Towards a new state of resilience for the socio-technical system of the sea fishing industry ?

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Abstract. The sea fishing industry belongs to the category of ultra efficient systems. It is set apart by a low security level (10^{-3}) and run according to a model based on the professionalism and individual skill of operational actors (fishing skippers). These skippers, once at sea, are subject to very few pressures, either from the authorities in charge of regulations or the companies fitting out their vessels. This gives them an even greater autonomy. The result, as far as their activity is concerned, is that safety depends exclusively on them, as self-sufficient actors who have every freedom to maximise performance without necessarily taking into account safety criteria.
In this paper, we will attempt to answer the following questions: 1. How is safety integrated into this system, and according to what model? 2. Is this system resilient? 3. If it is, can its current level of resilience be explained, and is it likely to change?

1 INTRODUCTION

Sea fishing is the most dangerous of all professional activities. Fishermen perform in a hostile, changing environment which adds greatly to the dangers of the crews' tasks aboard the vessel. A sea fisherman is exposed to different risks (falling overboard, being cut, burned, crushed…), and thus to serious or even fatal injuries. In France, in the year 2000, the frequency of occupational injuries was of 44 work-related accidents per 1000 workers in other fields, and 143 accidents per 1000 sailors. Even more striking, the rate of fatal injuries per year is much higher in the fishing industry than in any other profession. The statistics for the year 2000 showed a rate of 5 work-related fatalities per 100,000 workers in "ordinary" jobs, 15 per 100,000 in the building industry (a branch considered to involve real risks for its workers) and 100 deaths per 100,000 sailors. These figures show very clearly the low level of security in the sea fishing industry's socio-technical system (rate of work-related fatalities: 10^{e-3}). Moreover, Morel and Chauvin's work has shown that the system's mode of activity stands outside the boundaries of safe operations (Morel & Chauvin, 2006).

To approach the question of risk management within this specific socio-technical system, we would like to submit some ideas along the lines of current research on the resilience of complex systems.

Resilience if the ability of an organised body to keep, or to recover quickly, a state of balance enabling it to continue its activity during and after a major accident, or in the presence of great and continuous pressure (Wreathall, 2006). In other words, resilience is a system's ability to fulfil its objectives in spite of negative events or great constraints. This aspect of resilience does not explicitly refer to safety but rather to the economic prosperity of the system. Hale and Heijer (2006) suggested broadening the definition to include a system's ability to operate smoothly even in difficult conditions. Resilience, or a system's capacity to adapt and adjust, can therefore be approached either from the economical point of view or through the question of safety. The adjustments to be made can be analysed at several different levels; McDonald (2006) made a distinction between the following levels: 1. operation; 2. organisation ; 3. the industrial system where technology is designed and produced. He also insisted that it is necessary, if the nature of resilience is to be understood, to analyse these different levels and the relationship between them.

Following the authors quoted above, we intend to analyse the resilience of the sea fishing industry's socio-technical system, at both the macroscopic level and operational levels. The key question today is the economic survival of this system— or at least the survival of some of its component parts. In this paper, we will attempt to answer the following questions: 1: How is safety built into the system and according to what model? 2: Is this system resilient? 3. If it is, can its current level of resilience be explained, and is this level likely to change?

2 THE SEA FISHING SYSTEM

2.1 The Organisation of safety

The European sea fishing sector is highly regulated, but it also has a very strong hierarchy. Organisations and actors responsible for the safety and working conditions of sea fishermen can be found at every level of the system's hierarchy (figure 1). The highest of the five levels[1] of this hierarchy is represented by the International Maritime Organisation. Regarding safety, its mission is to establish the regulations and agreements which prevail in the international maritime community.

At the second level (European) the Directorate-General of Fisheries (DG XIV) is in charge of defining the common fishing policy. Its main objective is to limit the fishing effort so as to protect the resource; its main tools are the TAC (admissible catch rates) and QUOTAS, which mainly involve fishing techniques, and the effort to cut down the vessels' workforce through plans helping fishermen to cease their activity and/or retrain. The Directorate-General of Fisheries is also responsible, to a lesser extent, for the question of safety. Its actions are limited to giving grants in accordance with the

[1] International, European, National, Regional and Local.

common policy it has defined. This means that the main function of the European authorities regulating and controlling the sea fishing sector is to protect the resource, and not to deal the safety of the fishermen.

