RISK IN FISHERIES MANAGEMENT: FROM RULE-BASED TO FUNCTION-BASED MANAGEMENT IN NORWAY?

Ingrid Bouwer Utne, Department of Production and Quality Engineering, Norwegian University of Science and Technology (NTNU), E-mail: ingrid.b.utne@ntnu.no

ABSTRACT

Great efforts have been made in order to manage the fisheries more sustainably, but so far, most of these efforts have failed. This is putting the welfare of current and future generations at risk. The fishing fleets have catching capacity that well exceeds the rate at which ecosystems can produce fish, and thus many fish stocks are being overexploited.

One of the objectives of the Norwegian government is to manage the fisheries in accordance with sustainable development. Sustainable development and risk management are frameworks with some mutual qualities. In the Norwegian petroleum industry, risk management of Health- Safety and Environment (HSE) is based on functional or goal-oriented regulations. Functional regulations focus on the result without describing in detail how it may be attained, e.g. an acceptable safety level at a petroleum installation.

This paper discusses the possibility of transferring experience and knowledge of risk management and functional regulations from the Norwegian petroleum industry into the Norwegian fisheries management in order to increase sustainability in the fishing fleet. An important research question is the connection between an acceptable sustainability level in the fisheries, and transforming the fisheries regulations into functional regulations based on management objectives.

Keywords: Sustainable fisheries, risk management, functional legal regulations

INTRODUCTION

In a global perspective, the overcapacity in the fishing fleets is considered as the most important reason for overexploitation of the world's resources. Both globally and nationally, overcapacity leads to misuse of the production resources in the society. Thus, capacity adjustment is necessary to obtain a sustainable exploitation of the marine resources. Capacity adjustments have been and still are an important challenge in the Norwegian and international fisheries politics [1].

Most of the Norwegian regulations have been introduced as a consequence of resource- and capacity problems. Despite the efforts of limiting an additional expansion of the fisheries, the catch capacity has continued to increase. Standal [2] has found that even though the number of vessels has been reduced within a regulated regime, factors like new gear technology, larger boats, more engine power etc. have contributed to more effective fishing vessels. In order to reduce overcapacity, various policy instruments have been introduced over time in the different fleet groups. Voluntary structural means have been carried out to adjust the capacity, but the challenge is to make sure that these instruments have the intended effect.

A small quota foundation for the fishing fleet leads to low profitability, which again reduces the ability for renewal in the fleet. Old vessels may reduce the fleets' ability to compete for qualified employees; they reduce the safety, the catch effectiveness, and the quality of the fish meat. Another consequence of overcapacity is complex and detailed regulations, with high inspection and administrative costs [1].

The past decades have been a difficult period of adjustment for the Norwegian fisheries management. The early Norwegian regulations were based on the use of licenses, but were later on expanded to total quotas, group quotas, and individual vessel quotas. Broadly speaking, all kinds of regulations have been tried; limitations to number of boats, licenses, size of vessels, type of fishing gears, replacement regulations, etc. [3]. The problem is that the fishers compensate for the regulations by a process called technological creep. This means that the fishers adapt their gear, vessels and behavior to maximize profit when effort restrictions are imposed, a process that leads to little reduction of catch effectiveness [4]. Today, the Norwegian regulations are mainly aimed at controlling catch capacity by use of licenses and vessel parameters, at controlling resource exploitation by use of quotas, by limiting access, by restricting gears, and by allocating resources between vessel groups, gear groups, regions, and with regard to the delivery situation in the fishing industry [5].

The regulations imposed, have been based on a mutual understanding between the authorities and the fishers' own organizations. Nevertheless, the regulatory system has been much criticized. One of the main problems is that the system is complicated, difficult to follow, cost-driving, and very detailed [3], [5], [6], [7]. In 2003-2004 the goal achievement in fisheries management was evaluated by the Office of the Auditor General. The report concluded, among other things, that the Ministry of Fisheries and Coastal Affairs has only to a very limited extent carried out systematic analyses of the effectiveness of regulations and various arrangements [8].

The problem of overcapacity necessitates consideration of technology as a dynamic process in the fisheries. The discussions of systems engineering principles in fisheries management integrate the technological dimension with the prevailing scientific disciplines of biology, economy and social sciences [9], [10]. In systems engineering the whole is more than just the sum of its parts, which in most cases implies a top-down perspective of the system.

