auto-pilot which turned the moving vessel hard to port. This probably happened shortly after the auto-pilot was engaged but with sufficient time for the vessel to have attained nearly full speed.
2. This incident highlights the danger of relying on the auto-pilot when navigating close to other vessels or dangers and the need to keep a proper lookout at all times. It is even more dangerous to place reliance, especially in a close quarters situation, on any equipment known to be unreliable.
3. An off course alarm would have given warning that the required course was not being maintained.
4. Merchant Shipping Notice No M.1471 gives guidance on the use of the automatic pilot and the testing of steering gear. This M Notice is based on the Merchant Shipping (Automatic Pilot and Testing of Steering Gear) Regulations 1981 (SI 1981 No. 571) which carries penalties for non-compliance. Also Merchant Shipping Notices M.1020 and M.1190 emphasise the vital importance of keeping a proper lookout at all times.

In certain cases, the Chief Inspector of Marine Accidents may order a Special Investigation of the event and this will usually result in a detailed published account of the circumstances. In the majority of fishing vessel losses however, a routine investigation is pursued, involving self-report by the Master and crew (where available) of the vessel or vessels involved usually, though not always, followed up with interviews. The interviews are not based upon a standard format since it is MAIB policy that the Investigator should be allowed to use his discretion to attune the questioning to acquire the necessary information in the most effective way. (*pers. comm.*, Capt. P.B. MARRIOTT, Chief Inspector of Marine Accidents, MAIB, 1995). *Prima facie*, this represents a laudable approach, and undoubtably holds the potential to yield the information necessary to derive fundamental causal factors where the interviewer is thoroughly conversant with operational procedures aboard fishing boats. Unfortunately, at the time of writing, none of the MAIB investigators have any working experience of fishing operations and tend to draw upon the principles and practices of the merchant marine where the operational ethos is, in a number of respects, quite distinct from that of the fishing industry.

The result of this lack of feel for the fishing operation is that accident reports often contain information gaps or worse still, misinterpretations that obfuscate vital details of the event. In addition to this lack of empathy in MAIB reports, causes of loss are often attributed in a mechanistic way with little evidence of inclusion of factors beyond those that are immediately obvious in primary analysis of the event.

6.2.2 Sunderland Marine Mutual Insurance Co Ltd

Clearly, the records of the Sunderland Marine Mutual Insurance Co Ltd only hold details of the circumstances of vessel losses where insurance had been placed with the company. As the largest current insurer of fishing vessels in the UK (in 1995) however, the company has held an interest in a substantial proportion of recent fishing vessel losses which have been due to collision and grounding. As might reasonably be expected, access to records for the purposes of this study was limited to an anonymous outline of the details of relevant cases with no subsequent insurance related analysis of cause, since this is confidential. The outline information provided was nonetheless quite comprehensive in most cases and yielded much useful data for inclusion in causal analysis.

6.2.3 LLoyds Casualty Week

LLoyds Casualty Week is published weekly by LLP Ltd. and gives details of all manner of catastrophies that have happened, worldwide. Amongst these are fishing vessel casualties that have occurred, the report usually including details of vessel type, timing of the incident, position, weather conditions at the time, loss of life, etc. Initial casualty reports are often followed up with updates in subsequent issues which may offer more expansive details on a previously reported incident.

6.3 Sample Size and Representativeness

A total of 34 cases of loss of fishing vessels in collision and grounding events during the period 1989 - 1994 were sufficiently well described in one or a combination of the sources to allow for isolation of the components of the chain of causation. Before results can be obtained that may be credibly generalised to the whole population however, it is necessary to demonstrate that the sample used is representative. This means that the sample should ostensibly show the same characteristics, in the same proportions as the population from which it was drawn.

One means of testing whether the sample used in this study is representative is to compare the distribution of collision and grounding losses by vessel length class, over the same period as the sample data was collected. Figure 6.3.1 shows that for the smallest class of vessels (<12 metres) the data sample offered a perfect match and for the larger classes, fell well within the bounds of credibility with a strong positive correlation of 0.99 ($p < 0.05$) existing between the two sets of figures.

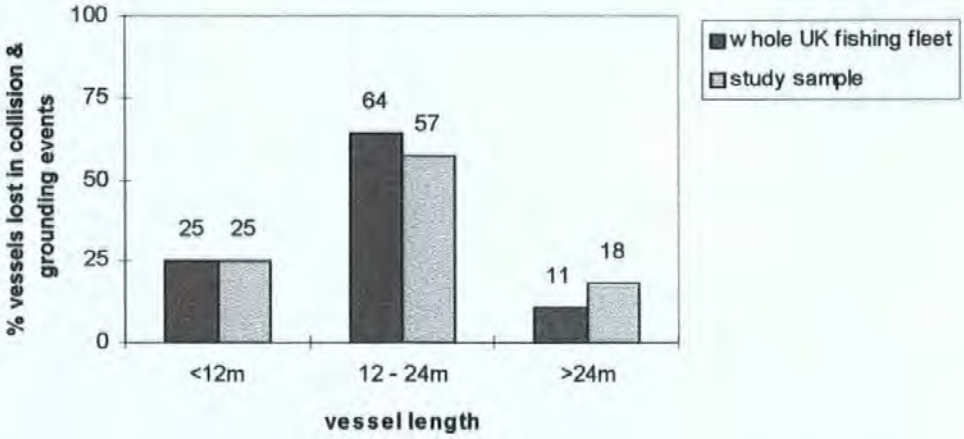


Figure 6.3.1. Comparison of percentage of study sample with actual UK fishing fleet losses due to collision and grounding by size of vessel, for the period 1989 - 1994.

6.4 The Chain of Causation

It is common for one particular reason to be cited as being the cause of some catastrophic event. This is understandable, given the natural human urge to simplify the situation in order to attribute blame in the most politically expedient manner. In reality however, it is unusual for things to be so simple. Although one particular ingredient may stand out amongst the others, catastrophies rarely flow from a unique cause and tend to be the end result of several factors which follow on from each other, i.e. a "chain" of causation. This is almost universally the case in fishing vessel traffic accidents, and thus the mechanism leading to the top event - loss of the vessel - may generally be described in a meaningful way using an event tree system.

6.5 Event tree analysis

Event tree analysis is a technique that allows the logical representation of many factors that interact to result in an undesirable top event. While the available literature does not credit the technique to any single originator, LAMBERT (1973) and FUSSELL (1976) give early accounts of its use in safety and reliability studies, while DRAGER *et al* (1978) and WAGENAAR & GROENEWEG (1987) illustrate the feasibility of applying fault tree analysis to incidents involving cargo vessels. No instance of the use of event trees with specific regard to fishing boat casualties could be found in published literature to date.

The analysis proceeds by working backwards from the top event through the compilation of a network of contributory factors, set in chronological order. It is normally assumed that all the basic events contributing to the top event are statistically independent but this does not preclude the possibility that one basic event may generate a number of factors that give rise to that top event. A hypothetical example of this would be where an explosion occurs, simultaneously rendering the watchkeeper unconscious and disabling the vessel's automatic steering. This is referred to by ALDWINCKLE & POMEROY (1989) as a "common cause failure".

Some users of the event tree concept advocate the differentiation of links between factors into AND or OR gates. This may be helpful, especially where the analysis pertains to an undesirable event in one of the process industries, but was not employed in the current exercise since the trees had to be as uncomplicated as possible to allow for rapid and easy assessment by successive independent interraters.

6.6 Causal networking

Event trees may provide qualitative or quantitative analysis, the former being a reduction the tree into implicant set combinations of contributory factors while the latter addresses the probablity of occurrence of the contributory events within a given time scale. The implementation of fault trees in this study is aimed at providing a simple description of the relationship between the factors that contribute to each casualty in the data set and thus falls into the qualitative category. In truth, this current approach might more properly be termed "causal networking", since the process serves simply to provide the components of a block scheme of causal factors for further analysis rather than to ultimately produce some probablistic numerical output.

By way of illustration, the event tree arising from the case illustrated in the extract form MAIB Summary of Investigations No. 1/94 (Section 6.2.1), in combination with additional data on the same event, derived from other sources, is reproduced in Figure 6.6.1.

COLLISION BETWEEN F.V. *ACTIVE* AND F.V. *SUPREME*, 13/10/92.

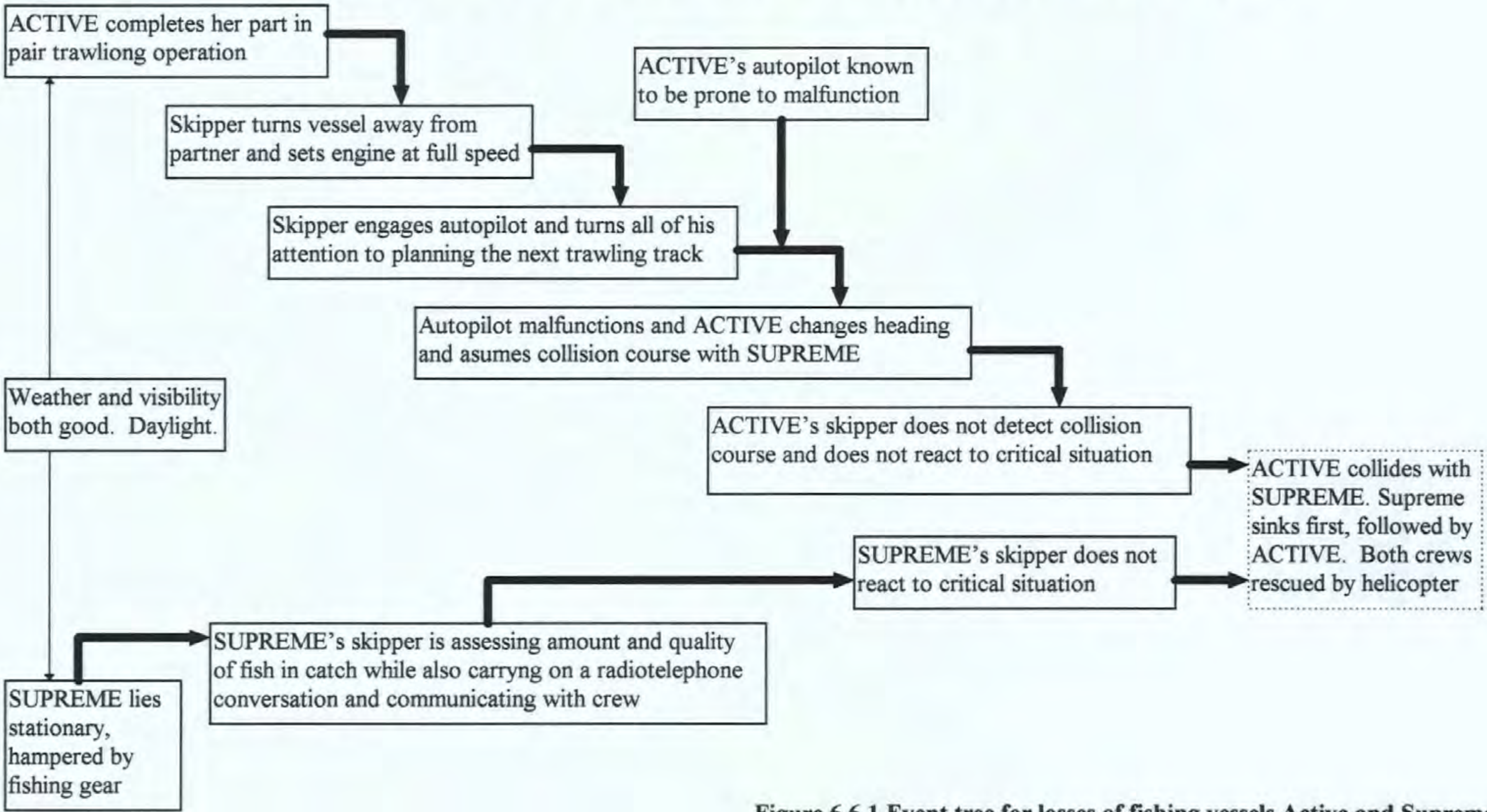
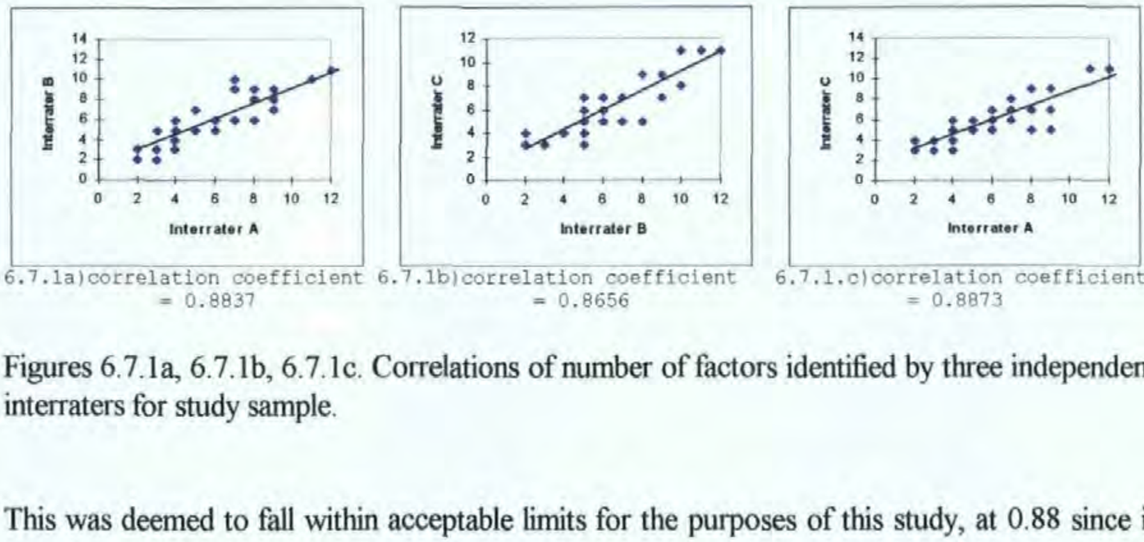


Figure 6.6.1 Event tree for losses of fishing vessels Active and Supreme.

6.7 Network reliability

There is a possibility that any attempt to link the known circumstances surrounding a vessel's loss may be open to interpretive variability. To counteract this and ensure the reliability of the process, three independent interraters were used, operating with the single criterion that only information present in the three data sources should be drawn upon, thus limiting both the historical and peripheral extent of the network. A reliability coefficient based upon mean Pearson product moment correlation was produced for number of factors identified in each case at a significance level of $p < 0.05$, (Figures 6.7.1a, 6.7.1b and 6.7.1c).



6.7.1a)correlation coefficient = 0.8837 6.7.1b)correlation coefficient = 0.8656 6.7.1.c)correlation coefficient = 0.8873

Figures 6.7.1a, 6.7.1b, 6.7.1c. Correlations of number of factors identified by three independent interraters for study sample.

This was deemed to fall within acceptable limits for the purposes of this study, at 0.88 since it compares favourably with the value achieved by WAGENAAR & GROENEWEG (1987), who in a similar validation exercise, achieved a correlation value of 0.84 for number of causes.

6.8 Block Scheme and Causal grouping

When the contributory factors in each of the 34 fishing vessel traffic losses in the data set had been identified and set in causal networks, they were subsequently allocated to one of three type groupings; human, technical, environmental..

It was anticipated that this allocation might, in some instances, prove problematic where a particular causal factor appears to span the division between one group and another. In the event however, there was surprisingly strong agreement between the group allocations of three independent competent experts.

environmental factors	number of occurrences
daylight	18
twilight	5
darkness	11
good visibility	9
moderate visibility	3
poor visibility	3
strong winds	6
heavy swell/ship motion	5
calm conditions	5
inadequate/misleading coastal marks/lights	2
close proximity of navigational hazard	12
approaching unfamiliar port	3
dense traffic	1
moderate traffic	1
other ship on collision course	6
other ship does not react to critical situation	5
other ship's speed excessive in circumstances	2
TOTAL	97

Table 6.8.1. Environmental factors group with number of factor occurrences.

Pearson moment correlation applied to numbers of factors grouped by type gave a mean coefficient value of 0.82 ($p < 0.05$). Any dispute with regard to the appropriate group for particular factors was resolved by discussion and eventual concensus. The grouped factors listed in Tables 6.8.1, 6.8.2, and 6.8.3 were drawn from the event trees compiled and the block scheme shown in Figure 6.8.4. was drawn-up on the basis of this allocation.

technical factors	number of occurrences
steering system malfunction	3
propulsion system failure	6
mooring system failure	4
poorly maintained engines/hydraulics	2
fouled propeller	3
internal communications failure	2
badly arranged navigational equipment	1
poor visibility from wheelhouse	1
undermanning	4
unattended wheelhouse	9
poorly maintained wheelhouse equipment	3
no clearly defined watchkeeping system	7
TOTAL	45

Table 6.8.2 Technical factors group with number of factor occurrences.

human factors	number of occurrences
watchkeeper fatigued	8
watchkeeper asleep	4
wilful risk taking	5
lack of visual observation	10
watchkeeper leaves wheelhouse unattended	4
no reaction to critical situation	12
clear over-reliance upon specific equipment	2
inadequate/incorrect noting of depth soundings	5
watchkeeper overloaded, unaware of hazard	14
watchkeeper underloaded, unaware of hazard	9
watchkeeper distracted by non-routine event	6
watchkeeper absorbed in secondary task	9
watchkeeper unaware of correct procedure	9
incorrect interpretation of radar display	3
incorrect interpretation of position fixing information	2
poor communications procedure	4
inappropriate manoeuvre	8
inexperienced watchkeeper	4
untrained watchkeeper	3
inadequate briefing at handover of watch	3
TOTAL	124

Table 6.8.3. Human factors group with number of factor occurrences.

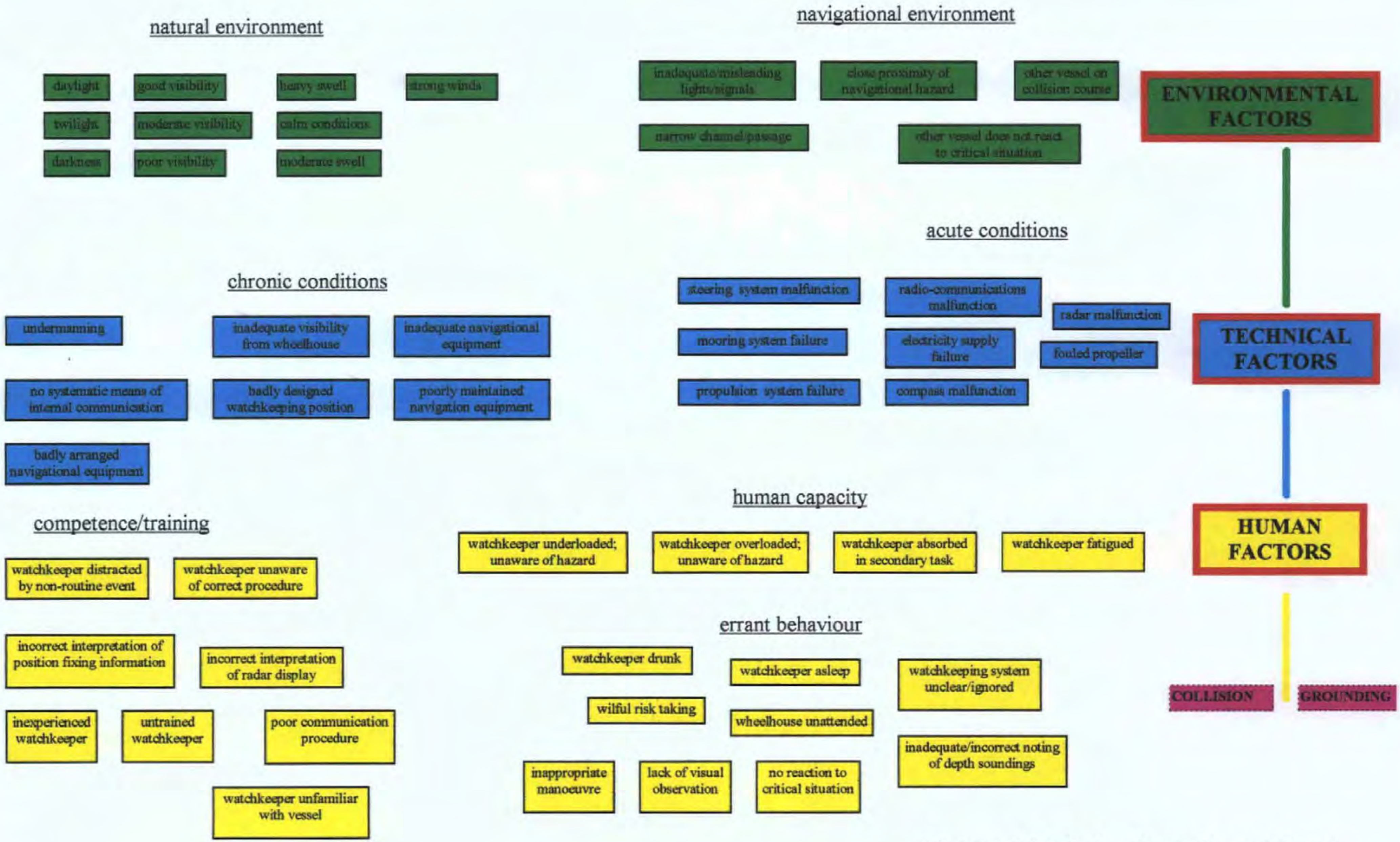


Figure 6.8.4. Block scheme of causal factors

The event trees compiled for each of the 34 losses in the sample led to the identification of 49 factors which, between then occurred 266 times. The greatest number of factors were isolated in the human factors grouping, followed by environmental and then technical groups (Table 6.8.4).

groups ➡	environmental factors	technical factors	human factors
no. factors	17	12	20
% of total	34.7	24.5	40.8
no. occurrences	97	45	124
% of total	36.5	16.9	46.6

Table 6.8.4. Numbers of factors identified and numbers of occurrences by main factor groups.

Factor occurrences were also strongly biased towards the human factors group, with 46.6% of the total followed by environmental factors, with technical factors accounting for a modest 16.9%. Table 6.8.5, gives a breakdown of numbers of factors and factor occurrences by sub-groups.

groups ➡	environmental factors		technical factors		human factors		
sub-groups	natural environment	navigational environment	chronic conditions	acute conditions	human capacity	competence/ training	errant behaviour
no. factors	9	8	6	6	4	7	9
no. occurrences	65	32	25	20	41	27	53
% of total	24.4	12.2	9.6	7.7	15.8	10.2	19.9

Table 6.8.5. Numbers of factors and numbers of occurrences by factor sub-groups.

6.9 Weighting categories

KOSTILAINEN and TUOVINEN (1981) evaluate each factor in a causal analysis exercise on merchant shipping casualties in the Baltic Sea in accordance with the degree of influence, or "effect level", that factor is deemed to have had upon the casualty. They use a system which provides four possible levels of weighting for each factor (Table 6.9.1).

CATEGORY	DEFINITION
ESSENTIAL FACTORS	Absence of the factor or its replacement with a correctly functioning one would have had a .9 - 1.0 probability of preventing the casualty
PART FACTORS	Absence of the factor or its replacement with a correctly functioning one would not alone have prevented the casualty. Prevention would require the effect of at least two part factors
CONTRIBUTING FACTORS	The factor has an effect on the occurrence of the casualty but its elimination, alone or with other factors would not have prevented the casualty
INDEFINITE FACTORS	Causal relationship to the occurrence of the casualty is insignificant

Table 6.9.1. Categorisation of factors used by KOSTALAINEN & TUOVINEN (1981).

PARK (*unpublished 1994)* used an alternative list of five categories in analysing shipping casualties in Korean waters (Table 6.9.2).

CATEGORY	DEFINITION	MAX. WEIGHT COEFFICIENT
ESSENTIAL	factors which had a clear and undisputed effect on the circumstances leading to the event	1.0
LIKELY	factors likely to have affected the circumstances leading to the event	0.75
POSSIBLE	factors judged to have less importance in contributing to the event	0.5
CONDUCING	factors which had a little influence on developing the event or where the significance of the factor is difficult to judge	0.25
INDEFINITE	factors which have an indefinite or insignificant causal relationship with the event	0

Table 6.9.2. Categorisation of factors and effect level weightings used by PARK (*unpublished 1994*).

Both these studies involved the analysis of large numbers of casualties, (not only loss events) where comprehensive data was available. KOSTILAINEN & TUOVINEN were furnished with data on 707 casualties from the Swedish/Finnish National Boards of Navigation, while PARK had information on 381 casualties through the published verdicts of the Korean Central Marine Accident Inquiry Agency. In view of the difficulty in acquiring comparably comprehensive information in respect of UK fishing fleet, it was decided to adopt only three weighting categories in the present study - essential, contributing, and indefinite. Limiting the analysis to these three categories also made the arduous task of categorisation much easier since, this being an arbitary process, it reduced the likelihood of 'borderline' decisions occurring.

The criteria used for categorisation in this study are as follows:

essential factor - the absence of the factor would in all probability have prevented the loss of the vessel; weighted up to 1.0. An example of an essential factor would be where the watchkeeper falls asleep. Note however that since there is clearly no absolute guarantee that the same watchkeeper would have taken action to avert the top event had he been wide awake it is rare for the maximum weighting to be fully implemented.

contributing factor - the factor contributed to the loss of the vessel, though it is uncertain whether the absence of the factor would have prevented the casualty; weighted up to 0.5. An example might be a bad arrangement of navigational equipment in the wheelhouse.

indefinite factor - the relationship between the factor and the loss of the vessel is of no apparent significance; weighting always 0. An example of a zero weighted factor would be daylight in the event tree relating to a particular loss, since it is unlikely that this would have any significance.

Three experts with experience in the operation of different types of fishing boats were called upon to arrive at mutually agreed weighting coefficients for factors in each individual loss scenario in the sample, following study and discussion. Although all of the events in the sample were assessed, the level of agreement between experts in five events which were chosen at random was determined. It was necessary to limit this to five because of the vast amount of time that correlating for every last factor weighting decision would have consumed. The mean correlation coefficient ($p < 0.05$) was 0.84, indicating good general agreement between assessors.

Only 46% of the losses studied included factors which fell into the essential category. It is worthy of further note that in the majority of these, the essential factors occur towards the end of the chain of causality. The environmental grouping paradoxically contained both the greatest number of essential and the greatest number of indefinite factors. This is due to the inclusion of both natural environment (fog, rain, snow, etc.) and navigational environment (proximity of reefs, traffic density, etc.) under the same umbrella title for the sake of expediency.

The degree of influence perceived by the expert analysts as pertaining to each of the three causal groups can be crudely compared by calculation of the mean value of the weightings applied to the grouped factors. For the sample of vessel losses used in this study, the mean weight coefficients of grouped factors are shown in Table 6.9.2. From this, it is clear that human factors are easily the most commonly implicated agent in the pathogenesis of fishing vessel collision and grounding loss events.

groups ➡	environmental factors		technical factors		human factors		
mean weightings	0.26		0.42		0.63		
sub-groups	natural environment	navigational environment	chronic conditions	acute conditions	human capacity	competence/ training	errant behaviour
mean weightings	0.12	0.43	0.18	0.61	0.65	0.22	0.58

Table 6.9.2. Mean weightings attributed by expert analysts to factor groups and sub-groups.

6.10 Effect Level of Causal Groups

A more refined and sophisticated reflection of the relative importance of the factor groups is obtained from the effect level calculations since this relates the strength of the weighting to both the frequency of the occurrence of factors and the number of casualties in the analysis.

Calculation of the effect level of causal groups, in relative terms, is done using the equation exemplified by PARK (1994) *(equation 1)*.

$$\text{effect level of group } (e_i) = \frac{\sum_{j=1}^{m} w_{ij}}{\sum_{j=1}^{m} \sum_{i=1}^{n} w_{ij}}$$

equation 1

Where the weight coefficient of factor, i in a given vessel loss incident, j is w_{ij}, the number of factors included in the analysis is n, and the number of casualties in the study sample is m.

The percentage effect levels of the three groups and seven sub-groups are outlined in Table 6.10.1 which lucidly ranks human factors, in particular human capacity, as being the most significant followed by technical factors. Environmental factors, markedly the natural environment as defined in this study, are shown to have by far the least effect in fishing vessel groundings and collisions.

groups ➡	environmental factors		technical factors		human factors		
effect level	16%		31%		53%		
sub-groups	natural environment	navigational environment	chronic conditions	acute conditions	human capacity	competence/ training	errant behaviour
effect level	4%	12%	11%	20%	27%	8%	18%

Table 6.10.1. Percentage effect levels of factor groups and sub-groups.

6.11 Discussion

With adequate information being available for only thirty-four relevant fishing vessel losses, it would perhaps be ambitious to expect a causal analysis, however thorough, to offer a totally comprehensive overview of the situation. Notwithstanding this relatively small sample size certain basic yet important conclusions may be drawn from the results.

Of these, probably the most important is the unequivocal agreement with anecdote, that human factors bear the greatest share of the blame for the loss of fishing vessels in collision and grounding events. This agrees with the findings of Park's (PARK, 1994) study of all types of vessels (Table 6.11.1), and with Aldwinckle's (ALDWINCKLE, 1990) general comment that marine underwriters estimate some 70% - 80% of marine insurance claims to arise from human failure.

	collisions	**groundings**
environmental factors	0.35	0.30
technical factors	0.02	0.10
human factors	0.63	0.60

Table 6.11.1. Relative importance of factor groups derived by PARK (1994).

To counter this, the finding is out of line with Tuovinen's (TUOVINEN *et al* 1983) results (Table 6.11.2) in which environmental conditions are more heavily implicated in collisions and roughly equate with human factors in groundings.

	collisions	**groundings**
environmental factors	0.77	0.44
technical factors	0.07	0.11
human factors	0.16	0.45

Table 6.11.2. Relative importance of factor groups derived by TUOVINEN *et al.* (1983).

The difference in these two studies is that in the former, there were 145 fishing vessel casualties included in the sample of 381, while in the latter, only merchant vessel casualties were considered. This may offer an indication that fishing vessel watchkeepers are relatively more prone to error than those on merchant vessels.

With fewer than 50% of losses in this study being attributable to essential factors, it is clear that combinations of factors give rise to the catastrophe in most cases. Even where there were unequivocal essential factors, these were usually located near the end of a chain of events. In a sense, this tends to undermine the categorisation process outlined above since it is open to question whether it is actually possible to fulfil the essential criterion - ie. elimination of the essential factor would have prevented the loss - or whether loss of the vessel is the inevitable crescendo of a precursory symphony of events. Where essential factors appear in the human error group, the factor, "watchkeeper overloaded" also appears in around 80% of cases. This provides evidence that the developing situation leads to overloading of the watchkeeper to the extent that he is operating beyond his capacity, the consequence of which is his making a fatal error which is easily isolated in a retrospective analysis. This feature suggests that some analysis of the workload of the watchkeeper, including identification of the limits of capacity and the times during the fishing trip where these are exceeded through both work overload and underload, also a prolific feature in the analysis may provide useful baseline information for future safety studies.

6.12 Chapter summary

- A total of 49 causal factors are identified for the study sample, which between them occur 266 times.

- The greatest number of factors, 46.6% of the total, was identified in the human factors group. 36.5% of factors were environmental and only 16.9% were technical.

- Within the environmental factors group, sub-factors pertaining to the natural environment made up 24.4% of the total but these were in many cases deemed by the Expert Panel to have had little influence on the casualty.

- Only 46% of losses under scrutiny were perceived by the Expert Panel to include essential factors (i.e. factors which, if absent, would probably have prevented the loss). Where these did occur in the event tree, it was often in the later stages of the chain of causation.

- The environmental factors group proved paradoxical since it contained both the greatest number of essential yet also the greatest number of indefinite factors. This was probably a feature of the grouping criteria used.

- The Expert Panel assigned the heaviest mean weighting to human factors, with particular significance being attached to human capacity and errant behaviour sub-groups.

