

This paper not to be cited without prior reference to the authors

---

**INTERNATIONAL COUNCIL FOR  
THE EXPLORATION OF THE SEA**

C.M. 1990/B:17  
Fish Capture Committee

**SAFETY INTEGRATED REDESIGN OF DUTCH BEAMTRAWLERS**

by

F.A. Veenstra  
Netherlands Institute for Fishery Investigations  
P.O. Box 68, 1970 AB IJmuiden  
The Netherlands

J. Stoop  
Technical University Delft, Safety Science Group  
Kanaalweg 2b, Delft  
The Netherlands

**SAFETY INTEGRATED REDESIGN OF DUTCH BEAMTRAWLERS**

by

F.A. Veenstra  
Netherlands Institute for Fishery Investigations  
P.O. Box 68, 1970 AB IJmuiden  
The Netherlands

J. Stoop  
Technical University  
Safety Science Group  
Delft  
The Netherlands

**Contents**

- 1.1. Safety regulations for beamtrawlers**
  - Introduction
  - Safety aspects onboard beamtrawlers
- 1.2. Dutch beamtrawlers**
  - Introduction
  - Beamtrawler layout
  - Beamtrawler (safety) design
- 1.3. Safety Analysis methods**
  - Introduction
  - Safety problem solving method
  - Role of safety in the design process
  - Safety integrated approach
  - Safety analysis in beamtrawler (re)design
- 1.4. Occupational accidents/workload beamtrawlers**
  - Introduction
  - Material and method
  - Accident analysis
- 1.5. Generation of solutions**
  - Retrospective solution matrix
  - Prospective solution matrix
  - Goodness of solutions
- 1.6. Conclusions**
- Acknowledgement**
- References**

## ABSTRACT

Unlike merchant marine vessels, safety regulations for fishing vessels have been mainly left to the discretion of each national administration. Learnt from bitter experiences the global safety aspects (stability, constructions, equipment) have been improved in the last decades for the Dutch beamtrawlers, however the personal safety aspects (linked to the working conditions) are still a matter of free and competitive interest for the shipyard/designer and skipper-owner.

The traditional beamer layout --single deck hull, extended forecastle and the accommodation with wheelhouse aft-- gives some major unsafe drawbacks:

- very poor vision lines;
- high noise levels;
- high occupational accidents.

Only by integration of an initial theoretical safety problem solving method, as developed by the Safety Science Group of the Delft University of Technology, and the practical RIVO beamtrawler design knowledge, the drawbacks can be solved with acceptable residual (occupational) risks.

As an example of safety integrated redesigning of fishing vessels a case study to improve the working conditions and to prevent occupational accidents on the beamtrawler deck is given and a redesign is shown with mentioning of good solutions, residual risks and cost-effects involved.

## 1.1. SAFETY REGULATIONS FOR BEAMTRAWLERS

### Introduction

Shipsafety means freedom from danger or risk for crew, ship and environment.

The special operating conditions and design of the Dutch beamtrawlers (figure 1) create a situation involving various potential dangers, particularly as regards intact stability which could cause accidents resulting in capsizing due to bottomnets fastening on one side (ship wrecks, stones, etc.). After many capsize accidents in the sixties, the stability requirements for beamtrawlers increased considerably, described in the Dutch Regulations "Voorschriften voor Vissersvaartuigen", which are adapted now to the IMO Safety of Fishing Vessels, 1977.

Besides these global safety aspects in beamtrawler design, also rules have been drafted concerning safe navigation, life-saving and fire-fighting equipment as well as preventing oil pollution.

However safety directly linked to working conditions, the personal safety is still a matter of free interest of the shipyard/designer and the skipper-owner.

No mandatory rules have been drawn yet, although a new EC and national working condition law, the so-called ARBO-Law, have entered The Netherlands, which may be expected to become also compulsory onboard fishing vessels in the nineties.

In this ARBO-Law several fundamental safety principles of proper cooperation between employee and employer are given aiming healthier and safer working conditions.

### Safety aspects onboard Dutch beamtrawlers

When in the sixties the Dutch fisheries started to implement the beamtrawl fishing method on existing fishing vessels a lot of casualties occurred. On the one hand side capsizings due to

hampering of the nets to bottom obstructions and on the other hand personal injuries due to gear handling onboard a moving platform at sea.

For the first problem increased intact stability requirements have been worked out and fishblock sliplines have been indicated. However the stability requirements are based on still water calculations integrating some safety margin for operating in seaways (beam-trawler metacentric height is 20% higher than for regular fishing methods, but at least 0.50 m). Because one of the major causes of capsizings was the lack of watertightness new rules have been drafted, also with regard to the necessary crew's certificates.

To increase the manoeuvrability during fishing and to avoid rapidly bottom obstructions, the towing point of the fishing lines moved forward, giving the beamtrawler the nowadays characteristic layout.

Besides the above mentioned global safety aspects another group is dealing with personal safety of the crew, to which hardly any mandatory regulations have been drafted yet. Learnt by (bitter) experiences, skipper-owners and (shipyard) designers improved these safety aspects step by step, as far not intervening too much with the daily fishing and building practice. Inherent to the traditional layout and fish procedures, the modern beamtrawlers still suffer from three major drawbacks:

- vision lines (wheelhouse);
- noise control (accommodation);
- occupational accidents (working deck).

## 1.2. DUTCH BEAMTRAWLERS

### Introduction

The Dutch fisheries can be characterised in three types of fishing vessels, mainly designed and built by national shipyards:

- the deepfreeze sterntrawlers (Number: 13; Length: 75-110 m, Installed HP: 3000-8000 kW),
- the mussel- and cockle dredgers (100; 30-35 m, 200 kW) and
- the beamtrawlers:
  - . length 24-45 m (220-3000 kW)
  - . demersal and small pelagic fish (flatfish, shrimps, herring, cod, whiting)
  - . Northsea
  - . number 600 (in 1988)
  - . employment 3000
  - . value landed fish 600 10<sup>6</sup> Dfl.