The objective of this paper is to discuss new approaches to regulations of the fishing fleets that may simplify and improve the current regime, by applying a top-down perspective. Simplification of the public regulations in the business sector is on the Norwegian government's agenda through the plan of action “Simplifying Norway” (In Norwegian: “Et enklere Norge”) [11]. The discussion in this article brings in experiences from the functional legal requirements within health, safety , and environment (HSE) systems in the Norwegian petroleum industry, where the detailed regulations have been replaced by functionally oriented requirements. This article concludes that a technological perspective on rule development in the fishing fleet through the systems engineering perspective, especially on those rules affecting the technological development, may lead to increased sustainability and reduced complexity in fisheries management.

MANAGEMENT OF THE NORWEGIAN FISH RESOURCES

The Norwegian public regulations regarding the fisheries are divided into three phases: Admission to catch fish, the fishing itself, and landing of fish. The regulations are complex and there are comprehensive demands to reporting. The complexity has increased due to the closing of the commons, introduction of technical regulations, quota and control systems. Problems related to complicated regulations are well documented [5], [7], [12]. Simplification and harmonization is an ongoing process with high priority in fisheries management [6].

The fishers' main criticism of the regulations is that the set of rules is so complex that it is difficult to understand the content of the rules, and to know which rule applies at what time. Thus, violation of the rules may occur without intention [7]. A simpler set of rules for fisheries management is considered to be a prerequisite for industrial and commercial development by removal of obstacles to such development,

without sacrificing a responsible management of the resources. Parts of the regulations are already examined, and the work continues [1].

In Norway “paragraph vessels” is a remark which is used partly to describe obstacles to the fishers' effective adaptation in the fisheries, and partly to express an effective policy instrument preventing unprofitable overcapacity in the fishing fleet. Since the 1970's, the number of “paragraph vessels” in the Norwegian fisheries has increased as a result of the technological development. The fisheries management has put limitations to physical parameters of the vessels, such as length and gross tonnage weight, in order to adjust the catch capacity to the available resources.

The regulations concerning the “paragraph vessels” generate considerable side effects. The fishers, ship owners, and consulting engineers use their creativity to adapt the design of the vessels and evade the law. Besides, many fishers have quota rights in different fisheries, and thus try to design the fishing vessel for dual operation. Investors seek to maximize catch capacity. These various priorities have caused the development of “paragraph vessels” with a negative impact on the stability of the vessels, on the working environment for the fishers, on profitability, and on fuel consumption [13].

The formal procedures and politics in fisheries management is further described, e.g., in [7], [14].

A SYSTEMS APPROACH TO MANAGEMENT OF THE NORWEGIAN FISH RESOURCES

The ecosystem approach has been agreed on as a management principle by the Norwegian parliament [15]. The framework for the ecosystem approach, that the Ministers at the 5th North Sea Conference in Bergen in 2002 agreed on, has 5 components [16]:

- Objectives or targets based on the overall condition of the ecosystem
- Monitoring and research, necessary to provide relevant information about the status and development of the ecosystem
- Assessment of the current situation in the ecosystem
- Advice to be used in the decision-making
- Adaptive management, which means that measures are adapted to the current situation in the ecosystem in order to achieve the stated objectives

The marine fisheries are complex adaptive ecosystems, difficult to understand completely and even harder to control. An ecosystem-based management of the marine resources recognizes that nature is integrated, and it promotes decision-making in a holistic perspective.

In a system theory perspective, a core concept is “wholeness”, which means that a system is not understandable by evaluation of the constitutive parts in isolation [17]. The Norwegian fisheries regulations constitute a complex system that has evolved in a time period of major technological developments. Since the technological development in the fisheries is an ongoing, dynamic, and continuous process, the solutions that yesterday were considered to be up-to-date, may already tomorrow be out-of-date. It is impossible for the authorities to be ahead of the development, which may imply that the regulations should not be too detailed [18]. Still, the existing regulations have been imposed as a result of a stepwise development and a crisis-driven process, so that the system today is constituted by several individual decisions instead of a planned whole where implemented efforts are adapted to each other [7].

Holistic problem-solving may characterize the systems engineering process, which starts by identifying the user or the stakeholders' needs. There are several stakeholders of varying relevance to the fisheries,

e.g., the fishers, the management, the society etc. Stakeholders and their relation to fisheries management in a systems engineering perspective, is further discussed in [9]. Based on the needs of the stakeholders, the requirements to the system may be determined and specified, conflicting objectives may be traded-off, and the chosen solution may be designed, tested, and verified [19].The objectives of the various regulations in the fisheries may be related to requirements and specifications to the fisheries system performances. The top-down approach of the systems engineering process, should not be confused with the characteristic of a centralized, top-down management in the fisheries.