- Normalisation of the causal analysis by calculation of the effect levels shows that human factors are the most serious agent in fishing vessel colision and grounding losses, followed by technical and lastly, environmental factors.

- The small number of losses being directly attributable to essential factors implies that combinations of factors are usual in this type of loss event.

- The substantial effect level attributed to the human capacity sub-group suggests that this may be a fruitful area for further research.

6.13 References

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Chapter 7

WATCHKEEPING OBSERVATIONS AND ANALYSIS

"Oh wad some pow'r the giftie gie us,
Tae see oorsels as ithers see us,
It wad frae mony a blunder free us,
And foolish notion".
Robert Burns 1759-1796

7.0 Introduction

Although the work outlined in Chapter Five clearly implicates human error as being the prime cause of collision and grounding losses, it has also been demonstrated that only rarely does one discrete factor lead to a loss event. As indicated in Chapter Five, it is usual for a chain of events to occur in a given set of circumstances. Clearly, it was realised in advance that it would mercifully be unlikely that such a chain of events leading to the loss of a vessel would actually be observed during the course of this work. It is possible however, to examine the human factors situation that prevails during the watchkeeping process on fishing boats - aspects such as the way in which attention is allocated, workload at different stages of the fishing cycle and whether boredom has a part to play.

Although the scientific ideal of being able to change input variables, observe what happens then repeat until reliability is established is extremely difficult to attain in a study involving working fishermen and their vessels, the environment in this "real" situation could never be realistically simulated in laboratory studies. In the laboratory, the risks are low, the objective of the subject's task usually very well defined and very ofen the subject is actually controlled by the task rather than the other way round as happens in the wheelhouse of a fishing vessel. Thus it is proposed that the value of the data generated in this part of the study lies in its reality, in that is comes from normal procedures observed during ordinary working days on board fishing boats.

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 other tasks and long periods of inactivity interrupt this from time to time. He also asserts that interruptions of visual inspection vary considerably in length with longer intervals occurring less frequently than shorter ones. The problem with this treatment of watchkeeping as a stochastic process is that it is only feasible where the watchkeeper is regarded at any given moment as being either unequivocally devoted to visual inspection or not, with involvement in all other tasks being grouped together in the latter category. For fishing vessels, although this approach could be applied at certain times during the fishing trip, its inherent simplicity means that it cannot provide for a general analysis of watchkeeping behaviour. While merchant vessels are usually engaged in making safe and speedy passage from point A to point B, fishing boats must, in addition to pursuing this same objective, address a number of additional requirements. WITTY, (1984) identified three navigational tasks facing fishermen;

i) *guiding the craft safely and by the most direct route between port and the fishing grounds*

ii) shooting, towing and hauling fishing gear in a manner that prevents it being damaged or becoming fastened on any seabed obstructions

iii) searching for aggregations of commercial species and by the use of fishing gears, to capturing viable quantities of these

KNOX (1994) reinforces this notion of complexity in the role of the fishing watchkeeper by stating that when fishing operations commence, the skipper is usually on his own in the wheelhouse and his responsibilities involve surface and seabed navigation, hunting of elusive fish, ship to ship and ship to shore communications and administrative work including compliance with the vast amount of fisheries regulations. Because of the convoluted nature of the fishing watchkeeper's duties, the observation programme in the present study was designed to record the circumstances that prevail during the watchkeeping process rather than to highlight individuals making specific errors that might contribute to the loss of the vessel. Acts and omissions which might have led to the creation of an unsafe situation were however noted and are discussed.

Collection of data was much simplified by having a clear idea of type of baseline information that might be derived from a programme of observation and used in a model of the watchkeeping process on board fishing boats. This was founded upon earlier identification of human factors as the dominant pathogen in collision and grounding events in causal analysis (Chapter 6), the circumstances of relevant loss events (Chapter 5), and also drawing on the first hand experience of the author as a fishing skipper.

Ultimately, the aim of this part of the study was to derive some of the most important constituents of a human factors model of fishing vessel watchkeeping, using recognised techniques and observed data from the real operational environment. This approach was not intended simply to provide a repository for information whose usefulness is judgeable only by its quantity, but to contribute to a multi-dimensional assemblage of validated information on critical aspects of fishing vessel watchkeeping systems.

It was anticipated that the observation programme would go some way towards providing answers to fundamental questions relating to attention allocation, workload, boredom and complacency amongst watchkeepers, all of which figure prominently though usually without substantiation in both official and anecdotal comment upon the circumstances of fishing vessel losses (e.g. MAIB *Summaries of Investigations*; *Pers. Comm.* various fishing skippers, 1994-1997). The ideal observation programme is one which totally excludes all subjectivity. However, given that this study was carried out in the operatonal setting, in somewhat arduous conditions and with resources limited both by the bounds of practicality and the current state of human knowledge regarding human factors investigations, it is an accepted criticism that this ideal has not been wholly satisfied. To mitigate this potenial weakness, a concurrent validation approach has been employed, where the results of each measuring device used are correlated with those of another that is accepted in the scientific literature as broadly testing the same features.

Five measures were employed in the observation programme on board fishing boats. These were; *time allocation, time line analysis, the Stroop Task, self-reported boredom* and *time estimation.* Each of these is introduced individually, the results presented and then analysed in a brief discussion in discrete sections. These are drawn together in a General Discussion with a Chapter Summary at the end of the chapter. With the exception of time allocation (which is an essential precursor to time line analysis) each of the measures not only provides information in itself but also acts to validate one of the others. This system is illustrated in figure 7.0.1.

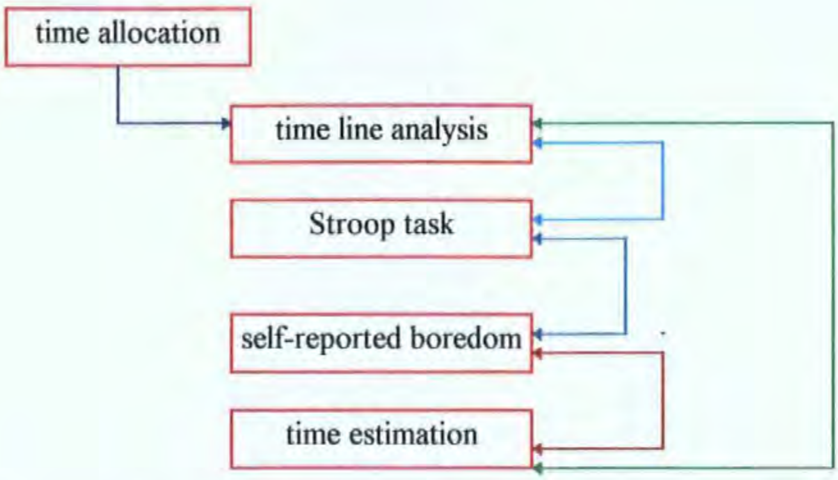

Figure 7.0.1. The validation system used in this study.

The term, “human error” carries with it connotations of deficiency on the part of the person responsible and consequent blame for the result of the error. It is quite natural therefore that individuals will show antipathy towards the prospect of being observed in a performance situation where there exists the possibility of making a recognisable error. While HUNNS (1982) reports that this type of reluctance is impossible to overcome in many workplaces, the author generally found that his subjects were compliant and over time became largely ambivalent towards his presence in the wheelhouse during observations.

7.1 Notes on general criteria applied

The wheelhouse of a fishing vessel is not a vacuum. Numerous biotic and abiotic factors are liable to intrude upon the watchkeeper's approach to his work and influence his performance. The aim of any empirical study, such as this one, must be to generate findings which are applicable, in a general sense, to situations other than the exact ones in which they were observed with the object of fostering what CHAPANIS (1988) calls, "generalisability". To this end a concerted effort was made to as far as possible standardise the prevailing circumstances by carrying out observations on the various vessels only when certain criteria had been met. This pre-condition therefore demands that the qualification, "in ideal conditions" should accompany the accumulated data and results. This does not prejudice the quality of the final analysis which is aimed at producing baseline information.

The following simple criteria were satisfied before observations began:

- *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 subjects under observation was in accord with that which they would display in normal conditions. To this end, subjects were never informed whether the procedures they were following were either "good" or "bad". Their behaviours and activities were simply accepted. Subjects were not told of the results of any individual observations until after the fishing trip had ended.

Before it began, the work was approved by the University of Plymouth, Science Faculty Research Ethics Committee, who were satisfied that subjects were ethically protected and that adequate measures had been put in place to ensure that the safety of the vessel was not being compromised in any way. Further to this, as O'DONNELL & EGGMEIER (1986) strongly recommend, all subjects were instructed, both verbally and in writing that the safe navigation of the vessel and the safety of the crew while engaged in fishing operations took absolute priority over the observation, particularly where secondary task measures were being employed. A copy of the consent form signed by all participants is included in Appendix 6.

7.2 The "Time Machine" computer program

Many of the observations carried out relied upon the unobtrusive and non-interventional timing of certain activities carried out by the watchkeeper in the course of his duties. Extensive scanning of available software listings in search of a suitable timing system for the work in this part of the project proved fruitless. It was therefore necessary to create an application with the required attributes. "Time Machine" (Plate 6.3.1) is a computer program which was written by the author using Microsoft® Visual Basic programming language. By accessing and making use of the inherent timing function of the microcomputer, Time Machine is capable of recording the cumulative amount of attention devoted to up to ten different tasks over any given block of time, even when these tasks are being pursued simultaneously. The respective timers can be attributed according to the user's preference and are activated and subsequently stopped either by the use of a pointing device (mouse, trackball, etc) or more effectively, by simple keystrokes. With practise, the observer can start and stop the timers without looking at the keyboard and can thus focus his attention on the subject being observed. At the end of the time block, the recorded cumulative times were downloaded to a database also built into the programme. Samples of database recordings are shown in Appendix 3.

Plate 7.2.1 Portable computer running the Time Machine programme.

7.3 Vessels used in this study

Observations were made on board three three British fishing boats, the essential details of which are shown in Table 7.3.1. 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 UK 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 rota since they kept watch when the vessel was leaving and entering port, during deployment and recovery of the fishing gear and for much 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 haphazard, particularly when compared to the standard merchant navy four-hour watch system.

	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 Kw	500 hp Kw	670 hp Kw
area of operation	Scottish west coast (area 5)	Northern North Sea (area 1)	Central North Sea (area 2)
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 x class 2 fishing ticket (18 years) 1 x 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)

Table 7.3.1. Details of the vessels used in observations at sea.

This system is fairly typical of that used in much of the UK 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. On all three vessels, watchkeepers were on duty alone. Questionnaire data indicated that 63% of watches on British fishing boats are taken by lone watchkeepers but responses to the same question in interviews suggest that this figure may in fact be 80% or more. Not every member of these three crews were active watchkeepers; 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 duty while the vessel was fishing.

The range of seagoing experience among crews was wide, from 4 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 the 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 in the study.

7.4 Allocation of Attention

A study of safety on Dutch beam trawlers by VEENSTRA & STOOP (1992) includes cursory mention of the frequency of observation and/or operation of wheelhouse equipment. No details of how the data were acquired are provided but these authors suggest, in agreement with common anecdote, that navigation related tasks, particularly the keeping of a good lookout, are progressively neglected as the fishing-related workload increases.

As stated in Section 7.3. the vast majority of UK fishing vessels operate with only one person on watch at any time. A specific system for paired watches aboard UK fishing boats is actually very rare and exists mainly on the larger (over 24 metres) vessels 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. It is therefore of interest to consider how the lone watchkeeper allocates his attention during the different phases of the fishing trip and to attempt to assess whether there are significant differences between skippers, mates and crewmen in this respect.

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 Heinrich's points are extremely difficult to overcome in any programme of work involving watchkeepers in their real 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 spent sweeping to each of the items of equipment that could be viewed during the sweep.

Another problem arose in deciding when the watchkeeper was not, in fact doing anything, that is to say, he was not allocating any 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 extreme concentration on the part of the observer. It is clear however that even where the observer's quality of judgement and concentration were applied at optimum level, it would be difficult to argue that the results could be any more than approximate. To palliate this lack of precision it must be borne in mind that the results presented in this section are derived from 112 blocks of observation taken over three fishing trips aboard three different vessels, so it is proposed that this repetition in different circumstances greatly enhances the reliability of the results.

Much of the watchkeeping task aboard fishing vessels involves passive monitoring; of position indicating displays, radar screens, depth/fishfinding displays, systems control and monitoring displays and of the traffic situation outside. In these circumstances, where not all actions are overt, measurement of the allocation of attention is not an easy proposition. The fact that this study was pursued 'in the field', also meant that it was necessary to be as unobtrusive as possible so that firstly and most importantly, the safety of the vessel was not compromised in any way and secondly to try and get around the problem of the watchkeeper diverging from what would be his normal behaviour simply because he is under observation. The tendency for workers to show improvements in efficiency simply as a result of receiving the experimenter's attention is well known and has become known as the "Hawthorne Effect" (ROETHLISBERGER & DICKSON, 1939; *cited in* HOCKEY, 1983) - after the manufacturing plant where the phenomenon was first noted.

Thus while the intention was to gain some notion of the way in which the watchkeeper's attention is distributed during the different stages of the fishing trip, 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, Time Machine was used along with visual observation of the watchkeeper's allocation of attention.

7.4.1 Method

It was anticipated that there would be three phases in the fishing cycle where the level of the watchkeeper's attention devoted to navigational tasks would be most likely to vary - during *steaming to and from port and between fishing grounds*; while *actually fishing*; and during *shooting and hauling of fishing gear*. This was confirmed by the fishermen themselves who, during interview, frequently referred to their varied approaches to watchkeeping at these different stages of the fishing cycle, as described in Chapter Four. These phases were treated in the present study as being discrete and their definition is regarded as being axiomatic. 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 and/or Decca receivers) and the track plotter (video or paper) 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 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 would be recorded during a watch whenever it was practicable, so long as the general criteria set out in Section 7.1 had been met.

The observation would proceed as follows; the observer would site himself in one of the rear corners of the wheelhouse where he was usually 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 any 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 normally would, five minute blocks of observation would be carried out. The watchkeeper was not told when the block had either started or when it had ended. On the few occassions where a watchkeeper suddenly became aware that an observation block was in progress, and instituted a marked and obvious change in behaviour, that block was discounted from the final data set. During the hours of darkness, it was usually possible to note 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. Indeed, observation was actually much easier at night.

7.4.2 Results

The stored information held in the Time Machine database was transferred to the Microsoft® Excel spreadsheet computer program and segregated into recordings for skippers, mates and crewmen with sub-divisions for when the watch 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 7.4.1. 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.

	SKIPPERS			MATES		CREWMEN	
	steaming	fishing	shoot/haul	steaming	fishing	steaming	fishing
echosounder	12.56	28.95	24.04	18.83	9.96	5.88	5.31
windows	7.79	10.03	35.52	11.45	14.95	9.25	7.53
external communication	0	18.93	17.2	0	2.81	0	0
video 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 system	4.97	2.35	23.62	1.79	3.56	5.08	4.32
administration / other duties	0	13.03	5.38	4.04	1.23	1.0	3.04
internal communication	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 or incapacitated	3.87	0	6.02	1.72	0	0	0

Table 7.4.1. Comparison of percentage allocation of attention between watchkeeper ranks during phases of the fishing cycle.

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.

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 (Figure 7.4.1). All of the skippers observed seemed from time to time to also become preoccupied with the navigation system 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 considerable more time engaged in external communications, mostly with other fishing vessels (Figure 7.4.2) 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 (Figure 7.4.3) 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 exagerrated. The level of attention to the radar display was roughly even regardless of the vessel status.

Figure 7.4.1. Mean time allocation to navigational tasks by Skippers while on watch during steaming periods.

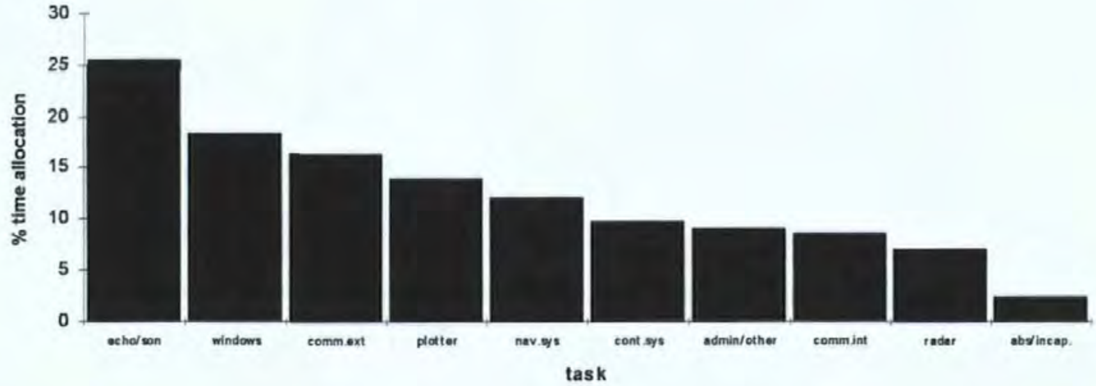

Figure 7.4.2. Mean time allocation to navigational tasks by Skippers while on watch during fishing.

Figure 7.4.3. Mean time allocation to navigational tasks by Skippers during shooting and hauling of fishing gear.

Figure 7.4.4 offers a comparision of percentage allocation of Skippers' time during the different phases of the fishing trip.

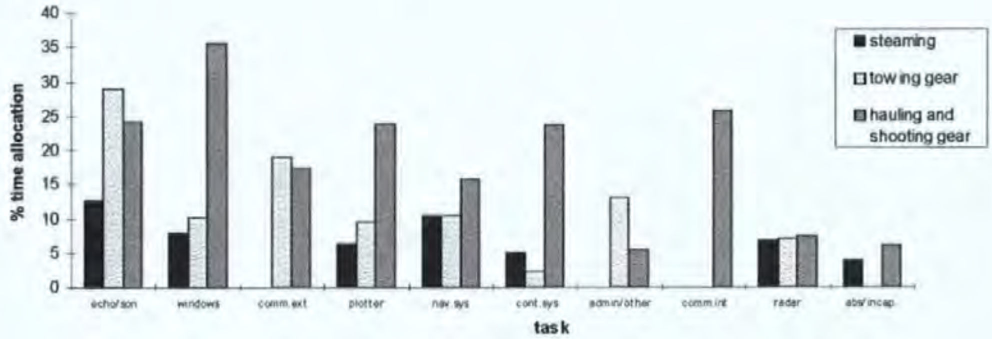

Figure 7.4.4. Comparison of mean time allocation to navigational tasks by Skippers during different stages of the fishing cycle.

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 occassion that observations could feasibly have been pursued.

The pattern of attention allocation to the echosounder and 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 (Figure 7.4.7). 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 (Figure 7.4.5 *cf* Figures 7.4.1 and 7.4.8.) There was however little difference betwen 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 plotter during fishing watches (Figure 7.4.6). Comparison of percentage attention allocation by Mates during different phases is offered in Figure 7.4.7.

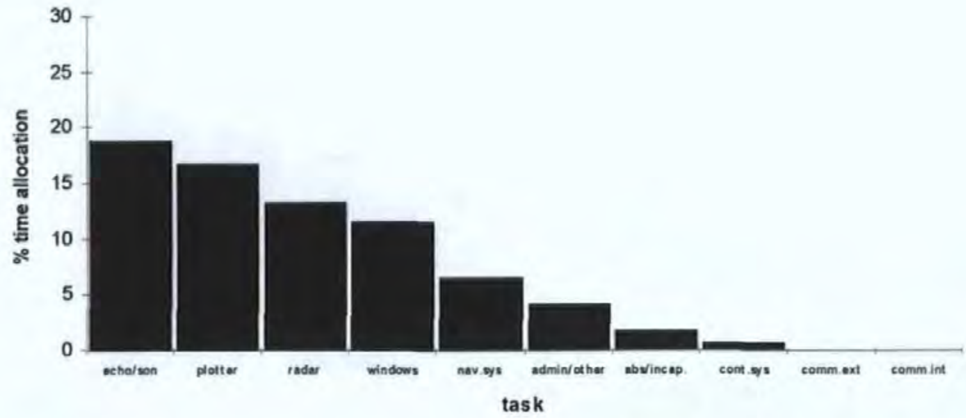

Figure 7.4.5. Mean time allocation to navigational tasks by Mates while on watch during steaming periods.

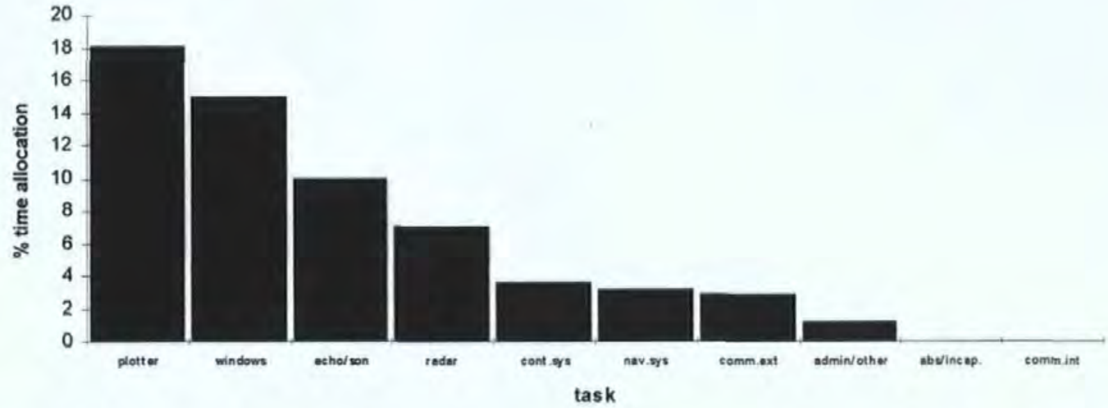

Figure 7.4.6. Mean time allocation to navigational tasks by Mates while on watch during fishing.

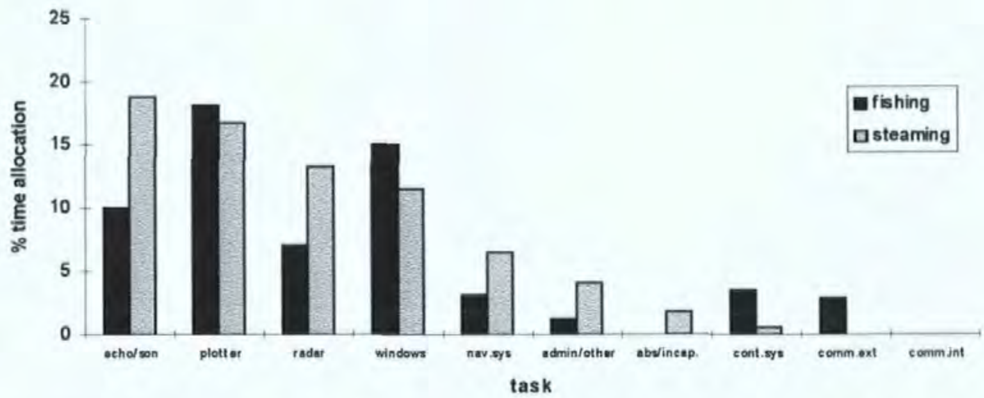

Figure 7.4.7. Comparison of mean time allocation to navigational tasks by Mates during different stages of the trip.

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 (Figure 7.4.8) and virtually none at all while fishing (Figure 7.4.9). They showed notable devotion to the video plotter screen during both types of watch.

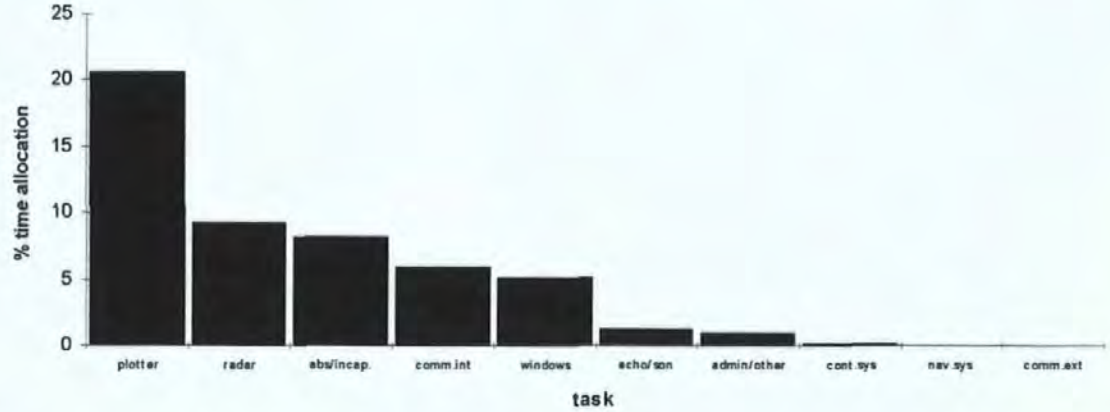

Figure 7.4.8. Mean time allocation to navigational tasks by crewwen while on watch during steaming periods.

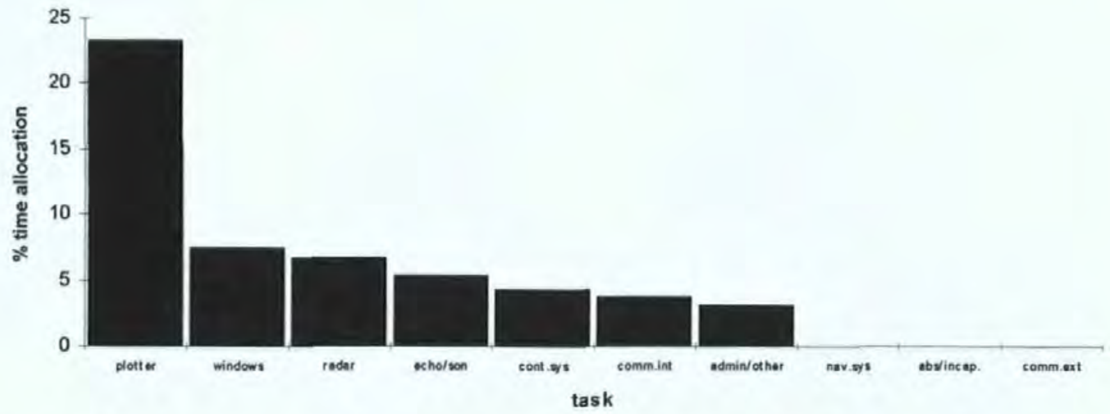

Figure 7.4.9. Mean time allocation to navigational tasks by crewwen while on watch during fishing.

Comparison of percentage attention allocation by crewmen during steaming and fishing watches is given in Figure 7.4.10.

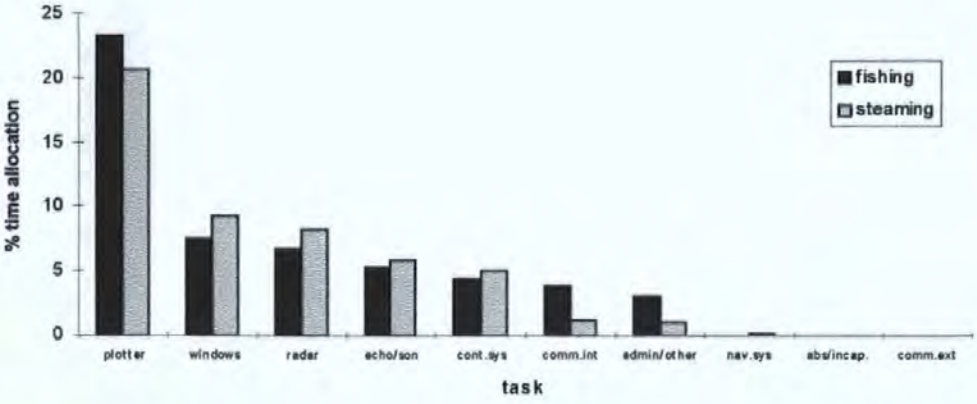

Figure 7.4.10. Comparison of mean time allocation to navigational tasks by crewmen during different stages of the trip.

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 7.4.2. 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.

	P <= t		
	skippers	mates	crew
fishing compared with steaming	0.076	0.345	0.467
steaming compared with hauling/shooting	0.002	n/o	n/o
fishing compared with hauling/shooting	0.031	n/o	n/o

Table 7.4.2. 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)

7.4.3 Section 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 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. Given that the echosounders on all three vessels had coloured displays one might conclude that they were preoccupied with the search for a pot of gold at the bottom of the rainbow! 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. This is more fully explored in Section 7.5 of this chapter, on "workload".

Moreover a point of interest arises here. It has already been shown in Chapter Five that more fishing vessels are lost in groundings towards the end of the week, when a high proportion are returning to port. 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 video 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 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 video 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 questionnaire responses from a representative sample of 171 UK fishermen, only 27% admitted to navigating using the video plotter .

Although testing the degree of actual reliance on any one piece of equipment did not directly form part of this research, it might reasonably be inferred that crewmen in particular and mates to an extent, were heavily, perhaps even over-reliant upon the video plotter display.

When asked at the end of the fishing trip, why they gave so much attention to the 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 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 video plotter.

HEINRICH (1988) noted that watchkeepers aboard the single vessel used 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 so pronounced as to be worthy of comment as in Heinrich's study. Indeed 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.

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 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.

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 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 comunication with other skippers. The mate, operating the 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 on watch simply performs a compensatory tracking task in keeping the virtual vessel shown on the video plotter on it's virtual track, even though there is no guarantee that this is a true representation of the actual 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 Laughery and Laughery's statement;

> "*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*",
>
> (LAUGHERY & LAUGHERY, 1987).

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 equipment and were for the most part operating on a logical, task-by-task basis in fulfilling the watchkeeping mission. Crewman 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 answer 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 occassional viewing of the radar display.

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.

7.5 The watchkeeper's mental workload: Time Line Analysis and the Stroop Task

The observations outlined in section 7.4, which gives an account of how attention is allocated during watches, also provide for a nominal analysis of the mental workload experienced by watchkeepers at the different stages of the fishing cycle.

Human attention is a limited resource. It is widely recognised that where it becomes necessary to address several tasks simultaneously, or where individual tasks become particularly demanding, the watchkeeper may become "overloaded" and unable to deal effectively with any exigency that might arise (e.g. WICKENS, 1992; MORAY, 1989; O'DONNELL & EGGEMEIER, 1986; GOPHER & DONCHIN, 1986; WIERWILLE & WILLIGES, 1979). SHUFFEL *et al.* (1989) comment on the other extreme - a situation of "underload" where the watchkeeper may be in a poor state of readiness to react quickly when this is required and where his attitude to the job will be negatively affected.

Modern fishing vessel wheelhouses have become complex control centres with a proliferation of increasingly sophisticated fishing, communications, propulsion and navigational components. Nonetheless, no research appears to have been focused upon whether the fishing watchkeeper, who usually works alone, can effectively perform all of the tasks the system demands of him.

While physical workload is not difficult to measure, mental workload is a different matter. As a concept, the latter is nebulous, pervading every aspect of the performance of a given task by drawing upon features that are not easy to measure empirically. The term, "mental workload" itself is is readily understood, but difficult to precisely define, (KANTOWITZ & CASPER, 1988; GOPHER & DONCHIN, 1986). In the present study, the term, "workload" is proposed as a convenient term to describe the synthesis of all of the mental task demands that are being placed upon the watchkeeper at any one time. Measuring the workload of the watchkeeper is considered a worthy objective not only because of its clear and direct implication for the safety of the vessel, but also because it could be used to evaluate the effects of crew sizes and of the introduction of new technology and ergonomic measures.

The measurement of mental workload has been the subject of considerable discussion in the scientific literature and has evoked such controversy that GOPHER and DONCHIN (1986) propose that it is in fact a hypothetical construct comprising elements that are actually beyond evaluation. Reviews of the methods of mental workload assessment are provided by KANTOWITZ (1987), O'DONNELL & EGGMEIER, (1986) and EGGMEIER and WILSON (1991). In the present study, the mental workload of watchkeepers has been measured and mapped using an established technique, the results of which are validated by another accepted means of testing for reserve mental capacity.