### Beamtrawler layout

In figure 1 (general arrangement) and figure 2 (beam trawling) it can be seen that the applied fishing method dictates the layout to a greater extent. All beamtrawlers are towing two trawlnets by means of booms (or outriggers) perpendicular to the shipsides.

The characteristic construction is a single deck hull with design trim (maximum propeller diameter) and extended forecastle (fish handling) and aftward the accommodation (4-7 persons).

Below the maindeck the hull is often divided in:

- fore peak
- fish hold (+ 0°C)

- net store
- engine room
- crew's quarters
- aft peak

In the engine room a medium or high speed diesel engine is installed which drives, coupled to a reverse and reduction gear a fixed pitch nozzled propeller, designed for the fishing condition, maximum pull at 4-7 knots. Often the DC main supplies electricity to the fish winch and bowthruster while the AC main is indispensable for the auxiliaries. Both mains are generated independently, either diesel engine driven (high speed) and (partly) or diesel main engine driven (pto). The fully automated cool- and crush ice unit is installed in the fish hold. The beamers are designed and built according the Rules and Regulations of the Dutch Shipping Inspectorate for seagoing fishing cutters.

### **Beamtrawler (safety) design**

As in the Dutch fishing industry a fishing company with more than 3-5 vessels is an exception, a company oriented design approach is absent. Every skipper/owner prefers his own shipyard and/or designer. Once a good vessel design is build, many newbuildings followed with the skippers adjustments and with often increased main dimensions (similar upscaling). So that although the main features (layout, fishing method) of these vessels are the same, hardly two ships can be found with identical installations and equipment.

Instead of an ad-hoc design approach for the personal safety aspects, a new beamtrawler design method has to be introduced in the Dutch fisheries, the design-spiral (figure 3).

This iterative design spiral is already a well-known method in the merchant marine shipbuilding industries, although also without the personal safety design requirements.

In the new design method all different design requirements, including the personal safety aspects can be properly matched with the required fishing vessel and catch effort by the potential skipper/owner, without radical changes of the traditional layout and equipment.

The spiral is turning inward to represent an increase in accuracy (drawings, calculations) and the sectors represent the decisive design requirements for the Dutch beamtrawlers.

Because all the decisive design requirements can be properly integrated in the design, no excessive costs will be the case, also for the personal safety aspects. Important for acceptance by the skipper and crew without mandatory regulations. This iterative design spiral is applicable to new vessel types as well as to existing ones.

## **1.3. SAFETY ANALYSIS METHODS**

### **Introduction**

In the light of the European Community Directive on product liability and the coming revision of the Dutch Commodity Act, which governs product safety in The Netherlands, "foreseeable misuse" of products, machinery components as well as (fishing) vessels is becoming increasingly important as a factor in safety.

Strategies on product safety in the past have mostly concentrated on risk awareness, individual motivation and instruction of users. Risk compensation by a financial buy-off and risk delegation through the limitation of liability by contract or transfer of risk to insurance companies are no longer seen to be satisfactory as the sole instruments to manage safety problems arising from defective products and equipment.

The technology choices involved in the product design are beyond the control of the user, but manufacturers and designers are increasingly being compelled to improve the safety qualifications of their product before they come into the market. As a result emphasis in safety strategies is beginning to shift from damage and injury reduction to **accident prevention**. Designers must also be able to translate the feedback of user experience (beamtrawl fisheries) into design improvements before accidents occur. To do this there is a growing need for **conceptual designing**.

### **Safety problem solving method**

Since accidents are the main indicator of disturbances and failure in practice, the starting point of many safety analysis is a retrospective approach, focussing on the user and vessel components involved in an accident. The effectiveness of the solutions generated by this approach is limited, since it lacks predictive potential, especially in the application of new products, design and new technologies. Therefore, the basis of the methodology of the Safety Science Group has been to study the undisturbed as well as the disturbed use process, to use simultaneously a **prospective and a retrospective approach** and so obtain more independent ways into the problem.

Accident factors can originate during either the development, production or use of the product. The relevant factors can be determined both by analysing previous accidents and by analysing the undisturbed use process. In the undisturbed use process in particular the actual use is studied and compared with the designed use, to find out whether the use was foreseen in the design phase and whether the actual users were the target group as defined by the designer.

The methodology is based upon the common basic cycle of problem solving: **information collection, analysis, generation of solutions, synthesis, evaluation.**

The approach is based on an information collection strategy with four dimensions or angles of approach:

#### Historical analysis

This provides an insight in the development of the beamtrawl fisheries, work procedures, trends, general demands and the boundary of the system to be defined.

#### Normative task analysis

This gives an insight into beamtrawler tasks under ideal working conditions, user activities and their interactions.

#### (Re)design analysis

This gives insight in the system fishing vessel, defined by the role and functioning of the system components, integrated in the design and building of the vessel.

#### System analysis

This provides an insight into all the system objectives related to the problem area of safety and working conditions; e.g. the fish processing deck, and the potential solutions.

In considering these four dimensions data should be collected from literature (fishery research, references), expert opinions (fishery designers/researchers, Par. 1.1. and 1.2), aggregated data from accident registration (Radio Medical Service, Shipping Inspectorate) and information about occupational diseases (GAK, Social Funds for Partnershipfishing). Above mentioned information provides a qualitative insight into the system and describe

together all of the factors that contributed to accidents as well as preventing accidents (user scenario's) and/or minimize the residual risks by generating (safety) solutions onboard of the beamer.

### **Role of safety in the design process**

Safety has always been an aspect in the design of products, even (fishing) vessels. The need to implement safety as early as possible in the design process is frequently argued on the basis of cost and effectiveness. Moreover, historically seen, the interest in safety has been different in different design disciplines and fields of application. There have been distinct differences and little coherence between the occupational, housing (sea) transport and product safety fields. Even within one field of application such as vessel design safety has been assessed differently with regard to the safety of crew, ship, freight and the environment. Up to now solutions to safety problems have been largely approached from a practical point of view, not from a scientific point, or have been restricted to one component and not generally available for the total system.