Systems engineering may be used to integrate a technological perspective into fisheries management. Further discussions of the systems engineering process related to fisheries management may be found in [9], [10].

SUSTAINABLE DEVELOPMENT AND RISK MANAGEMENT IN THE FISHERIES

Sustainability and risk may be seen as complementary concepts for studying and managing environmental consequences of human actions [20]. Both concepts are much discussed, still the most authoritative definition of sustainable development may be that of the Brundtland commission's: "Development that meets the need of the present without compromising the ability of future generations to meet their own needs" [21]. "Risk" may be described as the potential that a physical loss will occur, where uncertainties are integrated in the measurement of risk. Mainly, risk management deals with risk in terms of the probability of given undesirable outcomes [20].

Table I: A comparison between risk management and sustainable development, based on [20].

Feature	Risk	Sustainability
Main focus	Loss	Benefits and system limits
Type of potential loss considered	Mainly human/ biological/physical	Environmental, economic, social
Uncertainties	Explicitly calculated	Implicit
Level of analysis of potential loss	Individuals/ groups	To systems
Time reference	Short to medium-term future	Medium- to long-term future
Feature	**Risk management**	**Sustainable development**
Decision-making approach	Risk-benefit assessment/optimization	The Precautionary principle
Context	Management	Development (change)

Increased added value in the marine sector is an overall objective in Norwegian fisheries politics. In order to achieve this goal, the fish resources have to be managed in a sustainable way [1]. Sustainable development in the fisheries means to establish a system that fulfills the needs for fish both for present and future generations. Such a system should prevent hazards that may threaten the sustainability. Risk management is a tool that may be used to measure and reduce potential hazards [22]. Table I sums up the similarities and differences between risk management and sustainable development, based on [20].

FUNCTIONAL RULES, PRESCRIPTIE RULES, INTERNAL CONTROL, AND THE TOP-DOWN APPROACH

The current trend in development of rule systems is to move from detailed prescriptive rule solutions towards functional rule solutions directed at decision-making and management [23], [24]. A goal-oriented or functional rule states what the legislator means the result should be, e.g., "a fully responsible working environment", without specifying how the result is to be achieved. This implies an increased use of internal control principles that represent more hierarchical strategies to rule system development. Functional rules require frequent evaluations of performance, which may be carried out by use of performance indicators. The focus of such rules may be directed towards technical equipment, human performance, and organizational conditions [23].

Internal control as the main principle for controlling safety was first introduced in the Norwegian offshore petroleum activities in the 1980's. The reform was made mandatory for all private and public enterprises by new regulations in 1992 [25]. At the same time, the internal control was extended from major hazard control and occupational safety to promote improvements in the working environment and safety in enterprises, prevent damages to health or disturbances to the environment from products or consumer services, protect the external environment against pollution, and improve treatment of waste [26].

The Norwegian Internal control regulations define internal control as "Systematic measures designed to ensure that the activities of the enterprise are planned, organized, performed and maintained in conformity with requirements laid down in or pursuant to the health, environmental and safety legislation". Compared to a control regime of detailed regulations, the internal control regulations focus on the obligations of the responsible person of the enterprise, on systematic and documented actions based on principles for written HSE objectives, on system deviation control, and on system audits as a control tool for the enterprise and for the authorities [25].

Various types of regulation regimes have advantages and disadvantages depending on the content of the rule and the stakeholders involved. Functional regulations presuppose that the rule-imposer knows what the desired goals are and that the rule-follower knows how to achieve those goals. Functional regulations combined with clear specifications of responsibility, may contribute to fulfillment of the rule objectives. Complexity, technological development, and rapid adjustments may complicate updating of the regulations. Thus, functional regulations handle rapid development better than detailed regulations, because the focus is on the legislative objectives, and not on the instruments [23], [27]. Functional based requirements presuppose detailed knowledge about the requirements to the system and how the system is supposed to function. This may be related to the functional analysis, which is the process of translating system requirements into detailed design criteria, in the systems engineering process [19].

Every system is made of components, and every component can be broken into smaller components, in a hierarchical structure. The total system, at whatever level in the hierarchy, consists of all components, attributes, and relationships needed to achieve an objective. The systems engineering process is based on a top-down approach (deductive), however, most projects will first reduce the complexity by reducing the system into its elements, and then bottom-up design (inductive) to realize the elements for that system [28]. In rule development, this implies that prescriptive or detailed rules should be derived from higher order goal-oriented rules. According to Hovden [25], internal control means both a top-down approach and a bottom-up approach, represented by the top management and democratic stakeholder participation.

