Work package 3
Operational tools and adaptive management

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0 Summary

In the Green Paper on the Reform of the Common Fisheries Policy (CFP) (COM 2009 163), ecosystem based management (EBM) is a focal concept. EBM implies the application of a more holistic perspective when managing commercially exploited fish stocks in EU waters. A holistic perspective in turn requires the consideration of

a. other *users* (species) belonging to the same ecosystem
b. other *uses* (user groups) of the ecosystem

In this report we focus upon the second aspect of an ecosystem based approach to fisheries management in that we analyse and discuss the effects of allowing user groups of the ecosystems that commercial stocks belong to, have a say in the management of these stocks. We also discuss the first aspect, in the analysis of management tools, where many of the different tools applied have specific aims with regard to interactions with the ecosystems.

The use of different tools to regulate input and/or output in the EU fisheries has varied over time and across countries and fisheries, and still does. In all EU fisheries several tools are applied simultaneously, and whereas there is always a good reason for introducing a specific tool to regulate a specific aspect of a specific fishery, it has not always been the case that the effects of the new tools have been assessed given the existing tools already regulating the fishery. Furthermore, management tools or measures are put in place at several levels, both at an EU level and a national level. On this background we start out this report by making an inventory of the most common tools applied in the regulation of the EU fisheries, and discuss their intended and actual effectiveness.

The tools used to regulate the EU fisheries are divided into three groups;

a) tools to regulate input
b) tools to regulate output
c) economic tools (incentive mechanisms)

The main argument for applying different tools to manage the fisheries activity is that they are efficient in reaching particular (intended) aims. In order to assess the efficiency of the different tools we have first assessed their intended effect on four specified aspects (politically acceptability, cost effectiveness, ecological effectiveness and dynamical effectiveness). Next, we have collected the expert opinion of the diverse MEFEPO project members regarding the intended effects of the different tools. The results show great divergence of opinion, but also some agreement. This illustrates which tools can successfully be implemented on an overall EU level, and which are more appropriately implemented at a national level.

Moving to stakeholder involvement , in the inclusion of new stakeholders in the management of the fisheries we have simplified the use of tools, and concentrated on measures which can be translated into (economic) terms which either deter effort (make effort more expensive) or promote effort (make effort cheaper). Taking an ecosystem perspective, we have assumed that the new stakeholders given a say in the management of the fisheries represent “environmental” aspects, either in the form of interest groups representing other species in the eco-system (e.g. bird watchers), or environmental NGOs (ENGOs) whose aim it is to make fisheries sustainable. Formally, we have given them a say in the fisheries management by letting them formulate an incentive scheme where they on the one hand can tax or subsidy the

fisheries activity (here limited to effort), but on the other hand have to take into account the fishers' participation constraint, i.e. they must compensate for losses such that the fishers are not driven out of the fishery. The latter is done in order avoid the typical corner solutions where the regulators, especially the ENGOs, tax the fishers "to death", i.e. such that it is not possible to survive in the fishery (to decide whether a fishery should "survive" at all is another discussion). The above analysis is a theoretical application of a common agency model; a model where two principals can use tools to affect a single agent's behaviour. We show that when a new stakeholder is given a say in the regulations of the fisheries and the new stakeholder has strong environmental interests towards the fishery, the authorities will moderate its regulations, i.e. set lower taxes (restrictions) or be more prone to support (subsidise) the fishery activity. However, the aggregate of the regulations over the two regulators is greater than the regulations by the authorities alone. In other words, the reduction in the authorities' regulations is smaller than the regulations introduced by the new stakeholder, such that the aggregate tax rate becomes higher, and the subsidy rate becomes smaller.

We have applied results from the theoretical model in order to discuss three EU fisheries; the sandeel fishery in the North Sea, the nephrops fishery in North Western Waters, and the purse seine sardine fishery in South Western Waters. These three cases give different stakeholder inputs into the model, and show how these new entrants on the management scene affect the way the resources are managed.

The last part of the report is dedicated to studying how the environmental aspects of EBM enter at many levels of fisheries management. This is done in lieu of the increasing number of international treaties and EU directives, which affect fishery activity. Briefly stated, fisheries policy is to an increasing degree the result of other regulations than those found within the CFP. Especially, there is a vast number of environmental treaties and directives, which the fisheries must take into account. This, in turn, will affect the regulations of the fisheries through the CFP and/or national legislation. Translated into our model, this means that the environmental interests get an increasing importance when the regulators choose their regulations, at the expense of economic and social interests, which the regulators also hold towards the fisheries. We coin this EBM approach as *exogenous*, due to the external nature of with which these regulations enter into fisheries management, especially seen from a fisheries standpoint. This in contrast to a more *endogenous* EBM approach, where the fishers themselves seek solutions to the environmental challenges they face. One such example is many fisheries' application for certification, where the certificate work as a (eco) label securing the consumers in the market that the fishery is sustainable.

1 Introduction and background

1.1 Background

Ecosystem-based management is at the core of the new EU fisheries policy, which is going to be implemented in all EU sea areas. The basic idea is that a shift is needed away from single-species management to a more holistic management of the whole marine ecosystem, taking into consideration that the seas provide a huge amount of goods and services not directly commercially valuable, but necessary for the existence of commercially valuable species.

The EU's Common Fisheries Policy (CFP) has been criticised for being "the most top-down command and control management regime in the developed world" (Hegland and Wilson 2008). An alternative to a top-down implementation and enforcement of a fisheries management system is a bottom-up implementation of such a system, implying that stakeholders (groups of actors with interests, stakes, in the seas) are consulted and taken into account when regulations and measures are developed. This allows stakeholders to inform the regulators about their interests, and if the participation process works, this information is taken into account when formulating the regulations and measures in the new system. The latter is what characterises an adaptive management process.[1] The adaptation part consists of the evaluation of the functioning of the system on a regular basis, in order to check whether the measures are effective in meeting the targets of the policy and whether any stakeholder group have been disadvantaged due to the regulatory system. To the degree that the new system has detrimental effects on stakeholder groups or fails to meet the policy targets, this is sought remedied by looking for alternative solutions.

Adaptive management was designed to integrate uncertainty into the decision making process, and to ensure that policy makers and managers could learn from their successes as well as their failures. It emphasises how institutions may respond to environmental and societal feedbacks, and it takes into account the fact that jurisdictional institutions seldom are in tune with the scales at which ecosystems function. Hence the need for cross-scale institutions, which are able to both intercept the feedbacks and to transform them into new decisions (regulations) with less detrimental effects (Berkes 2003).

[1] Adaptive management – defines a management system characterised by effort and response. That is; a measure is introduced and after having worked for some time its effect (ecological, economic and societal) and the response to it from affected stakeholders is tested/evaluated. Then the use of the measure (and other measures) is reconsidered according to the results of the evaluation

Box 1. North Sea stakeholder participation

The North Sea was the first sea area for which a stakeholder participation process was set up when trying to implement the new system for the management of the sea at the EU-level. A working group on EU-level, North Sea Common Fisheries Policy, participated in meetings with ICES prior to their quota advice. Only representatives from the commercial stakeholders (fishers and the fishing industry) together with scientists and regional authorities participated in the group. Later the group was turned into a RAC (Regional advisory committee) for the North Sea (NSRAC), and then extended to include representatives from NGOs.

Source:North Sea RAC home page:

Due to the discrepancy between individual and collective rationality in the exploitation of commercially valuable, renewable, natural resources there is a need for societal (government, authorities) intervention in the form of regulations of the exploitation of such resources. This is especially the case regarding the exploitation of marine (fish) resources, and at least in industrial countries we observe regulations that are meant to make individual behaviour match more closely with the collective rationality. The lack of individual incentives to comply with the regulations necessitates enforcement of the regulations, and annually large amounts are spent on management of the world fisheries. No exact number exist for these costs, but the World Bank and FAO in a recent report suggest that the cost of enforcement alone annually ranges from 1 to 14% of the landings value (The World Bank and FAO 2008). In 2004 the value of the (registered) landings of fish on a global scale was $ 78.8 billion (op cit), which implies that enforcement costs are between $ 0.8 and 11 billion for that specific year. Additional are the costs of managing and monitoring the fisheries, which can be expected to exceed these costs.

Taking into consideration these calculations, one crucial question concerning the fishery management is whether it is possible to create regulation regimes that to a greater degree are in line with the individual interests of the fishers?[2] One aim must be to reduce the enforcement costs of fishery management by making it (more) in the interest of the fishers to accept and comply with the regulations and measures applied in the management of the marine resources.

It is necessary to understand how comprehensive the task of developing such a regime may be. From a social point of view it is true that “What makes an ecosystem ‘large’ is not the acreage but interdependent use” (Juda and Hennessey 2001, p 60). And, indeed, the number of stakeholders within most fisheries, which more or less depend upon each other, is huge.

[2] The alternative is to delegate the regulation of specific fisheries to a whole community, which would then regulate the exploitation of the resource based on a collective rationality. This has been tried (see e.g. Jentoft 1989, Sen and Raakjær 1996) but the problem is, again, that the larger the community, the larger the discrepancy between what is rational for the community as a whole and the single community inhabitant. Another issue that has been discussed in the literature is the importance of legitimate regulation (Jentoft 2000), i.e. regulations that are perceived as acceptable and just amongst the stakeholders. However, even for such legitimate regulations the issue regarding individual and collective rationality is relevant, as long as the gains from diverging from the regulation are sufficiently beneficial to the individual.

This is true not at least due to the large, hierarchical authority system, where authorities on different levels and with different competencies manage a common resource, in this case the marine ecosystem, and its exploitation. In addition there are the different user groups; fishers, the fishing industry, aquaculture, tourism, and the conservationists. There are strong interdependencies both between and within these stakeholder groups.

1.2 The content of Work Package 3

1.2.1 Inventory and assessment of mangement tools

The main goal of the Common Fisheries Policy (CFP) as of today is to ensure the sustainable development of fishing activities from an environmental, economic and social point of view. Two basic principles in the CFP are: 1) on one hand to protect and conserve living aquatic resources, 2) on the other hand contribute to efficient fishing activities within an economically viable and competitive fisheries industry. The Commission proposes common measures to make the CFP implementable (achieve the various principles and goals in the CFP), and the measures have to be passed by the Council of Fisheries Ministers. This demands a majority, but not a consensus in the Council, which means that all coastal member states do not have to be in favour of the proposed, and passed, measures.