There are two extremes possible in the approach to safety in the design process:

- **the common one:**  
historically and ad-hoc based engineering
- **the new one:**  
safety integrated design approach on a conceptual basis.

### **Safety integrated approach**

The development of engineering has a long history with a shifting emphasis in material, energetic and informational aspects and a development from component engineering to systems engineering. Safety problem solving strategies in engineering, education and enforcement developed along these lines as well. Experts like engineers, psychologists, legislators and physicians have each played their own independent role. From this basis a scientific system-based approach to safety problems is emerging, in which a problem-orientated, interdisciplinary problem solving process integrates the technical, organizational and social measures into a coherent risk assessment and control strategy. There is an obvious need for an integrated approach to the design based on arguments of prevention, legislation and optimization of techno-economical conditions. This raises the question how and in what phase safety can be linked to design activities in a systematic way.

### **Safety analysis in beamtrawler redesign**

The starting point of the safety analysis in the Dutch fishing industry lay in the analysis of accident data available from several sources, together with studies of the long term effect of noise and vibration. The analysis generates 12 use scenario's, depending on the type of fishing gear, ship and fish processing characteristics. The 2000 hp beamtrawler scenario stood out as the most important on the basis of future trends, the number and severity of accidents, number of ships and crew involved. Moreover the exposure to hazards, the aggravating circumstances and the high working load on the fishing deck and bridge made the beamtrawler an excellent candidate for redesign. On beamtrawlers accidents were found to occur on deck, during processing of the catch and in the fish hold. A sufficient number of accidents was available to make a typology of accidents possible for several working areas. The distribution of accident types differed for the deck activities, fish processing and storage. Work in the processing of the catch and fish hold storage showed few accident cases, but the

work load under heavy sea conditions in a 3 hours long, 40 times repeated, working cycle over 5 days added undoubtedly to the overall accident liability by fatigue and climatic conditions.

Accident prevention priorities were determined on the basis of criteria of numbers, severity, availability of information, aggravating circumstances and interrelation with other problem areas. On this basis accidents on the fishing deck were selected as primary fields of interest.

A normative task analysis was used to provide a coherent description of the task, tools, working stations, accidents and aggravating circumstances.

The normative task analysis of fishing deck equipment, work procedures, tasks, accidents and long term effects laid the basis for the redesign of the fishing deck layout and equipment.

The safety analysis permitted the structuring of the problem area into a number of manageable subproblems and the setting of priorities by the allocation of criteria and weighing factors. On this basis safety could be made explicit in the formulation of the Programme of Requirements for fishing vessels, to be fed into the safety integrated design method (see also figure 3 - design spiral).

The overall Programme contains groups of design aspects with regard to the

- **fishing method** such as fishing grounds, fishing gear and gear handling in relation to constraints on shaft horse power;
- **fish processing** such as fish quality, fish storage and mechanization and automation of the processing of the catch in relation to constraints on deck layout;
- **catch capacity** such as fish hold, cooling and freezing equipment, weights, ballast and stores in relation to constraints on stability and trim as vessel structural and global safety aspects;
- **ship dimensions** such as layout, manufacturers' coefficients, structures with respect to strength calculations in relation to constraints on displacement;
- **propulsion plant** such as cruising and fishing speed, manoeuvring and auxiliaries in relation to constraints on engine room layout;
- **working conditions** such as sea performance, ship acoustics and vision lines in relation to constraints on personnel safety at all work stations.

The eventual contents of the Programme will depend on the weighing of needs and objectives of the skipper/owners involved and on the assessment strategy for the introduction of the redesign into the beamtrawl fisheries.

As an example one of the beamtrawler design drawbacks, safety on the workdeck, is worked out. In the same way the other beamtrawler safety aspects: noise/vibration, vision lines, bridge- and engineroom layout, hull form (sea performance) can be studied, resulting in a complete safety integrated new design of beamtrawlers.

## **1.4. OCCUPATIONAL ACCIDENTS/WORKLOAD BEAMTRAWLERS**

### **Introduction**

Almost one year ago the project "Working conditions in the Dutch sea fishing industry" started at the Delft University of Technology (Safety Science Group) in cooperation with The Netherlands Institute for Fishery Investigations (RIVO) at IJmuiden, partly granted by the Ministry of Social Affairs.

The first research objective was to analyse the occupational accidents and working conditions onboard Dutch seagoing fishing vessels in order to determine the problem areas, especially



onboard the beamtrawlers. Secondly solutions for the most urgent safety bottlenecks (personal safety, Par. 1.1) have to be engineered as well as pre-proposals for developing of educational material (Fishery Schools) should be generated.

## Material and method

Material on accidents on Dutch seagoing fishing vessels was acquired from 4 different sources. When someone is injured aboard a ship at sea it can be necessary to get medical assistance. When there is no near harbour, the skipper usually gets in contact with Scheveningen Radio. This station brings the skipper in contact with a doctor of the Radio Medical Service (RMD) of the Red Cross. The RMD doctor makes notes on standard forms. These notes dealing with occupational accidents aboard fishing vessels from 1983 to 1988 were analysed. In almost every case it was possible to ascertain the type of ship, the length and the installed power. Every report contains a short description of the accident. Sometimes it is necessary to evaluate the patient immediately. Usually this is done by means of a helicopter. The actions are coordinated by the Coast Guard. In this case the Shipping Inspectorate is informed of the accident. From these investigation reports the extended descriptions of about twenty severe accidents between 1981 and 1988 were analysed. As a result of an occupational accident the fisherman can be (temporary) unable to work. When he is a wage-earner (30% of the fishermen) he gets benefit according to the Health Insurance Act (GAK). In that case information about the accident is registered (GAK). The registration-forms mention the owner of the ship, the date, a short description of the accident, the type of injury and the estimated length of absenteeism. The registration-forms from 1983 to 1987 were analysed.