7.5.1 Time Line Analysis

The aim of this part of the research was to establish the average extent of the workload imposed upon the watchkeeper at various points during the fishing trip. Using the time allocation data gathered in observation trips at sea it was possible to pursue a technique known as Time Line Analysis (TLA). This gives a composite picture of the duration of individual tasks and from this, more importantly, it establishes a relationship between these tasks and time itself. The TLA concept then illuminates the existence of any time-critical sequences that are inherent in the watchkeeping system. PARKS (1979) credits the founding of the technique to SMITH (1975) who applied it in aviation and found that, at workloads in excess of 80%, pilots began to neglect what they considered to be "non-critical" tasks. Smith also showed that, at very low workload levels, pilots voluntarily added extra tasks such as more instrument scanning and cross-checking.

The rationale for TLA lies in acceptance of the principle that workload is proportional to the ratio of time occupied in performing tasks to total time available, (PARKS & BOUCEK, 1989). Since the basic technique is essentially descriptive, reliability and validity are high and because time itself, although an abstract concept, is an objective dimension, the results must be fundamentally "real".

7.5.2 Method

As in the data collection method expounded in section 7.4, the Time Machine computer programme was used with a notebook computer in the observation programme aboard three British fishing boats. The reader is referred to Sections 7.2, 7.5 and 7.5.1 for a comprehensive description of the method, including vessels and the essential criteria that had to be satisfied before data recording could proceed. The data recorded in the Time Machine database in the form shown in Appendix 3 was later entered into the Microsoft® Excel spreadsheet package for processing.

The workload estimate was calculated using *equation 2*, (PARKS & BOUCEK, 1989);

$$\%\ WORKLOAD = R_t / T_a \qquad \textit{equation 2}$$

where; R_t = time used
T_a = time available

The estimates can then be used to give a mean workload level for each phase of the fishing cycle or plotted over the duration of the watch to produce a time history of the workload in the form of a "timeline".

7.5.3 Results

The results of this part of the work are presented as timelines for each of the three ranks in different phases of the fishing cycle.

Skippers

The three skippers in this study were observed in all phases of the fishing cycle - steaming; shooting and hauling the gear; towing the fishing gear. This allowed for the construction of the timeline in Figure 7.5.1 which shows how the mean workload level changes during these phases. The skippers usually took over the watch at around a half hour prior to the deployment of the fishing gear. From this point, their workload increased, reaching a first peak during the shooting of the gear. Where the skipper stayed on watch during the fishing phase, the workload level was fairly even, ranging from 50 to 100% before a second, much higher workload peak occurred when the gear was being hauled. The mean level of

184.44% recorded at this stage was by far the highest at any stage of the cycle, and for any of the three ranks.

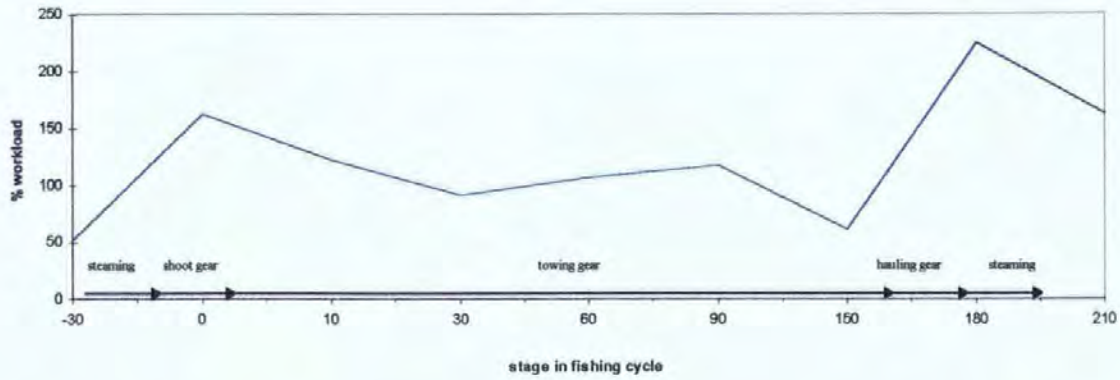

Figure 7.5.1. Typical distribution and degree of mean workload level in fishing Skippers over one complete fishing haul.

Only two complete observations of the skipper on watch during steaming were made. Because of the resultant paucity of data, no timeline has been constructed for skippers during this phase.

Mates

Observations were recorded for mates during both steaming and fishing watches, although it should be noted that the timeline for fishing is based on only three complete observations. The timelines in Figures 7.5.2 and 7.5.3 show that on average, mates' workload level rose towards the end of the watch in both steaming and fishing conditions.

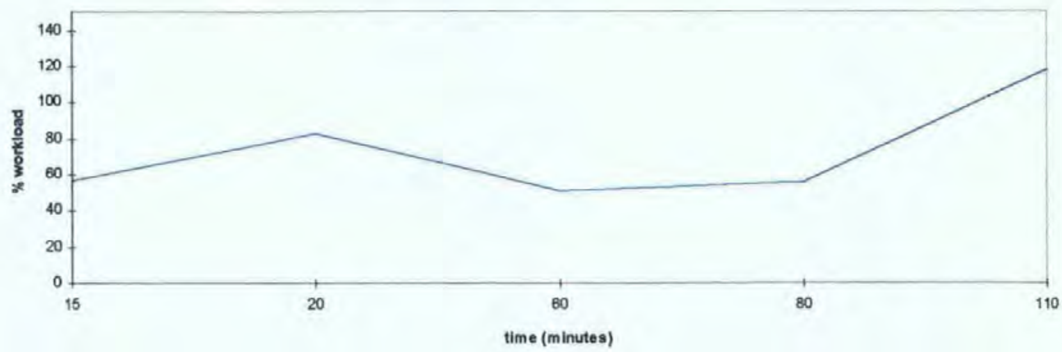

Figure 7.5.2. Mean observed workload level for Mates as steaming watches progress.

The timeline for mates while on watch during the fishing phase (Figure 7.5.3) suggests a gradual increase in workload but the low number of observations giving fairly scant data, may mask a less regular pattern over the period. None of the mates was on watch during hauling or shooting of the fishing gear so no record of their workload level at this time is noted.

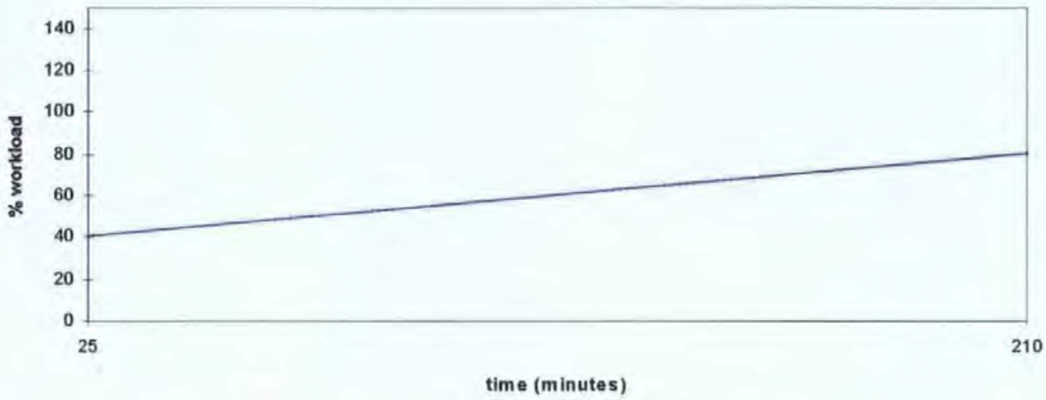

Figure 7.5.3. Mean observed workload level for Mates as fishing watches progress, (based upon three observations only).

Crewmen

Observational data allowed for compilation of timelines for crewmen during steaming watches and fishing watches, but not during shooting and hauling of gear since only skippers were on watch during this phase. During steaming watches, crewmen displayed a fairly rapid decline in workload within the first 20 minutes of the watch. This was followed by most of the watch being spent at relatively low levels before a slight rise prior to their being relieved (Figure 7.5.4). The average workload attributed to crewmen over steaming watches was the lowest out of all ranks, in all phases of the fishing cycle (Table 7.5.1).

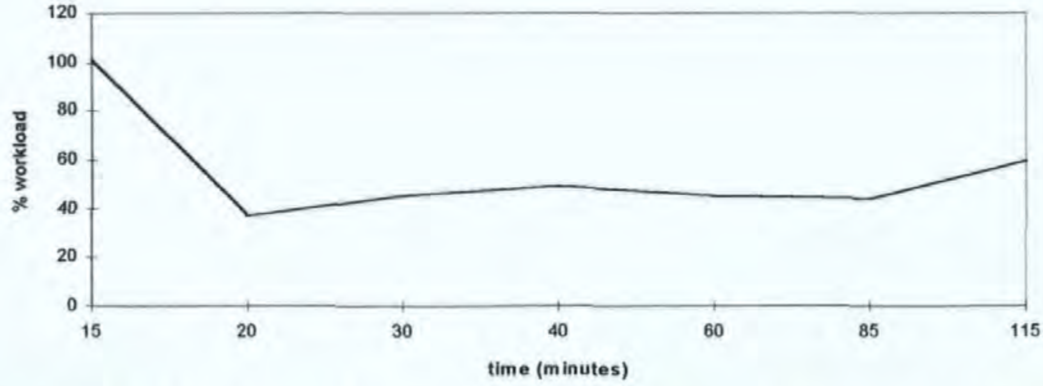

Figure 7.5.4. Mean observed workload level for crewmen as steaming watches progress.

Crewmen's average workload during fishing watches was marginally higher than that exhibited during steaming, but only by 2.5% (Table 7.5.1). This statistic must however be considered in the light of the fairly acute drop in workload where fishing watches lasted more than one and a half hours (Figure 7.5.5). The timeline in this figure shows that while workload in this situation is more or less steady between 60 and 70%, where a crewmen is on duty in a fishing watch lasting almost three hours, mean workload drops to around 20%.

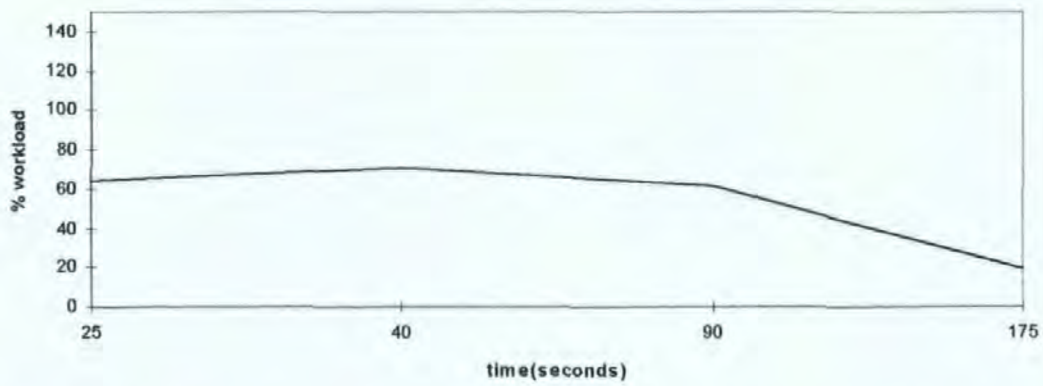

Figure 7.5.5. Mean observed workload level for crewmen as fishing watches progress.

Table 7.5.1 shows that for skippers, a workload gradient exists with steaming at the lower end and shooting / hauling at the other. In mates this effect is reversed, while in crewmen the difference between the two conditions is negligible.

	Skippers	Mates	Crewmen
steaming	52.42%	73.12%	51.41%
fishing	100.11%	60.77%	53.91%
shooting/hauling	184.44%	not observed	not observed

Table 7.5.1. Comparison of mean workload levels for different ranks at various stages of the fishing trip.

7.5.4 The Stroop Task

In an early paper on the mental demands of car driving, BROWN (1962) said that a "good" driver is, "*one who maintains sufficient spare capacity to deal with an unexpected but possible event*". The same probably holds true for watchkeepers on fishing vessels and given the variation in workload observed at different stages of the fishing cycle, it is of interest to know how much "spare capacity" is available at these times.

The Stroop Task (STROOP, 1935) is a means of measuring in terms of time, the perceptual "cost" of processing information. This was selected for use in the programme of observations as a "secondary task" (WICKENS, 1992; OGDEN *et al*, 1979; ROLFE, 1973) which would measure the residual information processsing capacity of the watchkeeper, beyond that which was being directed at the primary task of navigating and controlling the vessel and where appropriate, managing the fishing operation. It was anticipated that the results of administering the task would contribute to identification of the periods of work underload and work overload during the fishing cycle and thus as well as giving useful information in its own right, would validate and augment the results of TLA.

The Stroop Task is based upon inducing a form of confusion, referred to by ERIKSEN & ERIKSEN, (1974) as "response conflict" in the subject. The confusion is attributable to the difficulty experienced in separating the semantic characteristics of a word displayed in a coloured font from the colour of the ink in which the word is printed. Reponse conflict arises in this case because of the similarity of the stimulus properties of text and colour when they are displayed in a common location. WICKENS (1992) offers a validation of the properties of the task in that, while colour words displayed in different coloured fonts clearly interfere with the subject's ability to report the font colour, colour-related words, like "sky" or "grass", give some though reduced interference and colour-neutral words, such as "will" or "five" produce very little interference.

Figure 7.5.6. Cards used used to administer the Stroop task. Full size cards are plastic laminated and measure 25cm x 10cm each.

7.5.5 Method

At the start of the fishing trip, personnel were briefed in respect of the Stroop Task and later asked, in private, whether they would be willing to participate in this section of the work. The purpose of doing this was to allow anyone who lacked skills in literacy to withdraw without being caused embarassment. Clearly, this form of the Stroop task cannot give meaningful data if the subject does not possess the ability to read with competence. As early in the trip as possible, each participating subject was shown ten different 25cm x 10cm Stroop cards as illustrated in Figure 7.5.6. Using the Time Machine timing programme (Section 7.2), the time for each correct response was noted and the mean response time over the ten attempts provided a "Stroop baseline" for that subject. Each time the task was administered thereafter the response time, plus or minus relative to the subject's baseline, was recorded.

7.5.6 Results of the Stroop task

The results of administering the Stroop task are displayed on standardised figures which show the range of responses at different times during the watch, with the mean response time above or below the baseline plotted as a line. The longest response time amongst all subjects was 4 seconds over baseline (+4) and the shortest was 1 second under (-1).

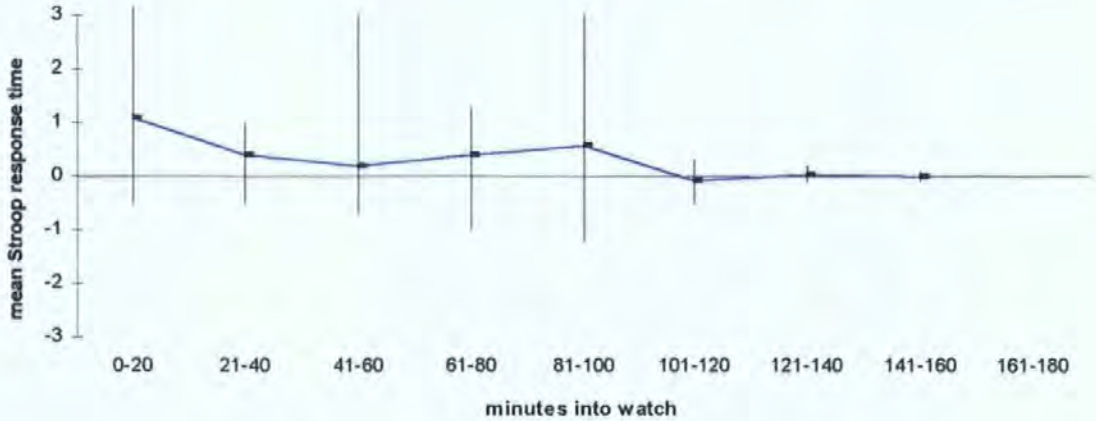

Figure 7.5.7. Mean Stroop response times for all fishing vessel watchkeepers during all types of watches.

When a general view of the results is taken (Figure 7.5.7), it can be seen that the trend is for a slight improvement in spare cognitive capacity over the first hour or so, followed by a decline then, where watches extend beyond about two hours, another improvement.

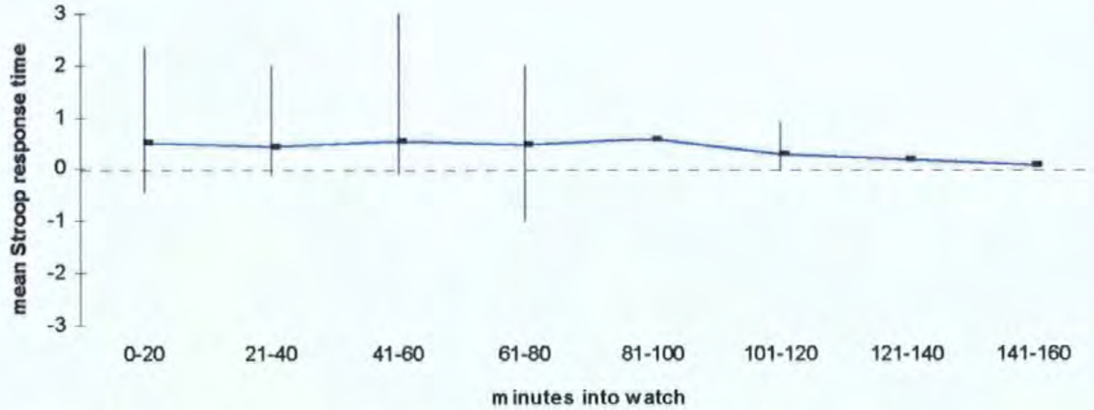

Figure 7.5.8. Mean Stroop response times for all fishermen during steaming watches.

Splitting the general situation into steaming and fishing watches (Figures 7.5.8 and 7.5.9) shows that while the pattern of cognitive loading seems to be reasonably even during the former, it is much less so during the latter.

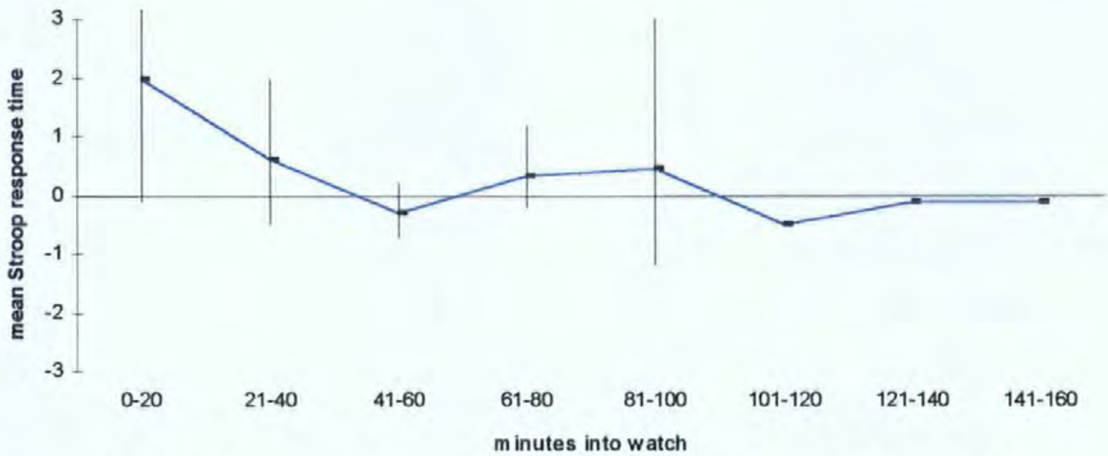

Figure 7.5.9. Mean Stroop response times for all fishermen during fishing watches.

The related *t*-test applied to mean Stroop responses for steaming and fishing (Figure 7.5.10) showed that the difference in results between the two conditions was not significant (P (T<=t) = 0.72).

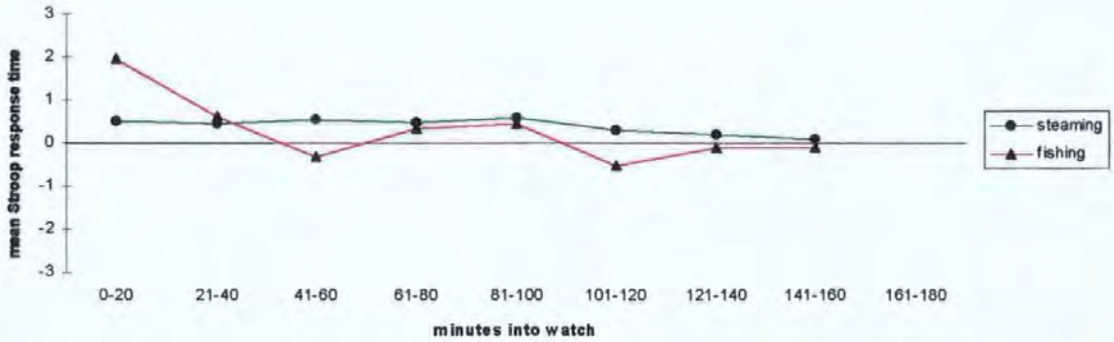

Figure 7.5.10. Comparison of mean Stroop response time patterns recorded for all watchkeepers between steaming watches and fishing watches.

Figure 7.5.11 reviews the Stroop response times for skippers on their own. The reader should note that the Stroop task data for skippers where the watch extends beyond the two hour mark does not include any recordings taken during hauling of the fishing gear. Skippers' mean Stroop response time during shooting of the fishing gear on trawlers was a relatively lengthy 2.05 seconds. On a number of occassions when Skippers were asked to respond to the Stroop cards at this stage of the fishing cycle, they would look at the card and quite clearly struggle to differentiate between the wording and the colour, although this did not always happen.

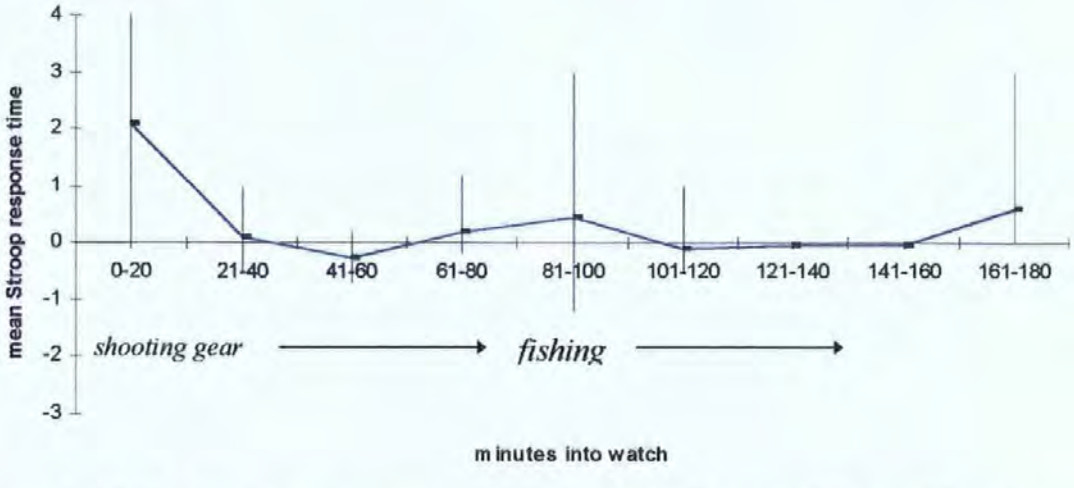

Figure 7.5.11. Mean Stroop response times for fishing skippers while watchkeeping.

The response times for mates ranged from almost a second over baseline in the early stages of watches to near enough a second under, after an hour and a half on duty (Figure 7.5.12). The mates on whom the Stroop test was administered in this study seemed to enjoy being faced with the task during their watches and it may be that the validity of the results are compromised to some extent by their efforts to be seen to 'perform efficiently' in the task.

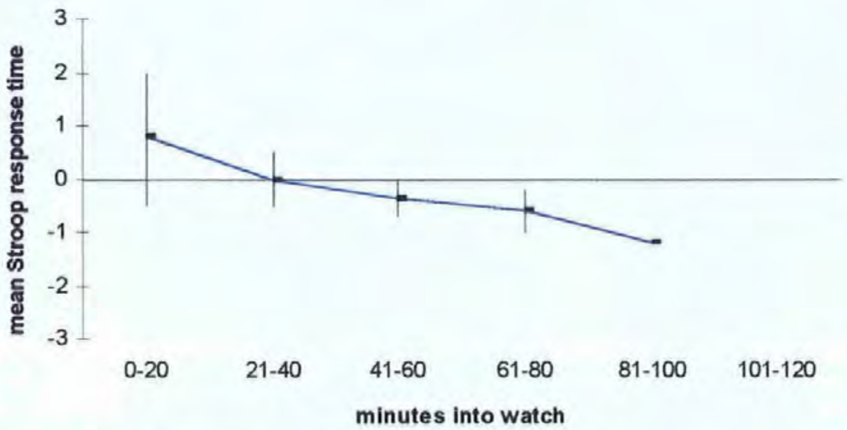

Figure 7.5.12. Mean Stroop response times for fishing Mates while watchkeeping.

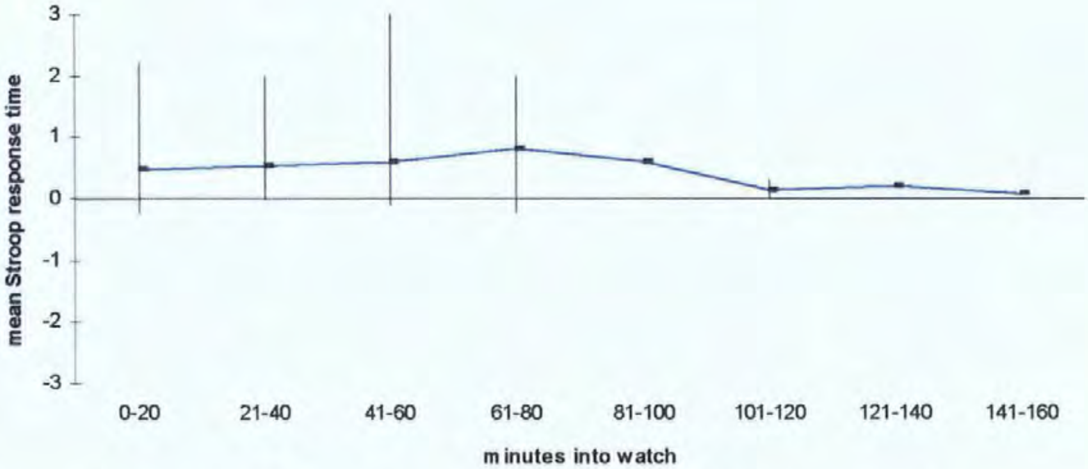

Figure 7.5.13. Mean Stroop response times for crewmen while watchkeeping.

Crewmen's average response times varied least across the duration of watches, ranging between baseline and one second over, throughout. Responding to the Stroop cards took them slightly longer during the first hour of the watch but the degree of dispersion around the mean response times shown in Figure 7.5.13 suggests that in some instances very little spare cognitive processing capacity was available up to this point. Most crewmen's watches lasted under two hours (during steaming usually only one hour) so the small number of times the Stroop task could be administered beyond this undermines the reliability of the data over the 120 minute mark on the x-axis.

Figure 7.5.14 compares the pattern of mean response times for skippers mates and crewmen. It can be seen that the amount of spare mental capacity available to skippers fluctuates, while that available to crewmen remains quite stable. Mates appear to have a gradually increasing level of spare capacity as the watch progresses.

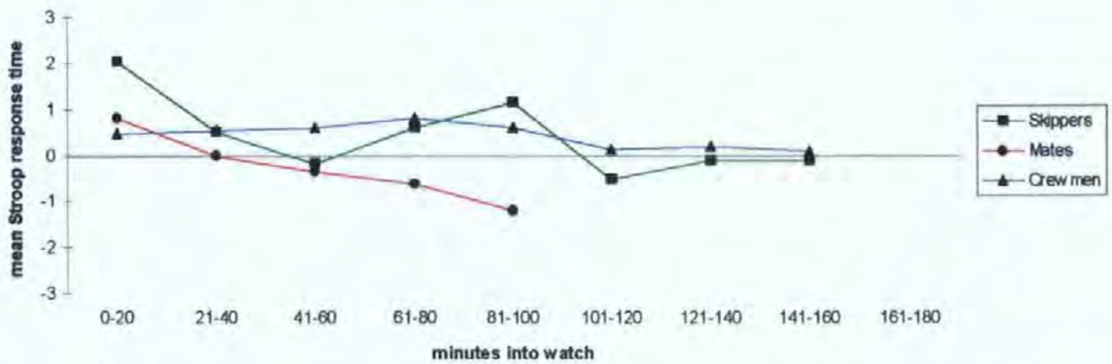

Figure 7.5.14. Comparison of mean Stroop response time patterns between Skippers, Mates and crewmen on fishing vessels.

7.5.7 Validation and section discussion

Because of the limitations imposed by availability of data, it was not possible to investigate the relationship between Stroop test results and percentage workload for all possible combinations of watchkeeper rank and vessel condition, for example the time during which

Skippers were on watch while steaming, or when Mates and crewmen were on watch while fishing.

Plotting workload levels against mean Stroop task results where this was possible shows that the two appear to move together, (Figures 7.5.15; 7.5.16 and 7.5.17) and the statistical significance of the correlations between the two, for both skippers and crewmen, tends to confirm the intuitive expectation that higher levels of workload are accompanied by a reduction in the watchkeeper's reserve mental capacity (Table 7.5.2). The correlation for mates was not significant but this may be a function of having too few observations rather than there being no relationship in existence. In the light of these results, it is proposed that the observation-based method used to calculate workload is valid and that the results could contribute to a fishing vessel watchkeeping model.

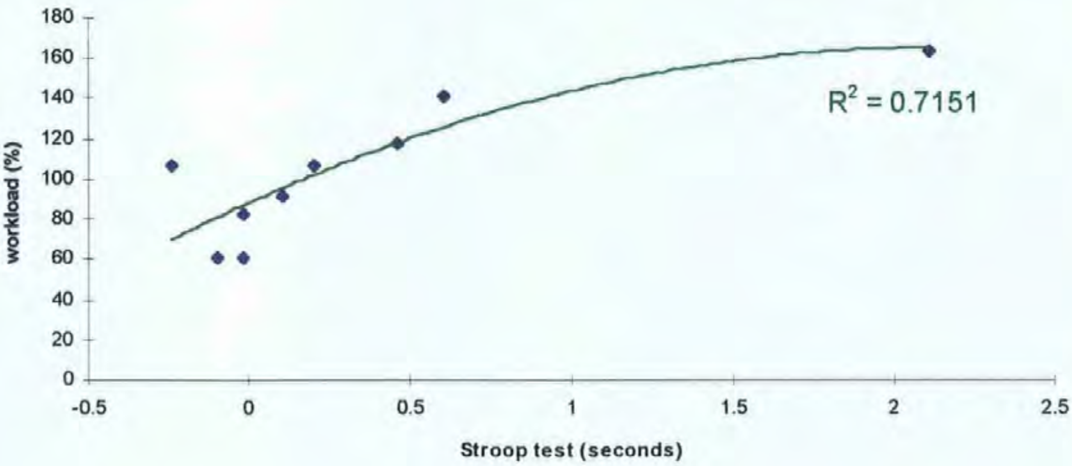

Figure 7.5.15. Skippers' mean observed percentage workload levels correlated with mean Stroop test results during fishing watches.

The correlation of workload with Stroop test results for skippers is of particular interest. In Figure 7.5.15, the polynomial trend line which most appropriately fitted this correlation indicates a disproportionate increase in the mental cost of processing information as workload rises.