The implementation of the CFP, encompassing enforcement and control, is the responsibility of the member states. In addition to the measures adopted in the CFP the member states also have the possibility to introduce their own measures in order to comply with the principles and goals mentioned above. As the measures applied for enforcement and control may vary between the coastal member states, and the fact that the member states have varying incentives to implement the principles and goals, the Commission has its own inspectors to make inspections of member states' control and enforcement systems. Due to poor performance when it comes to enforcing the CFP the Commission has newly introduced a body, whose task is to tackle the shortcomings in the member states' control and enforcement systems; Community Fisheries Control Agency. Violations of the measures, adopted either at member state level or EU level, are handled by the judicial system of the member states. By repeated violations, or a member states failure to comply with the measures adopted by the CFP, the case may be taken to the European Court of Justice.

Some super-ordinate measures are decided by the Commission, and the most prominent example here is the fixing of the TACs (Total Allowable Catch) for each regulated species and distributing the TACs between the member states. The distribution of the TAC between the member states is done based on the principle of relative stability, implying that the (relative) share of the TAC to each member state should be stable over time. The distribution of the allotted quota within each member state is the task of the national authorities, and the allocation mechanisms vary between the member states. Furthermore, though some detailed regulations are set by the Commission, the member states also set their own regulations as tools in the management of national fisheries.

A common way to describe such management tools applied within the fisheries sector is to divide them into three groups:

I) Input regulations – which regulate the harvesting effort
II) Output regulations – which regulate the catches
III) Economic measures – which regulate the fishers adjustment and behaviour

Within these three different groups; input, output and economic regulations; there is a large variety of different management tools. We will in section 2 present the tools and their intended effects.

Usually, there will be a connection between the fisheries regimes (way of thinking about fisheries activities) and the measures applied to regulate these activities. For example, when the gear became increasingly efficient (during the 1960s and 1970s) leading to a sharp increase in catches, the response from fisheries authorities was to set input regulations (maximum engine size, limiting number of days at sea), and when new equipment was introduced, making it simpler to find and catch the fish, regulations with respect to the gear (minimum mesh size, bycatch devices) were implemented. This development obviously was a kind of “mouse’s game with the cat”, where the industry invented more and more efficient boats and gear, and the authorities introduced new regulations to prevent the catches from increasing to a size of non-sustainability as the input became more efficient.

Understanding this game, and that there could be no winner in it, there was a shift in the authorities’ approach from input regulations to output regulations. This was the time for introducing the TAC system (1980s) which is still one of the cornerstones in the CFP. This, however, led to another type of game, namely one between the member states and the EU authorities. The relative stability principle implies that the (relative) share of the TAC allocated to each coastal member state shall remain constant, whereas the actual size of the quota to each member state will vary with the TAC. It is the member state’s task to enforce the national TACs, and this division of tasks gives rise to a type of behaviour characterised by the 1/N effect. If all other coastal nations fish only their quota then one nation may “default” and beneficially exceed its quota. As the consequences of this single nation’s overfishing has to be born by all coastal member states, the consequences for the single member state will be small. This is however the perspective of each state, and hence we are back in the “tragedy of the commons” situation, which the regulations were supposed to conquer. This situation is characterised by the fact that individual rationality diverges from what is rational taking the whole society (EU) into consideration.

MEFPO’s precursor, the EFEP project, carried out a stakeholder investigation where they asked for some stakeholder’s responses to selected regulatory tools (or combination of tools) and to what degree these were acceptable tools. In this report we study a broader set of management tools, but limit our investigation to expert opinion regarding these tools. We focus on four criteria in order to measure and assess the management tools; politically acceptability, cost effectiveness, ecological effectiveness and dynamic effectiveness. With regards to *political acceptability* we concentrate on the political acceptance of the *decision makers* (e.g. bureaucrats or politicians) in the relevant fisheries management. *Cost effectiveness* is secured in two possible ways; 1) when there is an aim of improving the economic performance of a given fishing fleet, and some improvement may be expected to take place and/or 2) when the aim of the management tool is to conduct the fishery as whole in the most cost effective way. *Ecological effectiveness* is characterised by the measure reaching some ecological goal, for instance securing the stock size at some level, or ensuring that only fish over a certain size is caught, while *dynamic effectiveness* is the securing of the *ecological* goal over time. I.e. can the management tool be expected to sustain its ecological aim over time? Strictly assessing according to the aims of the tools gives different assessments compared to when experts view the tools from a national or even European Commission perspective. This clearly points to the potential problems of implementing management tools above the national level for cultural and fisheries diversity such as one finds within the EU.

1.2.2 Stakeholder involvement and adaptive management

All implementation of regulations (management tools) may face challenges when it comes to enforcement of the regulations. This is simply due to the fact that the regulator and the regulated bodies do not have the same interests in the matter concerned (thus the regulations). In its simplest form this may only mean that the regulations impose costs upon those being regulated. In order to follow the regulations there must then either be an enforcer (typically policing and judicial system) or there must be an incentive scheme (some combinations of reward and punishment for behaving in accordance to the regulations). The former is the simplest solution, and the solution applied within the CFP, although it will often be associated with significant costs. Also, as monitoring the behaviour restricted by the regulations is seldom perfect, there will always be defections. Rewarding the regulated bodies for complying is a much more complicated task, but has the advantage that if the scheme for rewards and punishments is accepted by the regulated bodies the regulations are self-enforcing and defaults are not an issue.

A principal-agent model defines a situation where one actor (a principal) wants another actor (an agent) to behave in a certain manner, and where behaving in the desired manner imposes costs upon the agent. The principal therefore has to formulate an incentive scheme which also rewards the agent for behaving in the preferred (by the principal) manner. The formulation of optimal (cost minimising) incentive schemes is the outcome of principal-agent models and analyses.

The hierarchical structure regarding the distribution of power and tasks inherent in the CFP implies that the CFP, as formulated today, gives rise to a series of principal-agent situations. First, there is the "traditional" principal-agent situation, here represented by the relationship between national authorities (member states) and the fishers in that state. Second, there is the relationship between the EU-authorities (the EU Commission) and the member state authorities (agents), as the member states are obliged to implement the regulations passed by the Council of Fisheries Ministers and included in the CFP. Third, there is the relationship between the authorities, consisting of both the EU Commission and national authorities (principal), and the fishers (agent). The situation with two (or more) principals regulating one (group of) agent(s) is denoted common agency, and is a sub-group of the principal-agent models. The different models are presented in table 2.

Table 1.1 Principal-agent relationships to be treated in this work

Level	*Stakeholder*	*Delegated agency*	*Common agency*
Supra-national	EU, NGO	Principal	Principal
National	Members states, NGO	Agent	Principal
Local	Fishers		Agent

1.2.3 Environmental issues and changes in EU fisheries policy

The multitude of marine and maritime policies developed over the past decades has implications for fisheries management at both EU and national levels. The main underlying hypothesis of this work is that fisheries in EU waters are not only increasingly having to deal with other users and uses of the ocean but are also being confronted with a shift on the stage upon which marine policy is conceived. This shift consists of moving ocean management away from National Fisheries ministries and DGMARE towards the environmental stage, resulting in more integration over activities and stakeholders and a more conservationist discourse. In the fourth section of this report we study how this environmental focus enters at different levels and in different ways to affect fisheries policy.

In this discussion the role of the environmental non-governmental organisations (ENGOs) is of special interest. These are naturally heterogenous entities, and this reflects the way they attempt to affect behaviour in the fisheries sector. Some ENGOs work only at the political level, exerting pressure upon authorities in their formulation of directives, rules and regulations affecting the environment. These ENGOs have typically chosen an exogenous way in their effort to try to influence the fisheries environmentally in that they do it by exerting external pressure on them. Other ENGOs utilise "green" preferences among consumers, expressed in a willingness to pay for sustainably harvested food and safe food, and organise campaigns directed towards consumers in order to induce them to boycott fish from for instance unsustainable fisheries. An alternative is that they offer fisheries, that fulfil conditions for sustainable harvesting, a certificate which is reliable in the market and thus secure higher prices and/or larger markets. This is an example of how one by the use of market preferences can make it in the fishers' self-interest to behave in an environmental friendly way, and we denote it an endogenous way. In the fourth section we discuss these endogenous and exogenous approaches, and how they affect fisheries.

2 Operational tools, their effectiveness and acceptability

2.1 Background

The main goal of the Common Fisheries Policy (CFP) as of today is to ensure the sustainable development of fishing activities from an environmental, economic and social point of view. Two basic principles in the CFP are: 1) on one hand to protect and conserve living aquatic resources, 2) on the other hand contribute to efficient fishing activities within an economically viable and competitive fisheries industry. The Commission proposes common measures for all member states in order to to achieve the principles and goals of the CFP, i.e. make the CFP implementable, and these measures have to be passed by the Council of Fisheries Ministers.

The implementation of the CFP, encompassing enforcement and control, is the responsibility of the member states. In addition to the measures adopted in the CFP the member states also have the possibility to introduce their own measures in order to comply with the principles and goals mentioned above. As the measures applied for enforcement and control may vary between the member states, and the fact that the member states have varying incentives to implement the principles and goals[3], the Commission has its own inspectors to inspect member states' control and enforcement systems, the Community Fisheries Control Agency. Violations of the measures, adopted either at member state level or EU level, are handled by the judicial system of the member states. By repeated violations, or a member states failure to comply with the measures adopted by the CFP, the case may be taken to the European Court of Justice.

The fact that the decision-making framework of the CFP does not distinguish between the *principles* of fisheries management and the actual *measures* of implementation (ie. chosen tools) is one of the structural failings of the CFP, as stated in the Green Paper on the Reform of the Common Fisheries Policy (Anon, 2009). As described above, the measures used to fulfil the goals in the CFP are decided both on an EU and a member state level.

Some overarching measures are decided by the Commission, the most prominent example here being the determination of the TACs (Total Allowable Catch) for each regulated species, and the distribution of the TACs between the member states. The distribution of the TAC between the member states is done based on the principle of *relative stability*, implying that the (relative) share of the TAC to each member state should be stable over time. Green Paper on the Reform of the Common Fisheries Policy (Anon, 2009) presents three ways that the principle of relative stability limits management flexibility in the CFP; 1) the rigidity of allocations hinders the usage of different fishing activities, techniques and patterns, and 2) creates an inflationary pressure on TACs, as it is in each member states' interest to increase TAC's in order increase their nominal share, and 3) contributes to discards as it creates constraints for countries that have fished up quotas on species that enter as bycatch, leading to discards that could have been converted into quota catches if relative stability did not hinder a different allocation. This leads to another overarching management choice, namely the *lack* of discard ban. As stated in the European Commission report on discard policy (Anon, 2007), the EU has no measures in place that directly address discarding[4], though there are indirect measures such as minimum mesh size, bycatch devises and closed areas. We will in this

[3] This situation, that the member states have varying incentives for implementing the super ordinate goals in the CFP is also called agency drift, and is extensively treated in the literature, see e.g. Gezelius and Raakjær 2009.