However most of the Dutch fishermen work in partnership (70%). These fishermen are usually insured by the "Social Funds for partnership fishing" (SFM). From the file of this organization all cases were analysed where the fisherman was unable to work for more than one year. It was possible to find the complaint that caused the disablement, whether it was due to an accident aboard, the age of the person involved, the date. The files between 1973 and 1988 were analysed.

The data acquired from these four sources were classified in a data base. The different sources were checked for overlaps, using the data of the accident and the name of the ship.

Besides proceeding from the normative task analysis or description (comprises all subtasks in a time sequence) an estimation was drafted of the workload of beamer fishermen (gear and net handling, fish processing, -storage).

The activities were divided in a number of movements, for which the energy consumption was calculated (product of the applied force and the moved distance).

## Accident analysis

To analyse the occupational accidents profoundly, a classification have been drawn of 18 types in 8 groups as given in Table 1.

Group	Typology	Accident type-No.	Description
I	Capsize	1 2 3	Capsize caused by uneven load on warps Capsize caused by high towing point of warp Capsize caused by overload warp
II	Gear	4 5 6 7	Caught in winch Jamming of fingers/hand Hit by breaking warp or hook Hit by warp
III	Moving object	8	Hit or crushed by moving object or gear component
IV	Net	9 10	Jammed between net and guard rail Pulled overboard by net
V	Tools	11 12 13	Cut while cleaning fish Wounded by fish Other injury caused by tools
VI	Falling	14	Falling, slipping on deck
VII	Box	15	Box filled with fish on hand or foot
VIII	Rest	16 17 18	Jamming in door Accidents during housekeeping Rest, cause unknown

**Table 1 - Classification of occupational accidents onboard beamtrawlers**

Together with the schematic fishing cycle and estimated workload, the beamtrawler results are given in figure 4.

Occupational accidents onboard fishing vessels are a serious problem, out of view in many ways (fishery and legislative organizations). However times are changing by implementation

of the national working condition law (the so-called ARBO-Law), also onboard fishing vessels.

Without going in all the accident details (see Ministry of Social Affairs reports), generally speaking the accident rate of the Dutch fishermen is about 50 per 1000 workers per year and about 3 per 1000 are becoming permanently disabled due to an onboard accident. These figures are more or less comparable to the situation in the building industry ashore. However occupational accidents onboard often result in very severe injuries (multiple fractures, inner hemorrhage, unconsciousness).

The majority of the occupational accidents occur on the foredeck; besides falling/slipping the main causes are handling of the gear and crushing by moving objects.

Because the beamtrawlers are fishing during 5 days per week (about 40 per year, day and night), the estimation of workload was analysed for an one week working schedule on deck:

- beamtrawlgear + netting handling (about 12-15 tons of weight) at the start and end of the week;
- codend hauling, -shooting (emptying net) and fish processing and -storage (5-10 fishboxes á 40 kgs weight, excluding discards) during 40 times per week.

The results are given in figure 3. Again, generally speaking, a nowadays beamer fisherman consumes about two times more energy per day than a bricklayer ashore, however he continuously works 4-5 days per week on a moving working platform, the fishing vessel at sea. It is not wonderfull that back- and jointproblems are the common causes for disablement (ages: 40-45 years).

On the fishing deck three hazardous working stations were identified:

- working along the side with heavy gear;
- working with warp head- and jumper line by the winch house beneath the bridge for transport and lifting of heavy objects;
- the emptying of the codend of the net into the fishing dumps.

Accidents occurred through the handling of warps and blocks, swinging and lashing of beams, blocks, loads, nets and chains, moving objects on deck such as stones, bits of wrecks and by falling on a moving, slipperly deck.

The workstation for the processing of the catch is underneath the forecastle deck, with very high acceleration levels ( $> 1$  g) and has to be reached by crossing the fishing deck, adding to the interference between activities.

## 1.5. GENERATION OF SOLUTIONS

For the generation of solutions to solve the analysed problem areas (Par. 1.4) on the beamer working deck, two solutions matrices can be used to order the known and newly generated solutions (retrospective matrix) as well as to enable decision making in the selection of solutions (prospective matrix).

### Retrospective solution matrix

The first matrix relates the level of intervention to intervention strategies, also containing prevention measures of a technical, designing as well as an organizational, and social nature. In terms of the system (fishing vessel) approach three levels can be divined, at which intervention (solution generation) is possible.

The first level is the micro level, which contains the beamerfishermen in their direct interaction with the gear-, netting- and fish handling equipment on the foredeck, directly linked to local engineering solutions of the vessel equipment.

The second or meso level is the level at which skipper/owners and designers are located, describing the system fishing vessel as a whole, linked to redesigning solutions of system components and working areas.

The third level is the macro level, dealing with organizational measurements and training courses, directly linked to Shipping Inspectorate and national working conditions laws.

Applied to the beamtrawler circumstances, in Table 2 the three levels and five intervention strategies are given.

Retrospective solution	Micro	Meso	Macro
Strategies/levels	Local engineering	Vessel design	Organizational/legislatives
Elimination of warphead (Jilson winch)	X	--	X
Improving the beamtrawlgear- and net handling	X	X	--
Improving the codend (netting) handling	X	X	--
Adapting the fish processing and storage procedures	--	X	--
Redesign with regard to changing the layout/working areas	--	X	X

**Table 2 - Retrospective solution matrix beamtrawler**

The first strategy aims at the elimination of the hazard (accident No. 4-7) by replacing the technological principles used, while the other strategies are increasingly aiming at isolating the hazards (No. 4-10, 14/15) and preventing destabilisation of the system fishing vessel (protection, reduction of damages/injuries) and minimizing the residual risks. As an example and within the scope of this paper the fifth strategy is chosen at the meso level, generating good solutions (dealing with a high number of solutions at the time).