A functional set of rules will obviously be of smaller format than more detailed regulations. Still, general requirements should be avoided, because generalization makes the regulations more difficult to understand so that instructions may be needed instead. If many instructions are needed, the total amount of regulations may be large and too complex. Inspections and control under conditions of functional

regulations require a high level of competence and knowledge, and may also face challenges related to clarification of the content in the regulations. Very general regulations may cause problems for the police and law courts, as rule violations are difficult to determine so that equality before the law may be undermined.

Detailed or prescriptive rules describe how to respond in certain situations. The disadvantage with detailed regulations is that the rules may be complex, fragmented, and that they may slow down the progress in regulated areas. The ambition level may also be lower than the potential in the industry. Detailed regulations require a continuous update in order to follow the developments [27].

FUNCTION-BASED MANAGEMENT IN THE NORWEGIAN OFFSHORE PETROLEUM INDUSTRY

When the offshore petroleum industry in Norway started, in the mid 1960s and early 1970s, the safety equipment and emergency response systems had to be regulated. At that time, the Norwegian Petroleum Directorate made detailed prescriptive regulations, similar to those commonly used in shipping. Gradually, it became apparent that another approach was necessary if further safety improvements were to be achieved, and the detailed regulations were replaced by functionally oriented requirements. The new requirements encourage extensive use of analysis and risk-based approaches, and an increased flexibility in the choice of solutions. The changes were implemented to achieve focus on accident prevention instead of protection, but also to benefit from improvement processes in a modern industry dedicated to "management by objectives" [29].

The Norwegian internal control reform was an attempt to develop new approaches and means to handle problems and misfits between technology development and regulations in the offshore petroleum industry in the 1970's [25]. In order to match regulatory risk problems and means, the Norwegian Petroleum Directorate (NPD) decided that the operating companies on the Norwegian continental shelf should take responsibility to design the most appropriate solutions. The reason for this was to ensure the safety of each single activity, based on risk and emergency preparedness analyses. The success of such a decision presupposes dedicated and sincere companies that really wish to improve safety. Unfortunately some companies have misused their increased freedom to cut "needless" and costly emergency response resources [29].

In 2001 it was decided to include all relevant requirements from the pollution and health authorities into one set of health, safety, and environment (HSE) regulations for petroleum activities. From 1990-1993, all previous regulations were replaced by 14 new regulations, which proved to have common organizational and management components, operational and maintenance requirements, and general safety principles, such as barrier requirements. In 2001, four groups were developed, and the common requirements became four new regulations:

- Duty of information regulations. Requirements related to the information to be submitted to the authorities
- Management regulations. Requirements related to health, safety and environment management systems
- Facility regulations. Requirements related to design and outfitting of facilities
- Activity regulations. Requirements related to the conduct of activities

The companies operating on the Norwegian continental shelf have obtained their licenses on the basis of mutual trust; a section about safety culture is included in the new regulations in order to emphasize management commitments to safety.

FUNCTION-BASED MANAGEMENT IN THE NORWEGIAN FISHERIES

Sustainable development and risk management have common characteristics. The trend in risk management is a change from detailed prescriptive regulations towards goal-oriented functional regulations. The HSE regulations in Norway have forced the companies operating on the Norwegian continental shelf to participate proactively in the process of increasing the safety level. Ecosystem-based management in the fisheries recognizes the need for a holistic decision-making, which implies more long-term planning in the fisheries. The overcapacity in the fisheries is a major problem that has to be reduced in order to increase the sustainability level in the fisheries. The technological development and the problem of overcapacity indicate that use of goal-oriented or functional regulations may be applicable in the Norwegian fisheries management, not only as means to increase, e.g., safety[a], but as means to increase the overall sustainability in the fisheries.

One attribute of a sustainable fishing fleet is fuel consumption or the amount of greenhouse gasses emitted [30]. Fuel consumption is an important attribute in a technological perspective of sustainability [10]. Despite the Norwegian regulations restricting the technical fishing vessel parameters, and a substantial reduction in the total number of fishing vessels in the time period 1980-2004, the total engine power (hp) in the fishing fleets has increased [31] (Figure 1 and 2). Engine size may be considered as an important characteristic of a fishing vessel's catch capacity [2].