[4] However, in a "statement on discards" dated May 25, 2009, Joe Borg, member of European Commission and responsible for Fisheries and Maritime Affairs, announced that the EU will start a work towards the elimination of discards in EU-fisheries.

report *not* focus on the overarching principles, but rather the actual management measures or tools of CFP implementation, be they decided at an EU or national management level.

So, moving toward the national management level, the TAC allotted each member state according to relative stability is then distributed by national authorities, and the allocation mechanisms vary between the member states. As part of this work we have executed case studies of 3 EU-fisheries (see section 3.5). The experience from studying just these 3 cases is that the member states apply a vast array of different management tools, and the tools vary both across member states and across fisheries. Most member states now apply some kind of rights based management (RBM) tools when distributing their quotas internally and MRAG et al (2009) catalogue the RBM tools applied in different EU member states, based on the typology described in a study by the OECD (2006). The two above mentioned reports, together with Anon (2007) which gives examples of bycatch and discard management from some representative countries, present a vast array of national fisheries managements. Hence we will not spend any further time on going in more detail into the use of management tools in each of the coastal member states in this work. We will instead focus upon the different management tools generally, and from an EU perspective. First we will catalogue and assess the tools based on their aims, and finally assess the tools from the perspective of different EU countries, based on expert opinion.

2.2 Management tools

The focus of the MEFEPO project is ecosystem based management. In this part of the work we want to discuss management tools and their relationship to ecosystem based management. In essence the ecosystem relationships or issues that the ecosystem based management tools are applied to manage are:

1) Inter-stock relationships (fishing on predators or prey)
2) Intra-stock relationships (fishing on sections of stocks; size overfishing)
3) Habitat relationships (habitat destructive fishing)

In Table 2.1 we present which management tools may specifically be geared towards regulating how fisheries affect the different relationships described above.

Table 2.1 Ecosystem issue and tools which may be geared towards regulating these issues

Ecosystem issue	**Tools of management**
Inter-stock relations	Mesh size, gear type, seasonal restrictions, area restrictions, bycatch limitations, discard rules, bycatch devices, quotas, taxes, subsidies
Intra-stock relations	Mesh size, gear type, seasonal restrictions, area restrictions, minimum size limitations, quotas, taxes, subsidies
Habitat effects	Gear type, area restrictions, taxes, subsidies

Though the ecosystem issues presented above are all related to the natural ecosystems it is worth noting that it is the *human* interaction with these natural systems that the tools are meant to correct or affect. Many of the management tools in fisheries treat the human behaviour, i.e. fishing activity, as exogenous to the ecosystem, and a command and control approach is used to manage how fishers engage with the natural environment. Other management tools treat humans as an integral part of the ecosystem, and thus their behaviour (fishing ativity) becomes endogenous to the ecosystem such that eventual negative effects of this behaviour are taken into account. Rights based management rules or property rights have been espoused as a way to make the fishers' behaviour endogenous to the ecosystem, or in other words; to internalise the external effects that fisheries create and thus eliminate the commons problems. Hence, it is important to study management tools that are not necessarily designed for ecosystem based management, but have shown to have advantageous environmental effects (e.g transferable rights).

A common way to describe management tools applied within the fisheries sector is to divide them into three groups:

IV) Input regulations – which regulate the harvesting effort
V) Output regulations – which regulate the catches
VI) Economic measures – which regulate the fishers adjustment and behaviour

Each group consists of a series of tools, and each tool has an intended effect. This is shown in Table 2.2.

Table 2.2 Management tools applied in the fisheries sector and their intended effects.

Group	**Tool**	**Intended effect**
Input regulations	Mesh size	Limit the catch of undersize fish
	Gear type	Limit catch or type of catch
	Limited licensing	Limit catch
	Engine size	Limit catch
	Seasonal restriction	Limit catch or type of catch
	Days at sea (individual)	Limit catch
	Area restriction	Limit catch or impact on habitats or other species/age groups
	Bycatch devices	Limit catch of non-target species/size
Output regulations	TAC	Limit total catch
	Group TAC	Limit or secure catch of certain vessel group
	Individual quotas	Control of harvest and improve economic performance
	Bycatch regulations	Limit catch of non-target species/size
	Minimum landing size	Limit catch of undersize fish
Economic measures	Subsidies	Encourage certain behaviour
	Taxes/fees	Discourage or reduce certain behaviour. Reduce catch
	Individual transferrable effort	Secure efficient effort allocation
	Individual transferrable quotas (ITQs)	Secure efficient quota allocation

Usually, there will be a connection between the fisheries regimes (way of thinking about fisheries activities) and the measures applied to regulate these activities. For example, when the gear became increasingly efficient (during the 1960s and 1970s) leading to a sharp increase in catches, the response from fisheries authorities was to set input regulations (maximum engine size, limiting number of days at sea), and when new fishing gear and technology was introduced, making it simpler to find and catch the fish, regulations with respect to the gear (minimum mesh size, bycatch devices) were implemented. This development obviously was a kind of "mouse's game with the cat", where the industry invented more and more efficient boats and gear, and the authorities introduced new regulations to prevent the catches from increasing to a size of non-sustainability as the input became more efficient.

As managers learned to understand this game, and that there could be no winner in it, there was a shift in the authorities' approach from input regulations to output regulations. This was the time for introducing the TAC system (1980s) which is still one of the cornerstones in the CFP. This, however, led to another type of game, namely one between the member states and the EU authorities. The relative stability principle implies that the (relative) share of the TAC allocated to each coastal member state shall be constant, whereas the actual size of the quota to each member state will vary with the TAC. It is the member state's task to enforce the national TACs, and this division of tasks gives rise to a type of behaviour characterised by the 1/n effect. If all other coastal nations fish only their quota then one nation may "default" and exceed their quota without it creating too large consequences for the total overfishing. Also, the consequences of overfishing have to be born by all coastal member states, such that the consequence to each member state will be "small". Then we are back in the "tragedy of the commons" situation, which the regulations were supposed to conquer. This situation is characterised by the fact that individual rationality diverges from what is a rational adjustment taking the whole society (EU) into consideration. Hence, at present there is a problem with the enforcement of the quota limitations due to the division of power and tasks between two authority levels; the EU authorities and the member state authorities.

2.3 Assessing the effectiveness and acceptability of the tools

We have made the assessment of the effectiveness and acceptability of the management tools applied by the different member states in a two-step procedure: First, based on knowledge of the different tools (how does a tool work and what is the intended aim of applying the tool) we use logical and (economic) rational thinking to deduce to what degree each of the tools is effective according to three different criteria (see below) in reaching their goals. Based on observations of to what degree the different tools are applied combined with knowledge about why they eventually are not applied we draw conclusions about to what degree each of the tools are politically acceptable. Together, this provides us with a table where (all) tools are characterised with respect to whether they are politically acceptable or effective (see table 2.3). So far, all information is theoretical. Second, we distribute the list to partners of the MEFEPO project. They are asked to confront experts on fisheries management in their respective countries with the table, and get comment whether our initial characterisation of the tools are in accordance with the experts experience with the use of the tools. Finally, we put the experts' opinions from the different countries together to see whether the comments from the different countries vary or whether they are in concert. Below, the criteria we used to assess the management tools, both theoretically and empirically, and the initial list of the tool assessments are presented. This is followed by a table summarising to what degree the experts' opinions about the tools' effectiveness and acceptability are in concert with each other.

Assessing the effectiveness and acceptability of the tools we use the following criteria, which are often used to assess measures applied to reach goals within the management of environmental and natural resources.

a) politically acceptability
b) cost effectiveness
c) ecological effectiveness

d) dynamical effectiveness

Political acceptability will often vary both geographically and between different interest groups. We will concentrate on the political acceptance of the *decision makers* (e.g. bureaucrats or politicians) in the relevant fisheries management. The prevalence of a measure does to some degree indicate the acceptance, though lack of presence does not necessarily imply lack of political acceptance[5]. Clearly over time political acceptability of tools may change and we are interested in the *current* political acceptability.

Cost effectiveness is secured in two possible ways; 1) when there is an aim of improving the economic performance of a given fishing fleet, and some improvement may be expected to take place and/or 2) when the aim of the management tool is to conduct the fishery as whole in the most cost effective way. In the first case, limiting the number of vessel, for instance using limited licences may improve the economic performance of a vessel group, at least in the short run. In the second case, an individual transferable quota regime aims at securing that a limited quota is harvested by those that are willing to pay the highest price for the rights. The most efficient agents are willing to pay the most, and hence the most cost effective harvesting takes place.

Ecological effectiveness is characterised by the measure reaching some ecological goal, for instance securing the stock size at some level, or ensuring that only fish over a certain size is caught.

Dynamic effectiveness is the securing of the *ecological* goal over time. I.e. can the management tool be expected to sustain its ecological aim over time? Note that a tool may not be ecologically effective instantaneously, but may be so in the long run. In this case it is not ecologically effective but dynamically effective. There may also be examples of vice versa.

The symbols used for the four assessment criteria are as follows;
Politically acceptable △
Cost effective □
Ecologically effective ○
Dynamically effective ⬭

We measure the four assessment criteria of the tools according to a "traffic-light" method:
Red: no
Orange: may be
Green: yes
White: irrelevant

A red circle indicates *no* ecological effectiveness, an orange circle indicates that there *may be* ecological effectiveness in some form, a green circle implies that the ecological goal of the tool *is* reached, while a white circle states that ecological aims are *irrelevant* for the tool in question.

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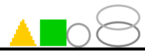
[5] Even though the implementation of a policy may be controversial among some stakeholder groups, the fact that it is implemented implies that it is politically acceptable. Furthermore, some of the tools presented may not have been implemented, not due to lack of political acceptance, but rather because they are either incompatible with existing measures, or are superfluous.

In Table 2.3 the expected outcomes of the four assessment criteria for each tool are presented. The assessments of the expected outcome of the management tools in Table 2.3 are made based on the intended effect or aim of the tools[6], and are logic combinations of the description of the intended effect and the definition of the efficiency/acceptability criteria.

Table 2.3 Tools and their effectiveness/acceptability. Expected outcome of tools are measured according to their intended aim[7] (shown in Table 2.2).