### Prospective solution matrix

Once a solution strategy is chosen, a second solution matrix should be drawn to increase the solution selection criteria. This means an inventarisation of which safety/working conditions bottlenecks can be solved (retrospective), which residual risks are left or introduced and what does it mean for the fishermen workload (prospective). Although from a point of safety and working conditions it is difficult to speak of cost-effective solutions, so in fishing vessel designing it is very important to point out the redesigning costs. Especially dealing with solutions which are not covered by any rules or legislative measures.

In Table 3 these decision criteria and two solution levels are given in redesigning the beamtrawlers.

Prospective solution criteria/level	safety/working condition bottlenecks (table 1 nr)	residual risks	reducing fishermen workload	extra investments of % new building
1) changing winchhouse (midships) and fish processing space (forecastle)  (Figure 4)	4,5,6,7,9,10,14	8,14,15,17	40%	15%
2) idem 1) + moving fish gallow and fish dump aftwards + installing two deck cranes for codend and beamtrawl gear handling  (Figure 5)	4,5,6,7,8,9,14,15,17	14	70%	25%

**Table 3 - Prospective solution matrix beamtrawlers**

For solution level 2 the residual risks is as low as possible in redesigning an existing modern beamtrawler. Reducing the risk of falling due to a cruel seaperformance (high stability requirements), systematically seaperformance model tank tests are inevitable!

Introducing deck cranes for the codend and gear handling means an improvement in controlling the hoisting and shifting of (heavy) components on a moving working platform at sea, while the gallow derricks are only used for towing of the two beamtrawls.

### Goodness of solutions

In order to convine experienced fishermen and skipper/owners the quality of the solutions is of great importance. Good designs solve a number of problems at one time and have well thought out advantages which outweigh possible disadvantages.

Exchanging the positions of the winchhouse and the fish processing workstation in the existing vessel layout has not been considered before in nowadays practice, but offers many advantages, which deal with a number of accidents and fatigue problems as given in Table 4, including the major drawbacks (vision lines, noise control).

Multiple solutions	Description
Vision lines	<ul style="list-style-type: none"> <li>- the foredeck could be lowered and provide the skipper with a better vision ahead in accordance with the IMO Regulations;</li> <li>- at night the skipper would no longer be hindered by the lights in the processing station;</li> <li>- operation of the gear and codend would occur within clear sight of the man on the bridge. This would allow improved communication, give the local operator back cover from the sprayhood, give the local operator a good view of the beam and codend and separate him from the side where the heavy beams are located;</li> <li>- there is more accommodation space on the maindeck (skipper cabin no longer on the wheelhouse deck, resulting in better vision lines aftward.</li> </ul>
Noise control	<ul style="list-style-type: none"> <li>- the noisy winches would be reallocated to foreship, away from the accommodation</li> </ul>
Occupational accidents working deck	<ul style="list-style-type: none"> <li>- vessel motions in the midships are less violent (about 50%) than in the peak, thus reducing the workload in the processing of the catch. This work occupies many hours at present and thereby increases the accident liability because of fatigue;</li> <li>- warps and lines would no longer run across the working stations on deck;</li> <li>- transit of crew members between accommodation and the processing workstation would no longer interfere with the fishing deck activities.</li> </ul>

**Table 4 - Goodness of redesign solutions beamtrawlers**

As in many other engineering disciplines, ad-hoc solutions are always very expensive, so that technically spoken above mentioned multiple safety/working condition solutions can cheaper be applied to a safety integrated new design of beamtrawlers.

The estimated extra investments will be reduced to 5-8% of a nowadays newbuilding beamtrawler of 2000 hp, depending on installation of deck cranes or not.

In the meantime solving the sub-area problems (Table 2 - Solution strategy 1-3) along the safety problem solving methods means a considerable reduction of the occupational accidents and the fishermen workload versus a modest extra investment of about 1-4%.

## 1.6. CONCLUSIONS

After a period of growth and mechanization, the Dutch fishing industry faces a period of quality improvement and cost reduction. Future restrictions on the European fishing industry, future safety regulations from ILO and IMO, national and international legislation on working

conditions and the increasing concern for the marine environment will have to be reflected in common vessel design approach.

Before safety aspects can be integrated in the beamtrawler design, good knowledge of the beamer practice is essential. Both for the global safety aspects and for the personal aspects, to which global aspects underlying many mandatory rules often learnt by bitter experiences.

However safety directed linked to the working conditions is still a matter of free and/or competitive interest of the shipyard/designer and skipper/owner, although a national working condition law has entered The Netherlands, which may be expected to become compulsory onboard fishing vessels in the nineties.

Only by application of (fishing) vessel design spiral techniques, including the safety and working conditions as a grown set of design requirements (RIVO) and the safety problem solving method-techniques (Safety Science Group, TU-Delft) are leading to a safety integrated (re)design of beamtrawlers as shown in this paper.

Safety and working condition aspects as explicit feed-forward constraints from the beginning of the fishing vessel design process together with the traditional craftman skills may contribute to innovation in the fishing industry to cope with the demands and needs of the near ARBO future.

Various skippers, designers and crews are believing that safety problems in this field only occurring onboard colleague vessels. Carefully analysing of the state of the art, occupational accidents and longterm workload are still showing a worse situation.

In case of conceptual redesigning the beamer workdeck and considering the design spiral again with the other beamtrawler safety aspects, the multiple solutions are ultimately leading to the design goal of a "safety integrated new design of a Dutch beamtrawler: the beamer 2000".

#### ACKNOWLEDGEMENT

The authors would like to thank the Ministry of Social Affairs (accident analysis) and the the National Foundation for Dutch Maritime Research (CMO, shipacoustical integrated beamtrawler design) for partly granting the safety integrated fishing vessel design studies.

Also some designers and fishermen in the Dutch beamtrawlfisheries for the fruitful discussions.

Besides the authors want to express their gratitude to Capt. Ir. L. Brink and Ir. R. Hoftijzer (Ministry of Social Affairs) for the stimulating discussions regarding safety integrated versus ad-hoc solutions in redesigning fishing vessels.