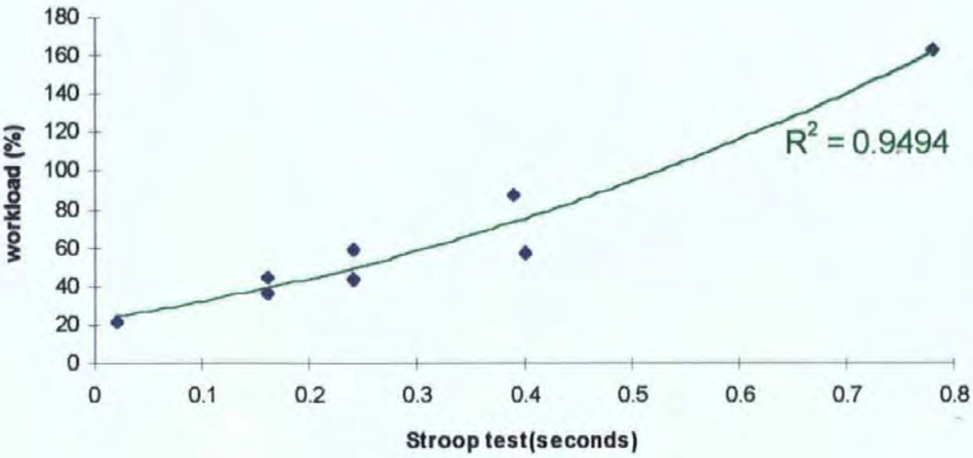

Figure 7.5.16. Crew's mean observed workload levels correlated with mean Stroop test results during steaming watches.

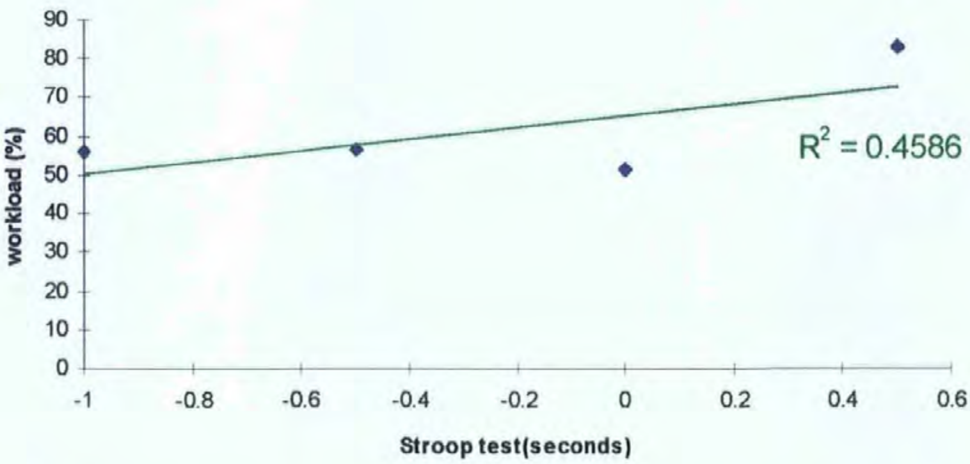

Figure 7.5.17. Mates' mean observed workload level correlated with mean Stroop test results during steaming watches.

	skippers (fishing only)	mates (steaming only)	crewmen (steaming only)
correlation coefficient	0.82	0.68	0.96
number of pairs in sample	9	4	8
significant at $p<0.05$?	yes	no	yes

Table 7.5.2. Results of Pearson's product moment correlations between Stroop test results and % workload.

The question that begs to be addressed here is that of deciding where on the timeline horizontal lines representing "overload" and "underload" could be superimposed?

The times when fishing gear was being deployed and recovered were periods of peak workload and these correspond with the greatest reductions in spare cognitive capacity (mean Stroop response of +2.05 seconds / mean workload level 184.44%). During the observation programme, the skippers were invariably on watch during these periods and in spite of their training and expertise, were so loaded with tasks that their ability to deal with additional activities demanding attention and requiring some calculated response would clearly have been diminished. Where Stroop responses were correlated with workload and a polynomial trendline fitted to the resulting data points, the curve begins to flatten out when Stroop responses exceed one second over the baseline level. It is therefore proposed that this is an identified point of overload since beyond this, workload no longer increases but the time taken for cognitive processing does. This implies that wherever the timeline rises above 140%, the skipper on watch is in a state of mental overload. Figure 7.5.18 shows that this level was broached during both shooting and hauling of gear.

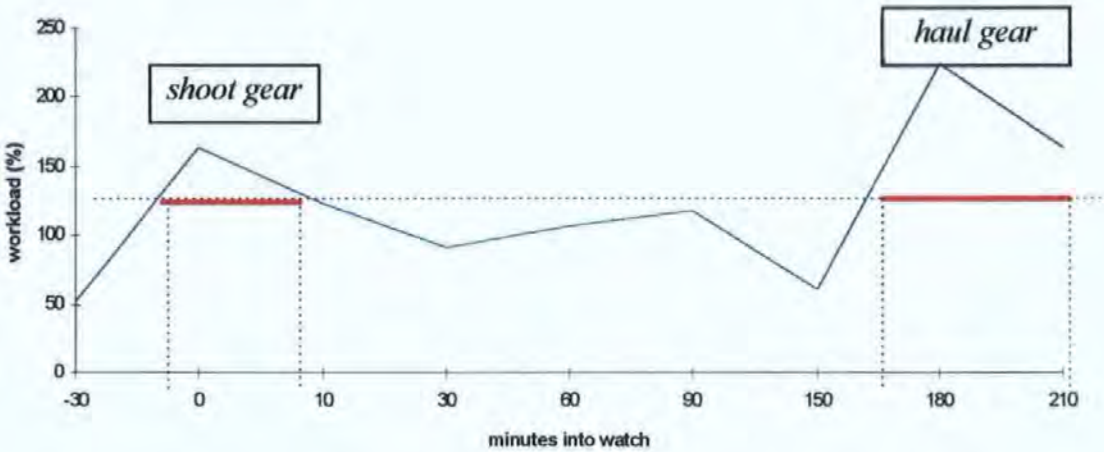

Figure 7.5.18. Stages in during fishing watches where skippers are overloaded.

While the discussion above centres on data for skippers, because of their superior training and experience it is unlikely that the same overload threshold will be directly transferrable to mates and crewmen. Fitting the same type of polynomial trendline to the correlation between Stroop response and workload for crewmen during steaming watches, for example failed to identify any levelling-off point although admittedly only one datapoint occurs at workload level of over 100% (Figure 7.5.16). It is probable that crewmen and mates will have their own thresholds but the data in this study does not allow for identifying these.

Determining the underload threshold is an even more fraught matter. Both skippers and crewmen showed what might be termed a "sixty minute effect". In the case of crewmen, although the workload level appeared to be fairly stable, at around 50%, about one hour into steaming watches, their Stroop Task response times rose markedly above their baseline levels. Skippers showed broadly the same effect during fishing watches. In crewmen, the underlying mechanism for this may be disaffection with the simple tracking task they perceive watchkeeping to be, and in skippers of vessels used in this study, this seemed to be rather an "uninteresting" phase of the watch during which their skills are not being challenged. While it may be that this effect signifies the onset of boredom and monotony, the trigger for which is mental underload, the data gathered in this study does not provide adequate support for this theory. It has therefore not been possible to reliably identify a level of workload that corresponds with a state of mental underload in fishing watchkeepers even though this threshold probably does exist.

Although there were only three observations of mates during fishing watches, they on average showed a rise in their workload towards the end of both steaming and fishing watches. This end-spurt is something that was also observed, though not explained in road safety studies by MCDONALD (1984) in truck drivers. The effect is reversed in Skippers and crewmen who show a decline in workload towards the end of lengthy steaming and fishing watches. During the observations, mates were clearly observed to make a conscious effort to increase their subjective workload at a given point in the watch, in many cases by finding things to do (e.g. making rope strops for deck work, reviewing net plans, doing fishing gear calculations, etc.) and noticably investing extra time and effort into routine watchkeeping tasks. This agrees with the idea that where a professional ethic exists or has been entrained, subjects will voluntarily add tasks when their current mental workload is low (SMITH, 1975). Being generally recently trained, the mates in this study reacted positively to the onset of boredom and lethargy in this way because the accompanying feeling of underactivity arouses inner feelings of guilt and lack of professionalism.

The degree of dispersion around the mean results of the Stroop task suggest that while the average level of workload experienced by the watchkeeper during a given time period can be reviewed using the TLA method, the instantaneous level of reserve mental capacity at any given point during a watch may vary quite markedly. For the purpose of TLA in the present work, it has been convenient to assume that the individuals observed were similar in their ability to respond to given sets of task demands. Clearly, this may not actually be the case and the the question of individual differences in ability to receive, process and act upon information between subjects must be considered. Furthermore, WICKENS (1992) expounds the axiom that workload is a multidimensional construct and therefore while two shared but easy tasks may not exceed 100%, two shared difficult tasks might. Thus if in any future work in this area, TLA is to reach beyond the fairly simple mapping of temporal relationships attempted here, some moderation of the time quantity would have to be achieved. This could be done by assigning numerical weightings to the cognitive dimension of each observed task, perhaps based broadly upon the "Cognitive Workload Component Scale" proposed by ALDRICH *et al.* (1989) shown in Table 7.5..3.

weight	***task type***
1.0	automatic (simple association)
1.2	alternative selection
3.7	sign/signal recognition
4.6	evaluation/judgement (single aspect)
5.3	encoding/decoding
6.8	evaluation/judgement (multiple aspects)
7.0	estimation, calculation, conversion

Table 7.5..3 From Workload Component Scales for the UH60A mission/task/workload analysis (Source; ALDRICH *et al*, 1989).

7.6 The watchkeeper's mental state: Subjective boredom scores and time estimation

Throughout the twentieth century, the term, "boredom" has proved very difficult for researchers to define. J.E. Barmack, one of the early workers in this area suggests that boredom is:

> *"A phenomenon of conflict between the tendency to continue and the tendency to get away from a situation which has become unpleasant, principally because one is responding,or may respond, to it with inadequate physiological adjustments, caused in turn by inadequate motivation"*
>
> (BARMACK, 1937)

More recently, a less pedantic approach has become fashionable with boredom being more simply described as, "*an individual's emotional response to an environment that is perceived to be monotonous*" (DAVIES *et al.*, 1983). WELFORD (1965) suggested that the state of boredom might be equated with a situation of underload in the person concerned. More recently, BRADBY *et al.* (1993) note that while boredom is not entirely synonymous with underload, the possibility of a link between the two does provide a basis for research in this area. In aviation research, BOEHM-DAVIS *et al.*, (1983) showed that the boredom and complacency arising from work underload led to undesirable responses in pilots, such as failing to stay abreast of the current status of an ongoing flight.

DAVIES *et al.* (1972), (reported in DAVIES & PARASURAMAN, 1982) showed significant negative correlations between boredom and concentration, and between boredom and perceived expenditure of effort where individuals were faced with a problem-solving task. This basic principle is summarised in Figure 7.6.1.

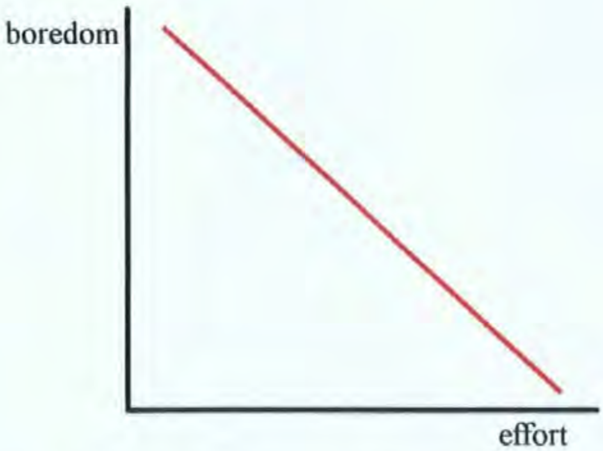

Figure 7.6.1. Davies *et al.*'s proposed relationship between boredom and perceived expenditure of effort. Source: DAVIES and PARASURAMAN, 1982.

HILL & PERKINS (1985) suggest that feelings of boredom have both affective and cognitive components, the latter being derived from the perception that the tasks in hand lack challenge and demand minimal activity while the former comes from the way in which tasks are actually interpreted and executed. There has been considerable debate on whether boredom is physiologically correlated with the psychological concept of arousal (HEBB, 1955; BERLYNE, 1960; GEIWITZ, 1966; LONDON *et al*, 1972). As recently as 1993, BRADBY *et al.* were equivocal with their findings in this respect, stating that while laboratory-based experiments show decreased arousal to be linked to subjective boredom, this may not be the case with airline pilots whose "professional ethic" may induce the opposite effect. While the present work makes no express attempt to address these fraught issues they nevertheless have some bearing on the findings and are briefly discussed in respect of their relevance to fishing vessel watchkeeping.

This section of the present study is not directed at producing any definitive answer to the question of whether an increase in boredom necessarily leads to a decrease in the quality of the watchkeeper's performance with consequently increased likelihood of a navigational error - far too many eminent psychologists have already argued around variations on this general theme without agreement. The results nevertheless allow for inferences to be drawn. The primary aim was to find out whether watchkeepers actually felt bored, whether this subjective feeling was measurable in an objective way, at what stage of the watch the onset of boredom ocurred, and whether this overlapped with other measurable changes that could indicate a watchkeeping performance decrement. It was also proposed to explore whether any sub-group of watchkeepers was more or less susceptible to feelings of boredom than others and if so to explore possible reasons why this might be.

7.6.1 Method

By virtue of the rather nebulous character of the term, any research work directed at the measurment of boredom is bound to be open to criticism on methodological grounds. The simplest approach possible was employed in this study because it was felt that this would be least intrusive and hence produce the most accurate result with fishing boat watchkeepers. A "Likert scale" with a 10cm bar separating the wording, "very bored" from "not bored at all" was reproduced on slips of paper (Figure 7.6.2).

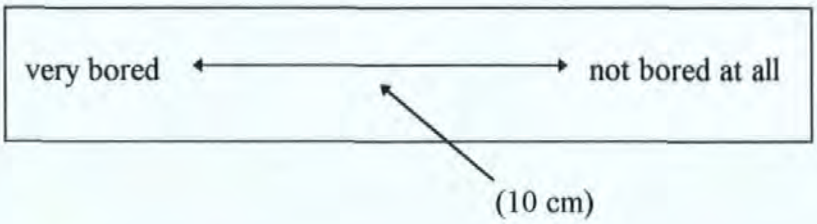

Figure 7.6.2. Likert scale slip used to record self-reported boredom level.

At various stages in the duration of the watch, the watchkeeper was handed a clipboard with one of these slips attached, and a pencil and asked to mark the line at a place appropriate to how they felt at that moment in time. By measuring left to right using a 10 centimetre ruler where the mark occurred on the line, it was possible to attribute a self-reported boredom score on a scale of 1 to 10 for that point in the watch; i.e. where the line was marked 3 cm from the left end, this gave a score of 3, corresponding with quite a strong feeling of boredom in the subject.

7.6.2 Results

When all the self-reports were taken together and related to the stage of the watch during which they were recorded, a pattern of increasing , decreasing then increasing boredom, with a wide response range, can be seen (Figure 7.6.3).

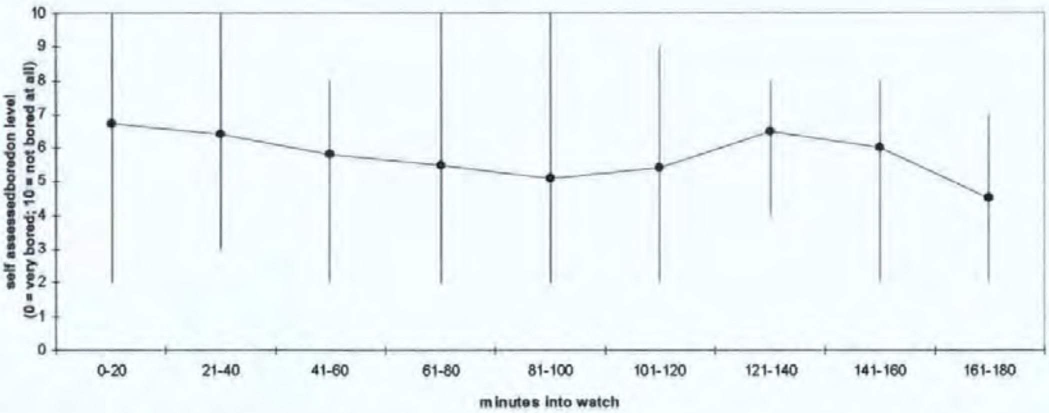

Figure 7.6.3. Mean self reported levels and response range of boredom at different stages of the watchkeeping duration for all ranks of fishing vessel crews.

It is more informative however to look at the results for skippers, mates and crewmen individually. Crewmen report slowly increasing levels of boredom more or less throughout the watch (Figure 7.6.4). There is a noticable reduction in boredom in crewmen when the watch extends beyond two hours, although it must be borne in mind that only a proportion of the crewmen in the sample group were on watch for this long and these tended to be older and relatively experienced.

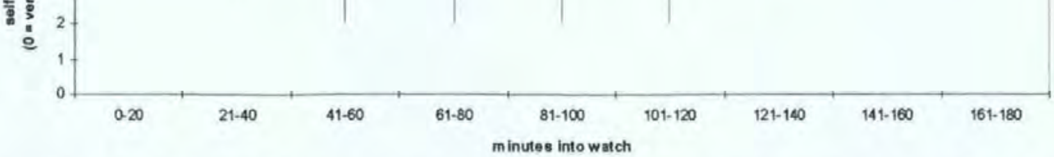

Figure 7.6.4. Mean self reported levels and response range of boredom at different stages of the watchkeeping duration for fishing vessel crewmen.

The mates contributing to this part of the study also showed an increase in boredom level over the first one and a half hours of the watch (Figure 7.6.5) with a more pronounced reduction as their relief time drew closer.

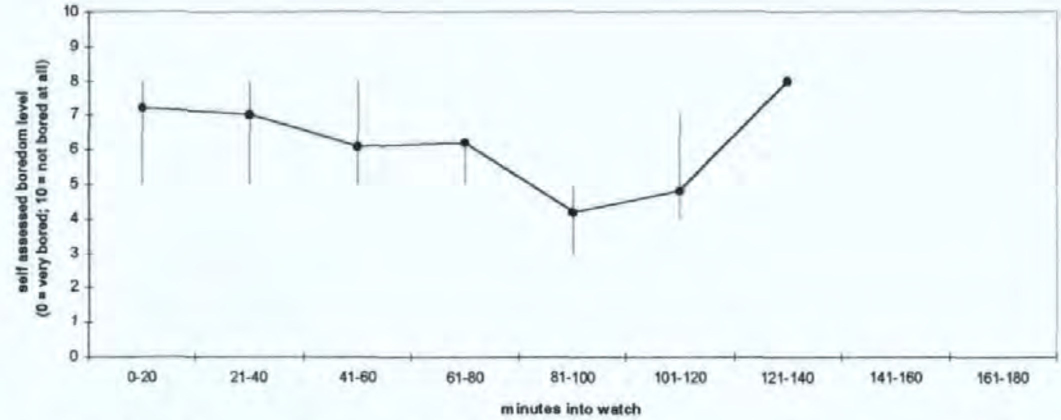

Figure 7.6.5. Mean self reported levels and response range of boredom at different stages of the watchkeeping duration for fishing vessel Mates.

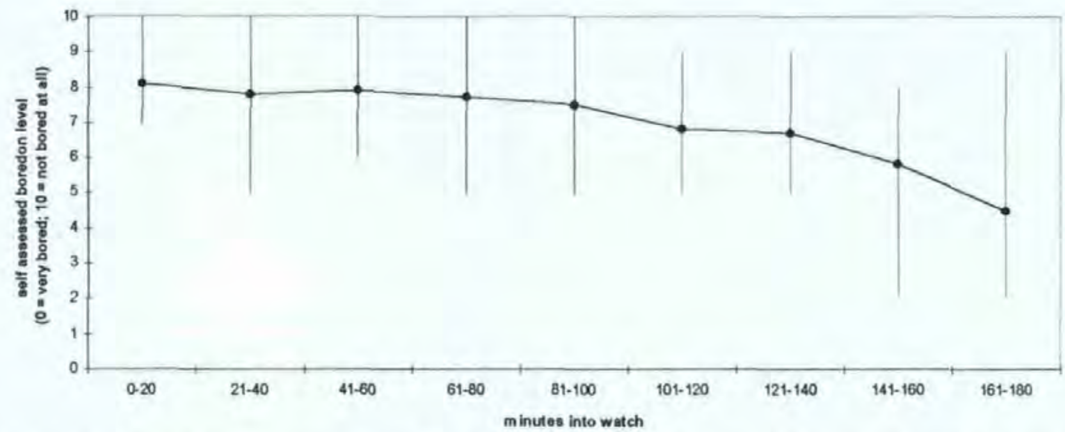

Figure 7.6.6. Mean self reported levels and response range of boredom at different stages of the watchkeeping duration for fishing vessel Skippers.

Skippers also reported gradually increasing levels of boredom throughout the watch (Figure 7.6.6), but unlike their colleagues, there was no reduction as the end of the watch came to hand. They reported much lower levels of boredom at respective stages of the watch than mates who in turn reported lower levels than crewmen.

7.6.3 Time Estimation

HART (1975) showed that when subjects were asked to estimate retrospectively a time interval of given duration, they tended to overestimate that interval when they were preoccupied with some task and underestimate when they had little to occupy them mentally. This, as WICKENS (1992) says, simply confirms the adage that "time flies when you're keeping busy". He goes on to plausibly suggest that high levels of workload interfere with the internal mechanism responsible for monitoring the passage of time.

This secondary task was selected as a validatory measure for correlation with data on self-reported boredom and Stroop task responses. The measure was deemed suitable for use with fishing vessel watchkeepers because it is ostensibly unobtrusive, does not demand the processing of stimuli, and requires a minimal response on the part of the subject. It should be noted however that DAVIES & TUNE (1970) found no connection between the ability to estimate the passing of time and quality of vigilance, thus care has been taken not to infer any direct relationship of this kind purely from the results of time estimating.

6.7.4 Method

As soon as possible during the fishing trip, subjects were briefed with regard to the details of the time estimation task. At irregularly spaced junctures during watches, the subject was asked with as little formality as possible to say when one minute had elapsed, starting from a point in time when the author said the word, "now!". The Time Machine timing programme, loaded on notebook computer, was used to record, in seconds, the time that elapsed up until the point when the subject indicated that, in his opinion, one minute had passed. The number of seconds over or under 60 was noted. Subjects were not informed of the accuracy of their estimates until the end of the programme of observation aboard that vessel so that reinforcing or inhibitory effects would be avoided.

7.6.5 Results

A simple explanation of the regime employed in compiling the following figures may aid the reader's clearer understanding of the results. Where subjects on average, underestimated the passing of one minute, this is recorded as a negative datapoint. At a superficial level at least, this would suggest that the subjects were under-occupied mentally. Conversely, where a positive data point is recorded, this indicates an overestimate of the passage of time and hence one might conclude that the subjects were mentally "busy".

Figure 7.6.7 illustrates the general pattern of time estimation for all watchkeepers over both steaming and fishing watches. A trend towards underestimating is evident during the first hour of the watch, reaching an extreme in the period between 60 and 100 minutes into the session.

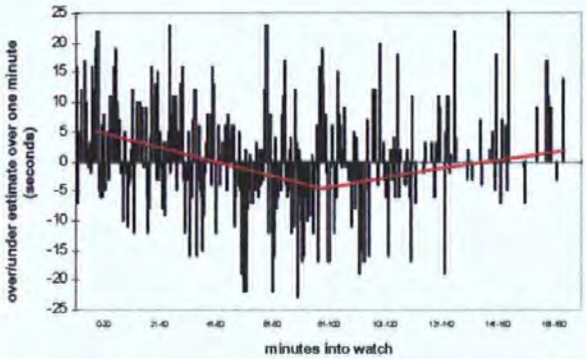

Figure 7.6.7. Pattern of over/under estimating of one minute passing while on watch, for all watchkeepers during all types of watch.

During steaming watches, crewmen showed variable abilities to accurately estimate the passing of one minute but throughout observations they were never off the mark by more than five seconds either way. Mates showed more variation in their accuracy on this task with a range of over 14 seconds betweeen the largest average over and under estimates. None of the skippers was observed on watch for longer than one hour while the vessel was steaming and this is reflected in the trendline for time estimating . Figure 7.6.8 shows the pattern of estimates for each rank with smoothed lines fitted to the data.

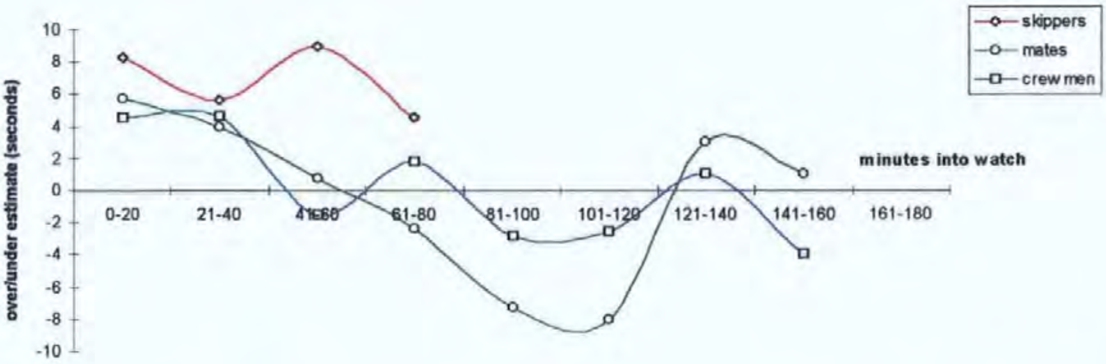

Figure 7.6.8. Individual patterns in time estimates for skippers, mates and crewmen during steaming watches.

During fishing, crewmen seemed to be unable to accurately assess the passing of one minute at any stage of the watch and on average, gave underestimates at every stage except during the first 20 minutes on duty (Figure 7.6.9). Skippers and mates however produced remarkably similar patterns of average time estimation while fishing. The largest mean underestimates made by these latter two groups were 1.6 and 2.3 seconds respectively and notably, both of these occurred around one hour into the watch (Figure 7.6.9).

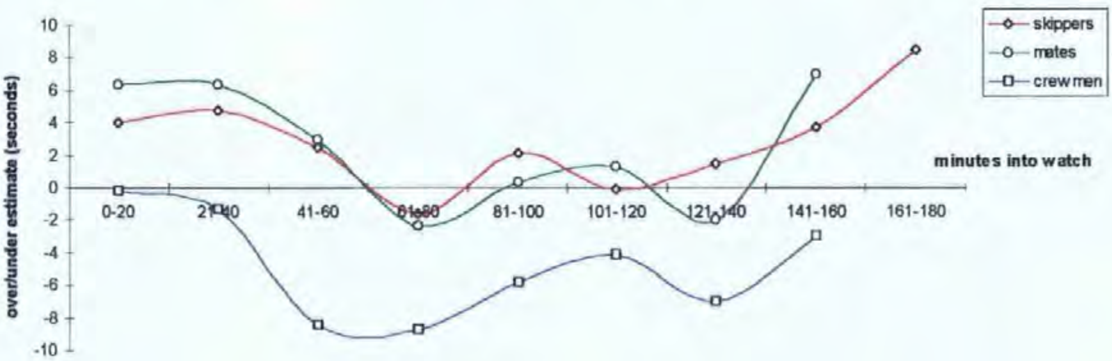

Figure 7.6.9. Individual patterns in time estimates for skippers, mates and crewmen during fishing watches.

7.6.6 Validation and Section Discussion

During steaming watches, both crewmen and mates showed a positive correlation between the means of their ability to estimate the passing of time and self-reported levels of boredom, i.e. a notion of time dragging corresponds with feeling bored, (Figures 7.6.10 and 7.6.11).

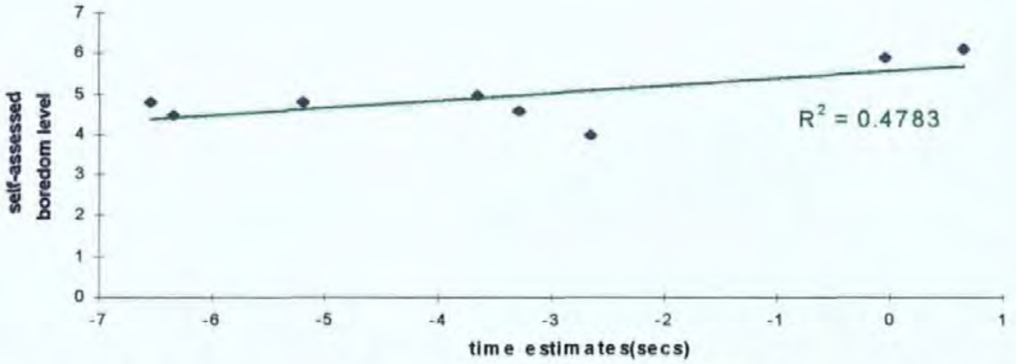

Figure 7.6.10 Time estimates correlated with self-reported boredom level for crewmen during steaming watches.

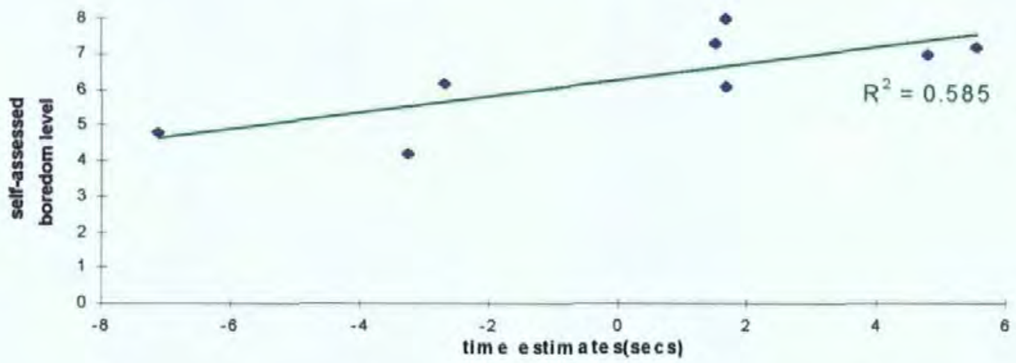

Figure 7.6.11. Time estimates correlated with self-reported boredom level for mates during steaming watches.

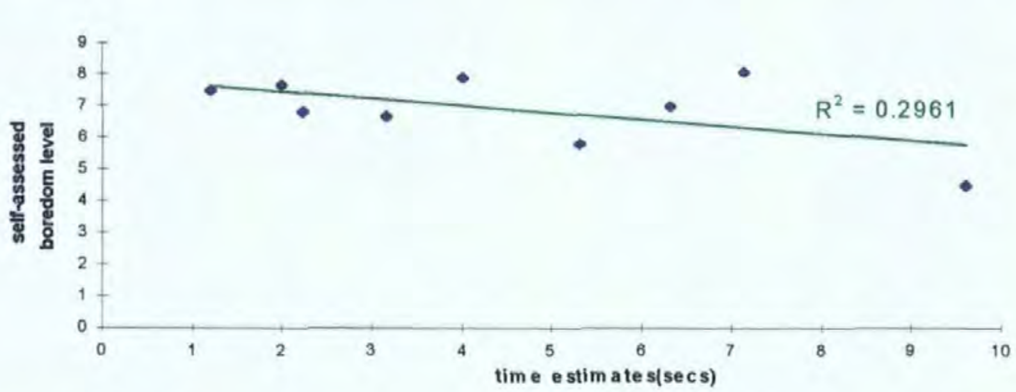

Figure 7.6.12. Time estimates correlated with self-reported boredom level for skippers during steaming watches.