Tool	**Aim**	**Expected outcome**
Input management tools:		
Mesh size	Limit the catch of undersize fish	
Gear type	Limit catch or type of catch	
Limited licensing	Limit catch, or number of vessels	
Engine size	Limit catch	
Seasonal restriction	Limit catch or type of catch	
Days at sea (individual)	Limit catch	
Area restriction	Limit catch or impact on other species/age groups	
Bycatch devices	Limit catch of non-target species/size	
Output management tools:		
TAC	Limit total catch	
Group TAC	Limit or secure catch of certain vessel group	
Individual quotas	Control of harvest and improve economic performance	
Bycatch regulations	Limit catch of non-target species/size	
Minimum landing size	Limit catch of undersize fish	
Economic incentive mechanisms:		
Subsidies	Encourage certain behaviour	
Taxes/fees	Discourage or reduce certain behaviour. Reduce catch	
Individual transferrable effort	Secure efficient effort allocation	
Individual transferrable quotas	Secure efficient quota allocation	

The thinking behind the expected outcome for the different tools in Table 2 is as follows;

Input management tools:
Mesh size: the Expected outcome assessments are based on the following; the political acceptability is green, i.e. it is acceptable, as this management measure is widely used. The Cost effectiveness is white, i.e. irrelevant, as mesh size regulations have no aim regarding the economics of the fishery. The ecological effectiveness is green, as the aim of limiting catch of undersize fish is in theory achieved by this specific management tool. The dynamic effectiveness is green, as given unchanged economic and ecological structures, this management measure will sustain its effect indefinitely.

[6] One exception is the political acceptance. The expected outcome here is mainly based on the EFEP study of stakeholder opinions and prevalence of a number of different management tools.
[7] See the additional attached appendix for more in depth explanations of the traffic light colour choices made in the Expected outcome column.

Gear type: Here the political acceptability is green, as gear restrictions are highly common. The cost effectiveness is white as these regulations are seldom intended to improve the economic situation in the fishery. The ecological effectiveness is orange, as limiting some gear types may have an ecological effect in limiting type of catch. But it may also be a blunt instrument in the sense that the actual total catch may not be affected. This is also the case over time hence the dynamic effectiveness is also orange.

Limited licensing: Again the political acceptability is green, as limited licensing is common. The cost effectiveness is orange, as sometimes this management tool is implemented to improve the economic situation in an open access fishery. In the short run, this may also be achieved. However, the most effective harvesters may not be those obtaining licenses, hence cost effectiveness is not ensured. The ecological effectiveness is also orange, as limiting the number of vessels may have the ecological effect of limiting catch. The dynamic effectiveness is red, as over time technological improvement will increase the harvesting capacity.

Engine size: Political acceptability is orange, as this measure has at least historically been applied, though less and less common in recent years. This tool may indeed increase cost, making cost effectiveness red. The tool is exceedingly blunt with regard to limiting catch, hence ecological effectiveness is orange similar to limited licensing, and the dynamic effectiveness also red.

Seasonal restriction: Political acceptability is green, as seasonal restrictions are common. This measure has little or no economic motivation, and cost effectiveness is as such irrelevant. Seasonal restrictions may when implemented in order to protect specific parts of a life-cycle have ecological effectiveness. This may also secure this protection dynamically, hence both ecological and dynamic effectiveness is green.

Days at sea: This measure is politically acceptable some places, and it is therefore coloured orange. The remaining arguments are as for engine size.

Area restriction: Political acceptability is green, as seasonal restrictions are common. This measure has little or no economic motivation, and cost effectiveness is as such irrelevant. Area restrictions may when implemented in order to protect specific species or age groups have ecological effectiveness. This may also secure this protection dynamically, hence both ecological and dynamic effectiveness is green.

Bycatch devices: Bycatch devices for the reduction of bycatch are increasingly being applied, and therefore politically acceptable. The economic aspect is however not present, and cost effectiveness is therefore irrelevant. The ecological effectiveness is clear, as is the dynamic effectiveness.

Output management tools:
TAC: This highly common tool is clearly politically acceptable most places, but has limited or no economic justification, as effort is not limited. The limiting of harvest makes the ecological effectiveness green. If TACs are set under full knowledge of stock size, and with full control of harvests, this measure may be dynamically effective.

Group TAC: The measures of the criteria are similar to the TAC, only in this case the group limitation is often made in order to secure some vessel group economically. Hence there may be some economic improvement, making cost effectiveness at least orange. . If TACs are set under full knowledge of stock size, and with full control of harvests, this measure may be dynamically effective.

Individual quotas: This measure is similar to the group TAC, only in this case securing the economic situation of single vessels or firms.

Bycatch regulations: Bycatch regulations limiting the amount of bycatch function in a similar way as the Bycatch devices above.

Minimum landing size: This tool functions much the same as minimum mesh size above.

Economic incentive mechanisms:
Subsidies: This tool is becoming less and less politically acceptable, due to global and EU limitations in national subsidies. Given that the subsidy is introduced to correct for negative effects of the fishery activity, it will usually increase effort which may lead to downfishing of the stock and higher costs. Subsidies may however also be used to encourage more advantageous input combinations, and therefore we have used the orange for cost effectiveness. Subsidies to encourage specific harvest forms may result in ecological effectiveness, hence the orange colour here and over time.

Taxes/fees: Taxes and fees have largely not been used for specific management purposes in fisheries, and hence political acceptability is measured to be red. The economic effects are deemed positive, in the sense that effort taxes may reduce effort and increase rents in the fisheries, making cost effectiveness green. The reduction in effort can be expected to have positive ecological effects, and this can be upheld dynamically.

Individual transferrable effort: This tool is found applied in some countries, while not at all in others, and is therefore given an orange political acceptability. The transferability of effort ensures that the most efficient effort remains in the fishery, making cost effectiveness green. The measure has in itself no ecological aim, making ecological effectiveness as defined here white, as also the dynamic effectiveness.

Individual transferrable quotas: This tool functions in the same way as the individual transferrable effort as regards our four criteria.

2.4 Expert opinion of acceptability and effectiveness

Intended effect and theoretic assessment of management tools may not coincide with the *actual* effects of the applied tools. One reason for this, especially relevant within the CFP, is that a series of tools are applied simultaneously. Another reason is that the tools may depend on additional controls or monitoring that is not sufficiently present or possible. Furthermore, the multispecies nature of EU fisheries results in the tools applied for the management of a single species often affecting other species as well, and not necessarily in a desired fashion. This makes it necessary to discuss actual (empirical) outcomes of the application of the management tools. International experience shows that different tools may be perceived to function in different ways around the globe (Worm et all 2009), and this is also shown to be the case within the EU. Table 2.4 summarises the results from the experts' opinions with respect to whether they agreed with our initial assessment of the tools, and how they perceived the tools functioning in the national fisheries (see table 2.3).[8]

[8] The questionnaire sent to the MEFEPO members is attached.

Table 2.4 Results of experts' opinions with respect to whether they agree with the assessment of the tools effectiveness and acceptability

	Input regulations	*Output regulations*	*Economic mechanisms*
Politically acceptable	Moderate agreement	High agreement	Highly varying
Cost effective	Highly varying	Highly varying	Moderate agreement
Ecologically effective	Highly varying	Highly varying	Moderate agreement
Dynamically effective	Highly varying	Moderate agreement	Moderate agreement

There seemed to be reasonable agreement regarding the political acceptability with regard to *output regulation* management tools, and these are all seen as acceptable, except for bycatch regulations. Regarding the *economic incentive mechanisms*, the political acceptability was highly varying while the different measures of effectiveness were somewhat more in line for this group of tools. For the output regulations, cost and ecological effectiveness varied substantially between the experts, while dynamic effectiveness was mainly as described in Table 2.3. For the *input regulation* tools, however, the expert opinion regarding all the effectiveness outcomes varied.

The results of this study give an indication of what tools are seen in a similar fashion throughout the EU. From this it may be possible to deduce which tools are acceptable to apply from the top down, i.e. at the EU level, and which should be kept at a national or regional management level. As we have not specifically asked whether the experts differentiated between the EU and national level management, this is not absolutely clear, though there seems to be a greater over-the-board political acceptance for output management tools. This is also the case, though to a lesser extent, for the input management tools. The perceptions of the effectiveness of the tools vary substantially, underlying differences in experience, types of fisheries, modes of control and possibly also understanding of the questionnaire.

Some critical points should be mentioned. The questionnaire is based on discussions carried out at MEFEPO project meetings, but there was no final project meeting to ascertain the complete understanding of the answers given prior to this report. Also within countries there was some disagreement regarding the evaluation of the outcomes of the different tools. A more focal group approach with discussion and deliberation might have clarified issues, and more agreement on the assessment of the different tools may have been reached. A broader expert group may also change some results. However, the approach carried out is a first step to discussing these issues and clarifying some aspects of management tools in fisheries.

Finally, it must also be stated that studying management tools in isolation may disguise limitations that the outer framework of the EU fisheries policy, or rather the *principles* of the CFP, lay upon the final management tools. This is another aspect that requires going deeper into the limitations that for instance a principle such as *relative stability* or the lack of a discard ban places upon the underlying tools of management, i.e. limiting their political acceptability and/or their cost, ecological and dynamic effectiveness.

3 Adaptive management, new stakeholders and the use of incentive schemes

3.1 Introduction

3.1.1 Background

In the Green Paper on the 2012 revision of the CFP (COM (2009) 163) ecosystem based fisheries management is introduced as a guiding principle. This implies a more holistic approach when managing specific stocks of species including taking into account other species and components of the ecosystem to which the species belong, and to take into account other uses of the ecosystem to which the species belong. One way to take into account other components of the ecosystem or other uses, is to introduce stakeholders who can represent them into the management and give them a say in the formulation of the CFP.

Adaptive management (AM), or adaptive environmental assessment and management as was its original name, defines a management practise that is based on predictive (scientific) modelling given the present knowledge, and as new knowledge is gained the models are updated and the management decisions adapted accordingly (passive AM). In some cases the management strategy is deliberately changed in order to test the effect on the system managed (active AM).

Our approach to AM is most in line with the passive version of the concept, as we in this section explore what happens to the management strategies of the traditional management bodies, EU and national authorities, when new stakeholders are given a say in the management. Starting out by analysing the present regulations of the EU fisheries as a principal-agent situation, we test analytically what might happen when a new stakeholder, a second principal, enters the scene and is given a say in the CFP. Principal-agent situations with more than one principal are denoted common agency. Using a common agency approach we discuss what will happen with the original regulation strategy of the authorities when new stakeholders are introduced in the fisheries management and what characterises the aggregate of the regulations compared to when the authorities were the sole regulators.