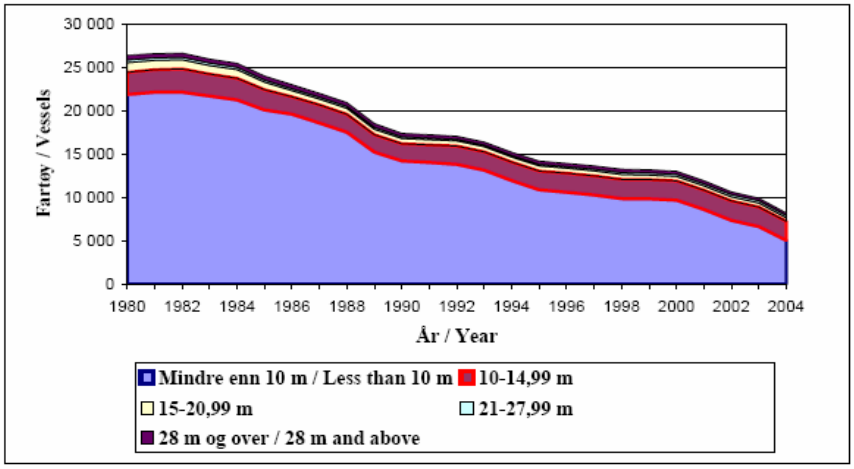

Figure 1: NUMBER of fishing vessels by length group. 1980-2004 [32].

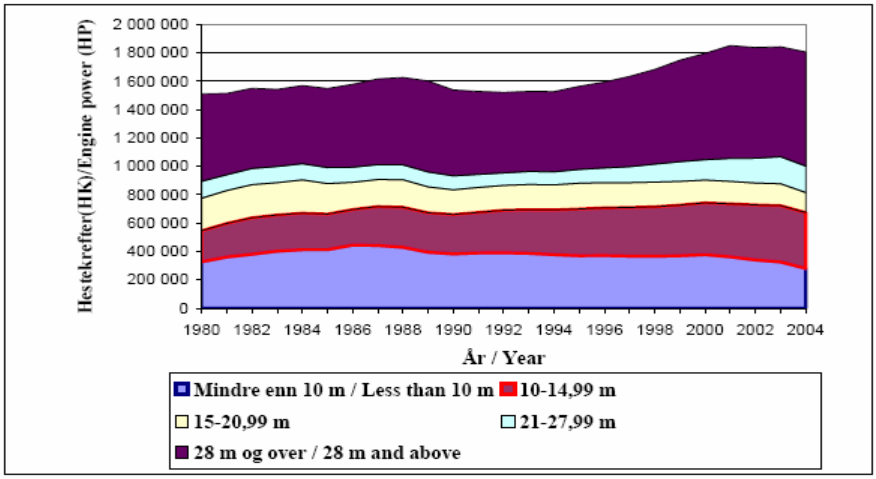

Figure 2: TOTAL engine power (hp) by length groups. 1980-2004 [32].

Reduction of greenhouse gas emissions from the fishing fleet is on the agenda of the Norwegian government as Norway is committed to international agreements such as the Gothenburg protocol [33]. Also, some vessel groups, e.g., the shrimp trawlers, experience serious profitability problems due to the increasing fuel prices [10]. Thus, a suitable question is if the technical vessel parameter restrictions and the Norwegian system of vessel quotas, that put limitations to the design of fishing vessels, should be replaced by regulations that are aimed at reducing the energy consumption.

In 2001, the Ministry of Fisheries proposed free green-house gas emission quotas for the fishing fleet [34]. The quotas are suggested to be estimated and allocated based on the fuel consumption of the most effective vessels in each vessel group. This means that most vessels will be assigned too small quotas, so that they have to pay for excess emissions. The proposition would probably lead to increased taxes for the fleets, which today are exempted from CO_2 tax. Such a system is a very interesting issue, because it may encourage use of less energy intensive catching methods.

A system of emission quotas would most likely have to be based on the vessels reported consumption of fuel. A goal-oriented regulation regime requires a system for internal control, which means that the vessel owners have to document their solutions to the objectives in the regulations, e.g., how they comply with their emission quota. Internal control means that written documentation has to be available for inspections, which may be carried out regularly or on grounds of suspicion.

Such documentation could be related to the design of the vessel. When fishing vessels are admitted to the fisheries, an overall objective should be to construct the vessel with the aim at achieving the lowest possible consumption of fuel. The ship owner would then have to document that the vessel is fitted with the most suitable equipment and fishing gear, that the vessel is as safe as possible, and that the fuel consumption is as low as possible. In order for such regulations to be effective, there must exist penalties and other sanctions for those not complying with the rules.