## REFERENCES

1. Changing design requirements for the seagoing Dutch fishing vessels; F.A. Veenstra, The Netherlands Institute for Fishery Investigations; RIVO-Report RO 89-02 (in Dutch).
2. Safety aboard Dutch fishing vessels; W.A.M. Hoefnagels, K. Bouwman, resp. University of Technology-Delft, Safety Science Group and the Netherlands Institute for Fishery Investigations; Rimouski-Canada 1989. (Symposium Safety and working conditions aboard fishing vessels).
3. Safety and bridge design Dutch beamtrawlers; J. Stoop, University of Technology - Delft, Safety Science Group; Rimouski-Canada 1989. (Symposium Safety and working conditions aboard fishing vessels).
4. Acoustical design aspects on board Dutch fishing vessels; F.A. Veenstra; The Netherlands Institute for Fishery Investigations; Rimouski-Canada 1989 (Symposium Safety and working conditions aboard fishing vessels).
5. Safety aspects in redesigning medium sized beamtrawlers; F.A. Veenstra, The Netherlands Institute for Fishery Investigations; ICES-FTFB Working Group Meeting - Dublin/Ireland 1989; ICES paper CM.89/B:39.
6. Safety and design process; J. Stoop; University of Technology - Delft; Safety Science group; doctoral thesis TU-Delft in press (1990).

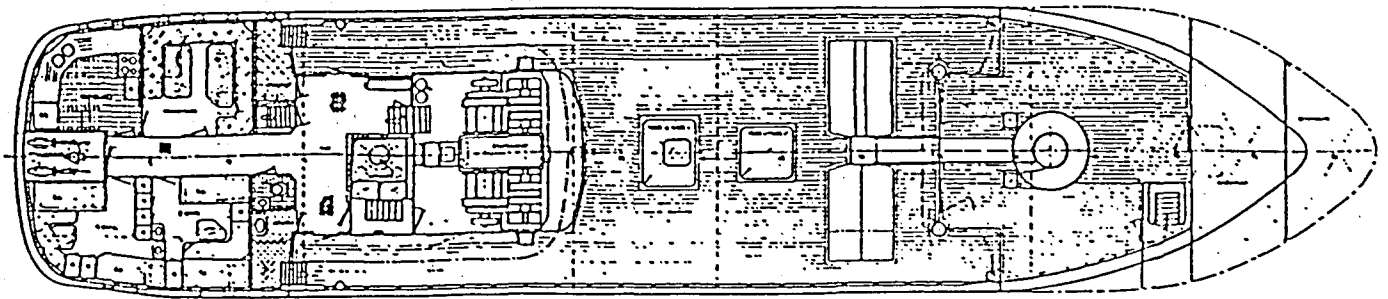


Figure 1 DUTCH BEAMTRAWLER (1990)

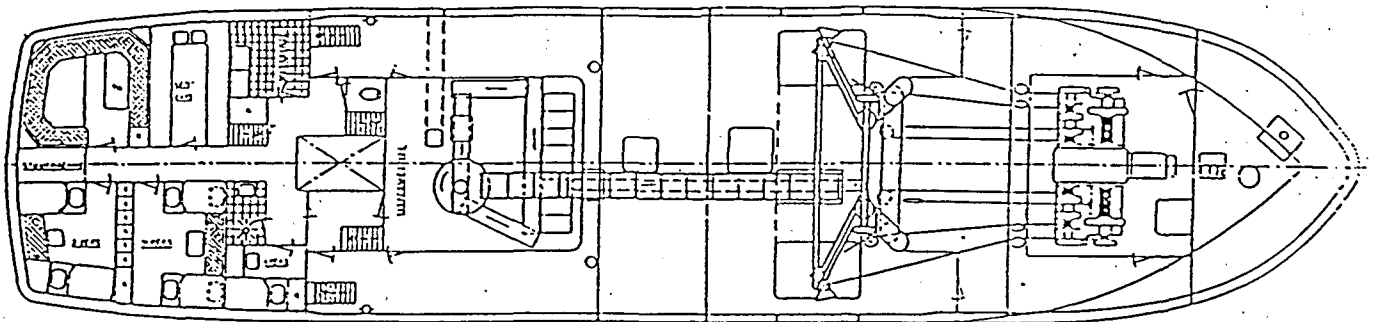


Figure 4 BEAMTRAWLER (REDESIGN WORKING DECK a)

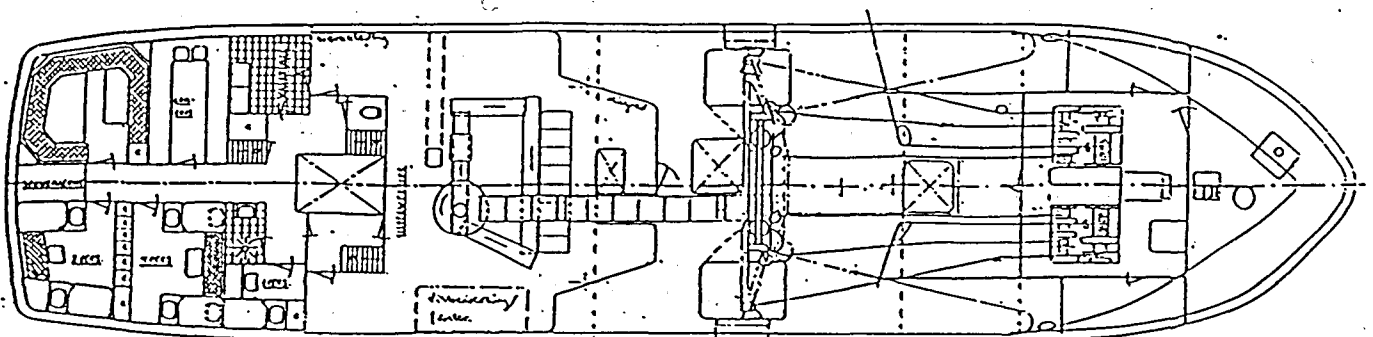


Figure 5 BEAMTRAWLER (REDESIGN WORKING DECK b)