This section aims at

- discussing how incentive mechanisms (incentive schemes) can be used to regulate effort, and thus harvest, in the fisheries given that there is only one regulator (the authorities)
- analysing what happens to the incentive schemes given by the present regulator (authorities) when new stakeholders are given a say in the formulation of the CFP
- analysing the consequences for the aggregate of regulations directed towards the fishers, when new stakeholders are given a say in the CFP

3.1.2 Interest groups, interests, and power structure in the CFP

The way the CFP works and the degree to which it is an appropriate tool for managing the EU fisheries, depends on the actors (interest groups) involved, their interests, and the power structure (who decides what).

The fisheries sector of the European Union (EU) is strongly administered and regulated, and the framework and public aims for the sector is set by the ministers in the Council of the

European Union (Council) usually acting on the initiative of the Commission of the European Communities (Commission) through the Common Fisheries Policy (CFP).[9] The Council also produces highly detailed regulations that are directly binding for the member states. Then it is up to the member state authorities to implement the EU Regulations, which implies regulating the behaviour of the fishery sector [10] so that – ideally - the aims of the CFP are reached. These three groups, Council and Commission, national authorities, and fishers, are traditionally the main interest groups of the CFP.

In the last decades NGOs, especially those concerned with environmental matters, ENGOs, have taken an increased interest in fisheries activities, not least in the EU fisheries due to their poor performance compared to similar fisheries other places. They do this by trying to influence the preferences, and thus decisions, of the three other interest groups such that environmental concerns obtain a greater weight at the expense of other concerns. Primarily, they do this by approaching the Commission and the ministers in the Council, or national authorities.[11] However, when these bodies are insensitive to the ENGOs' efforts, the ENGOs may exert effort directly upon the fishers. Examples of this are calls for boycott of fish products not harvested sustainably, dumping of rocks to mark marine protected areas, and issuing certificates for harvesting on sustainable stocks. The ENGOs will often try to affect the way the rules are implemented nationally, but traditionally the partnership between the industry actors and the administrations at the national level is strong vis-à-vis that of the ENGOs and the administrations. However, in some countries this balance has changed and there are indications that the ENGOs are increasingly claiming and obtaining a role in the corporative arrangements at national levels.

The main aims (objectives) of the EU fisheries can be expressed as a combination of environmental, economic and socio-economic interests, where the weights between the environmental and the other interests have changed over time. As stocks and thus harvests have declined, the tendency is to put more weight on environmental and ecological aspects. This is clearly stated in the Green Paper, preparing the 2012 reform of the CFP (COM (2009) 163).[12]

In the formal analysis we limit the interests of the four interest groups mentioned above to be concentrated around the following three objectives:

- environmental (ecosystem health, healthy fish stocks, sufficiently large stocks)
- economic (profitability, efficiency, rent extraction)
- social (employment, community development)

[9] Individual and personal aims for the sector, such as profitability, continuity, identity (being a fisher) are set by the fishers themselves.
[10] In the following analysis we will concentrate on one specific part of the fisheries sector, the fleet.
[11] The ENGOs tries to affect the EU level primarily by direct lobbying at the Commission and the ministers in the Council, but also through working in the Regional Advisory Councils (RACs) as well as through the European Parliament, which despite its so far low formal role in the CFP can function as a powerful way of raising attention.
[12] More concretely, these aims as formulated as follows in the Green paper: i) Restoring fish stocks to Maximum Sustainable Yield and apply an ecosystem approach to marine management. ii) Increase economic viability. iii) Less overall employment and community development must include other sectors than the fisheries, e.g. tourism

For the formal analysis we assume that each of the four interest groups (CEU, national authorities, fishers, ENGOs) have an objective function consisting of a weighted combination of the three objectives, or interest categories (henceforth for simplicity denoted interests), [13] and the weights will typically vary between the groups. Formally, such an objective function can be formulated as follows:

$$U^g = \lambda_1^g ENV + \lambda_2^g ECO + \lambda_3^g SOC \qquad g = EU, MS, F, NGO \qquad (1)$$

where U^g is the utility (well-being) of interest group g, ENV is the environmental interest, ECO is the economic interest, and SOC is the socio-economic interest. Assuming that $\forall g, \lambda_1^g + \lambda_2^g + \lambda_3^g = 1$, the parameters $\lambda_1{}^g$, $\lambda_2{}^g$, and $\lambda_3{}^g$ can be interpreted as the relative weight interest group *g* attaches to the environmental interests, to economic interests, and to social interests, respectively. EU denotes EU-authorities, MS denotes national (member state) authorities, F denotes fishers, and NGO denotes NGOs.

3.1.3 Incentives and regulations

When the interests of different actors within the CFP are not aligned the CFP can not be implemented without the use of coercive power or incentives. Both ways of implementing the CFP have substantial costs, but the advantage of regulating by the use of incentive schemes is that once in place it is in the interest of the regulated body, i.e. the fishers, to comply with them. There are indications that the interests of the different actors within the CFP are not aligned as of today. Though it is the Council, consisting of representatives from the different member states, which in cooperation with the Commission sets the main principles for the regulations of the EU fisheries, these regulations are repeatedly violated at the member state level. Examples of violations are overfishing of the TAC, not obeying closed areas, and capital stuffing. The violations are probably a consequence of the fact that in the Council the member states have to compromise in order to reach a solution for a common fisheries policy, and when operating at the national level they will “fail” to implement those parts of the CFP with which they were most at odds. Such “failures” in implementing the CFP nationally are denoted *agency drift* and is widely treated in the literature (see e.g. Gezelius and Raakjær 2008).

The CFP has been characterised as bureaucratic and top-down, and its implementation has been conducted by command-and-control (Hegland and Raakjær 2008). The Council is super-ordinate to the member states, which in turn are super-ordinate to the national fishers. To be super ordinate implies that this group has the power to impose regulations upon its subordinates. The fishers are not directly subordinates to the Council or the Commission, only to their respective national authorities. The ENGOs are not directly super ordinates or subordinates to any of the other interest groups. They direct their effort towards the Council, the Commission and national authorities. Sometimes they can also take actions which directly affect the fishers, as e.g. call for boycott against unsustainable fisheries or issue certificates (eco-label) to sustainable fisheries.

An alternative to a command-and-control system is to use (economic) incentives, which implies making it in the interest of the fishers to obey the regulations in the CFP, not because otherwise they will be punished by the law, but because they will receive a lower pay-off by

[13] These are relatively wide categories of interests, each encompassing several sub-interests.

not obeying the regulations. Mechanism design is the theoretical framework for how to develop incentive schemes which make it in the interest of an agent, i.e. the fishers, to behave in accordance with the principal's interests, i.e. the authorities. Incentive schemes are usually derived by the use of principal-agent models.

An incentive scheme is derived after the motto; "I give you an offer you can't refuse". The incentive schemes are formulated in a way which secures that it is always in the interest of the agent to accept it, as this gives her/him a higher pay-off compared to not accepting it. A particularly simple form of incentive schemes is the so-called Walsh-contract (Walsh 1995), which is a linear combination of an incentive parameter and a lump sum transfer. Formally this is formulated as $w_0 + wE$, where w_0 is a lump sum transfer between principal and agent, w is an incentive parameter, which is used to affect the behaviour of the agent with respect to the variable the principal wants to "control", and E is the variable, decided by the agent, but which the principal wants to "control". Hence, the principal decides w_0 and w, and the agent decides E. The principal's challenge is to set w_0 and w such that the agent chooses a level of E which is in the principal's interest. Typically in a fisheries context, E would be effort, decided by the fishers, whereas w is a tax or a subsidy on effort (or harvest), which promotes or deters the use of effort. Finally, w_0 is a compensation (or fee) to the agent in order to make her participate in the regulations voluntarily (she will be at least as well off as in her best alternative). If the principal has coercive power the participation constraint need not be fulfilled and w_0 can be set equal to zero, but then the incentive scheme has to be enforced, and we are back in a command-and-control system. In principle, incentive schemes can substitute setting a TAC, and then w and w_0 must be set such that the optimal effort to choose for the fishers (aggregate over all fishers) implies a harvest which corresponds to what would have been chosen as a TAC. Often, however, incentive schemes are applied in combination with control-and-command, in order to reduce management costs and leave the agents, the fishers with a higher degree of freedom. Today, many countries introduce ITQs, which when not given out for free, can work as part of an incentive scheme. These are usually combined with a TAC, and are a part of the overall regulations and the command-and-control system. They can, however, be seen as attempts to apply aspects of self-enforcing mechanisms in the fisheries management.

Note that w_0 and w do not need to be expressed in monetary units. They can represent whatever tool the authorities may choose in order to regulate the fisheries' activity, and which affect the costs of the fishing activity, negatively or positively. Each of the two parameters, w_0 and w, may be positive or negative, and a positive w implies an extra cost (tax) on effort, whereas a negative w implies a reduction in effort costs (subsidy) on effort. Table 3.1 gives examples of w_0 and w in a fishery management context.