Use of energy or emission quotas as a replacement for limitations to technological vessel parameters or the vessel quota system could be considered as an attempt to introduce more functional legal regulations in the fisheries. The fishers would have to decide for themselves how to catch the most fish with as little fuel as possible, and the technological development could possibly be moved towards an increased focus of achieving sustainable solutions.

DISCUSSION

Several efforts have been made in order to manage the fisheries more sustainably, but few if any attempts have succeed, as overexploitation and overcapacity in the fishing fleets still are huge problems. The main focus of fisheries management is on biological estimation methods and assessments, and on economic profitability. Overcapacity may be related to the continuous process of improving vessels and catching gear technology, which indicates that the technological dimension should be further integrated into fisheries management.

Fisheries management is a huge and complex area, struggling with many stakeholders promoting conflicting objectives. In Norway, the imposed fisheries regulations have been ad hoc solutions to problems when they have occurred. Thus, the regulations have become very complicated. Simplification of public regulations is on the agenda in Norway, including the fisheries. Projects have tried to reduce the complexity in the regulations [6], [12], [35], of which a few have used a goal-oriented approach to propose more user-friendly HSE-regulations within the fish industry [36].

A political goal in Norway is to maintain a diversified fishing fleet structure [3], [35]. The Limited Entry Act has structural effects, because certain conditions have to be fulfilled in order to gain access to

participation in a fishery. Quotas are allocated between the different vessel groups. Abandoning or changing the restrictions to the technical vessel parameters and the system of vessel quotas, are controversial issues, because they affect fishery politics. Still, if Norway is to comply with international agreements such as the Gothenburg protocol, efforts of reducing the green-house gas emissions from the fishing fleets have to be implemented. The increasing fuel prices also cause problems of reduced profitability in some fisheries, which indicates that the fuel consumption should be lowered.

Internal control related to the operation of the fishing vessels, requires documentation of how the ship owners comply with the rules. The existing regulations demand several documents to be completed in order to gain admission to the fisheries. Internal control documentation should therefore be a replacement for some of the existing requirements to documentations, and not as an addition to existing regulations.

The question raised is very complex, and there are no final conclusions. Even though functional legal regulations have worked for risk management in the Norwegian offshore petroleum industry (even though the subject has been and is thoroughly debated), the fisheries is a sector with different characteristics and challenges than those of the petroleum sector. Also, risk management and sustainable development have differences. Blakstad [23] concludes in her Ph.D. dissertation, about adaptation of rules in the Norwegian railway system towards a more risk based approach and a modernization of existing rules [23], that the modification process abandoned the intentions of hierarchical and risk-based approaches. The main reason was that the new approaches did not sufficiently integrate existing railway knowledge, found to be important for the safety performance, into a new risk-based approach system. Existing knowledge and prescriptive rules were used as a foundation in the safety work.

Drangeid [29] concludes that if the new regulations were made more detailed and prescriptive again, the safety level in the petroleum industry would hardly lead to improved hazard management. Hovden [25] argues that the Norwegian system of internal control, especially of that applied in the offshore oil industry, has been regarded as a model for other industries to follow. However, this reputation was deserved in the eighties, but in the nineties safety was increasingly sacrificed due to cost cutting. Safety depends more on the political and economic context than it does on the technicalities of the regulatory regime.

The discussion in this paper is based on the idea that a systems engineering perspective on rule development in the fisheries, with a holistic approach to problem solving, especially on those rules affecting the technological development in the fishing fleet, may lead to increased sustainability and reduced complexity in fisheries management. Functional or goal-oriented rules may be considered as means to integrate a more holistic management system, as risk management and sustainable development have common characteristics. Thus, such approaches to regulations and management may be applicable to discuss and evaluate. The discussion here is by no means a conclusion on how the management regulation system should be transformed. Risk management and measurement of the current risk level at a petroleum installation, is a more concrete task to do than measurement of the level of sustainability in the fishing fleet. Still, reducing complexity in the fisheries management requires a holistic perspective in the decision-making and problem solving.

FURTHER WORK

The issues raised in this paper should be further explored and related to practical implementation. The consequences of a transformation to more use of functional regulations in fisheries management should also be thoroughly evaluated.

ACKNOWLEDGEMENT

This paper was prepared with funds from the Norwegian Research Council through the Strategic Institute Programme, "Sustainable fishing technology and fleet structure", carried out by Sintef Fisheries and Aquaculture. Earlier drafts of this paper benefited from comments by Marvin Rausand and Dag Standal.