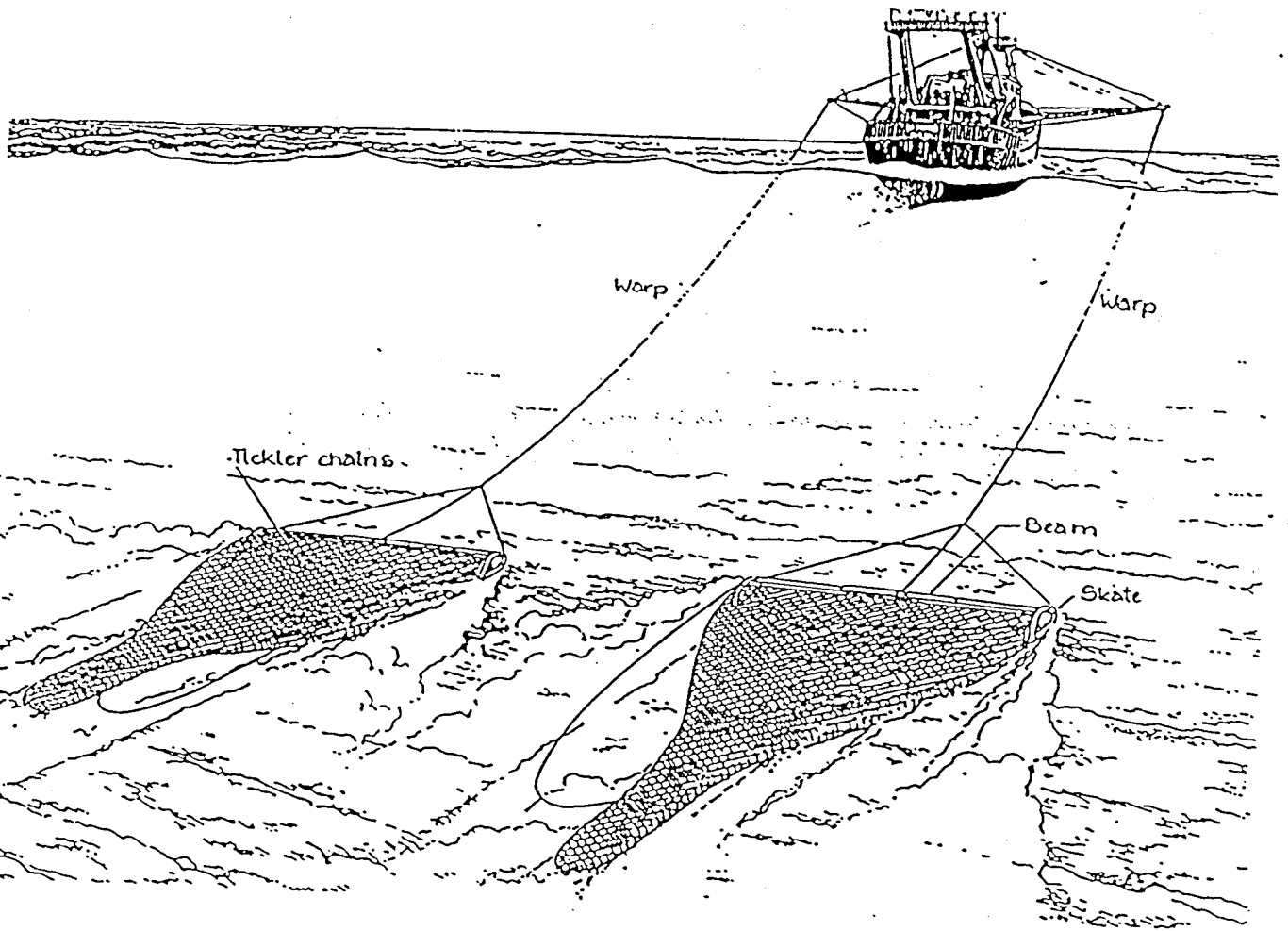
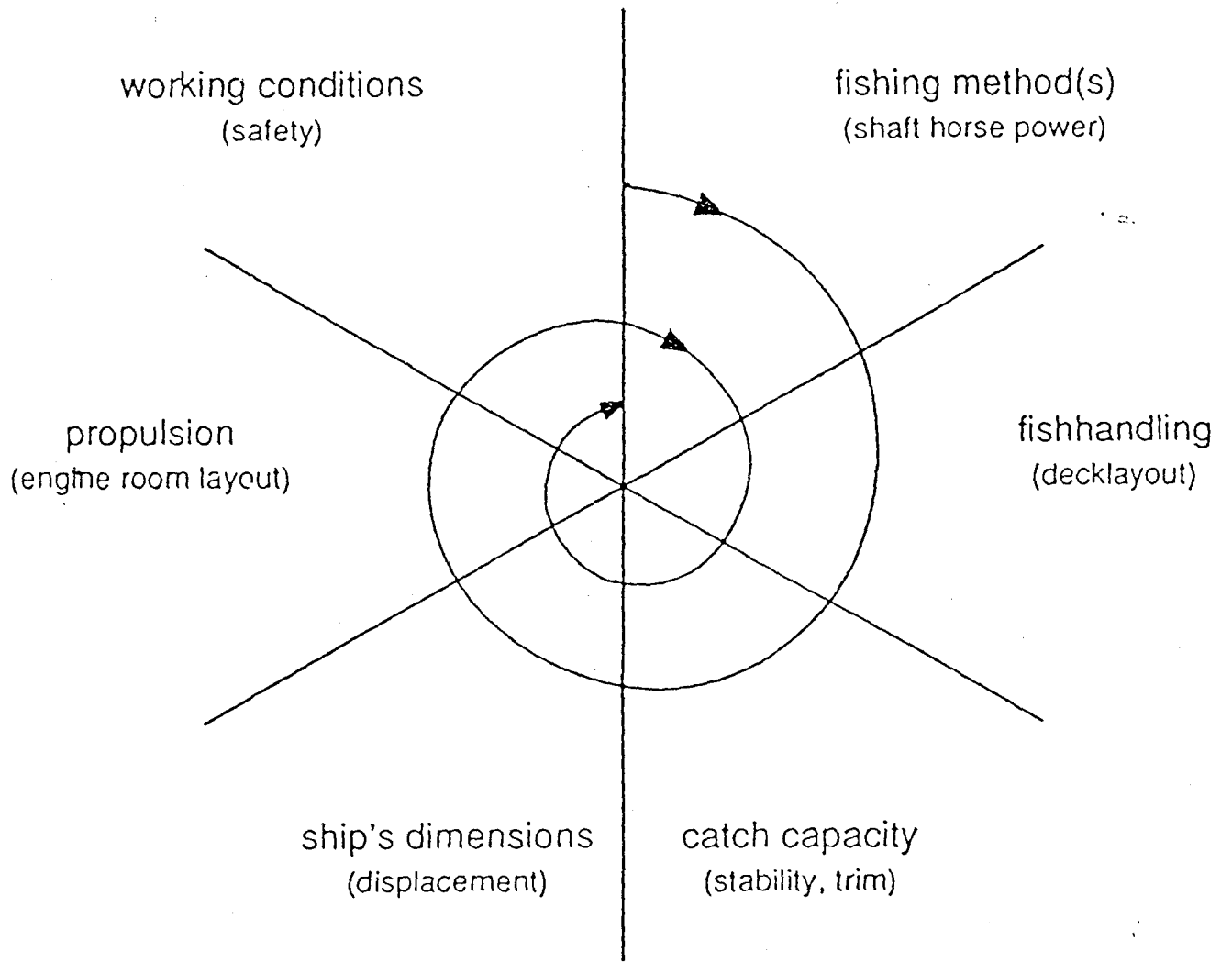