Table 3.1 Interpretations of the parameters in the incentive scheme

Parameter	*w*	*w_0*
Positive	Resource tax, effort quota price, mesh size, bycatch devices, area and seasonal restrictions	Licence fee,
Negative	fuel tax exemption	Decommission support,

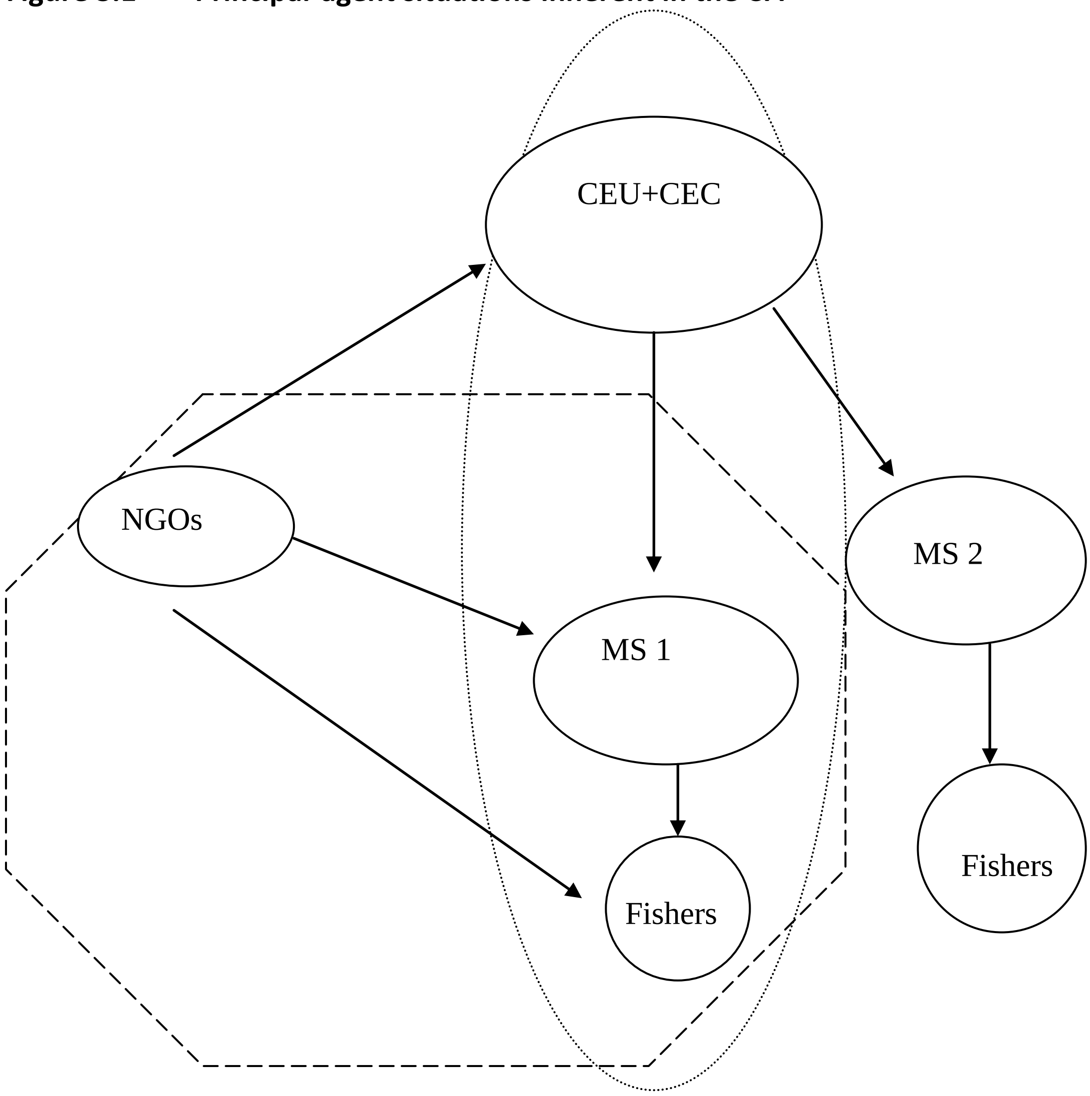
3.2 Analytical framework

We now assume that the CFP is to be implemented by the use of incentive schemes, and the crucial questions are:

1) what characterises an “optimal” incentive scheme in the present situation, i.e. a situation with agency drift and only national authorities setting the regulations
2) how will this optimal incentive scheme change if a new stakeholder, e.g. a ENGO, is given a say in the fisheries regulations

We start out with the present situation within the CFP, which can be termed delegated (or double) agency, indicating that one principal (the EU-authorities) indeed set relatively detailed regulations for the fisheries, but delegates to the national authorities to enforce the regulations vis-a-vis the fishers. In this model both EU and national authorities are principals, but on separate levels, and the fishers are the agent. Then, not exerting mere power, it is up to either the EU or the national authorities to formulate incentive schemes, in order to meet the main aims of the CFP. This model, delegated agency, is depicted within the oval in figure 3.1. Then we proceed by taking into account that an additional principal, symmetric to either EU or national authorities, is given a say in the regulations of the fisheries. By the use of a common agency model, given in the dotted hexagon in figure 1, we discuss how this affects the optimal incentive scheme given above, and characterise the aggregate of the incentive schemes.

Figure 3.1 Principal-agent situations inherent in the CFP



3.2.1 Agency drift

As shown by both Hegland and Raakjær (2008) and Gezelius (2008) for Denmark and Norway, and by van Hoof et al (2005) for Netherlands, France, Spain and Shetland, fishing policy (such as the CFP) is implemented as a corporatist system. This implies that the member state authorities and the fishery sector work closely to implement regulations of the activity. There are many reasons for this, and one is that the sector, though not large, represents an important voter group. According to Fort and Rosenmann (1993) the reason why we often observe inefficient regulations of e.g. natural resources, is that the regulator, i.e. national authorities, have other interests than economic (efficiency) when regulating the exploitation of natural resources, as fish, forest and oil and gas. If it is a goal to be re-elected they have an incentive to align their interests with those of large or popular voter groups. Though not large voter groups by number, primary production sectors often has wide popular support and are considered important for the nation. Thus, for a government aiming at staying in power it is rational to take into consideration the interests of actors in these sectors.

In Annex 4 we have derived the optimal effort levels, as seen from the perspective of the different interest groups. Table 3.2 gives examples of the optimal effort level for the different groups under varying assumptions about how they weight their environmental, economic and social interests.

Table 3.2 Optimal effort level measured as man-hours per year for the interest groups under varying assumptions about the weights of their interests

Optimal effort level in 1000 man-hours per year	*EU-authorities*	*National authorities*	*Fishers*	*NGO*
High alignment across all groups	246	248	243	250
Corporatist system	246	249	243	250
Large polarisation across the groups	241	246	230	250

The calculations above are based on the following assumptions: N=10 (the number of member states participating in the fishery), q=0,01 (catchability, i.e. how easily accessible is the fish, the higher the more easy to catch), p=1000 EUR per tonnes (first hand price), a=2 (cost factor, the higher a, the more the harvest costs increase when effort increases). The weights of the interests, the λs, vary between the three scenarios; “high alignment”, “corporatist system”, and “large polarisation”.

The scenario “h*igh alignment across all groups”* implies that we assume relatively small differences in the weights of the three interests across the groups. The weight of the environmental interests (λ_1) varies between 0,6 for the NGO to 0,3 for the fishers, the economic interests (λ_2) between 0,4 for the fishers and the national authorities to 0,2 for the NGO, and the social interests (λ_3) between 0,2 and 0,3. The results show limited variation in the optimal effort, measured in 1000 man-hours per year, between 243 for the NGO and 250 for the fishers. In the scenario “l*arge polarisation”* the weight of the environmental interests vary between 0,8 for the NGO and 0,1 for the fishers, the economic interests vary between 0,8 for the fishers and 0,1 for the NGO. The social interests are low across all groups, about 0,1-0,2. This results in considerably higher variations in the optimal effort level, from 230 for the NGO to 250 for the fishers. In the scenario “c*orporatist system”* we have set the weights of the different interests equal for fishers and national authorities. Still, the optimal effort level differs between the two and the reason is that we have assumed that the fishers are myopic in their optimisation, implying that they only take into account their own harvest, i.e. the total national harvest on a specific stock, and not the harvest of other nationals on the same stock.

3.2.2 Optimal regulations of the fisheries' activity: Incentive schemes

There are remedies to agency drift. These may be judicial sanctions, negotiations between the actors in order to try to align their interests towards the fisheries, and the application of economic incentives. As of today, if a national TAC is overfished or any other regulation violated, the EU authorities can punish the member state authorities, e.g. by fining them, and the national authorities can in turn fine or punish the fishers who are responsible for the violations. An alternative way to analyse the regulation of the fishery activity is to assume that the regulator (henceforth called principal), be it the EU authorities or national authorities, applies a carrot-and-stick system. The idea of this system is that on the one hand certain behaviour with regard to effort is promoted or deterred and on the other hand the there is a lump sum transfer to secure that the agent voluntarily adjust her behaviour as preferred by the principal. This carrot-and-stick system we call an (economic) incentive scheme.

Admittedly, this kind of incentive schemes is not widely applied within the CFP. However, the introduction of ITQs can be interpreted as a step in the direction of taxing, and thus deterring, harvest (and thereby effort) if the quotas were not given out for free. Distributing quotas for free to the incumbent fishers can be interpreted as compensation in order to make the fishers accept the system in the first place. We interpret this as an example of the increasing acceptance for applying economic incentives in the regulations of the EU fisheries. Another argument for introducing economic incentive schemes is that stakeholders, such as ENGOs and representatives of other industries, normally will not have coercive power over the fishers, and thus can not apply command-and-control systems to influence the fishers' activity. In order to compare the regulations set by the authorities and by the new stakeholders, we use carrot-and-stick systems, which are available to all.

Previously, Jensen and Vestergaard (2002) have applied a principal-agent model to analyse how the EU-authorities can deter agency drift by taxing national authorities for harvest taken by national fishers. The authorities may in turn tax the fishers based on registered harvest or effort. They derive a tax-scheme, which when applied will align the optimal effort level for the national authorities with that of the EU-authorities. They use a tax scheme which is non-linear in effort, i.e. the higher the effort is the higher is the tax per unit effort. They, however, admit that the realism of such a tax structure can be questioned. Applying a somewhat different methodology, we take as a point of departure that the authorities apply a tax scheme which is linear in effort, and that they use this to regulate the fishers' activity. Hence, we assume a situation where national authorities apply an incentive scheme directly towards the fishers in order to align their optimal effort level with that of the authorities'.

The model we apply is presented and solved in Annex 5. The idea behind the use of economic incentive schemes is that first the authorities, acting as a principal, formulates an incentive scheme and forwards this to the fishers. Next, the fishers decide whether to accept the incentive scheme and continue in the fishery, or reject it and retreat from the fishery. We assume that the incentive scheme has the following form; $w_0 + wE_j$, where w_0 is the compensation or fee, w is the tax/subsidy rate and Ej is the effort level exerted by a fisher in member state j. As we have assumed identical fishers, all fishers will exert the same effort when facing the same incentive scheme. The way we have formulated and solved the model implies that a positive w is a tax on effort whereas a negative w is a subsidy per unit effort. Correspondingly a positive w_0 will imply a fee that the fishers have to pay whereas a negative

w_0 implies compensation to the fishers. The characteristics of the two parameters in the incentive scheme, i.e. how they vary with the interest weights and other exogenous variables and parameters, are given in table 3.3.

Table 3.3 Characteristics of the parameters in the optimal incentive scheme

	λ_1^{MS}	λ_1^{F}	λ_3^{MS}	λ_3^{F}	λ_2^{MS}	λ_2^{F}	Outside option, U^{F0}
W	+	-	-	+	?	?	
w_0	-	+	+	-	?	?	-

Outside option, U^{F0}, denotes the pay-off to the agent (fishers) if they do not accept the incentive scheme.