In each case, these relationships were significant at the 5% level when tested using the Pearson's product moment correlation (Table 7.6.1). Relating time estimating ability to boredom for skippers on watch while the vessel was steaming resulted in a slightly negative trend (Figure 7.6.12) but the correlation was not significant (Table 7.6.1).

	skippers	mates	crewmen
correlation coefficient	-0.47	0.76	0.69
number of pairs in sample	9	8	8
significant at p<0.05?	no	yes	yes

Table 7.6.1. Results of Pearson's product moment correlations between self-reported boredom level and time estimates during steaming watches.

A similar situation pervades when time estimation was related to boredom during fishing watches in that both crewmen and mates provided positive relationships (Figures 7.6.13 and 7.6.14) which were also significantly correlated at the 5% level using Pearson's product moment (Table 7.6.2). A polynomial trendline gave the best fit to the scatterplot for skippers but this suggested that the feeling of time passing quickly was accompanied by an increased feeling of boredom. This is unlikely to occur and as in the case of steaming watches, the result of this correlation for skippers while the vessel was fishing was found to be not statistically significant. It may be that skippers, because of the long hours they spend on watch while the vessel is fishing, have acclimated to boredom and it does not therefore interfere so much with their ability to internally monitor the passing of time

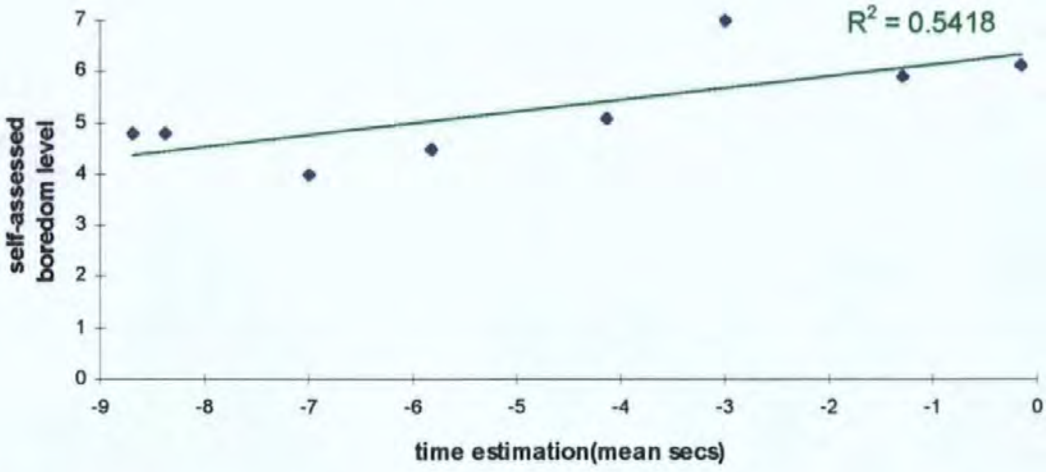

Figure 7.6.13. Time estimates correlated with self-reported boredom level for crewmen during fishing watches.

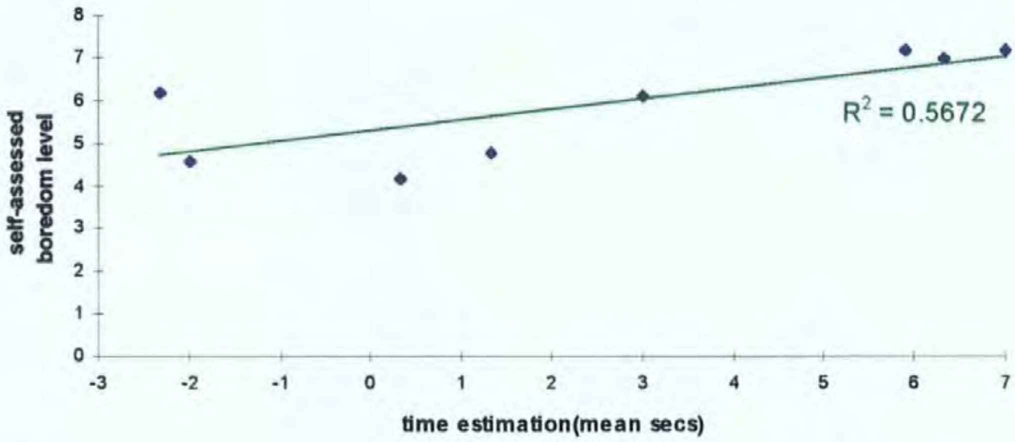

Figure 7.6.14. Time estimates correlated with self-reported boredom level for mates during fishing watches.

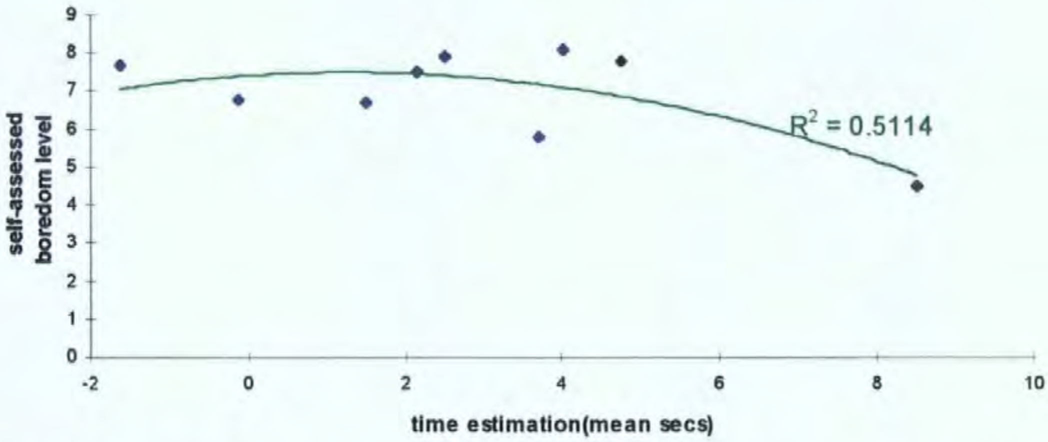

Figure 7.6.15. Time estimates correlated with self-reported boredom level for skippers during fishing watches.

	skippers	mates	crewmen
correlation coefficient	-0.54	0.75	0.74
number of pairs in sample	9	8	8
significant at p<0.05?	no	yes	yes

Table 7.6.2. Results of Pearson's product moment correlations between self-reported boredom and time estimates during fishing watches.

The significant correlations between boredom and time estimates for mates and crewmen in both steaming and fishing conditions suggests that for these groups, self reported levels of boredom are valid and thus underestimating of elapsed time can be taken as a surrogate for boredom in these cases. The negative relationship between the two variables in the case of skippers, both when steaming and fishing, is puzzling and the lack of significance in this correlation undermines the usefulness of the self-reporting techniques so far as they only are concerned.

7.7 Mental workload and boredom in fishing watchkeepers

In a study of vigilance, MACKIE *et al.* (1987) highlighted boredom as one of the factors that has the most significant deleterious effect among a range of variables. Although not manifest in the data presented, a number of the subjects in this study who gave relatively low self-reported levels of boredom appeared to engage in subsidiary behaviours that were not really relevant to their watchkeeping duties. Examples of this range from making rope strops and beckets that were not for immediate use, to spotting sea mammals and playing computer games. Identifying other fishing vessels that were in sight was also a popular distraction, particularly with Skippers and Mates.

WELFORD (1965) first expressed the now widely accepted view that "typically boring situations" are those in which attention is required but little information is conveyed. This is highly pertinent to the watchkeeping situation and helps to separate boredom from fatigue and anxiety.

Drawing on information presented in Sections 7.5 and 7.6 allows for examination of the relationship that might exist between mental workload and boredom in fishing watchkeepers.

Table 7.7.1 indicates that significant correlations exist between boredom and workload in all ranks while they are watchkeeping on fishing boats. The relationship between these two variables in both skippers and crewmen corresponds to that which might be expected in that they exhibit reduced levels of boredom as their workload increases (Figures 7.7.1 and 7.7.2). This effect falls in line with DAVIES *et al.*'s proposed relationship between boredom and perceived expenditure of effort (DAVIES *et al.* (1972) - see figure 7.6.1).

	skippers	**mates**	**crewmen**
correlation coefficient	0.76	-0.73	0.95
number of pairs in sample	9	7	9
significant at p<0.05?	yes	yes	yes

Table 7.7.1. Results of Pearson's product moment correlations between self reported boredom levels and % workload.

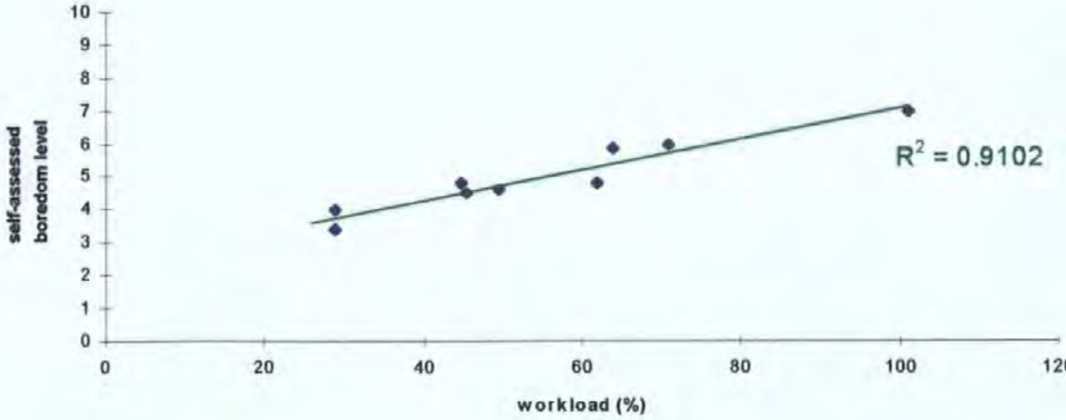

Figure 7.7.1. Workload correlated with self-reported boredom level for crewmen.

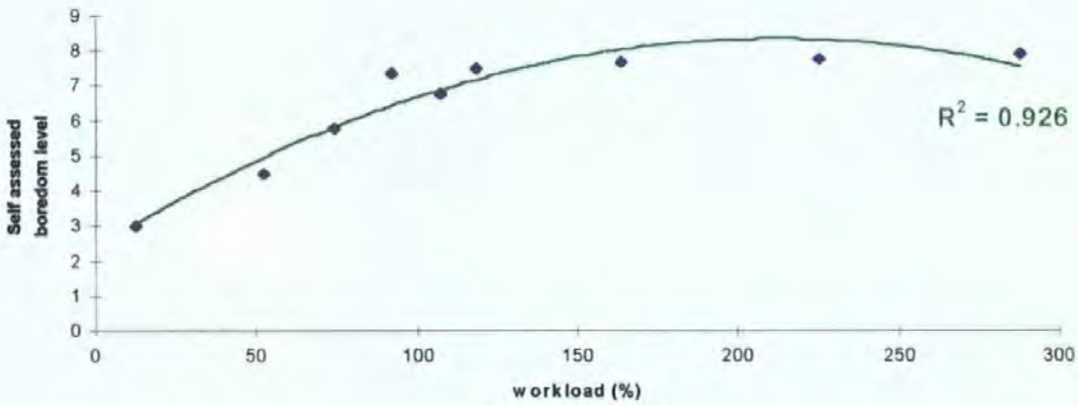

Figure 7.7.2. Workload correlated with self-reported boredom level for Skippers.

The equivalent relationship for the mates on the three vessels used in this study was totally contrary and paradoxically indicated an increase in boredom level as workload increased. This inversion of the anticipated relationship could be related to the tendency for mates to voluntarily increase their workload when feelings of boredom occur, as noted in section 7.5.7. When they begin to feel bored, mates seem to increase the amount of time they allocate to watchkeeping tasks, either to stave off the feeling, or because of the guilt it induces or both. The results of this research suggest that the success of this tactic may be questionable since even though the workload goes up, the feelings of boredom seem to linger on. The critical point is whether the induced increase in attention to navigational tasks increases the efficiency of the watchkeeping system in terms of safety.

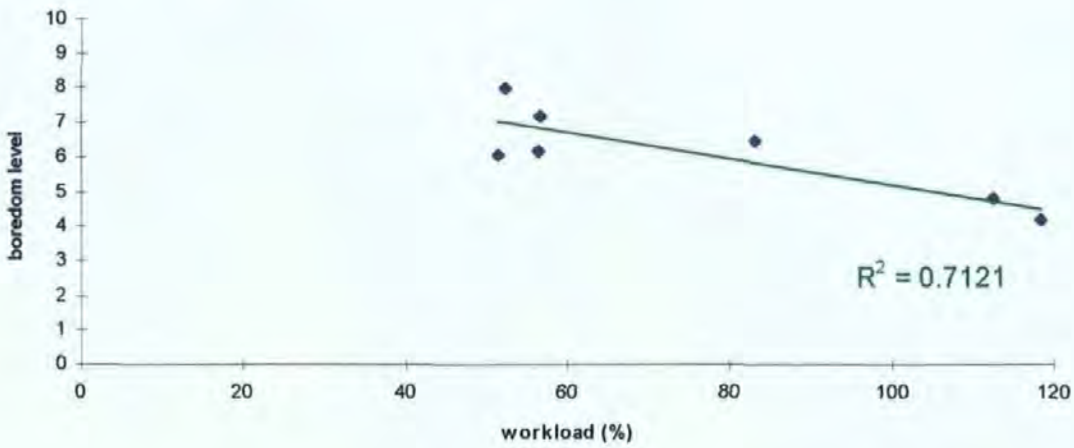

Fig 7.7.3. Workload correlated with self-reported boredom level for mates.

7.9 *Chapter Discussion*

SHUFFEL *et al* (1988) suggest that optimisation of safety and efficiency in ship control is not primarily a case of providing better equipment. In their view, allocation of tasks between men and automated equipment is the critical exercise.

The hypothesis proposed in Section 7.5.3 regarding the focus of attention on the video plotter by crewmen may have its explanation in what has become known as Rasmussen's "SRK framework of task performance" (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 (Figure 7.9.1). The lowest level, skill based performance, is based upon pre-programmed instructions. This would appear to be the level at which crewmen were operating when they were "following the line" on the video plotter. REASON (1990) in discussing his "Generic Error Modelling System" (GEMS), which is in turn based upon the

SRK framework, says that most errors at the skill based level are attributable to monitoring failures. Omitting to perform checks on the system at critical points can lead to a number of end states, which in the watchkeeping scenario could include grounding or collision. At the intermediate level, rule based performance, the mates tackled familiar situations using stored rules of the type, "if P then Q" as well as operating at the skill-based level. The skippers, in addition to these first two levels also operated at the knowledge based level, planning their actions "on line", using conscious analytical processes combined with stored knowledge.

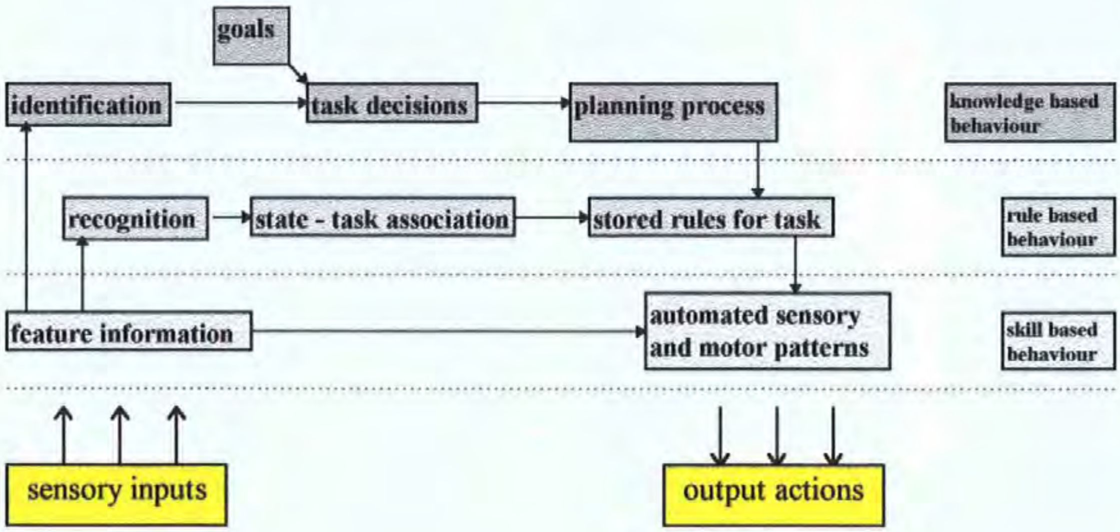

Figure 7.9.1. Schematic model of three diferent levels of human information processing. (Based on RASMUSSEN, 1986)

These differences in conceptual approach to the watchkeeping task feed into attribution of utility to the various sources of navigational information with the result that the skippers were using a completely different set of criteria to decide whether the vessel was in a "safe" situation or not. The general implication of this is that even where the cause of a fishing vessel loss can be squarely attributed to human error, modelling these individual failures cannot usefully be pursued in the absence of a dedicated decision theory model.

The period during deployment and recovery of the fishing gear has been identified as a critical period during which a lone watchkeeper, in the case of this study invariably the skipper, is operating in a state of cognitive overload and is unlikely to be giving the amount of attention that might be desirable to the task of safe navigation. This was probably not however the time during which the vessels (two trawlers and seine-netter) used in this study were most vulnerable since firstly, they were operating some distance from the shoreline and other navigational obstacles, secondly they were not usually moving very fast and thirdly, other vessels could readily see the fishing gear being streamed from the stern and thus knew to keep clear. Certain other types of vessels that compose the UK fishing fleet *do* tend to operate near navigational hazrds - crabbers for example, operating around rocky headlands - and the findings with regard to skippers' workload and capacity could have serious implications for these. In the future, it would be desirable to replicate this part of the research on board a greater range of fishing boats in different operating circumstances.

An estimate of the cognitive overload threshhold for skippers is presented in section 7.5.7, but this may not be suitable for generalising to the other groups of watchkeepers. If the three groups of watchkeepers are approaching the task at different levels it must be accepted that they will have different overload (and underload) thresholds. Beyond this, individuals differ considerably in their subjective reactions to vigilance situations and the attitudes they develop towards the task may well exert some effect upon their performance, (DAVIES & PARASURAMAN, 1982). It is possible that personality influences the kind of attitudes that are developed towards the watchkeeping task although to date, this appears to have received little or no consideration. Other factors that might affect the positioning of overload and underload thresholds are tiredness and the physical environment - heat/cold, noise, vibration, motion, etc. The influence of these could be assessed by compiling timelines for each day of trip to assess whether the pattern changes as the trip progresses and also perhaps, whether a significant difference in pattern occurs when a recognised environmental stressor is introduced into the wheelhouse. The ideal would be to devise some flexible system of watch scheduling that would smooth the peaks and troughs in workload, though undoubtedly this laudable aim would be extremely difficult to achieve in practice.

In 1937, BARMACK's seminal work showed that individuals who experienced the greatest increase in self-reported boredom showed corresponding increases in error rate and a decrease in work output. Many studies have since been pursued with the aim of linking boredom with an increase in the likelihood of human error (BRADBY *et al*, 1993; QUINN & FREEMAN, 1983; DAVIS *et al*, 1983; ENDO & KOGI, 1975). While testing the quality of vigilance and assessing the potential for error has not been directly addressed in this study, the fact that mates seem to react positively using compensatory behaviours, to the onset of boredom may be a contributory factor to the lower incidence of traffic losses that occur when they are on watch. Only 8% of fishing vessel traffic loss events occurred while the mate of the vessel was on watch compared to 47% and 30% while skippers and crewmen were on watch respectively (Chapter 5,). Even when these statistics are normalised to allow for the proportions of watches taken by the respective ranks, fishing vessels still appear to be relatively safer in the hands of the mate than with either the skipper or crewmen. There must nevertheless be limits to this compensatory effort and it could be that a particularly profound decline in performance would follow the breaching of this limit.

The data presented in this chapter suggest that attention allocation, boredom and workload are all factors which may have some bearing in fishing vessel collision and grounding events but that it is probably vacuous to refer to these in umbrella terms as is so frequently done in both official and anecdotal reports. The way in which skippers, mates and crewmen are affected by these and the strategies they employ are varied and may rely on features that are difficult to monitor, such as the individual's conceptual approach to the watchkeeping task.

7.10 Chapter summary

- The pattern of attention allocation while on watch varied between groups of watchkeepers; crewmen allocated their attention in the same way whether the vessel was steaming or fishing while skippers made significant changes in approach.

- Skippers and mates gave disproportionate amounts of attention to the echosounder, mainly looking for fish aggregations.

- Crewmen may be over-reliant on the video plotter, both during fishing watches and steaming watches.

- Different ranks appear to have different concepts of how the vessel's navigation system functions as an entity; this may have bearing on training regimes.

- The results of attention allocation studies can contribute to ergonomic wheelhouse design.

- Mental overload levels can be determined for fishing watchkeepers but underload thresholds are difficult to identify.

- The period during which the fishing gear is being deployed and recovered, the watchkeeper is likely to be operating in a condition of mental overload.

- While on watch, skippers and crewmen exhibit a "sixty minute effect" at which time, although mental workload is not excessive, cognitive processing seems to slow down.

- A professional ethic seems to pervade amongst mates and manifests itself in conscious attempts to increase workload when this falls below a certain level. However there is no evidence to suggest that this leads to better quality watchkeeping.

- The positive response to the onset of boredom shown by mates may be contribute to the lower incidence of fishing vessel traffic losses while they are on watch.

- The workload analysis in this study could be improved by attaching weightings to different components of the watchkeeping task.

- A statistically significant correlation exists between workload and boredom in watchkeepers of all ranks.

- An ideal watchkeeping system would be flexible and smooth the workload peaks and troughs.

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Chapter 8

CONCLUDING DISCUSSION AND RECOMMENDATIONS

"Break, break, break,
On thy cold gray stones, O Sea!
And I would that my words could utter,
The thoughts that arise in me."

Alfred Lord Tennyson 1809-1892

8.0 Introduction

The basis of a doctoral thesis is that its contents should represent an addition to human knowledge in the subject area. The development of a theoretical orientation of research into fishing vessel collision and grounding losses relies on a number of different avenues of research but historically, normative research describing the nature and extent of the watchkeeping 'problem' on fishing boats has been rudimentary and fragmented. The work outlined in this thesis lays new foundations for a coherent approach to addressing some, though by no means all aspects of the problem.

Chapters Three and Four provide a previously unattempted collation of necessary information on the working conditions on board British fishing boats and offers insight into the organisation of, and constraints upon watchkeeping routines. Chapter Five presents a broad analysis of the circumstances in which collision and grounding losses have occurred in the recent past a feature that also does not appear to have been addressed elsewhere but will be fundamental to future work in this area. Chapter Six describes the adaptation of a technique used in other spheres of safety research and applies this for the first time to fishing vessel losses to isolate human factors as the most profoundly influential factor group in fishing vessel collision and grounding losses. Chapter Seven, with its attendant sections, is devoted to providing previously unknown data on the cognitive state of fishing watchkeepers in actual operating conditions, by the use of new and adapted scientific techniques. These can be used in the development of measures of watchkeeping performance which are related to critical aspects of the human element in the system, such as allocation of attention, cognitive overload and underload, and compensation for boredom.

This final Chapter sets out to draw upon the topics covered earlier in the thesis to formulate a concluding discussion, culminating in a series of recommendations.

8.1 Fishing boat safety in a dynamic environment

In Chapter Two of this work it was shown that the size and structure of the UK fishing fleet are dynamic features, having changed markedly over the period since 1975. With severe pressure now being applied by the EU to align the catching capacity of the fleet with the available fish resources, more change is probably inevitable. There are indications from trends in recent data on the size distribution of vessels in the fleet that the future will herald a smaller British fishing fleet, composed of larger vessels, more efficient in fishing terms and more sophisticated navigationally. However, it is equally likely, particularly if overall European fisheries management policy veers towards regional management, that significant numbers of small vessels will continue to constitute a substantial component of the fleet. Whichever scenario develops, it is important that the implications of fisheries management policy for fishing boat safety are fully considered at the inception stage. This consideration should not be based on anecdote but on science and rational discourse, and should be the remit of an impartial authority with no vested interest in the fishing industry.

Before leaving the subject of linking fisheries management with safety management, it is worth considering that although the data on losses gathered for this study have been normalised to the number of vessels "at risk" to give a more realistic view of the relative pattern of vessel losses than is available from official sources, even this is not completely satisfactory. Inter-annual variations in the weather pattern could significantly alter the number of days fishing vessels put to sea in the various sea areas in certain years but the information necessary to retrospectively incorporate this into analysis is not available. This could be easily overcome by harbour control systems in the various fishing ports and fisheries managers both using a PC based recording system, downloading information to a central database. This arrangement may in itself come to pass for fisheries management reasons, particularly if a "days at sea" effort control system is implemented in the UK. It would be desirable however for the database to be available to safety researchers and for it to be appropriately arranged for safety analyses as well as for fisheries management.

8.2 Economic factors affecting fishing vessel safety

No overall connection was found in Chapter Two, between numbers of fishing vessels lost and the availability of money for vessel improvements. This suggests that financial resources allocated by the SFIA in vessel improvement grants might usefully be spent in other areas. In retrospect however, the analysis presented in Section 2.6 could be validated by correlating numbers of vessels lost, with the uptake of SFIA vessel improvement grants, rather than using a notion of the general availability of money available for borrowing.

Philosophically speaking, pursuing a programme of work to recommend ways of reducing fishing vessel traffic losses is actually quite illogical. After all, the loss of a fishing vessel may involve injury or loss of life, immediate financial loss and loss of possible future earnings, and may even lead to criminal prosecution. What more compelling incentives could be added to this list that would make watchkeepers more attendant to their duties? If one is to accept that increasing the likelihood of any of these penalties will act as an incentive to better the quality of watchkeeping, then the corollary - that decreasing their likelihood will impinge on the quality of watchkeeping - should also be considered.

The possibility of the watchkeeper promoting death or injury to himself through lack of care and attention quite probably does have a constant positive effect on his performance, as do the recent high profile punishments meted out by British courts to negligent and reckless fishing watchkeepers (*see for example* FISHING NEWS, 1996). Transferring the cost of groundings and collisions away from the owners of fishing vessels, who are in a great many cases the skippers, through the medium of marine insurance on the other hand radically reduces the financial cost of involvement in these events. Although no direct evidence has been presented in this thesis and this hypothesised effect has not to the Author's knowledge been quantified elsewhere, it would clearly not be rational for a vessel owner who felt that his watchkeeping regime was infallible to "waste" money on insurance to cover collision and grounding risk. It would be an impractical but nevertheless academically interesting proposition to test whether the numbers of fishing traffic losses would decline with marked effect if insurance provision for these risks were suddenly withdrawn from every vessel in the fleet. What does flow from this theorising is that the fishing vessel insurance companies are clearly an under-utilised means of exerting pressure on fishing vessel owners and skippers to tighten-up watchkeeping regimes and ensure that the performance of individual watchkeepers is up to scratch.

8.3 The need for a comparitive research approach

In Chapter Five the disproportionately high number of collisions and groundings that have occurred in the Central North Sea area was discussed and though some reasons for the collision rate were proposed in the Chapter Discussion, these were somewhat tentative. The following Chapter outlined a causal analysis that established human factors as the most important causal group by far in these types of losses. Logic would therefore dictate that finding a reason for the relatively high number of traffic losses in the Central North Sea could best be pursued through study of the prevailing watchkeeping systems and the behaviour and mental state of watchkeepers who operate in that area that might predispose them to invovlement in these events.

When it became apparent during the course of this research that the Central North Sea had a higher than expected traffic loss rate, the Author proposed to further examine MAIB records of collision and grounding losses that have happened there, to see if any common features, particularly one that are human factors related, could be identified. Unfortunately, for administrative reasons, access to these records was denied. One of the vessels taking part in the observation programme was operating in the Central North Sea but insufficient data was accrued to make any authoritive comparisons between the watchkeeping system and watchkeeper behaviour on board it and the same features on board the two vessels operating in other areas. Further research directed specifically at a compartitive study of watchkeeping practise in different areas would clearly contribute to better understanding of this situation.

8.4 Risk homeostasis in the UK fishing fleet

Historically, the bodies charged with working to reduce the numbers of fishing vessel losses have focused on technical solutions. The result is that "fishing vessel safety" has typically been reduced to specification of minimum acceptable standards of design, equipment and lifesaving apparatus. Until quite recently, little attention has been directed at improving the reliability of the human component of the system. It is therefore ironic that foundering and flooding losses, normally associated with technical and equipment failures, have shown an increase in number while traffic losses, shown in this Chapter Six of the present study to flow mostly from human error, have decreased over the last twenty years.

WILDE (1982) proposed a theory of "risk homeostasis" which states that wherever technological improvements are made to a system that increase its inherent safety level, the users of that system simply adjust their behaviour to return risk to its earlier setting. The theory has provoked considerable controversy amongst eminent writers on road traffic safety, (for example, GRAHAM,1982; McKENNA,1982; EVANS, 1986) but no reference to its application in marine situations could be found in the literature. This theory, which draws on both engineering and motivational factors, is worthy of consideration in relation to the data on fishing boat losses.

Risk homeostasis appears plausible with respect to fishing vessel losses when only foundering and flooding losses are reviewed. In Chapter Two, these were shown to increase by 10% over the study period in spite of the implementation of numerous measures aimed at their mitigation. Proponents of the risk homeostasis theory would contend that highly visible and much vaunted technical measures introduced over the last 20 years will have incited fishermen to "drive their boats harder", for example by travelling further, making longer trips and working in worse weather conditions than before. There were however, also great advances in navigation technology over the same period yet there was a concomitant 14% reduction in collision and grounding losses. This clearly undermines the theory, although it could be argued that the fitting of a watertight shelterdeck is more likely to induce a fishermen to work in bad weather than the latest chromoscopic radar system is likely to induce him to reduce his assessment of the closest acceptable point of approach to other vessels.

Central to the risk homeostasis theory is the idea that those in control of fishing boats will in some way attempt to maximise the "utility" offered by a known safety advance on their vessel. A compelling argument against risk homeostasis in fishing vessel watchkeeping is that the level of risk will change with regard to collision and grounding during the course of any given fishing trip. Both collision and grounding risk for example will increase considerably when a vessel approaches a busy fishing port in a craggy, reef-strewn bay but it is difficult to see what action a watchkeeper could take at these times to equalise the risk per unit of time here with that existing when the vessel is steaming in uncrowded waters far from shore. So far as collision and grounding is concerned, the Author has for the moment at least, joined the ranks of those sceptical of the risk homeostasis theory but there is clearly room for more detailed testing of its application in fishing boat safety.

8.5 Watchkeeper behaviour

It was conceded in Chapter Four that a VQ system is probably the most suitable medium for watchkeeper training in the UK fishing fleet. As the VQ regime gradually subsumes the old ticket system, it may bring forth an improvement in watchkeeper performance since this is what is tested in the VQ assessment regime, but it will not necessarily change watchkeeper behaviour.

SANDERS & McCORMICK comprehensively reviewed human factors in engineering and design (SANDERS & McCORMICK, 1992) and concluded that the efficiency with which information on hazards and the best way to avoid them (for example, good watchkeeping practice and adherence to the Collision Regulations) is communicated can modulate the level of safety in many industrial situations. In a number of cases of fishing vessel collision and grounding loss events however, the person on watch understood and usually observed the principles of good watchkeeping but failed to apply these at a critical time. Inefficient communication cannot account for this group of incidents so it is important to consider some of the other, less obvious factors that might be responsible.