FIGURE 2 - BEAMTRAWLING



**FIGURE 3 SAFETY INTEGRATED DESIGN SPIRAL DUTCH SEAGOING BEAMTRAWLERS**

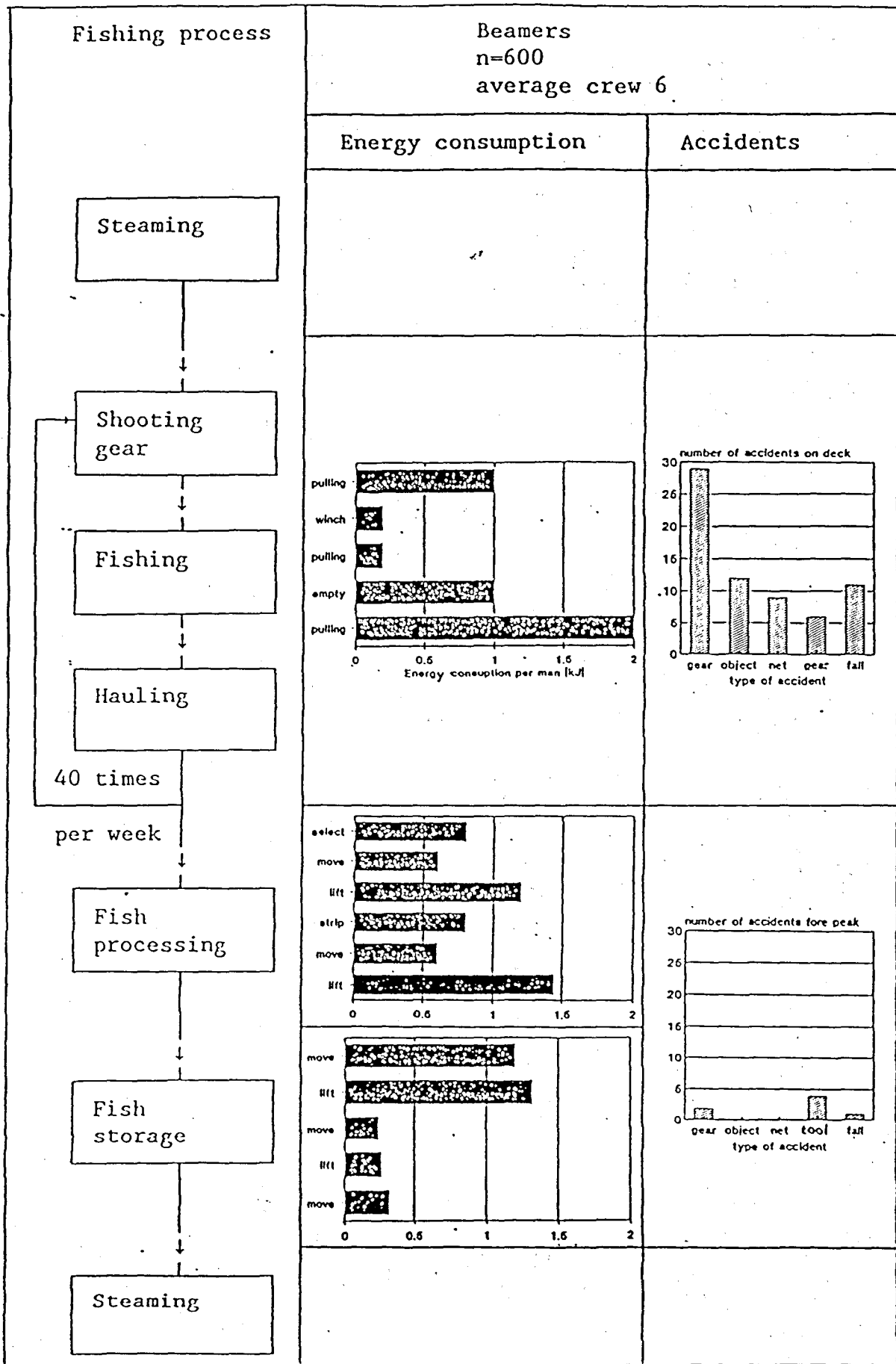


FIGURE 6

WORKLOAD AND ACCIDENT ANALYSIS  
BEAMTRAWLERS