The optimal tax/subsidy rate increases in the environmental interests of the national authorities, λ_1^{MS}, and decreases in the environmental interests of the fishers, λ_1^{F}. The latter is obvious because with more environmentally concerned fishers the need for strong incentives to limit effort is lower, and thus the tax can be set lower. High environmental concern on behalf of the fishers implies a lower tax rate, and for given values on the other model variables (see annex 4) this makes it more likely that the tax rate is negative, i.e. a subsidy rate. Further, w unambiguously decreases in the social interests of the national authorities, λ_3^{MS}, and increases in the social interests of the fishers, λ_3^{F}. The former is due to the fact that high social interests imply that the authorities prefer high effort in order to keep high employment in the fisheries. Then they are not interested in limiting effort by the use of a high tax rate.

The economic interests of the authorities, λ_2^{MS}, and the fishers, λ_2^{F}, have ambiguous effects an the tax/subsidy rate, w. On the one hand, high economic interests for the fishers imply that they will wish to have a high harvest, and thus they set a high effort. To deter this, the authorities will set a high tax rate. On the other hand, when effort is already high, increasing effort will reduce the net income, and then the fishers have no interest in further increasing effort. In turn, there is then no more need for the authorities to increase the tax rate in order to deter the fishers from increasing effort. The same argumentation goes for the authorities.

Remembering that w_0 is formulated as a lump sum transfer from the fishers to the authorities, it is the case that the higher the alternative income to the fishers if they retreat from the fishery (the outside option) is, the more likely it is that the lump sum transfer is negative, i.e. that it is compensation to the fishers. The reason is that we have assumed homogenous fishers, which means that if one fisher wishes to retreat from the fishery all fishers will retreat, and as long as the authorities have a positive pay-off from the fishery activity this is not in their interest. Hence, they will secure compensation sufficiently high to make the pay-off from the fishery higher compared to the outside option. When $0<w<1$, the lump sum transfer varies inversely with the tax/subsidy rate, and thus the weights of the interests have the opposite sign compared to for the tax/subsidy rate. The reason is obvious; if the authorities tax the fishers, i.e. a positive w, such that effort costs are increased the net income is reduced. In order to keep the fishers in the fishery they must be compensated through w_0, and a transfer to the fishers imply a negative w_0.

The optimal effort varies negatively with the tax/subsidy rate, w. Hence, when this rate is positive, i.e. a tax is induced on effort, the optimal effort level is smaller compared to when there is no tax on effort, and the vice versa.

3.2.3 New stakeholders get a say in the CFP

Ecosystem based management implies a more holistic view of the fisheries management, which includes taking into consideration other *uses* and other *users* of the marine ecosystems. Other *uses* (than fishing) are e.g. bird watchers who watch sea birds, and diving, enjoyment of benthic habitats, i.e. the tourism industry, or maritime transportation and energy. All these uses have their own NGOs that advocate their interests. Among the most popular NGOs we find environmental NGOs (ENGOs). Since the 1970s these have gained popular support and the number of ENGOs has increased.

Gaining popular support is an argument for demanding influence in societal decision making, and we see that some NGOs have increased their influence upon national and international authorities in their decision making considerably during the last decades. Examples are Greenpeace and MSC on an international level, and the Norwegian ENGO Bellona on a national level. The measures they use in addition to pressure upon politicians and other decision makers are e.g. calls for boycott of fish from unsustainable fisheries and eco-labelling of fish from well-managed fisheries. Such initiatives correspond to a tax or a subsidy on the fishers' activity (effort) as they either reduce or increase the (net) income to the fishers. Alternatively, we can also assume a scenario where representatives of NGOs are invited into the negotiations about fisheries' regulations and allowed to have a say in the final formulations of the CFP, or at least that their opinions are taken into consideration when formulating the CFP.

This means we have extended from one to two principals, which have a say in the fisheries' regulations. A situation where two (or more) actors have the possibility to forward incentive schemes for an agent is called a *common agency* (Bernheim and Whinston 1986). In this situation the two principals can either decide to cooperate and derive a common incentive scheme, or they can develop their measures separately and independently. In the last case each principal develops its' optimal incentive scheme, taking into consideration that the other principal acts accordingly. Then we get a solution characterised by so-called "best-replies", i.e. each scheme is a best reply to the incentive scheme developed by the other principal.

3.2.3.1 Cooperating principals

One option when there is more than one principal is that the principals cooperate and forward one common incentive scheme. Then they agree upon a common objective function, and derive the optimal incentive scheme as was done when there was only one principal (see above).

The main difference is the formulation of the common objective function or goal and the weighting of the different interests. This must be a compromise between the two principals. When the two principals are national authorities and a national ENGO the common objective function will be a weighted average of the interest weights in their respective objective functions. Thus, assuming that the NGO holds stronger environmental interests and weaker economic and social interests with regard to the fishery's activity than does the authorities, the common objective function will have higher environmental interests than the objective function of the authorities and lower than the objective function for the ENGO. For the economic and social interests it will be the vice versa.

When we formulate the common incentive scheme as follows; $c_0 + cE_j$, the tax/subsidy rate c, and the lump sum transfer c_0, relate to the incentive scheme of the single principal, the authorities, as shown in table 3.4.

Table 3.4 Changes in the incentive scheme with an additional principal

	ENGOs hold higher ENV and lower ECO	*Common interests*	*NGO hold lower ENV and higher ECO*
Tax/subsidy rate	c > w	c = w	c < w
Lump sum transfer	c0 < w0	c0 = w0	c0 > w0

In some situations with two principals, the net incentive scheme, i.e. the aggregate of the two incentive schemes, can be very strong (the aggregate of the tax/subsidy rates has a high absolute value) compared to what one principal would have forwarded as the single principal. This is the case when one principal has very asymmetrically weighted interests, i.e. either nearly only environmental interests, or nearly only economic and social interests, whereas the other principal's interests are more symmetric. Then, to avoid the strong tax/subsidy rate forwarded by the "asymmetric" principal, the "symmetric" principal may propose to cooperate and forward a common incentive scheme. As will be shown below, a common incentive scheme will almost always give a lower tax/subsidy rate when compared to the aggregate of two separately fixed rates. Hence, by cooperating, the "symmetric" principal tries to discipline the "asymmetric" principal.

The scenario "NGO hold lower ENV and higher ECO" may seem strange, all the time we consider environmental NGOs. However, the organisation "Kystens Venner" (Friends of the Coast) calls themselves environmental. However, as they see the fisheries as the most important industry along the coast, they will often hold stronger economic than environmental interests, at least towards some fisheries' activity, arguing that it is important to keep the fisheries alive. There are examples of corresponding organisations in other European countries, as Friends of the Sea (France?).

3.2.3.2 Symmetric stakeholders "compete" in regulating the fishery activity

There is also the possibility that the two principals, authorities and ENGO, do not cooperate and instead develop two separate incentive schemes. Denote the two schemes $t_0 + t_1 E_j$ for the authorities, and $\tau_0 + \tau_1 E_j$ for the ENGO respectively. The agent, i.e. the fishers, reacts only to the net incentive scheme, which is the aggregate of the two schemes.

One can argue that the ENGOs will have mainly environmental interests, but there are examples of ENGOs which also take into consideration the social and economic impacts the fishery activity has on local communities. We start off by assuming that the two principals are symmetric in the sense that they hold the same interests towards the fishery under consideration, and that they separately and simultaneously derive an incentive scheme in order to affect the fishers' behaviour with regard to choice of effort, and thus harvest. In formulating their incentive schemes, both take into account the fact that another principal formulates an incentive scheme towards the same agent. Taking into account this strategic interaction the tax/subsidy rate set by one principal becomes a function of the tax/subsidy rate set by the other principal. Interdependent tax/subsidy rates are also called reaction functions, and a reaction function gives one principal's best reply to the tax/subsidy rate of the other principal. Formally the optimal tax/subsidy rates for the authorities and the ENGO are given as below:

$$t_1^{R} = -A\tau_1 + B^{MS} \quad (2)$$

$$\tau_1^{R} = -Dt_1 + B^{NGO} \quad (3)$$

$t1^R$ and $\tau 1^R$ are the reaction functions of the authorities and the ENGO respectively. As the original incentive schemes are linear, the reaction functions are also linear (the full expressions for A, D, B^{MS} and B^{NGO} are given in Annex 4). The reaction functions in (2) and (3) demonstrate very clearly the point made by Bernheim and Whinston (1986) that in constructing incentive schemes in common agency each principal first outdoes (parts of) the incentives of the other principal and then creates its own incentives. Or put in their words; "only the net incentive scheme matters, so each principal can take out what others put in before designing his preferred scheme." (op cit, p 929). The formulation of the reaction functions in (2) and (3) shows that in our case each principal only partially eliminates the effects of the incentive scheme of the other principal. The reason is that both principals have interests that support deterring (taxing) effort (these are the environmental interests), and interests that support promoting (subsidising) effort (these are the social interests, whereas the economic interests partly promote and partly deter effort). Hence, when one principal has put something into its incentive scheme, e.g. a tax on effort, then the other principal due to its social and economic (partly) interests, has an incentive to "outdo" this by subtracting it from his own incentive parameter. However, as this principal also holds environmental interests he/she will not eliminate the "input" from the first principal, i.e. subtract it entirely from its own incentive parameter.

Solving for (2) and (3) simultaneously yields the mutually optimal tax/subsidy rates of the authorities and the ENGO. These are given in Annex 4, and in table 3.5 they are characterised with respect to their correlation with the interest weights.

Table 3.5 Characteristics of the tax/subsidy parameters and the net incentive scheme

	λ_1^{MS}	λ_2^{MS}	λ_3^{MS}	λ_1^{NGO}	λ_2^{NGO}	λ_3^{NGO}	λ_1^{F}	λ_2^{F}	λ_3^{F}
t_1	+	?	-	-	?	+	-	?	+
τ_1	-	?	+	+	?	-	-	?	+
$t_1+\tau_1$	+	?	-	+	?	-	-	?	+

Starting with the optimal tax/subsidy rate of the authorities, t1*, table 3.5 shows the interests of the other principal and of the fishers draw in the same direction. The higher their environmental interests are, the lower is the incentive parameter, and the more likely it is that the parameter expresses a subsidy (is negative). On the other hand, the higher their social interests are the higher is the incentive parameter and the more likely that it is a tax on effort. For the principal it is the vice versa. The logic behind these opposite dynamics is that when the agent and the other principal have high environmental interests they will choose a low effort (agent) and a high (positive) input to the incentive scheme. This means that the original principal can relax its (positive) input to the incentive scheme, because effort has already been limited by the two other players. When the original principal has high environmental interests this will motivate her/him to limit effort, which is done by introducing a high (positive) incentive parameter into the incentive scheme. A corresponding logic goes for the social interests, whereas the economic interests exert ambiguous effect on the optimal incentive parameters, as explained previously.