At the 3rd and 4th levels of the hierarchy (National and Regional), as at the European level, few offices deal with the safety of sea fishermen. In France, they are the Investigation Bureau for Accidents at Sea, the Maritime Institute for Prevention[2], the seagoing personnel medicine board, and Maritime Affairs. The job of the Investigation Bureau for Accidents at Sea is to perform the administrative technical investigation following an accident at sea. Its action is entirely « reactive », and this restricts the impact of prevention measures. Though it is affiliated to the Ministry in charge of Transportation and the Sea, this bureau is politically independent. The Maritime Institute for Prevention is a national, non-profit organisation; its mission is the prevention of occupational risks at sea and the improvement of living and working conditions for seagoing personnel. To do this, the Institute uses the data found in the questionnaires handed in to the ENIM (National Bureau of Disabled Maritime Personnel) with any declaration of occupational injury. Its action is primarily concerned with training seamen and advising on the design and construction of new vessels. This Institute's prevention effort is also based on a reactive approach, on the periphery of the organisations in charge of developing regulations. The seagoing personnel medicine board's role is very similar to the workplace medicine boards in charge of health control in so-called « traditional » industries. Finally, the Maritime Affairs supervise the implementation of regulations of all types, and coordinate the means used in sea rescue, in the surveillance of maritime traffic and the fishing effort. This means that in the sea fishing industry, the first four levels of the hierarchy are only involved in the « administrative » side of safety at sea; there is no genuine coordination in risk management policy. It is here, within these four levels of the hierarchy, that the latent conditions for accidents are created.

At the lowest level of the hierarchy (the local or operational level), safety depends exclusively on the system's « operational » actors: ship owners in charge of fitting out the vessels, fishing skippers and crews. It is important to stress that sea fishing, for the main part, is run as a craft. This essential characteristic is true of vessels less than 25 meters in length— which is true of 95% of the fishing fleet. These vessels are fitted out for inshore fishing[3], coastal fishing[4], or offshore fishing[5]. The sea fishing sector is a craft in both the legal and financial sense of the word (La Documentation française, 2003): a) the skipper is owner or co-owner of his vessel, and he goes out with the crew; b. the seamen are paid by shares, they are associates in the vessel's profits. Sea fishing is also very much a craft in the sociological sense of the word. The fishing skipper is an independent craftsman, performing a manual task he has learned as an apprentice; in most cases, his wife is involved in the management of the concern. The sea fishing

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[2] Created under the authority of the Ministry for Transportation and the Sea, the ENIM, the national syndicates representing sea fishing and sea aquaculture, shellfish farming and maritime transports.

[3] Vessels less than 16m in length and going out for less than 24 hours

[4] Vessels less than 16 m in length and going out 24 to 96 hours

[5] Vessels more than 16m in length and going out longer than 96 hours

sector also includes a few companies[6], with a captain in charge of fitting out the vessels, part of whose workload involves safety management. This activity is primarily focused on the implementation of current regulations, and on selective actions, mainly promoting the wearing of individual protection gear. It is here, at this operational level of the hierarchy, that the active conditions for accidents are created.

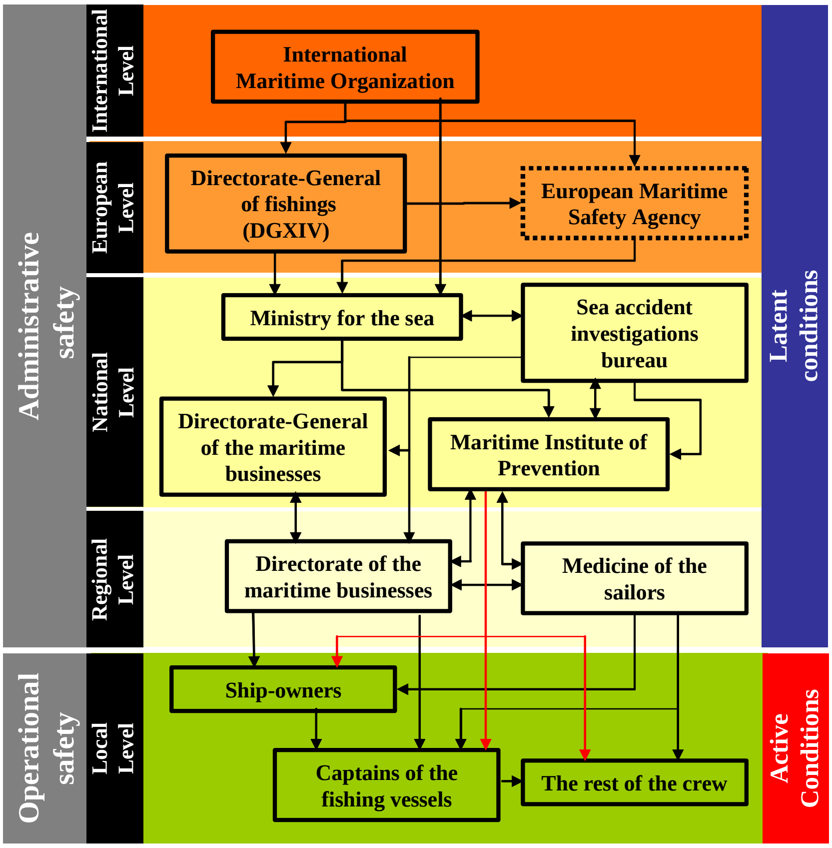

Fig. 1. Five-level safety organisation of the sea fishing system.