The first of these was exemplified in Chapter Four where it was established that the fishermen's subjective assessment of collision and grounding risks and their actual status are not necessarily linearily related and that their perceptions are prone to influence by awareness of recent events. In the course of observing watchkeeping behaviour in the working environment, it was noted that watchkeepers who although too tired to perform effectively, would rather risk an unlikely yet possibly catastrophic collision occurring while they had fallen asleep on watch than the mild vilification they might suffer at the hands of their crewmates if they declared their lack of fitness for duty. This concurs with earlier research findings using data relating to marine accidents where merchant ship crews disregarded rules in a way that tended to minimize what they perceived to be mildly unpleasant, high-probability events at risk of accepting highly unpleasant though low probability events (ZEITLIN,1975).

SLOVIC (1978) suggested that the perception of control increases the willingness to assume risk and STARR (1969) argues that an individual's propensity to take risks is not based on a differential assessment of the possible outcomes but on the level of utility that comes from accepting the risk. During observations on board the vessels taking part in this study, there were a number of occassions where the watchkeepers decided that although contrary to good practice, their perceived degree of control was adequate for them to leave the wheelhouse unattended for short periods and the utility of a fresh cup of tea or visit to the toilet over-rode the risk inherent in having no-one in the wheelhouse.

The data gathered for this study seem to support earlier substantive arguments for accepting that human behaviour is not determined by objective risk but by subjective estimates of it (e.g. HOWARTH, 1987). It would therefore seem fitting that any watchkeeper training programme should include measures to make risk assessment more objective. Research into fishing vessel traffic safety should also take account of both subjective assessment of risk and of the way in which watchkeepers respond to this.

One of the key outcomes of this research is the finding in Chapter Seven that keeping watch is a task that different ranks - skipper; mate; crewmen - appear to approach in different ways and furthermore that the same ranks approach the task differently according to the phase of the fishing cycle. The significant divergence in the patterns of attention allocation, exhibited by both mates and skippers between fishing and steaming phases of the fishing trip, suggests that they integrate the roles of lookout and helmsman with their other respective watchkeeping responsibilities quite differently.

Appraising potential solutions to collision and grounding loss of fishing vessels presents special problems since analytical assessment requires predictive models of human performance and these do not seem to be particularly well developed. Modern marine electronic equipment has allowed, both technically and economically, for the development of complex control systems which have meant that, even on small fishing boats, many of the well formulated tasks are commonly automated. The observation programme outlined in Chapter Seven showed that the level and recency of training seems to affect the way in which information from the equipment forming the navigation system as a whole is drawn and assimilated by fishermen. The implication for assembling the watchkeeping and navigating systems on fishing vessels is that designers should aim to produce a clearly defined field within which the operator may adopt effective strategies which can only be generalised, not specified, at the design stage. Advanced technology provides system designers with the power to select both the appropriate information for display and the most suitable means of offering it to the watchkeeper and some research has been done in this area (MILLS, 1996; SHUFFEL *et al*, 1989). These works have not however been accompanied by complementary analysis of the cognitive and mental approach of watchkeepers, so the recommendations may be inadequate and in many cases leave the watchkeeper no better off than if less sophisticated technological aids were in place.

An informed decision needs to be made about whether this situation is best tackled through changes in "liveware" (training and education) or "hardware" (more suitable design and layout of equipment), or both. This would require dedicated research to be directed at the earliest possible juncture towards investigation of how trained and untrained fishermen perceive the individual components of the navigation system and how these complement and interact with each other. Such research could be pursued using a suitably equipped navigation simulator but would need to be validated by observations in the operational setting along the lines of those illustrated in the present study. With appropriate input from psychologists this approach may offer insight into how best to design training regimes to improve understanding, particularly by untrained crewmen, of increasingly sophisticated systems.

At this point in the thesis, a general rule of scientific writing - that of not introducing "new" material in the final discussion - is about to be broken. This is because the discussion moves to a sensitive area for which the evidence is nebulous but which might or might not be a factor of contemporary importance in fishing vessel collisions and groundings. It has been established beyond all reasonable doubt that using alcohol increases the risk of a driver crashing his car (MOSKOWITZ & ROBINSON, 1987) and this doctrine probably applies equally to the lone watchkeeper on a fishing boat. Comparitively little of a specific nature is known of the effect of drugs, particularly illegal ones, on driving (SIMPSON, 1987) but the canon of rational discourse dictates that the prospect of drug use among watchkeepers is also a matter of concern. In the course of research for this thesis, the Author did not witness the use of alcohol or illegal drugs on board any of the vessels on which he sailed. This is not to say that the use of these substances is not a feature on board some British fishing boats but it is the Author's opinion that these problems are grossly exaggerated in anecdotal comment.

Far fewer fishing boats carry bonded stores now than used to in the heyday of the distant water fishing fleet in the middle part of the century, and the crews of those that do are motivated more by access to cheap cigarettes than to beer and spirits (*Pers. Comm.* with numerous fishermen, 1996/97). In fact most liquor is not consumed at sea but hidden from customs officers when the vessel docks, to be divided up among crews and illegally taken home. The paperwork involved and the ritual of having to wait for the arrival of customs personnel to perform their sealing duties at the end of each trip is more trouble for most present day skippers than it is worth (*Pers. Comm.* Mr Alan Mutch, General Manager, Fraserburgh Inshore Fishermen Ltd., 1997). There is still the problem of a vessel setting sail with some of the crew inebriate from drinking ashore and while this was certainly a problem in the heyday of the distant water fishing fleet in the 1950's and 60's, it is difficult to guage the importance of this as a factor in collisions and groundings in the present day fleet.

The potential problem attached to the increasing use of illegal drugs in the UK in general, particularly deserves comment in this study for if drugs have also found its way onto fishing boats, their effect on the short term behaviour and long term mental and physical wellbeing of watchkeepers could develop into an important factor in collisions and groundings. Talking to fishermen around the UK about the issue of drugs on fishing boats raised comments ranging from "its an epidemic" to "there isn't a problem". The concensus of opinion seemed to be that wherever a skipper becomes known to tolerate the use of drugs, this will attract local drug using fishermen whenever crewing vacancies arise. This seems to lead to the creation of extremely isolated instances where vessels which have become known in the fishing communities of North-East Scotland, for example, as "hash packets" - for obvious reasons. There is probably a very strong case for research to be directed in the very near future towards establishing the extent and type of drug and alcohol misuse on fishing boats, but gathering information that is truly reliable will require a very subtle approach.

8.6 The mental state of fishing watchkeepers

Researching the human element of fishing systems, in the the real working environment is a new area of work and although a relatively small sample has been used in this seminal study of the watchkeeping system, a number of important factors relating to the cognitive state of fishing watchkeepers have been investigated.

Since its first appearance in the UK fishing fleet in 1984, the video track plotter has become one of the most widely adopted items of electronic equipment in fishing boat wheelhouses. Its attraction to fishermen was obvious, superseding its mechanical predecessor which relied on clumsy rolls of plastic film which quickly became messy and inoperative because of tears in the traction holes at the sides, with a disc information storage system which holds large amounts of seabed information in easily copied form for transfer between skippers. Unfortunately, largely because of its readily understandable display, the video plotter has since become incorporated into common use as a navigational aid, a purpose for which it was not really intended. The results of the analysis of attention allocation in Chapter Seven show that fishermen, unqualified crewmen in particular, narrow the focus of their attention while on watch to the plotter display to the extent that other important watchkeeping functions are neglected.

Reliance on the video plotter has not been directly tested in this research but given that it is the focus of attention for many watchkeepers, it is probably safe to declare that certain groups of fishermen are indeed "reliant" upon video plotter displays. This is something that has become well known, indeed the MSA issued an M.Notice (MSA, 1996) warning of their limitations, but prior to this research no attempt had ever been made to test the actual extent of this reliance. There is little doubt that this is a problem that requires to be urgently addressed, though whether the issue of an M.Notice will have any measurable effect is open to question. As HAWKINS (1987) points out;

> "*in attempting to reduce human error, that is, to modify human behaviour, on a long term basis, exhortation alone is of little value*".

Pragmatically speaking, there are two options for dealing with the plotter reliance scenario; change the machine or change the man. The first of these would involve the development of a video display which overlays a range of other congruous information on to the simple track display. It is technologically feasible to include radar targets, depth display, fishfinding information and systems monitoring data on the same screen, and such systems are available but these are very costly items and there is no guarantee that the video plotter devotee would actually draw a more complete concept of his operating environment than he does at present. He may still direct his cognitive powers toward simply "keeping the dot on the line". The second options seems far more expedient and would be considerably cheaper. It could be achieved by including in even the most basic training courses, some coverage of the ways in which navigational tasks - tracking using the video plotter, cross-checking with position fixing means, analysing the radar display, even looking out of the window, complement each other as components of an integrated system. This would help to foster more awareness and familiarity with the tasks involved in watchkeeping and lessen the tendency for narrowing of attention to the plotter screen.

The narrowing of the focus of attention in crewmen may be a contributory factor to their proclivity to feel bored more readily than either mates or skippers. By validating self-reported boredom using time estimation, it is possible to conclude that crewmen really are feeling the effects of monotony. At the same time, the research shows that crewmen consistently had the lowest workload level while keeping watch.

Mates on the other hand also felt bored but appeared to respond by voluntarily increasing their workload. This did not seem to reduce their feelings of boredom particularly well, but the critical question is whether their level of vigilance was raised by this tactic. The results of the Stroop Task, administered to mates at the same time, show improved response times as the watch progressed although because of the small sample size, the correlation between Stroop results and workload were not statistically significant. In Section 4.8, it was shown that mates were on watch at the time of only 8% of fishing vessel collision and grounding losses, while crewmen were on watch at the time of 30% of these. Thus, while this research has not provided direct evidence, there is nevertheless a very strong circumstancial case for accepting that watchkeepers who "find things to do" when they feel bored are safer than those who do not. The logical conclusion is therefore that skippers should consider giving crewmen extra tasks, not necessarily related to navigation, to pursue while they are on watch, particularly when the vessel is steaming.

Motivation is a human factor that has not been directly considered in this study although the results of the various sections in Chapter Seven allow some related comments to be made. SENDERS (1977) proposed that motivation controls the fraction of capacity that is devoted to any given task; i.e. that high motivation induces the use of a high fraction of capacity and improves performance while low motivation limits capacity and consequently causes a situation of overload at low levels of task demand.

It is highly likely that the skippers, invariably also part-owners, who took part in this study were because of their responsibilities for overall safety of their vessels and making sure that enough fish were caught to make the trip viable, more highly motivated than the crewmen. Senders' hypothesis is borne out in the results of the correlation of Stroop task results (a measure of capacity) with workload, as it is defined in this study. At a workload of 80%, the mean Stroop response for crewmen was almost 0.5 seconds over baseline but skippers were, on average, responding well under (-0.2 seconds) their baseline at the same workload level. It may therefore be hypothesised that for fishing watchkeepers, the true amount of cognitive capacity available at any given time (C_a) for application to watchkeeping tasks is actually the product of the maximum amount of cognitive capacity that particular watchkeeper could possibly give (C_t) and a motivation factor (M) valued somewhere between 0 and 1 (*equation 3*).

i.e.

$$C_a = (M \,.\, C_t)$$

Equation 3

The implication is that it would be possible to improve the performance and presumably therefore safety of watchkeepers by increasing their level of motivation, particularly where the watchkeeper is operating at a low workload level. There are ways in which this could be achieved, for example by increasing the level of involvement of crewmen, whose workload levels during watchkeeping are lowest, in formulating a watchkeeping policy for the vessel they sail on. This idea is developed later in this chapter.

The Time Line Analyses reported in Chapter 7 provide a plausible guide to the levels of workload experienced by the skippers and crewmen on the vessels used in the study though much larger samples would be required to offer definitive TLAs. Correlating workload with cognitive capacity is a credible means of determining the overload threshold but again, much larger samples would be needed to provide a truly meaningful analysis. By virtue of this study being carried out in the field, it has not been possible to test whether, at the proposed overload levels, the watchkeeper had actually broken down as a functioning component of the navigation system. Laboratory experiments, using simulators could be designed to test this aspect by contriving a similar set of extended Stroop responses and presenting the watchkeeper with a critical navigational situation. This would also provide information on the extent of individual differences in overload tolerances.

It has long been recognised that man's performance of tasks requiring him to detect infrequent events over long periods is poor. In 1943, the Royal Air Force commissioned laboratory tests to determine the optimum watch length for radar operators on anti-submarine patrols. The results highlighted a phenomenon which became known as the "vigilance effect" (MACKWORTH, 1950). This was a marked deterioration in the performance of observers that consistently appeared after about thirty minutes. Since then, many other industrial studies have revealed a similar effect, although this is usually task-dependent and modified by differences between individual subjects. It has also been shown that experience and practice are not effective in eliminating the vigilance effect (DAVIES & PARASURAMAN, 1982). It was postulated in Section 6.6.7 that the skippers and crewmen observed in the present study exhibited a "sixty minute effect" where although the workload appeared relatively stable, extended Stroop Task responses indicated a marked increase in the time taken to process information.

The "quality" of vigilance was not directly tested in the present research so it is not possible to say whether this was compromised in accord with the onset of this extension in information processing time. It is also true to say that cognitive capacity did appear to improve as the watch breached the two hour mark, however this may have been due to subjects getting better at doing the Stroop Task rather than their undergoing an information processing renaissance. If this effect is intimating the existence of a sigmoid relationship between time and vigilance effectiveness, the implications for vessels operating watch durations in excess of two hours are obvious. The data presented in Chapter Four show that watchkeepers on fishing vessels operating in the waters around the southern half of the UK in particular, are regularly spending up to six hours on duty alone at one time, both while fishing and steaming. There do not appear to exist any UK guidelines regarding the length of watches on fishing boats but given the questions raised by this study, further dedicated research to provide these would clearly be desirable from a fleet safety point of view.

The astute reader may by now have begun to wonder why this research has not yet included some overt attempt to assess the role of fatigue in fishing vessel collisions and groundings. While it may indeed be a factor in this type of event, fatigue is an abstract concept that is almost impossible to define, let alone test in a rigorous scientific experiment. Feeling 'tired' may be common among fishing crews but does not necessarily correlate with degradation of watchkeeping performance. In a famous experiment in 1955, CHILES (reported in HOCKEY, 1983) had subjects perform continuously in an aircraft simulator for as long as 56 hours without rest, with the exception that they were periodically required to be tested on a tracking task. Towards the end of the experiment, some of the subjects were so exhausted that they had to be carried from the simulator but their tracking scores were nevertheless well within normal limits. Strenuous physical activity has also not been conclusively shown to have detrimental effects on performance in vigilance tasks similar to fishing vessel watchkeeping (DICKINSON, MEDHURST & WHITTINGHAM, 1979).

As long ago as 1921, it was argued that the concept of fatigue should be abandoned (MUSCIO, 1921) and it is the Author's contention that so far as fishing watchkeepers are concerned, fatigue is not a factor in itself; rather a synthesis of other factors, some very obvious such as lack of adequate rest and some cryptic like cognitive underload and boredom. Studies such as this one, which examinine the constituents of fatigue may therefore be the only profitable way of moving forward in attempting to assess its influence on watchkeeping performance.

8.7 Risk-based and systems approaches

The term, "safety" has been starkly defined by the British courts as, "*the elimination of danger*" (Latimer -v- AEC Ltd., 1953); "*danger*" being intended to embrace both the probability of an undesireable event and its possible consequences. More recently, the International Standards Organisation (ISO) has pursued a more considered definition of the same term in the wording; " *a state of freedom from the unacceptable risk of harm*" (FIDO & WOOD, 1989). Implicit in this second definition is some attempt to assess the level of risk being linked to empathy for operational circumstances. Adjusting the level of collision and grounding safety among fishing boats therefore requires manipulation of this "state" by making watchkeeping systems and their component parts perform in a more predictable manner but with due respect for the inherent constraints of commercial fishing.

Although it is seldom admitted publicly, major, high-profile loss events have frequently provided the impetus for action by regulatory authorities in respect of maritime safety (LANDMAN, 1995). Unfortunately, while this tends to calm immediate concerns there is often a knock-on effect of those in the industry being affected by the hefty financial cost of preventing a future event that in reality has only a slim chance of occuring. An alternative to this traditional, prescriptive approach is one that is "risk-based", taking a holistic approach and including the human component as part of the system. Recent UK legislation in other spheres of industrial safety have tended towards this latter approach with greater use of systems concepts such as "risk management" and "risk assessment", for example the *Control of Major Accident Hazards Regulations, 1984* (CIMAH) and the *Control of Substances Hazardous to Health Regulations, 1988* (COSHH). The application of systems management, risk-based decision making in particular, certainly warrants consideration in relation to fishing vessel watchkeeping safety.

A clear starting point for the risk-based approach in terms of targeting action to reduce collision and grounding losses in the fleet as a whole would be to identify the type of vessels that are most vulnerable and in what circumstances they become so. The results of the research outlined in Chapter Four can be used to create "typical" event scenarios for collisions and groundings, either of which lead to the loss of a British fishing boat.

Typical collision scenario

A vessel lost in a collision event is most likely to be over 24 metres long but of no specific age. The collision will probably have occurred while the vessel was steaming on a Thursday or a Sunday, sometime between May and October. The most likely venue for the event would be the central North Sea and the skipper will have been on watch if the visibility was reduced. If the visibility was good, then a crewman was most likely to have been the watchkeeper.

Typical grounding scenario

The "typical" fishing vessel to be lost as a result of grounding will be between 12 and 24 metres in length and will be likely to be over 20 years old. She may have run aground at any time of year but it will probably have happened at the weekend, quite possibly on a Saturday when there was very little other fishing traffic around. The grounding will most likely have taken place either between Rattray Head and The Wash on the East coast of the UK mainland, or off the Scottish West coast. It is most probable that the skipper will have been on watch in fairly good visibility although where the visibility is poor, a crewman may have been on duty. In neither scenario was the mate likely to have been on watch.

With information similar to the above, made more comprehensive by analysing a larger data set which would probably need to include serious casualties and near misses, it would be possible to begin to consider interventions, for example in the human element, which would act as a mitigating features in the identified situations where the highest level of inherent risk prevails. This approach offers a starting point from which safety could be increased without necessarily saddling fishing boat operators with heavy financial costs.

The IMO Maritime Safety Committee (MSC) has recently endorsed the application of what is termed, "Formal Safety Assessment" (FSA) (CANTER, 1997) for use in the field of merchant shipping. This is a risk-based approach to maritime safety which proceeds in five identifiable steps. Much of the data presented in this thesis could contribute to FSA for fishing vessel safety in general and of course, particularly for the traffic safety of fishing boats. The research methods used also have potential for future use in FSA. The relevant aspects of this study are related to the FSA process in Figure 8.7.1

There is also considerable scope for the implemtation of the systems concept at the level of individual vessels. There does not seem to be any reason why vessel owners should not be requested to produce a "Statement of Watchkeeping Policy" (SWP), based on the completion of a standard form, which reflects a commitment to safety and would also support the control of the watchkeeping system. The SWP would set clear guidelines for the way in which watchkeepers should interact with task-offloading aids, such as the autopilot, radar alarm, video plotter, etc. and could form part of the programme of periodic assessments presently carried out by MSA surveyors to see whether a fishing boat meets the requirements of the *Fishing Vessels Safety Rules, 1975.*

The SWP would take implicit account of factors such as boredom and tiredness to ensure that workload and system performance are maintained at a level which is not necessarily optimum, but acceptable in the specific operational circumstances of each vessel. Such a feature would represent a proactive rather than reactive control on the human element which is both consultative and achievable at minimal cost to vessel owners. A SWP flow model is shown in Figure 8.7.2. The components of this model could provide a basis for the development of a *pro forma* which would be completed by the vessel operator at regular intervals. Doing so would force both owner and crew to consider the watchkeeping system and become involved in maintaining and improving its quality. Following an extensive survey, a Confederation of British Industry (CBI) report in 1990 highlighted the need for all workers in an organisation - in this case, the whole crew of a fishing vessel - to participate in solving safety problems, in formulating safe working procedures and in developing a "safety culture" (CBI, 1990). This report observed that in practice, safety

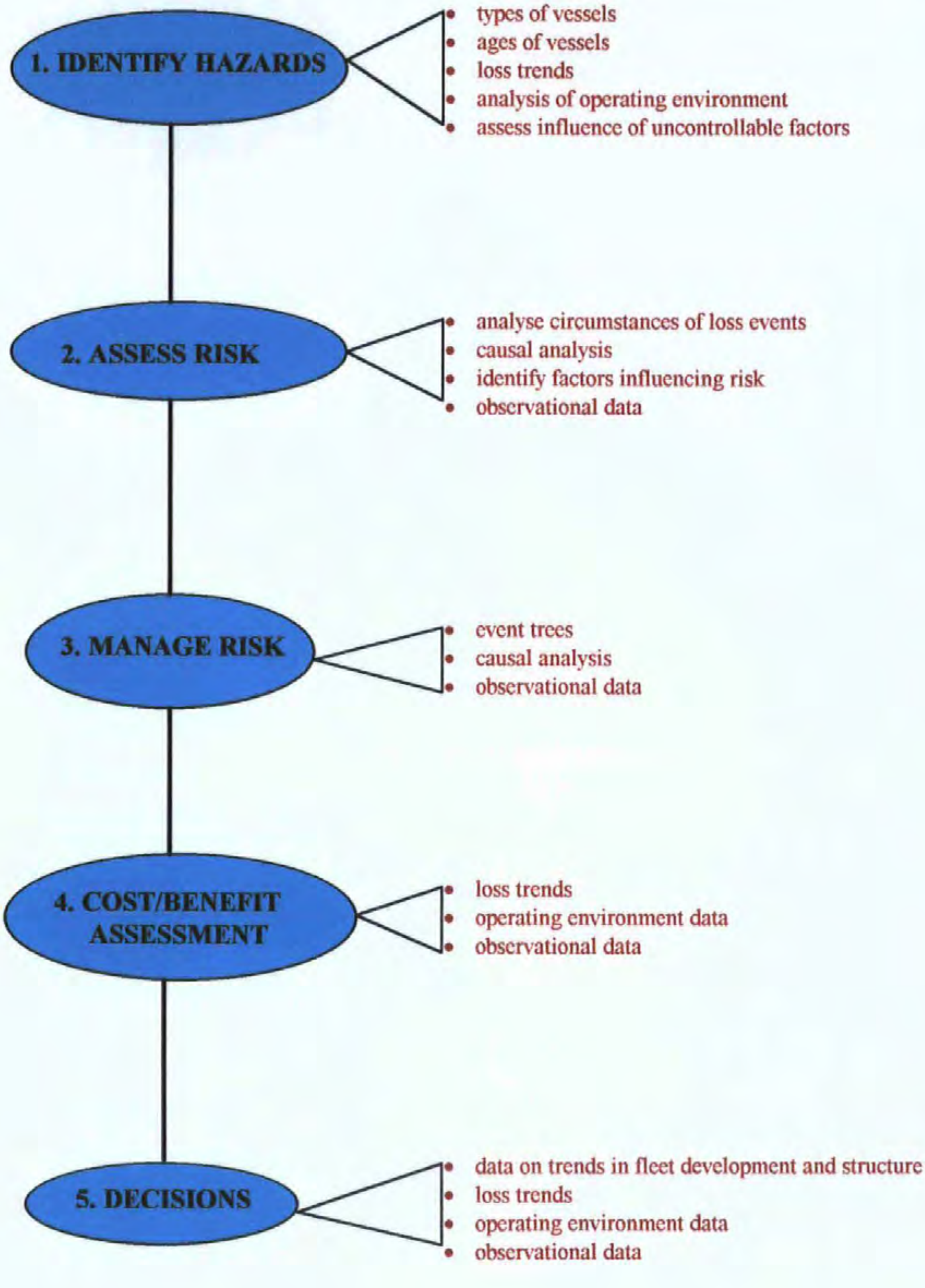

Figure 8.7.1. Aspects of the present research (red text) that could contribute to a *risk-based* approach to reducing collision and grounding losses in the UK fishing fleet.

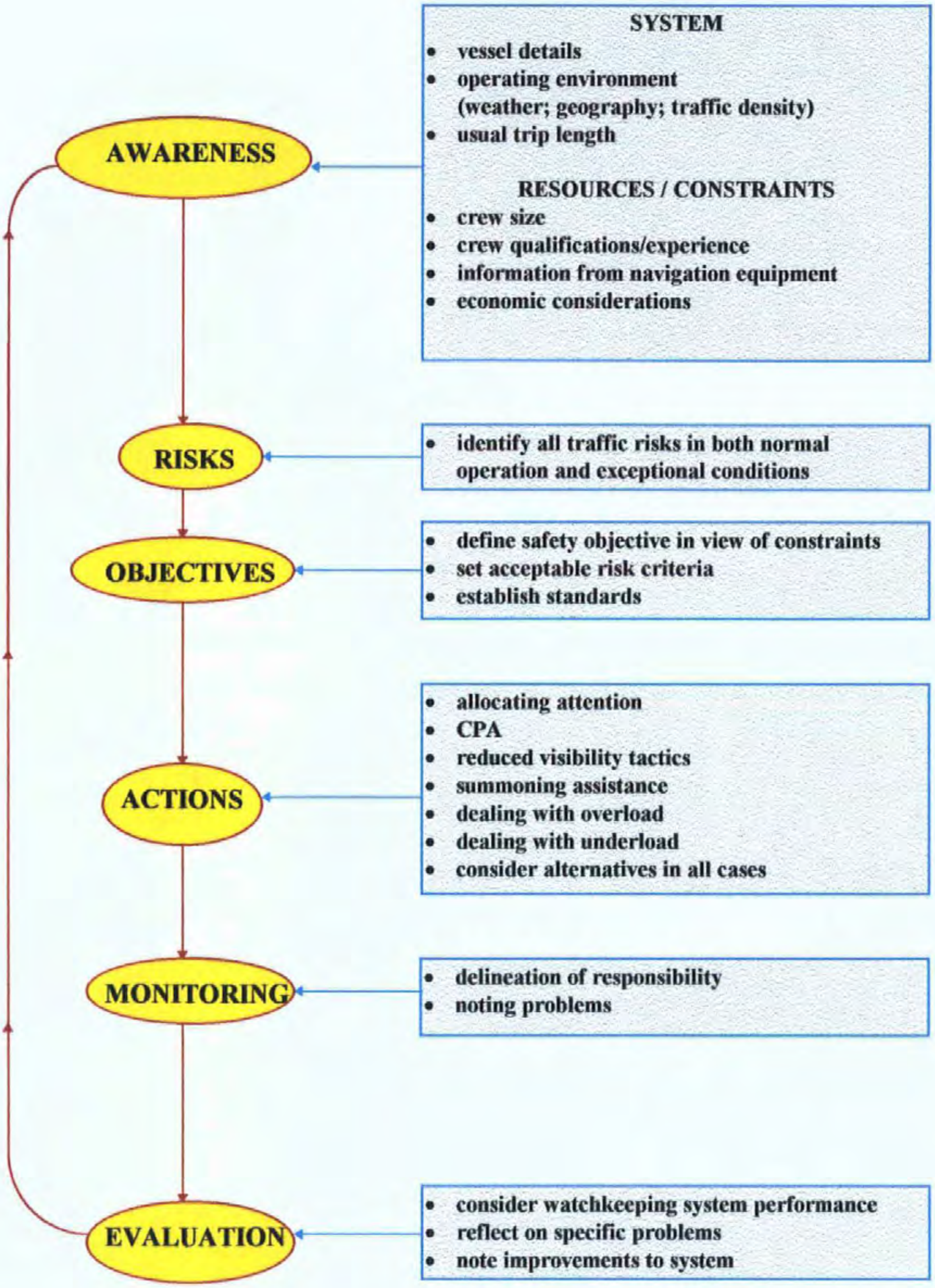

Figure 8.7.2. Flow model to illustrate basis of *Statement of Watchkeeping Policy*.

standards can only be upheld where the people involved in carrying out responsible tasks do so with an explicit interest.

8.8 A strategic approach

The results of the causal analysis in Chapter Six show that so far as collisions and groundings are concerned, removing or substantially reducing the instance of human error is probably the most effective route to reducing losses. While it is true that some national steps have been taken in attempt to reduce the instance of human error in watchkeeping (publishing of MAIB Investigation Summaries and highlighting of the need to maintain an effective lookout in M. Notices, as examples) their effect is not directly measurable and they seem to have been released on an *ad hoc* basis. On the training side there is the planned implementation of a national VQ system but this does not appear to form part of any overarching strategic approach by the UK authorities, emanating rather from external international initiatives such as the STCW-F.

A more positive approach has been taken in the USA, where the Office of Marine Safety and Environmental Protection and the Office of Navigation Safety and Waterway Services chartered what became known as the "Prevention Through People", Quality Action Team (QAT) to develop a long term strategy specifically aimed at preventing casualties caused by human error (SAFETY AT SEA, 1996). The QAT's report examined the extent of human error in marine transport, including fishing boats, and attempted to find out why it persists. Based upon its findings in these important respects, the QAT developed a strategy to focus effort on preventing human error and recommended an implementation plan which was both participatory and systematic.

The strategy revolves around four key elements;

- *national and international collaboration between interested bodies to address human error from a systems perspective*
- *using risk management methods to arrive at cost-effective preventative measures*
- *including human error assessments as part of standard safety inspections*
- *improving the collection and analysis of data*

The "participatory" element of the initiative is based on close liaison with industry which includes testing and validation of the research methods employed on board working vessels. Another key feature is that establishing the level of risk from human error is to be pursued regionally as well as nationally because in the USA, as the present study has shown in Chapter Five to be the case for the UK, this varies from region to region for different types of risk.

Other than cost there seems to be no reason why a similar scheme, even in a dilute form, could not be put in place in the UK. In fact, if the potential savings from losses prevented were reckonable in a cost/benefit analysis, it may be that such a scheme could easily pay for itself. After all, with a new 30 metre demersal trawler costing as much as £2 million and a new pelagic tank ship costing up to £12 million, very few of these types of vessels would need to be preserved.

8.9 Principal conclusions

1. *The implications of fisheries management measures for the safety of the fishing fleet should be considered at the inception stage. Any future database that is to be set up for fisheries management purposes should also be capable of supplying information for safety studies. Safety researchers should therefore be involved in the early stages of the development of such a database so that information can be drawn from it in a format that lends itself to their work.*

2. *Marine insurers are a presently under-used means of encouraging fishermen to adopt a more safety oriented approach to watchkeeping management.*

3. *A comparitive study of the human element in watchkeeping systems may offer insight into why the Central North Sea exhibits a higher than expected rate of fishing vessel collision and grounding loss.*

4. *Research should be instigated to further assess the applicability of the 'risk homeostasis' theory to fishing vessel collision and grounding losses. Knowledge of how subjective assessment of risk affects behavioural feedback could provide valuable information to safety legislators and training authorities.*

5. *Fishermen's training schemes should include material designed to help fishermen make more objective assessments of risk with regard to navigational safety.*

6. *Designers of fishing vessel wheelhouses and those responsible for compiling training material should be made aware that there may be a number of different levels of*

conceptual understanding of navigation systems among fishermen. Wheelhouse equipment should be selected and laid out in a way that allows the least qualified and experienced watchkeeper to understand how the navigation system 'fits together'. More importantly, training schemes must aim to foster understanding of how to use the various high-tech (particularly the video plotter) and low-tech components (such as looking out of the windows) of the navigation system to achieve a complete and validated picture of the navigational environment.

7. *Research should be commissioned to establish whether alcohol and drug abuse is prevalent on board fishing vessels and if it is, to what extent.*

8. *Consideration should be given by skippers to allocating extra duties to watchkeepers, particularly crewmen during steaming watches, in order to suppress reductions in cognition resulting from boredom.*

9. *Experiments using navigation simulators should be commissioned to confirm that overload and underload thresholds exist for fishing watchkeepers. Thses experiments should also be designed to ascertain whether the overloaded or underloaded watchkeeper has actually 'broken down' as a functioning component of the navigation system.*

10. *The results of the present study indicating that there may exist a vigilance decrement in fishing watchkeepers should be used as a foundation for further work in this area. This could yield information on which guidance on the maximum duration of watches on fishing boats could be based.*

11.Systems concepts such as 'risk assessment' and 'risk management' should be considered for use both in defining appropriate approaches to overall fishing fleet traffic safety and for arriving at suitable safety strategies for individual vessels.