REFERENCES

1. The Norwegian Ministry of fisheries (In Norwegian: Fiskeridepartementet), *Report no. 19 to the Storting (2004-2005): Marine industrial and commercial development. The blue field (In Norwegian: Stortingsmelding 19 (2004-2005): Marin næringsutvikling. Den blå åker)*.

2. Standal, D., *Nuts and bolts in fisheries management- a technological approach to sustainable fisheries?* Marine policy, 2005. **29**: p. 255-263.

3. The Norwegian Ministry of fisheries (In Norwegian: Fiskeridepartementet), *Report no. 58 to the Storting (1991-1992): About the structure and regulations in the fisheries fleet (In Norwegian: Stortingsmelding 58 (1991-1992): Om struktur- og reguleringspolitikk overfor fiskeflåten)*.

4. Jennings, S., Kaiser, M. J., Reynolds, J. D., *Marine fisheries ecology*. 2001: Blackwell Publishing.

5. Hansen, K.W., Sævik, M., Kristiansen, S., *Report. Cost-driving regulations for the Norwegian fishing fleet (In Norwegian: Rapport. Kostnadsdrivende regelverk for norsk fiskeflåte)*. 1998.

6. Normann, A.K., Hoel, A. H., Rånes, S. A., *A simpler Norway- also in the fisheries and aquaculture industry? (In Norwegian: Et enklere Norge- også i fiskeri og havbruk? Regelverk, informasjonsplikt og skjemavelde)*. 2005, NORUT Samfunnsforskning AS, Rapport 01/2005.

7. Jentoft, S., Mikalsen, K. H., *The fishers' legal position in the resource management (In Norwegian: Lastet til ripa. Fiskernes rettsstilling i ressursforvaltningen)*. 2001, Trondheim, Norway: Tapir Akademisk Forlag.

8. The Office of the Auditor General (In Norwegian: Riksrevisjonen), *The Norwegian Office of the Auditor General's investigation of the management of the fish resources (In Norwegian: Riksrevisjonens undersøkelse av forvaltning av fiskeriressursene)*, in *Dokument nr. 3:13 (2003-2004)*.

9. Utne, I.B., *Systems engineering principles in fisheries management.* Marine policy, Accepted for publication, February 2006.

10. Utne, I.B., *System evaluation of sustainability in the Norwegian cod-fisheries.* Marine policy, Submitted for publication, April 2006.

11. The Norwegian Ministry of Trade and Industry, *Simplifying Norway Action Plan 2005–2009. Streamlining and facilitation for trade and industry*. 2005.

12. Directorate of the Fisheries (In Norwegian: Fiskeridirektoratet, N.F., Norges Kystfiskarlag, Norsk Sjøoffisersforbund), *Report from a work group about simplification of rules for practical fishing (In Norwegian: Rapport fra en arbeidsgruppe for forenkling av regler for praktisk fiske)*. 2003.

13. Aasjord, H.L., Standal, D., Amble, A., *Rule changes for increased safety and improved profitability in the fishing fleet. About regulation parameters, fleet renewal, safety and operating profit (In Norwegian: Regelendringer for økt sikkerhet og bedre økonomi i fiskeflåten. Om reguleringsparametre, flåtefornying, sikkerhet og driftsøkonomi).* 2003, Sintef Fisheries and Acuaculture: Trondheim, Norway.

14. Mikalsen, K.H., Jentoft, S., *Limits to participation? On the history, structure and reform of Norwegian fisheries management.* Marine policy, 2003. **27**: p. 397-407.

15. The Norwegian Ministry of the Environment (In Norwegian: Miljøverndepartementet), *Report no. 21 to the Storting (2004-2005): The government's environmental policy and the state of the environment in Norway (In Norwegian: Stortingsmelding 21 (2004-2005): Regjeringens miljøvernpolitikk og rikets miljøtilstand).*

16. Misund, O.A., *Ecosystem based management: Definitions and international principles.* 2005.

17. von Bertalanffy, L., *General system theory*. 1968: George Braziller, New York, U.S.A.

18. Johnsen, K.O., Gilje, K. O., *From piece by piece to simple and complete. Proposition on simplification of the HSE-regulations (In Norwegian: Fra stykkevis og delt til enkelt og helt. Forslag til forenkling av regelverket innen helse, miljø og sikkerhet (HMS) .(TELFO, PIL, TBL, BNL, RBL, NHO)).* 2001.

19. International Council on Systems Engineering, T.b., *INCOSE Systems Engineering Handbook. A "WHAT TO" GUIDE FOR ALL SE PRACTITIONERS*. 2004, INCOSE: Seattle, Wa, U.S.A.