[6] For the most part, these use larger, industrial or semi-industrial vessels.

2.2 A Safety Model

To improve any system's safety level, a number of barriers must be crossed. Amalberti & al. (2005) postulates the existence of five successive systemic barriers, each characterised by a different connection between safety, performance, and the way the profession is organised. The higher the safety level, the more complex these barriers' mechanisms. In other words, the higher the safety level, the more difficult it will be to get over the next barrier. To this day, only ultra-safe systems have managed to get over the five barriers to reach a peak safety level of 10^{-7}. As far as our field of research is concerned, we find that the sea fishing system belongs to the family of « ultra-performing » systems, with a low safety level— a 10^{-3} rate of fatal accidents. Currently, it is situated between the first two systemic barriers[7] and has not yet passed the second. In its current state, the system's operational actors have a very high level of autonomy regarding the decisions they need to make (staying out in spite of bad weather, leaving a fishing zone for another, organising the watch…). Overpassing the next barrier would mean losing this autonomy. Moreover, the specific nature of the sector creates a major paradox: in spite of the existence of regulating tools (TACs and QUOTAS) the purpose of which is to severely curb performance, the operational actors are still in a position to maximise it. Today, TACs and QUOTAS are attributed each year to each member State of the EEC. In France, they are shared out among each region's Production Organisations (OP). This means the vessels belonging to an OP will be able to exploit the resource collectively, up to the TACs and QUOTAS level granted their OP. Consequently, until the TACs and QUOTAS are reached, fishing vessels are not limited in their performance. It is only when the QUOTAS are declared to be closed that the vessels are no longer allowed to fish a particular species. This type of regulation encourages competition between the system's operational actors.

3 RESILIENCE AND THE SEA FISHING SYSTEM

3.1 In its current state, is the sea fishing system resilient?

Amalberti (2006) defines resilience as a system's ability to prosper and survive occasional crises without having to change its basic nature. For this author, there are different states of resilience, each being characterised by a safety level. Changing levels is not a spontaneous phenomenon: the change occurs when the current level of resilience is no longer compatible with the system's financial objectives. Amalberti identifies 4 types of systems, characterised by different safety levels, different success or failure models, and different resilience criteria. The first distinction to be made between these systems is their « audience »: ultra-performing systems (low safety level) correspond to activities performed by individuals or small teams (as in the case of very dangerous sports): safety is managed at a personal level. The second level is the « client » formula, where professionals are hired from a regulated market to provide safety services. At this level, the concept of accidents only involves individuals, who are perceived as unlucky, or as the victims of the incompetence of professionals. The

[7] The first barrier is accepting to curb the system's maximum performance; the second is leading a system's actors to accept the loss of a great part of their autonomy.

third level is that of services or industries targeting a great number of consumers (the food industry, banking, utilities, etc.). At this level, resilience must take public opinion into account; an effort in communication on risk management is necessary. The fourth level involves systems in which the risk of mass fatalities is so high that even an accident is unacceptable; this is the case of chemical or nuclear industries or public transports. At this level, safety is managed by national or international authorities.

If we apply these elements to the sea fishing industry, we find a system characterised by a level 1 type of resilience, which describes highly competitive and low-safety systems. Once this first level of resilience is no longer viable, the system will shift to the next level and accept more constraints and regulations, greater safety and lower performance.

Success criteria and explanations of failure. According to Richter & Koch (2004), the craftsman or self-sufficient actor puts a high premium on job satisfaction. For him, the work or production process has a higher priority than safety. The satisfaction of putting out a high-quality product, or of mastering a technique, comes first. The danger is one of the job conditions; it is up to the worker to minimise the risk thanks to his skill. Safety measures are perceived as being counter-productive, and accidents or injuries as atypical, unpredictable variations of the normal situation. The sea fishing system comprises a low safety level, and its actors express a certain acceptance of the risks. Different studies on the perception of risk among sea fishermen bear out this conclusion. They point to a certain fatalism (Törner, 2000; Eklöf & Törner, 2002; BIT, 1999; Guillet & Morel, 2006); in other words, risks are accepted as being a part of the job, and facing risks even has a certain positive image. In this highly competitive sector, it is for instance badly accepted socially if a skipper does not take the same risks as his co-workers.