12.A mandatory requirement to produce a 'Statement of Watchkeeping Policy' (SWP), based on individual risk assessment, should be introduced into the UK fishing fleet. The SWP should be drawn up by the owners in consultation with skipper and crew; this will give a sense of involvement, increasing motivation and fostering the development of a 'safety culture'. This could represent a meaningful contribution to marine traffic safety at minimal cost to fishing vessel owners and could be actively promoted by fishing boat insurers to guarantee its rapid acceptance.

13.An overarching fishing vessel safety strategy to combat human error urgently needs to be developed by government for the UK fishing fleet, along the lines of the US Coastguard 'Quality Action Team' (QAT) initiative. Given the first cost of modern fishing vessels, this could prove to be a cost effective arrangement.

8.10 Epilogue

In theory at least, it should be possible at any time to take a cross-sectional view of the watchkeeping situation on a vessel and forecast a range of possible future states by predicting the actions and effects of system and watchkeeper and also influences from outwith the system. Compiling a system that takes account of as many of these factors as possible, however improbable they may seem will clearly lessen the chances of a catastrophic collision or grounding, provided that all of the system components proceed to function properly. Unfortunately, even the most thorough system will be a short term feature since the longer the period over which the forecast is applied, the greater the number of possible navigational circumstances and consequently the broader the range of potentially hazardous situations becomes. The maritime environment is dynamic and thus good navigational practice must also be dynamic and able to respond to change.

While in Chapter One, the set of factors leading to the loss of a fishing vessel in a traffic event were described as a "pathogenesis", such a medical analogy may not, in retrospect be particularly helpful. To liken collisions and groundings to diseases invites speculation that there may be some miraculous preventative measure waiting to be discovered, as there was for smallpox. The health of the fishing fleet in truth depends upon the deep involvement of those whose lives and livelihoods are at stake - the fishermen themselves. It is to they that the principles of this research must be conveyed.

"Not only will men of science have to grapple with the sciences that deal with man but - and this is a far more difficult matter - they will have to persuade the world to listen to what they have discovered"

Bertrand Russell (1872-1970)

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Appendix 1. Main fishing methods and vessel types in the UK fishing fleet

Contents

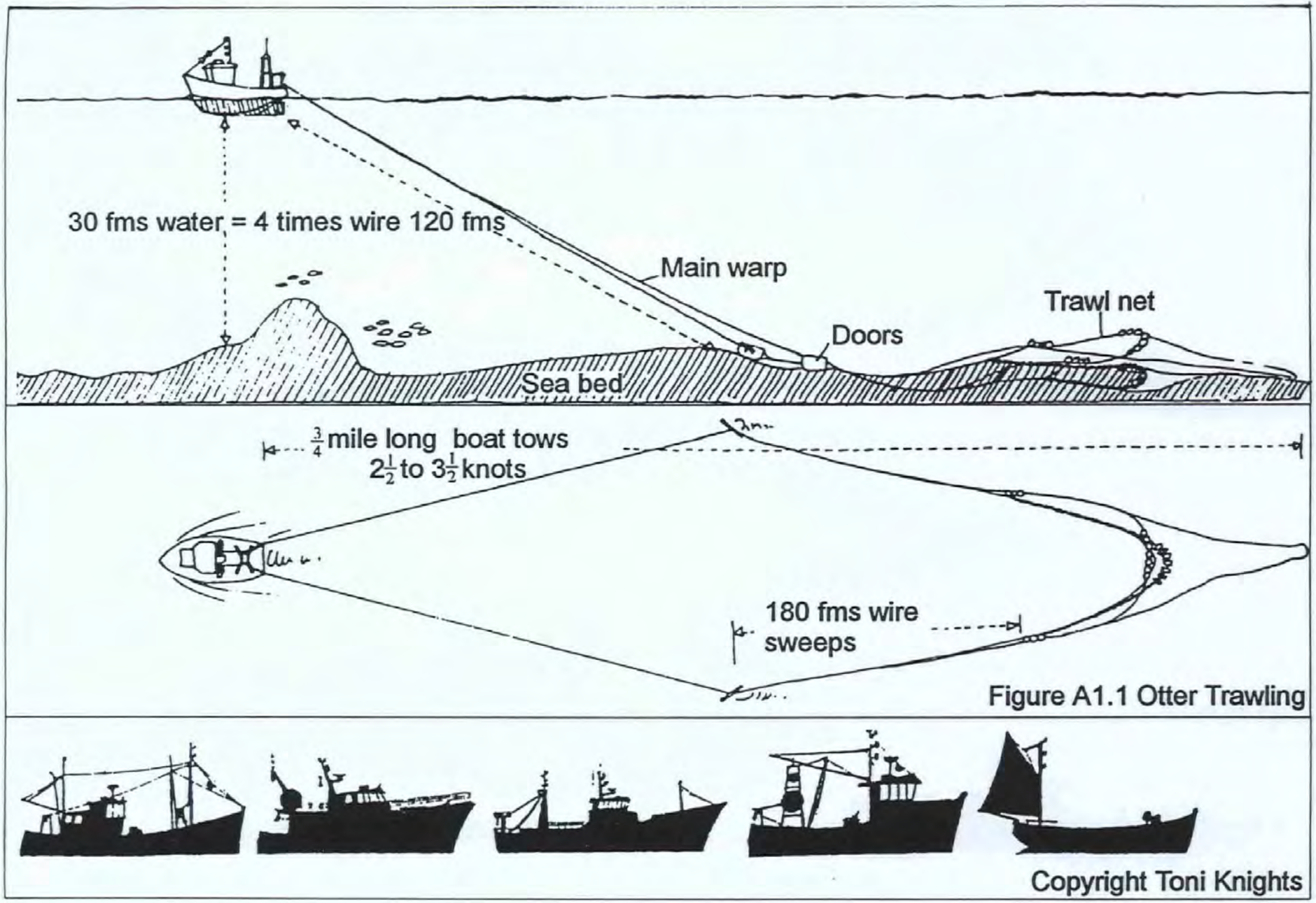


Figure A1.1 Otter Trawling

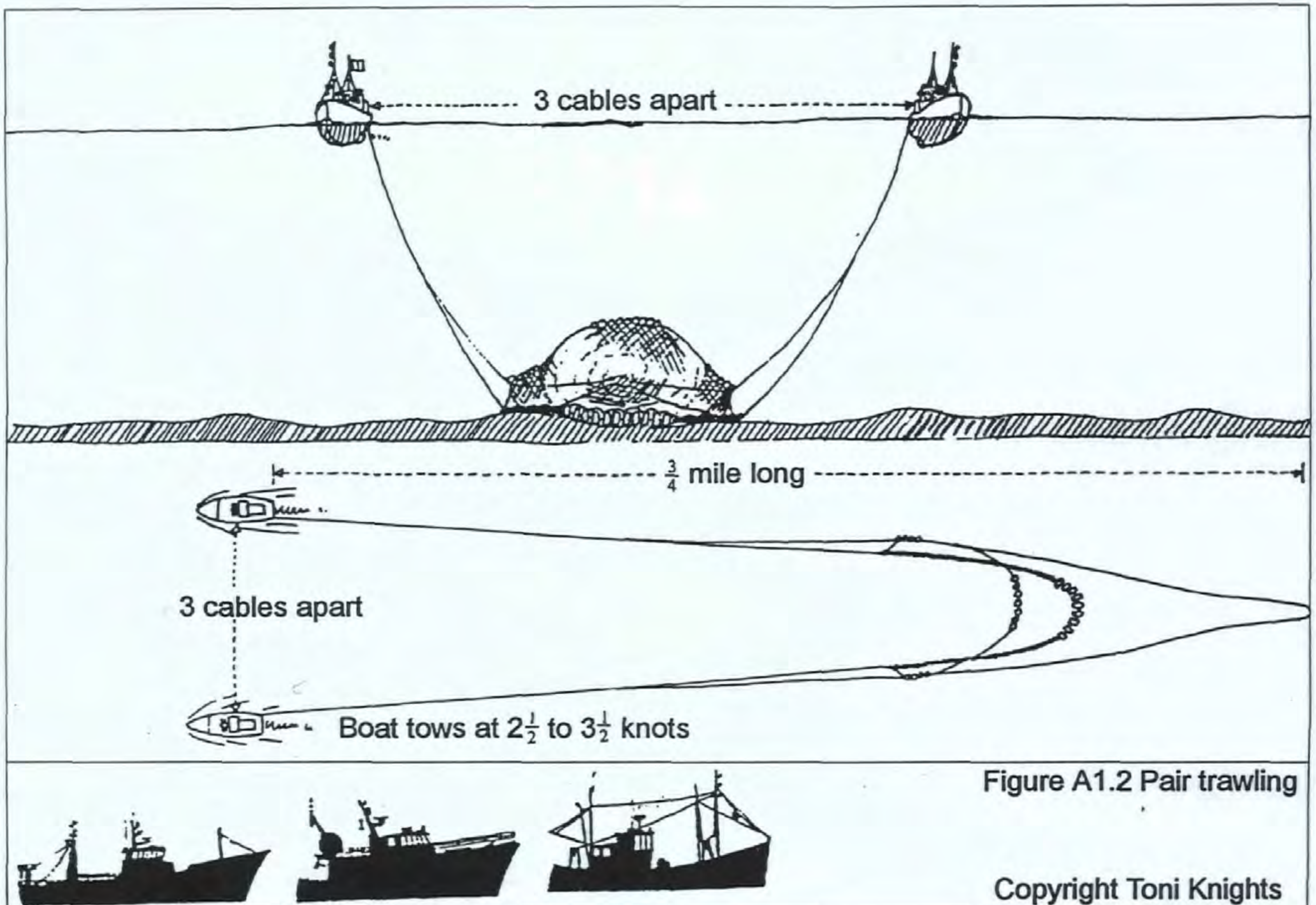


Figure A1.2 Pair trawling

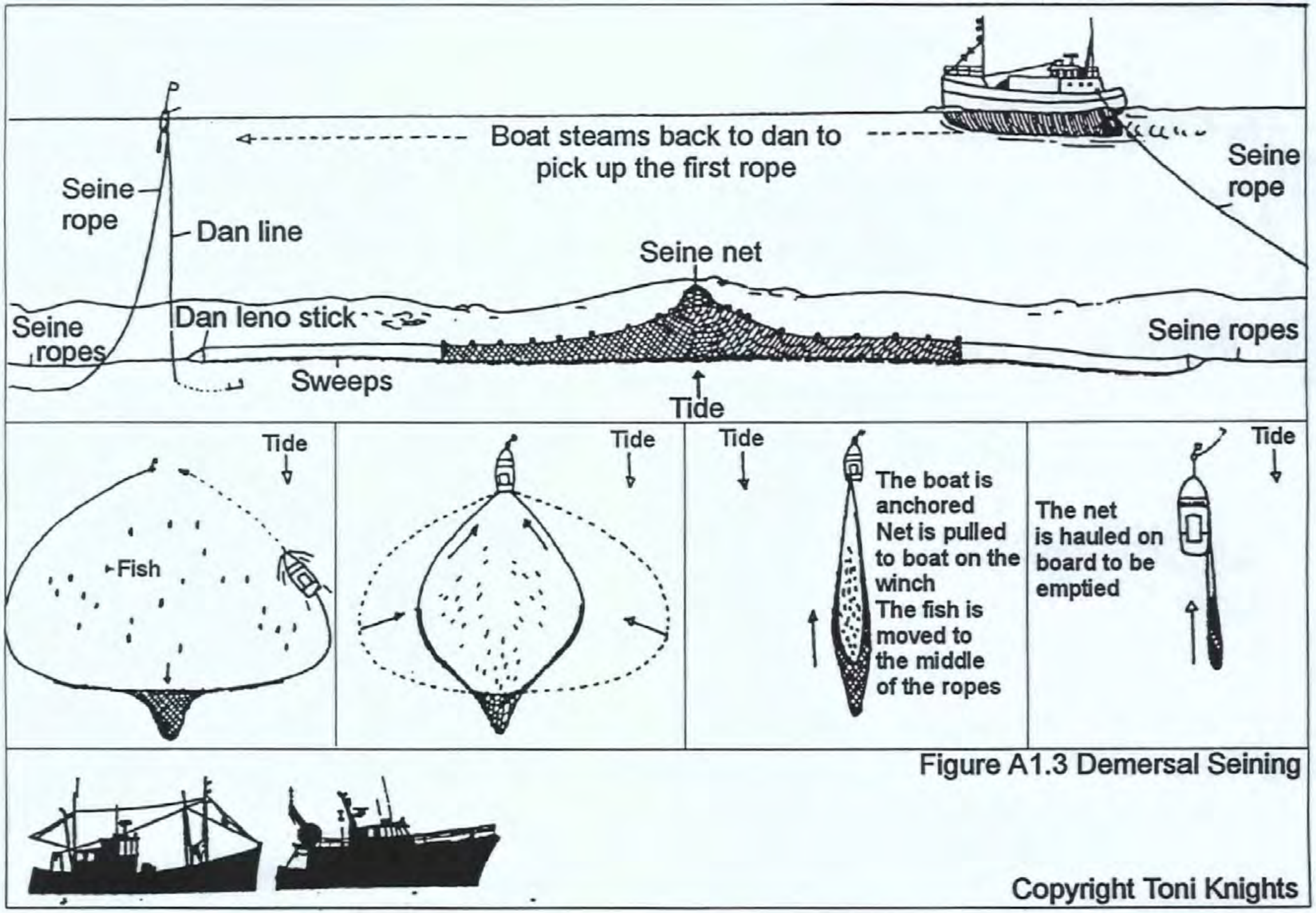


Figure A1.3 Demersal Seining

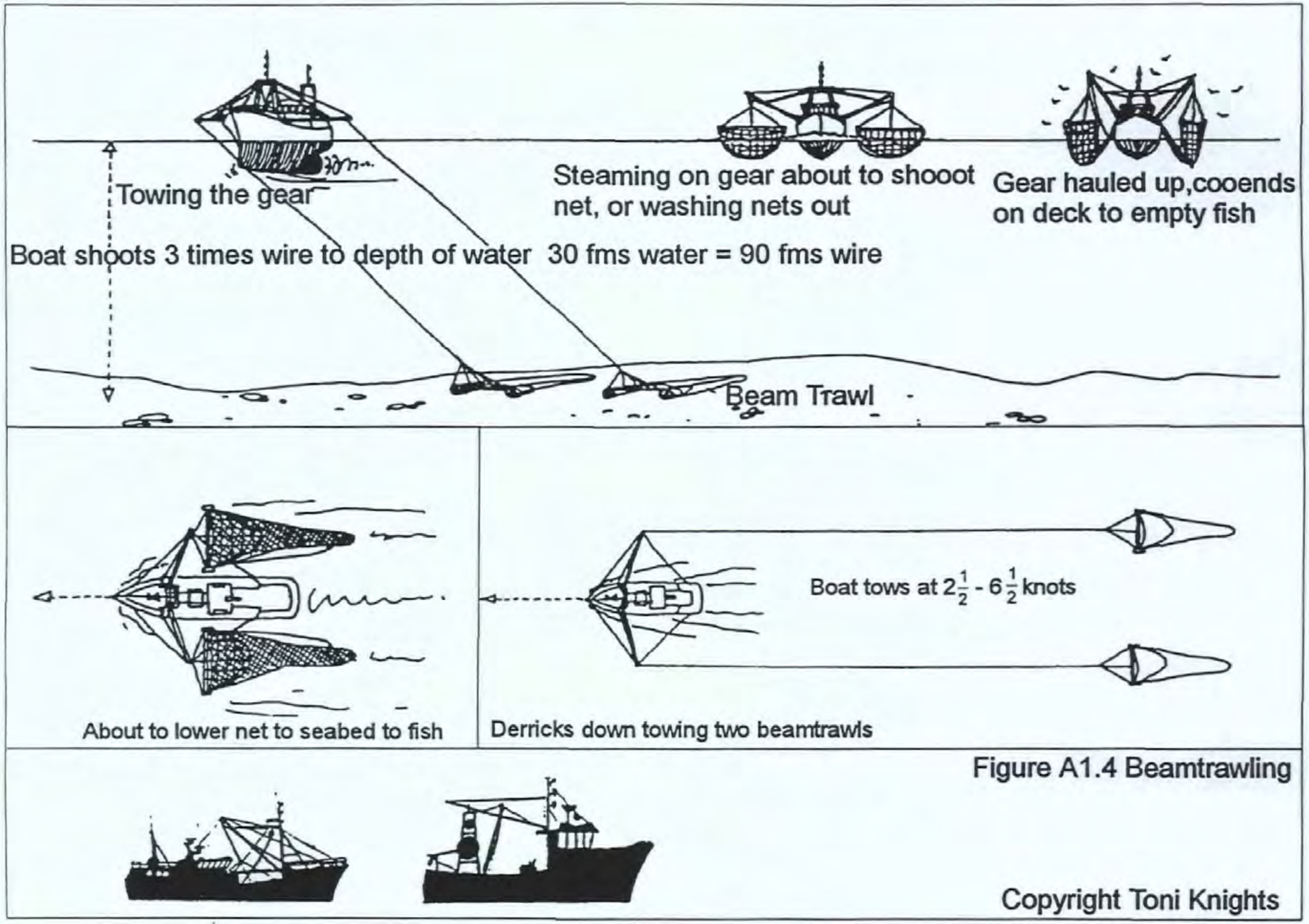


Figure A1.4 Beamtrawling

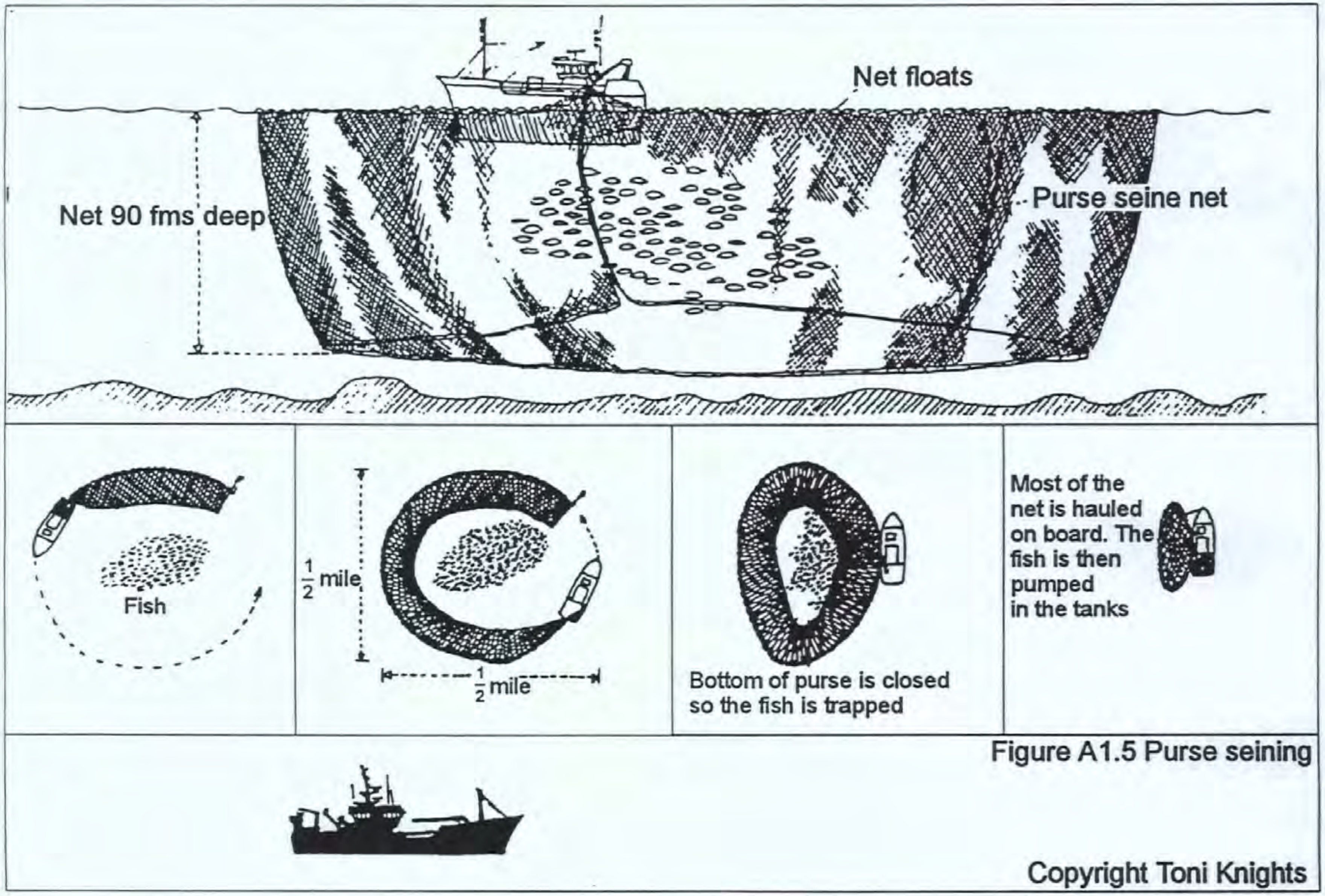


Figure A1.5 Purse seining

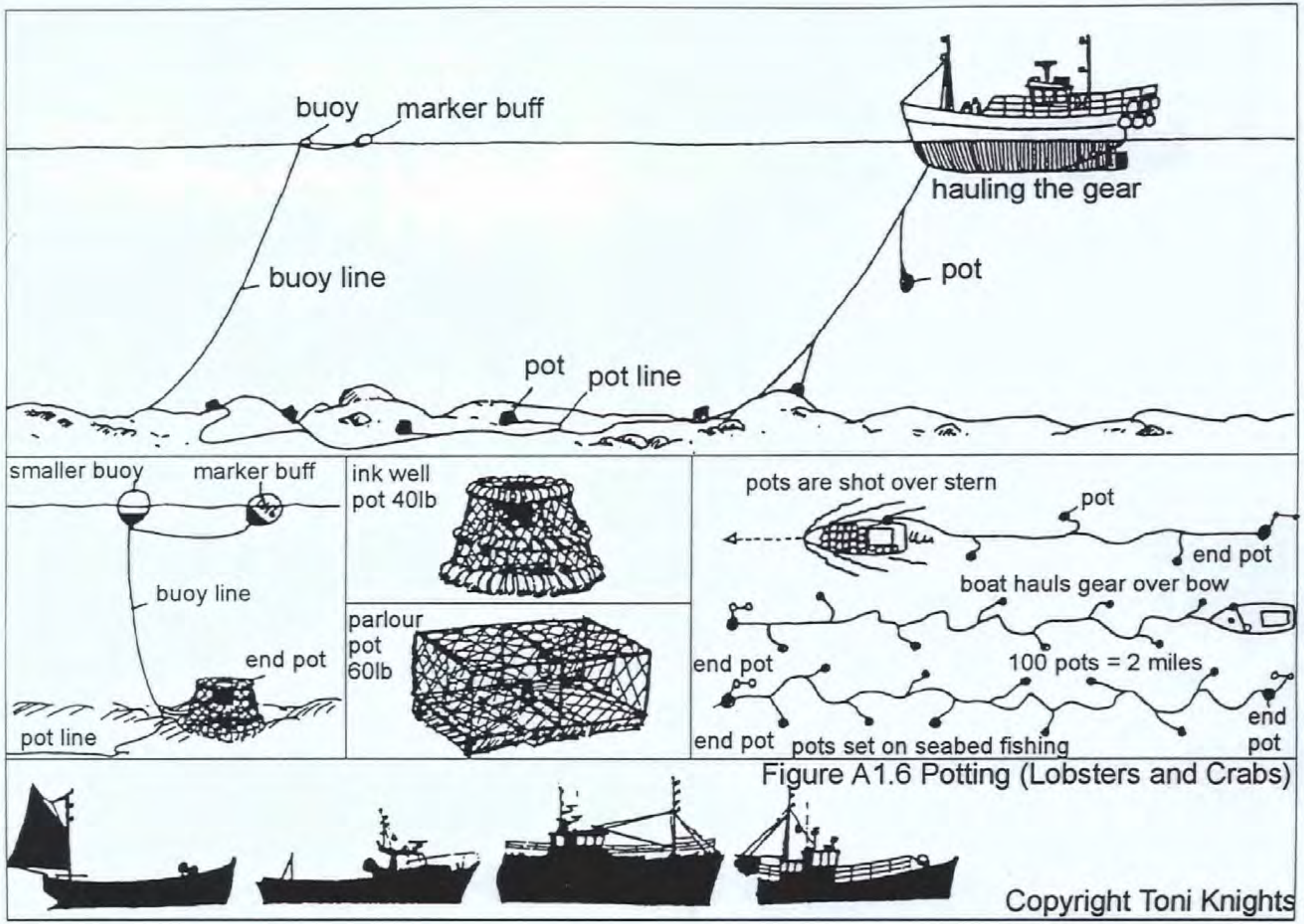


Figure A1.6 Potting (Lobsters and Crabs)

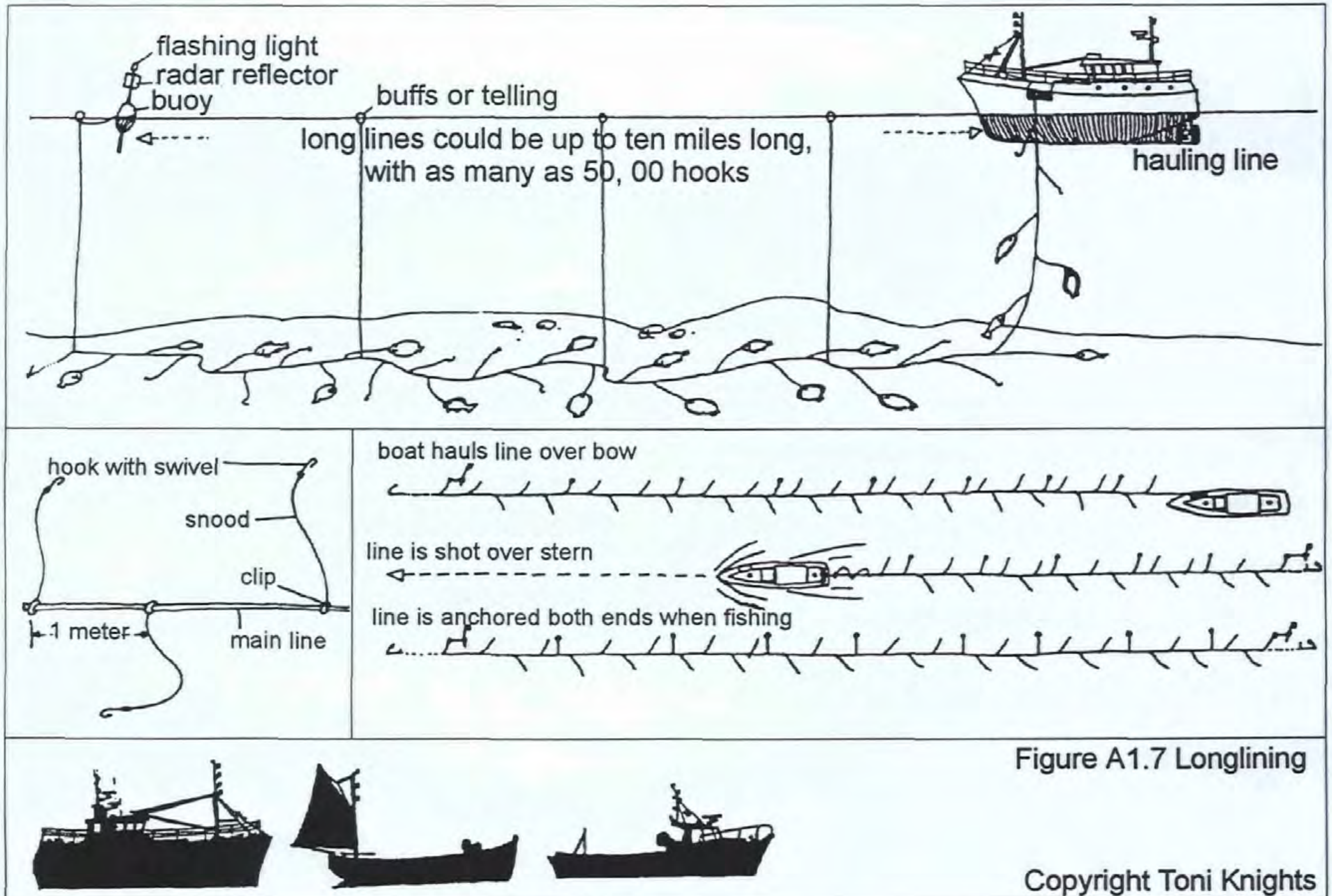


Figure A1.7 Longlining

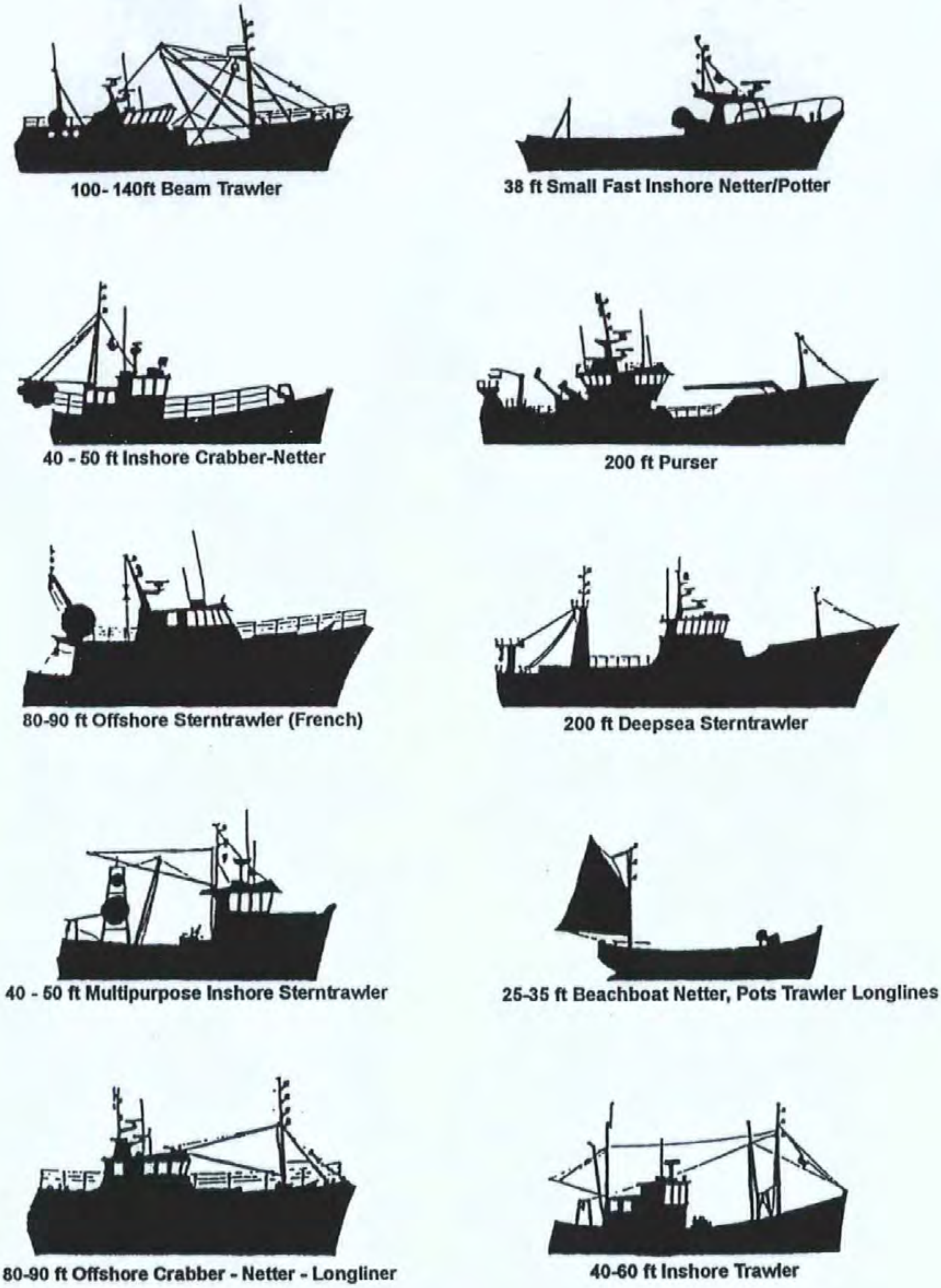


Figure A1.8 Silhouettes of vessel types operating in UK waters.