20. Gray, P.C.R., Wiedemann, P. M., *Risk management and sustainable development: Mutual lessons from approaches to the use of indicators.* Journal of risk research, 1999. **2(3)**: p. 210-218.

21. World Commission on Environment and Development (WCED), *Our Common Future*. 1987: Oxford University Press, New York.

22. Solli, A., Lygner, E., *Environmental risk indicators; Review and proposal*. 2002, Departement of Production and Quality Engineering, Norwegian University of Science and Technology, Trondheim, Norway.

23. Blakstad, H.C., *How did the Norwegian railway system adapt the existing experience based safety rules for traffic operation to a new organizational context and a risk based approach?*, in *Department of Industrial Economics and Technology Managment*. 2006 (forthcoming), Norwegian University of Science and Technology: Trondheim, Norway.

24. Hovden, J., *The development of new safety regulations in the Norwegian oil and gas industry*, in *Changing regulation. Controlling risks in society*, B. Kirwan, Hale, A., Hopkins, A., Editor. 2002, Pergamon, Oxford. p. 57-78.

25. Hovden, J., *Models of organisations versus safety management approaches: A discussion based on studies of the "internal control of SHE" reforms in Norway*, in *Safety management: The challenge of change*, A. Hale, Baram, M., Editor. 1998, Pergamon, Oxford. p. 23-41.

26. Ministry of Labour and Social Inclusion, M.o.t.E., Ministry of Justice and the Police, Ministry of Health and Care Services (In Norwegian: Arbeids- og Sosialdepartementet,

Miljøverndepartementet, Justis- og Politidepartementet, Helse- og Omsorgsdepartementet), *Regulations relating to systematic health, environmental and safety activities in enterprises (Internal Control Regulations)*. 1996.

27. The Norwegian Ministry of Labour and Administration (In Norwegian:Arbeids- og administrasjonsdepartementet), *Norwegian public reports, NOU 2004: 5 (In Norwegian: Norges offentlige utredninger. NOU 2004: 5. Arbeidslivslovutvalget. Et arbeidsliv for trygghet, inkludering og vekst)*. 2004.

28. Blanchard, B.S., Fabrycky, W. J., *Systems Engineering and analysis*. 1998: Prentice Hall.

29. Drangeid, S.O., *Will stricter regulations improve disaster management? A discussion of the Norwegian Petroleum Directorate's experience with the use of functional legal requirements.* International journal of emergency management, 2003. **3**: p. 268-277.

30. Album, G., Wiik, V., Aasjord, B., *Sustainable fisheries in northern- Norway (In Norwegian: Bærekraftig fiskeri i Nord-Norge)*, ed. S.t. mat. 2001: Novus forlag, Oslo, Norway.

31. Ellingsen, H., Lønseth, M., *Energy-reducing efforts in the Norwegian fisheries (In Norwegian: Energireduserende tiltak innen norsk fiskeri)*. 2005, Sintef Fisheries and Aquaculture: Trondheim, Norway.

32. Directorate of the Fisheries (In Norwegian: Fiskeridirektoratet), *Biological and economic key figures for the Norwegian fisheries (In Norwegian: Biologiske og økonomiske nøkkeltall for de norske fiskeriene)*. 2004.

33. Norwegian Pollution Authority (In Norwegian: Statens Forurensningstilsyn), *Effort analysis of NOx. Investigation of possible NOx-reducing efforts within the energy constructions offshore, in domestic shipping, and in the continental industries (In Norwegian: Tiltaksanalyse for NOx. Utredning av mulige NOx-reduserende tiltak innenfor energianleggene på sokkelen, innenlands skipsfart og fastlandsindustrien)*. 2006.

34. Alstadheim, K.B., *Fishing for climate quotas (In Norwegian: Fisker etter klimakvoter)*, in *Dagens Næringsliv, www.dn.no (Accessed: 2006:04:26)*. 2001: Oslo, Norway.

35. The Norwegian Ministry of fisheries (In Norwegian: Fiskeridepartementet), *Report no. 20 to the Storting (2002-2003): Structural efforts in the coastal fleet (In Norwegian: Stortingsmelding 20 (2002-2003): Strukturtiltak i kystfiskeflåten)*.

36. Johnsen, K.O., Gilje, K. O., *Simpler regulations for the fish industry (In Norwegian: Enklere regelverk for fiskeindustrien. Et prosjekt for økt regelverkskompetanse i virksomhetene)*. 2003.

ENDNOTES

[a] Safety may also be considered as an important attribute of a sustainable fishing fleet [11].