Resilience Criteria. In its current mode of operation, the sea fisheries' socio-technical system is characterised by three major criteria: 1. The skill and expertise of autonomous operational actors (the fishing skipper makes his own operational decisions): these actors aim for top performance, and success depends on the skipper's ability and know-how; 2. Efficient tools and means of production: the system's objectives could not be reached without skilled crews and sophisticated tools (the fishing vessels); 3. Various grants and assistance funds: the grants received by the fishing system enable it to stay at a high performance level; without them, the system would be hard put to survive the current economic situation (particularly the increase in fuel prices).

The Organisation of resilience. From these different analyses, it emerges that the sea fishing system's resilience depends on two major categories of actors: 1. The operational actors and the owners who fit out the vessels: to protect their profits, the latter are attempting to change their practices. Some companies for example have decided to assign their vessels to coastal rather than offshore fishing to save on fuel; 2. Political structures: in 2005, the Ministry of Agriculture and Fishing launched a plan for the future of the sea fishing industry organised around three themes: the resource[8], profitability[9], and attractiveness[10].

Table 1. Resilience characteristics of the sea fishing system

Safety level	Model of success	Model of failure	Criteria for resilience	Who is in charge of organizing resilience?
Sea Fishing Industry = Ultra performing system	Quest of maximum performance depending on the skill of independent operational actors	Fatalism Low skill/know-how Uncontrollable outside factors	Skill/know-how Expertise Efficient tools and means of production « Grants »	Operational actors organised as a network Vessel owners Political structures

4 TOWARD A NEW STATE OF RESILIENCE?

We have seen that the sea fishing system is defined by a level 1 state of resilience, which corresponds to a very low safety level (spontaneous or natural resilience). Once again, the transition from one state of resilience to the next is not spontaneous but requires a complex evolution process. According to Amalberti (2006), two causes can trigger this transition: 1. External causes (ex: a specific accident, an economic crisis,…); 2. Internal causes (related to the system's life cycle). These « forces » are going to induce a lack of adequation of the resilience status with the system's day-to-day operation, and this will tip the system over into a new state of resilience. To quote Amalberti (2006), this is a paradox in that resilience is, in essence, a concept expressing a resistance to change. To this day, the sea fishing system has been able to keep to its natural state of resilience, and this has enabled it to remain ultra-performing without ever tackling the question of safety. This level of resilience no longer seems compatible with today's political and economical objectives. This is shown by the presence of a number of external causes liable to bring the system to its transition point: the stoppage and/or decrease of certain grants[11] (which were one of the resilience criteria), the lowering of fishing quotas; the new regulations restricting the vessels' tonnage, the

[8] The idea is to create « routing sheets » defining each fishery's production target, and to deduce from this the necessary size of the fleet.
[9] The propositions are designed to reduce costs; they are mainly technical adaptations aiming at limiting costs, or introducing different fishing techniques. The aim is also to increase profits by making auction sales of the catch mandatory, hoping that an increase in volumes will help negotiations with the buyer and encourage a quality-oriented policy.
[10] Three aspects have been put forward: safety, income and training. As far as safety is concerned, the authors claim that the incidence of injuries could be reduced by the creation of a single, comprehensive prevention document and the mandatory wearing of protection clothing (VFI: clothing with integrated life jacket). Better signalling on the part of the vessels or on-board AIS should reduce the collision threat. As far as income is concerned, the profession as a whole prefers to keep the share system, but a better level of social protection is being considered through a national collective agreement. Finally, on the training front, the challenge is to develop specialised teaching while promoting on-going training.
[11] Grants for the building of new vessels or for modernizing equipment, compensation for the cost of diesel fuel…

increase in the price of diesel fuel[12], the difficulty of recruiting seamen, the frequent injuries,…

Today, the socio-technical system of the sea fishing industry is very close to its transition point: it is being « driven » by high-momentum external factors. This transition in the system's life cycle cannot be stopped, but it can be cushioned and helped along. If it is left to itself, the ecology of the system itself is threatened. If an attempt is made to force the resilience level to change, the consequence will be a rapid increase in safety but ultimately, the system would be exposed to a quicker decline, which would reduce its life expectancy. One thing is certain at this point: to improve this system's safety level, it must be handled so that the transition toward a new state of resilience does not end in total collapse. The question now is how and by what means this heavy task can be undertaken.

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[12] For deep-sea fishing vessels (15-day fishing rounds), diesel fuel consumption can reach thirty thousand litres, which represents about a third of sales figures and a flat loss, over four years, of fifteen thousand euros per year from the income of the crew.

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