Appendix 2. Questionnaires administered in this study

Contents

Questionnaire I

FISHING VESSEL SAFETY RESEARCH
University of Plymouth, Institute of Marine Studies.

Please complete the following questionnaire by marking or filling in the appropriate boxes. Your help in this research project is much appreciated.

You are ***not*** required to put your name anywhere on this questionnaire so that you may answer honestly, without fear of any repercussions. The data from the completed questionnaires will only be used collectively - i.e. no one response will be singled out.

1. Which of the following would you consider to be the most common cause of fishing vessel losses?

a) fire ❑

b) stranding ❑

c) flooding ❑

d) collision ❑

e) heavy weather ❑

2. Rank the following causes of fishing vessel loss according to how much concern they cause you. (Most worrying = 1, least worrying = 5)

heavy weather	collision	grounding	foundering/flooding	fire
❑	❑	❑	❑	❑

3. When at sea, how frequently would you estimate that your vessel encounters a potentially dangerous close-quarters situation with another vessel?

a) once every 6 months ❑

b) once a month ❑

c) once a week ❑

d) once a day ❑

e) more than once a day ❑

4. During your time at sea, how often would you estimate that your vessel has encountered a situation where you feel that there was a real possibility of running aground?

a) once every 6 months ☐

b) once a month ☐

c) once a week ☐

d) once a day ☐

e) more than once a day ☐

5. With regard to collision risk. Rank the following types of vessels in order of which you feel are the most likely to collide with fishing vessels?
(1 = most likely; 6 = least likely)

oil tankers ☐	coastal trade vessels (coasters) ☐	deep sea cargo vessels ☐
other fishing vessels ☐	recreational vessels ☐	oil/gas industry related vessels ☐

6. When steaming to, from and between fishing grounds, does whoever is on watch on your vessel navigate using?

a) GPS fixes and Admiralty charts ☐

b) video plotter at all times ☐

c) landmarks when within sight of land and video plotter on the open sea ☐

d) electronic charts ☐

e) Graphic GPS receiver ☐

f) other means. Please specify below ☐

....

....

7. Regarding collision and grounding incidents involving fishing vessels *in general*. Assess the factors below according to how often you consider they would appear as major causes?

Reduced visibility (fog, snow, rain, etc.)
never ❑ *rarely* ❑ *sometimes* ❑ *frequently* ❑ *in most cases* ❑

strong currents/tidal streams (especially in fairways, narrow passages, etc.)
never ❑ *rarely* ❑ *sometimes* ❑ *frequently* ❑ *in most cases* ❑

poor visibility from wheelhouse (whaleback/shelter too high, cluttered wheelhouse, etc.)
never ❑ *rarely* ❑ *sometimes* ❑ *frequently* ❑ *in most cases* ❑

mechanical/electronic failure (engine breakdown, steering gear failure, radar failure, etc.)
never ❑ *rarely* ❑ *sometimes* ❑ *frequently* ❑ *in most cases* ❑

poor navigational aids (boats navigation lights/shapes, buoys, lights)
never ❑ *rarely* ❑ *sometimes* ❑ *frequently* ❑ *in most cases* ❑

human error (incompetence, ignorance of Rules of Road, neglect, recklessness)
never ❑ *rarely* ❑ *sometimes* ❑ *frequently* ❑ *in most cases* ❑

congestion (dense concentration of fishing vessels, heavy merchant traffic, etc.)
never ❑ *rarely* ❑ *sometimes* ❑ *frequently* ❑ *in most cases* ❑

please note below, any other factors that you feel may commonly contribute to fishing vessel groundings and collisions, but are missing from the above list.

....

....

8. Would you consider that the safety of your vessel, while steaming to, from and between fishing grounds has been improved by the installation of any of the following?

a) GPS navigation system *very much* ❑ *a bit* ❑ *not much* ❑

b) Automatic Radar Plotting Aid (ARPA) *very much* ❑ *a bit* ❑ *not much* ❑

c) Adjustable alarm ring on radar *very much* ❑ *a bit* ❑ *not much* ❑

9. When your vessel is steaming to, from and between fishing grounds, what is the most common situation?

a) one man to be on watch ☐

b) watches to be taken in pairs ☐

c) the skipper takes all watches ☐

d) the skipper and Mate take all the watches between them ☐

If your answer is b), is it usual for a less experienced/qualified crew member to be paired with a more experienced/qualified one?

yes ☐ no ☐

10. Thinking back over your years at sea. Have you been in situations where you were *on watch* (i.e. in charge of the vessel) and faced a situation where you were *unclear* about the appropriate course of action?

(Examples might be; encountering a tug towing a barge at some distance and being unsure which way to alter course, or being faced with a large vessel which should give way but shows no signs of doing so, leaving you to make a decision)

Never ☐ seldom ☐ sometimes ☐ often ☐ very often ☐

11. When watchkeeping in conditions of impaired visibility - fog, heavy rain, snow, etc. - do you think that watchkeeping on fishing boats would be made easier if you could identify radar targets as being of a certain *size* (e.g. over 100t; over 1000t; over 10 000t; etc.); or *type* (merchant vessel steaming; fishing vessel engaged in fishing; sailing craft; etc.)?

a) *size* would be most useful ☐

b) *type* would be most useful ☐

c) having *size/type* displayed would not be any <u>more</u> useful than simply having a good standard target display ☐

12. Try to think back to when you kept your *very first watch* on your own, did you feel?

a) very apprehensive and not very confident ❑

b) slightly nervous but fairly confident ❑

c) neither nervous nor confident ❑

d) totally confident and composed ❑

13. At the time of taking that very *first* watch on your own, what previous training in navigation and in particular, in the "Rules of the Road at sea" had you received?

a) none at all ❑

b) no training, but had previously been on watch with an experienced hand ❑

c) some instruction "on the job" from the Skipper or Mate but no formal training ❑

d) some training ashore and "on the job" instruction from an experienced hand ❑

e) substantial training ashore, including familiarisation with the Rules of the Road at Sea, and initial supervision by the Skipper or Mate ❑

14. How old were you when you kept your *first* watch on a fishing vessel?

a) under 18 years old ❑

b) 18 - 21 years old ❑

c) over 21 years old ❑

15. Do you think that the possession of a Certificate of Competence makes a fisherman a *better* watchkeeper?

a) always ❑

b) in most cases ❑

c) seldom ❑

d) never ❑

If you have answered a) or b) to question 15, briefly say why;

....

If you have answered c) or d) to question 15, briefly say why;

....

16. Have you ever been aboard a fishing vessel when it has been involved in a collision, or has run aground?

Yes ❑ no ❑

17. On what type of vessel have you spent *most* of your time as a fisherman?

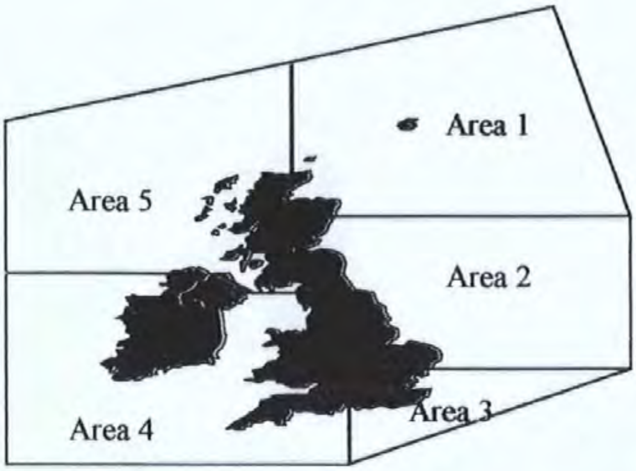
purse seiners (or single pelagic trawlers) ❑	pair trawlers (pelagic or demersal) ❑
demersal trawlers (single boat) ❑	demersal seine netters/pair seiners ❑
beam trawlers ❑	static netters/longliners ❑
crab/lobster boats ❑	other (specify below) ❑

18. How many years have you spent at sea, aboard fishing boats?
(Do not include part - time fishing)

.....................years

19. In which areas would you say you have spent most of your time working on fishing boats? (Mark more than one box if appropriate)

area 1	area 2	area 3	area 4	area 5	distant waters
❑	❑	❑	❑	❑	❑



20. Can you think of any legislative measures (i.e. rules and regulations) that could be taken to significantly reduce the risk of fishing boats being involved in collisions and groundings?

....
....
....

21. Can you think of any technical measures (i.e. equipment) that could be used to reduce the risk of fishing vessels running aground and being involved in collisions?

....
....
....

22. Do you have any ideas regarding the operation of fishing boats(i.e. system of watchkeeping, "wheelhouse behaviour", etc.) that could reduce the risk of collision and running aground?

....
....
....

thank you for your time and valued co-operation

QUESTIONNAIRE DESTINATIONS (Questionnaire I)

Subsequent to prior agreement over the telephone, batches of questionnaires with pre-paid return envelopes were sent to the following who very kindly distributed, collected and returned questionnaires.

Name/address	No. sent	No. returned
MR LEYS ABERDEEN INSHORE FISHSELLING 154 NORTH ESPLANADE EAST ABERDEEN AB1 2QO	20	10
KAREN WARD WESTSIDE FISHERMEN LTD BLACKSNESSS PIER SCALLOWAY SHETLAND ZE1 OTQ	20	8
MR P DONALD ARBROATH FISHERMAN'S ASSOCIATION 2 MARKETGATE ARBROATH ANGUS DD1 1AY	20	2
MRS McKELBIE EASTERN SEA FISHERIES JOINT COMMITTEE UNIT 6 NORTH LYNN BUSINESS VILLAGE BERGEN WAY KING'S LYNN NORFOLK PE30 2JG	20	9
MR MacNEIL ALEMAR HOUSE BREVIC CASTLEBAY ISLE OF BARRA OUTER HEBRIDES	10	2
CARRADALE FISHERMEN LTD OLD QUAY CAMPBLETOWN ARGYLL PA28 6ED	20	9
MR GEORGE WALKER F.M.A. EYEMOUTH LTD SAMPSON'S YARD HARBOUR ROAD EYEMOUTH BERWICKSHIRE TD14 5JA	20	13
MARK KING TOM SLEIGHT (FS) LTD RENOVIA BUILDING FARINGDON ROAD FISH DOCK GRIMSBY DN31 3TE	20	16
ALAN MUTCH FRASERBURGH INSHORE FISHERMEN LTD SHORE STREET FRASERBURGH ABERDEENSHIRE SCOTLAND AB4 5EB	20	19
MR ERIC MOORE ISLE OF MAN FISHERMEN'S ASSOCIATION STATION PLACE PEEL ISLE OF MAN UK	20	3
JILL NEAL PETERHEAD FISHERMEN LTD SUITE 13-16 FISHMARKET BUILDINGS GREENHILL PETERHEAD ABERDEENSHIRE AB4 6ZY	30	23

MARTIN HEARNE FISHERIES OFFICE 5 HAMILTON TERRACE MILFORD HAVEN DYFED WALES SA73 2AL	20	7
MR TERRY REID CALEY FISHERIES LTD TANNER'S BANK NORTH SHEILDS TYNE & WEAR NE30 1JJ	20	6
JANET SMITH LOWESTOFT FISHING VESSEL OWNERS ASSOCIATION LTD STAR BUILDINGS BEACH ROAD LOWESTOFT SUFFOLK NR32 1DS	20	15
LESLEY STUDHOLME MARYPORT & SOLWAY FISHING CO-OP FISHERMEN'S WHARF WEST QUAY MARYPORT CUMBRIA	10	1
MR GARY POSTON LINTELS BILSHIM ROAD YAPTON Nr ARUNDEL SUSSEX BN18 0JB	10	5
MR COLIN McRAE UNITED FISHSELLING LTD 52 LOW STREET BUCKIE BANFFSHIRE	20	13
SUPERINTENDENT DAVID MANN ROYAL NATIONAL MISSION TO DEEP SEA FISHERMEN CULAG PARK LOCHINVER SUTHERLAND SCOTLAND IV27 4LE	20	6
SUPERINTENDENT NEIL McGREGOR ROYAL NATIONAL MISSION TO DEEP SEA FISHERMEN FISH PIER KINLOCHBERVIE SUTHERLAND SCOTLAND IV27 4RR	20	20
SUPERINTENDENT GEORGE SHAW ROYAL NATIONAL MISSION TO DEEP SEA FISHERMEN SCRABSTER CAITHNESS SCOTLAND	20	9
HELEN HARRON THE HARBOUR (OFF PRINCESS ROAD) PORTAVOGIE NEWTONARDS NORTHERN IRELAND BT22 1EA	10	7
KEITH BOWER DEVON SEA FISHERIES COMMITTEE OFFICE NO 9 FISH MARKET THE QUAY BRIXHAM DEVON TQ5 8AW	20	16
JIM TAIT NAUTICAL STUDIES DEPT BANFF & BUCHAN COLLEGE OF EDUCATION HENDERSON ROAD FRASERBURGH ABERDEENSHIRE SCOTLAND	20	20
TOTALS	420	239

RETURN RATE = 57%

Appendix Figure A2. 1. Distribution of fishing ports from where responses to Questionnaire I were drawn.

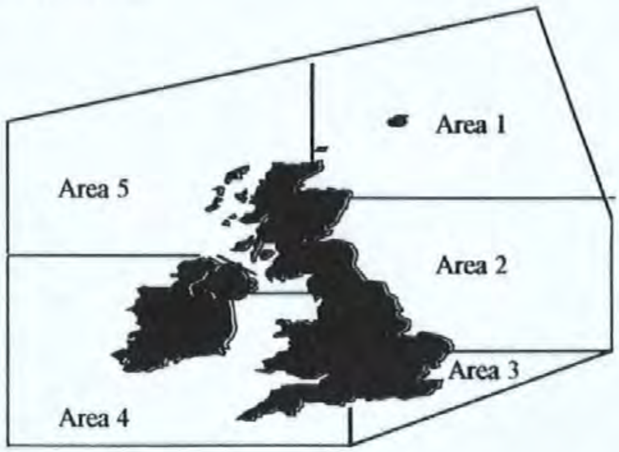
Questionnaire II

WATCHKEEPING PROCEDURE ON YOUR VESSEL

Please mark boxes as appropriate. You are **not** required to put your name anywhere on this form so you can answer honestly without fear of any comeback. The information from these questionnaires will only be used collectively, no one answer will be singled out.

Thank you very much for your time and co-operation.

1. Which area does your boat operate in?
   (Tick more than one box if appropriate.



area 1 ❑ area 2 ❑ area 3 ❑ area 4 ❑ area 5 ❑ distant waters ❑

If you have ticked more than one box, give a rough idea of how many months of the year in each area?

area 1 [ ] area 2 [ ] area 3 [ ] area 4 [ ] area 5 [ ]

---

2. What is the length of your boat?

under 12 metres (40ft) ❑ 12-24 metres (40-80ft) ❑ over 24 metres (80ft) ❑

---

3. How old is your boat?

under 5 years ❑ 5 - 20 years ❑ over 20 years ❑

---

4. Which of the following items of equipment does your boat have?

GPS	❑	video track plotter	❑
Decca	❑	paper echosounder	❑
other electronic position fixing system	❑	video echosounder	❑
Sonar	❑	video echosounder with digital depth display	❑
More than one VHF radio	❑	colour echosounder	❑
autopilot	❑	stabilised radar	❑
autopilot alarm	❑	radar range ring alarm	❑
gyro compass	❑	magnetic compass	❑
ARPA	❑		

---

5. What is the duration of watches on your boat?

a) when steaming [ ] hours

b) when fishing (if this is done) [ ] hours

6. Who keeps a watch on your boat?

	a) when steaming	b) when fishing
Skipper only	❑	❑
Mate and Skipper only	❑	❑
rota system; experienced crew only	❑	❑
rota system; whole crew	❑	❑

---

7. On your boat, are there clear guidelines to watchkeepers regarding the folllowing?

taking over the watch	yes ❑	no ❑
using navigational equipment	yes ❑	no ❑
keeping an effective lookout	yes ❑	no ❑
when to call the skipper	yes ❑	no ❑
using the autopilot	yes ❑	no ❑
using the engine controls	yes ❑	no ❑
what to do in the event of reduced visibility	yes ❑	no ❑
what to do in the event of an emergency	yes ❑	no ❑

---

8. If yes to any of the above, how are these guidelines communicated?

word of mouth ❑ written notices ❑

---

9. Is the watchkeeper informed of any malfunctioning equipment when he takes over?
yes ❑ no ❑

---

10. Does the watchkeeper have any duties other than keeping a lookout and attending to navigation ?
(Examples might be; cooking, gear repairing, dealing with the catch.) yes ❑ no ❑

---

11. Is there at least one VHF radio tuned to Channel 16 at all times in your vessel's wheelhouse?
(This may be done using a 'dual watch' function.) yes ❑ no ❑

---

12. Is a 'Listening Watch' kept during official 'Silence Periods' on your vessel?
yes ❑ no ❑

---

13. When you are on watch, do you;
a) take bearings of approaching vessels? yes ❑ no ❑

b) take bearings of landmarks that are in sight? yes ❑ no ❑

---

14. If your boat has an autopilot, is the autopilot alarm *always* in operation while steaming?

yes ❑ no ❑

---

15. Is the autopilot alarm always in operation while fishing?
yes ❑ no ❑

16. Are the watch arrangements on your vessel altered in any way in conditions of poor visibility?
yes ❑ no ❑

17. If watchkeeping on your vessel is organised on a rota basis, is the first watchkeeper allowed to rest prior to going on duty?
yes ❑ no ❑

18. When the watchkeeper on your boat leaves the wheelhouse, for example to go to the toilet or to make a hot drink, is the wheelhouse temporarily left unmanned?
yes ❑ no ❑

19. On your boat is there a means by which a watchkeeper can summon the skipper (or anyone else) without having to leave the wheelhouse?
yes ❑ no ❑

20. Does any watchkeeping training of any kind take place aboard your boat?
yes ❑ no ❑

21. Please try to answer this question honestly.... if your boat has a whaleback or shelterdeck, can you easily see over it from the wheelhouse?
yes ❑ no ❑

22. If yes, was the whaleback/shelterdeck fitted after the boat was built?
yes ❑ no ❑

23. On your boat, is the daytime fishing signal (basket or cone) taken down when fishing ceases?
yes ❑ no ❑

24. Roughly how many weekends per year does your boat spend at sea?
none ❑; less than 5 ❑; 5-10 ❑; over 10 ❑

25. Please mark the days on which your boat is most often steaming to and from fishing grounds;

Monday ❑; Tuesday ❑; Wednesday ❑; Thursday ❑; Friday ❑; Saturday ❑; Sunday ❑

Thank you for your help.

QUESTIONNAIRE DESTINATIONS (Questionnaire II)

Subsequent to prior agreement over the telephone, batches of questionnaires with pre-paid return envelopes were sent to the following who very kindly distributed questionnaires to skippers and subsequently collected and returned them.

Name/address	No. sent	No. eturned
MR LEYS ABERDEEN INSHORE FISHSELLING 154 NORTH ESPLANADE EAST ABERDEEN AB1 2QO	10	4
KAREN WARD WESTSIDE FISHERMEN LTD BLACKSNESSS PIER SCALLOWAY SHETLAND ZE1 OTQ	10	2
MR P DONALD ARBROATH FISHERMAN'S ASSOCIATION 2 MARKETGATE ARBROATH ANGUS DD1 1AY	10	2
MRS McKELBIE EASTERN SEA FISHERIES JOINT COMMITTEE UNIT 6 NORTH LYNN BUSINESS VILLAGE BERGEN WAY KING'S LYNN NORFOLK PE30 2JG	10	3
MR MacNEIL ALEMAR HOUSE BREVIC CASTLEBAY ISLE OF BARRA OUTER HEBRIDES	10	0
CARRADALE FISHERMEN LTD OLD QUAY CAMPBLETOWN ARGYLL PA28 6ED	10	4
MR GEORGE WALKER F.M.A. EYEMOUTH LTD SAMPSON'S YARD HARBOUR ROAD EYEMOUTH BERWICKSHIRE TD14 5JA	10	5
MARK KING TOM SLEIGHT (FS) LTD RENOVIA BUILDING FARINGDON ROAD FISH DOCK GRIMSBY DN31 3TE	10	8
ALAN MUTCH FRASERBURGH INSHORE FISHERMEN LTD SHORE STREET FRASERBURGH ABERDEENSHIRE SCOTLAND AB4 5EB	20	12
MR ERIC MOORE ISLE OF MAN FISHERMEN'S ASSOCIATION STATION PLACE PEEL ISLE OF MAN UK	10	3
JILL NEAL PETERHEAD FISHERMEN LTD SUITE 13-16 FISHMARKET BUILDINGS GREENHILL PETERHEAD ABERDEENSHIRE AB4 6ZY	20	9

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LESLEY STUDHOLME MARYPORT & SOLWAY FISHING CO-OP FISHERMEN'S WHARF WEST QUAY MARYPORT CUMBRIA	10	1
MR GARY POSTON LINTELS BILSHIM ROAD YAPTON Nr ARUNDEL SUSSEX BN18 0JB	10	5
MR COLIN McRAE UNITED FISHSELLING LTD 52 LOW STREET BUCKIE BANFFSHIRE	10	4
SUPERINTENDENT DAVID MANN ROYAL NATIONAL MISSION TO DEEP SEA FISHERMEN CULAG PARK LOCHINVER SUTHERLAND SCOTLAND IV27 4LE	20	14
SUPERINTENDENT NEIL McGREGOR ROYAL NATIONAL MISSION TO DEEP SEA FISHERMEN FISH PIER KINLOCHBERVIE SUTHERLAND SCOTLAND IV27 4RR	20	7
SUPERINTENDENT GEORGE SHAW ROYAL NATIONAL MISSION TO DEEP SEA FISHERMEN SCRABSTER CAITHNESS SCOTLAND	10	9
HELEN HARRON THE HARBOUR (OFF PRINCESS ROAD) PORTAVOGIE NEWTONARDS NORTHERN IRELAND BT22 1EA	10	4
KEITH BOWER DEVON SEA FISHERIES COMMITTEE OFFICE NO 9 FISH MARKET THE QUAY BRIXHAM DEVON TQ5 8AW	20	14
JIM TAIT NAUTICAL STUDIES DEPT BANFF & BUCHAN COLLEGE OF EDUCATION HENDERSON ROAD FRASERBURGH ABERDEENSHIRE SCOTLAND	10	10
TOTALS	300	139

RETURN RATE = **46%**

Appendix Figure A2. 2. Distribution of fishing ports from where responses to Questionnaire II were drawn.

Appendix 3.

Contents

Sample data recordings from "Time Machine" computer program

Task	Time (secs)
scan outside	19.07
radar	62.84
echosounder	37.95
plotter	
nav. systems	86.78
V/L control	29.34
comm. ext.	37.63
comm. int.	160.01
admin.	
abs. asleep	

Comments
5 minutes , t+5 minutes
Skipper on watch

shooting gear

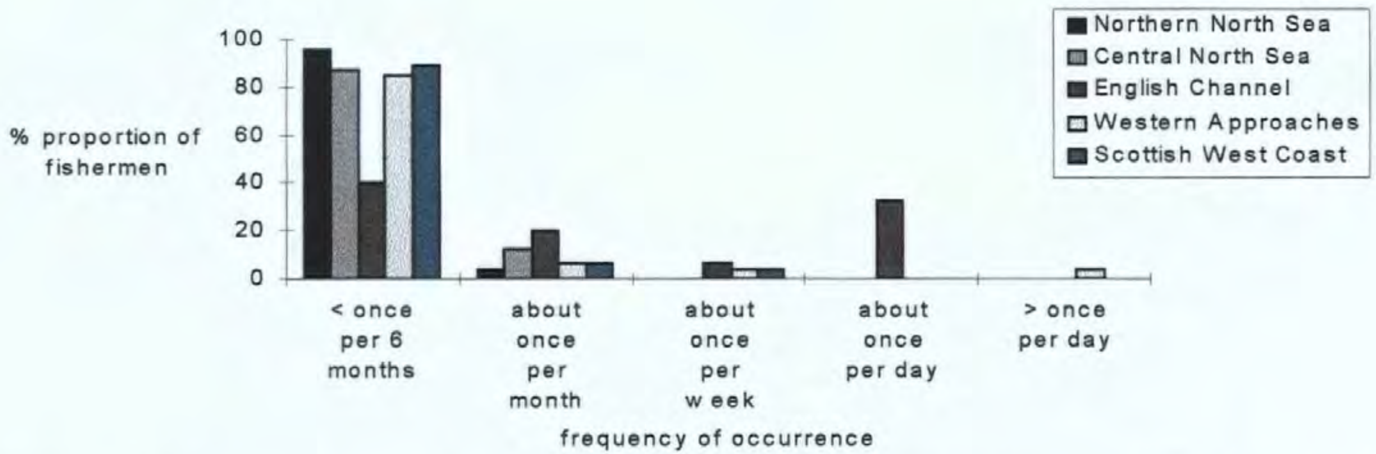
daylight; good visibility; wind force 3/4
light traffic

Task	Time (secs)
windows	75.63
radar	17.47
echo/sonar	47.79
comm.int	85.46
comm.ext	29.61
control sys.	206.52
plotter	60.63
nav. systems	60.20
admin.	48.50
sleep	43.62

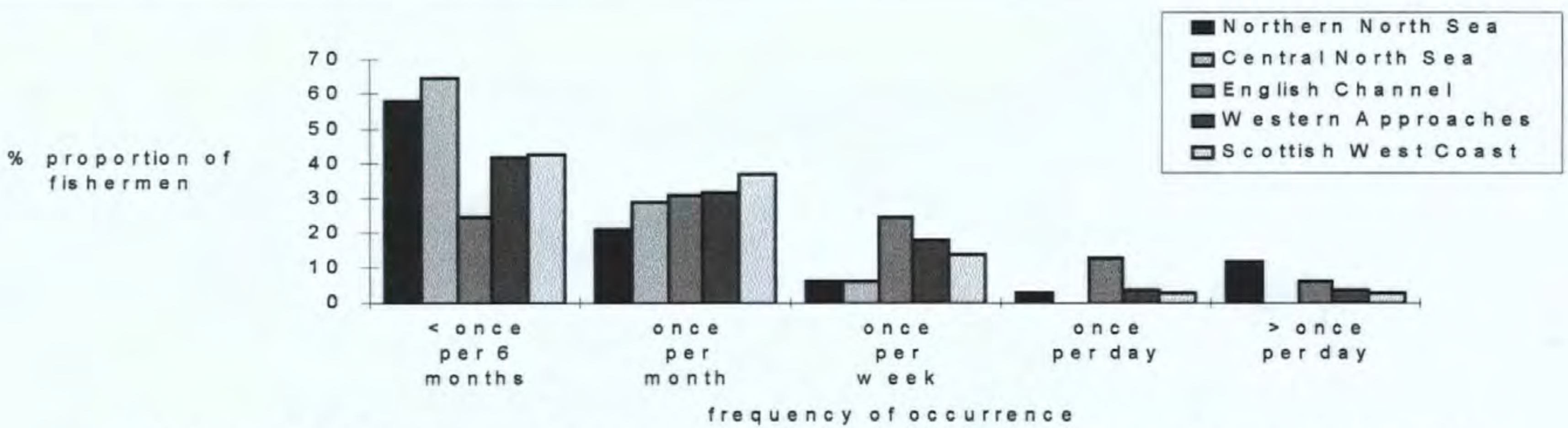
Comments
5 minutes t+180mins
Skipper on watch
hauling gear
darkness; light traffic; wind force 2/3
stroop; +3

Appendix 4. Supplementary information on the operational macro-environment of UK fishing boats.

Contents



Appendix Figure 4.1. Percentage proportion of fishermen experiencing potential running aground situations at various frequencies.



Appendix Figure 4.2. Percentage proportion of fishermen experiencing very close quarters situations with other vessels.

area	most important fishing ports	% of UK fleet operating in the area	main fishing methods used in area	fishing vessel to merchant vessel port entry ratio	% of fishing fleet built post 1980	% incidence of winds over Beaufort force 7		% visibility in excess of 5 mls.		% frequency of fog	
						Summer	Winter	Summer	Winter	Summer	Winter
1. Northern North Sea	Lerwick, Scalloway, Scrabster, Wick, Lossiemouth, Buckie, Macduff, Fraserburgh	26%	Otter-trawling, Beam trawling, Demersal seine-netting, Pair trawling/seining, purse-seining, crabbing, static-netting	30:1	43%	2 - 5%	10 - 30%	72 -83%	72 -83%	±5%	±2%
2. Central North Sea	Peterhead, Aberdeen, Arbroath, Eyemouth, North Shields, Grimsby, Scarborough, Bridlington	9%	otter and beam trawling, pair-trawling, crabbing, static netting	12:1	34%	2 - 5%	10- 20%	70 - 80%	60 - 75%	±2%	5 - 10%
3. English Channel	Lowestoft, Hastings, Newhaven, Poole	15%	otter and beam trawling, static netting, longlining, crabbing	3:1	37%	<2%	5 - 10%	75 - 80%	55 - 75%	±5%	±5%
4. Western Approaches and Irish Sea	Brixham, Salcombe, Plymouth, Looe, Mevagissey, Newlyn, Padstow, Bideford, Milford Haven, Fleetwood	20%	otter and beam trawling, static netting, long-lining, crabbing	8:1	19%	2 - 5%	10 - 20%	80 - 85%	75 - 85%	5 - 10%	2 - 5%
5. Scottish West Coast	Annalong, Kilkeel, Portavogie, Girvan, Mallaig, Oban, Stornoway, Ullapool, Lochinver, Kinlochbervie	30%	otter trawling, pair-trawling, purse-seining, crabbing	37:1	24%	2 - 5%	20 - 30%	77 - 82%	79 - 88%	5 - 10%	<2%

Appendix Table 4.1. Summary of macro-environmental information relating to five fishing areas around the UK.

Appendix 5. Consent document

Contents

Consent form completed by all subjects used in observations at sea

UNIVERSITY OF PLYMOUTH
INSTITUTE OF MARINE STUDIES

Fishing Vessel Watchkeeping Research

CONSENT FORM

This consent form relates to PhD research project work being undertaken by Malcolm Findlay. The aim of the project is to describe watchkeeping practices on various types of UK fishing vessels and to assess levels of workload, boredom and fatigue experienced by fishing vessel watchkeepers.

Subject's name (please print) ....

Vessel (include port registration) ....

Please tick the boxes below:

I understand the aims and objectives of the research project ☐

I understand that I may temporarily withdraw from the project if at any stage I consider that the safety of the vessel is being compromised ☐

I understand that I may permanently withdraw from the research project at any time and arrange for my data to be destroyed ☐

I accept that the investigator has, so far as is possible, taken all foreseeable action to avoid compromising the safety of my vessel, and also my personal safety ☐

I understand that my data is confidential and will not be made available or shown to anyone except the research team ☐

Under the circumstances outlined above, I agree to participate in the research project

signed, ... date, ...

COPYRIGHT

Signed ....

Date 17th March 1998.

Malcolm Findlay

Institute of Marine Studies
University of Plymouth
Drake Circus
Plymouth
PL4 8AA