The net incentive scheme is the aggregate of the two incentive scheme and the net tax/subsidy rate is thus given by $t_1^* + \tau_1^*$, and the full expression for this is given in annex 4. From table 3.5 we see that the principals' interests draw in the same direction, i.e. their environmental interests contribute to increase the net tax/subsidy rate whereas their social interests contribute to decrease the net tax/subsidy rate. This is opposite to the fishers' interests, where the environmental interests contribute to decrease the net tax/subsidy rate whereas their social interests contribute to increase it. For the economic interests the effects are ambiguous for all three actors.

Having two principals we must take into account the possibility that the agent can accept both, one or none of the incentive schemes. The pay-off from of each of these three possibilities may differ. If the agent chooses to reject the national authorities' incentive scheme it can either accept only the incentive scheme of the ENGO, or reject both schemes. Rejecting both schemes implies to retreat from the fisheries, and this provides the fisher with her outside option pay-off, which we have previously denoted U^{F0}.

It can be shown (mathematically, see annex 4) that in equilibrium the fishers will always either accept both or none of the offered incentive schemes. An underlying assumption for the analysis has been that as a point of departure none of the principals have an interest in driving the fishers out of the fishery. This is secured both through the choice of model parameters, and by imposing a participation constraint on the maximisation problem of each principal. On the other hand, as pay-off maximising actors, the principals are not interested in letting the fishers get a pay-off that is higher than what is necessary. This means that the principals fix the lump sum transfers, t_0 and τ_0, such that the pay-off to the agent equal its' outside option pay-off U^{F0} (or just above). However, as the net lump sum transfer, i.e. the aggregate of the two lump sum transfers, $t_0 + \tau_0$, is given by equalling the pay-off to the agent of accepting the two incentive schemes and their outside option, the division between t_0 and τ_0 remains indeterminate. This means that how much each principal has to contribute to the net lump sum transfers is the result of negotiations between the two principals, and thus decided outside this common agency model.

3.2.3.3 Asymmetric stakeholders "compete" in regulating the fishers' activity

In some cases it can be argued that an NGO, especially an ENGO, will hold solely environmental interests and not economic and social interests towards the activity in a specific fishery, i.e. that $\lambda_2^{NGO} = \lambda_3^{NGO} = 0$. Changing the interests of one principal implies a change in the strategic interaction between the principals and thus in the reaction functions of the two principals. These are now given by;

$$\boldsymbol{\tau_2}^{\boldsymbol{R}} = \boldsymbol{B_2^{NGO}} \equiv \boldsymbol{\tau_2^*} \tag{4}$$

$$t_1^{R} = -A\tau_1 + B^{MS} \tag{5}$$

where B_2^{NGO} is given in Annex 3.

Equation (5) shows that when the NGO has no economic or social interests it fixes the optimal tax/subsidy rate regardless of the tax/subsidy rate set by the national authorities. The

ENGO now unambiguously welcomes all measures which aim at limiting effort. Clearly, the ENGO has no interest in outdoing anything the national authorities put into the aggregate incentive scheme. The optimal tax/subsidy rate now contributes to fix the ENGO's pay-off equal to a constant. For any $\tau_2 > \tau_2 *$ the ENGO's pay-off from the fisheries' activity will be increasing in E, and the vice versa. However, when the above inequality is fulfilled, the net incentive parameter is also high, which in turn implies a low E. Hence, as a principal the ENGO faces a trade-off between a high incentive parameter, which, in isolation will contribute to increasing its pay-off from effort, but on the other hand, this will also contribute to a high net incentive parameter, which will limit effort. In optimum the ENGO balances the two effects and sets the incentive parameter such that they get a fixed pay-off independent of the choice of effort. This also explains why the optimal incentive parameter for the NGO is independent of the authorities' tax/subsidy rate.

The national authorities' reaction function has not changed due to the change in the ENGO's objective function. Though also aiming at limiting effort, national authorities have in addition economic and social interests which give them incentives to encourage effort. In order to prevent a very high net incentive scheme, the authorities outdo a part of the incentive parameter set by the ENGO. Hence, the ENGO, when setting their optimal incentive parameter must take into consideration that a part of this contributes to reduce the tax/subsidy rate set by national authorities and thus of the net tax/subsidy rate.

Table 3.6 summarises how the tax/subsidy parameters depend on the weights of the different interests.

Table 3.6 Characteristics of the tax/subsidy parameters and the net incentive scheme

	λ_1^{MS}	λ_2^{MS}	λ_3^{MS}	λ_1^{NGO}	λ_1^{F}	λ_2^{F}	λ_3^{F}
t_2	+	?	-	-	-	?	+
τ_2				+			
$t_2+\tau_2$	+	?	-	+	-	?	+

The tax/subsidy parameter of the ENGO now only depends on its weight of the environmental interests. Note, that it is also independent of the weights of the fishers' interests. The tax/subsidy parameter of the authorities has the same characteristics as in the symmetric case above when it comes to how it varies with the authorities and the fishers interests. Finally, the net incentive scheme now varies positively with the weight of the two principals' environmental interests, and negatively with the fishers' environmental interests. The reason for the later is that environmentally concerned fishers will restrict their use of effort and thus their harvest without external regulations, and thus the principals need not set strong regulations, i.e. high taxes on effort. The higher the social interests of the authorities the lower will it set the tax parameter as social interests imply that the authorities wish a high harvest and thus a high effort. The opposite is true for high social interests for the fishers. This will induce them to set a high effort, and to limit the high effort, the authorities set a high tax on effort.

As in the case with symmetric principals (see above) it is not possible to determine the lump sum transfers t_0 and τ_0 exactly. The net lump sum transfer must be sufficient to fulfil the participation constraint. However, how to divide the necessary transfer between the two principals is a question to be settled outside the model. This will probably depend on the negotiation power of the two principals.

3.3 Comparing the optimal tax/subsidy rate in the different cases

When a new stakeholder, e.g. an ENGO, enters the management of a fishery and gets a say in the management (becomes a principal towards the fishers) this will affect the optimal regulations of the present managers (authorities). How it will affect the present regulations depends on the how the two stakeholder groups, now called principals, relate to each other and how aligned their interests are.

Above, we have analysed three situations where two stakeholder groups, authorities and an ENGO, tries to affect the fishers' behaviour w r t use of effort. They do this by the use of incentive schemes, where effort is either taxed or subsidised, and the fishers are in addition either given compensation (if heavily taxed) or must pay a fee (if subsidised). We derived the optimal tax/subsidy rate to set for the two principals in the three situations.

In table 3.7 we have applied the same numeric values on the exogenous parameters as in the scenario "high alignment across all groups" in table 3.2, and calculated the optimal tax/subsidy rate for the two principals.

Table3.7 Optimal tax/subsidy rate in the different models

	National authorities	*ENGO*	*Net tax/subsidy rate*
Single principal	0.9		
Cooperating principals	1.3		
Symmetric principals	- 0.06	1.92	1.86
Asymmetric principals	- 0.6	3.0	2.4

First, we can see the relatively strong influence the ENGO has on the common tax/subsidy scheme when they cooperate with the authorities and forwards a common incentive scheme. We have assumed that the two principals have equal influence on the tax/subsidy rate, i.e. that their weights for each of the three interests counts the same in the common objective function. More realistically would it probably be to let the authorities' interests count more heavily than the interests of the ENGO. Then the optimal tax/subsidy rate would be lower.

When the two principals "compete" and forward separate incentive schemes to the fishers, table 3.7 shows that this leads to a "polarisation" between the principals, where the ENGO sets a high tax rate and the authorities moderates the effect of this by setting a negative tax rate, i.e. a subsidy. The net tax rate is still considerably higher compared to the tax rate set by the authorities alone.

Finally, when the ENGO holds only environmental interests towards the fisheries, they set a very high tax rate, which the authorities partly moderate by offering a subsidy. However, the net tax rate is still relatively high. This gives the highest tax rate out of the rates offered in the four situations we have compared.

3.4 Three case studies of possible consequences of giving new stakeholders a say in the fisheries management

Ecosystem based management implies a more holistic approach to fisheries management, and two aspects are here focal: 1) as the commercial fish stocks are parts of larger ecosystems the well-being of the whole system, not only the harvested stocks, must be considered, and 2) other (human) uses of the same marine resources must be taken into consideration. One operationalisation of such an approach is to let stakeholders representing species and activities other than the specific species/activity being managed have a say in the management. As a consequence, changes in the CFP towards ecosystem based management will imply greater and broader stakeholder involvement, which in turn will affect the present regulations of the specific fisheries activity. Table 3.8 gives some examples.

Table 3.8 Relevant new stakeholders in the CFP

	Example of component	Example of stakeholder
1) Other ecosystem components	Sea birds	Bird watchers organisation
2) Other (human) uses	Other fisheries, tourism	Representatives of other fishing industries and tourism industry

Examples of ecosystem considerations are i) that the relevant species serves as prey (food) for other species; marine (fish, etc), birds or mammals, ii) that the harvest of the relevant species implies bycatch of species which are of commercial value for other fisheries, and iii) that different commercial uses of a one species come in conflict, e.g. that coastal cod is both harvested by local fishers and by angler tourists.

For each of the case fisheries we assume that representatives for interests other than those of the actors within the fisheries are given a say in the management, as shown in table 3.9.

Table 3.9 Overview over the case studies

	Ecosystem aspect	New stakeholder
Sandeel, NS	Sandeel as prey for sea birds	Bird watchers organisation
Nephrops, NWW	Bycatch of juvenile cod, haddock and whiting in the nephrops fishery	Representative for the cod fisheries
Sardine, SWW	Low economic viability	Marine Stewardship Council (MSC)

Whereas some EU-fisheries have already taken up aspects of ecosystem based management in the form of eco-labelling (MSC certification), e.g. nephrops fisheries off the British and Irish coast and herring in the North Sea, others still have a more narrow focus on single-species management, e.g. sandeel in the North Sea. Other fisheries have chosen different strategies, which also have led to more sustainable activity. One example is the sardine purse seine fishery in Portugal and Spain. This fishery experienced very low stocks at the end of the 1990s, and as a reaction to that the EU-authorities (CEU) wanted to take action to reduce the capacity of the fleet. National authorities in Portugal and Spain then requested to be allowed to take the necessary actions themselves in order to make the fishery more sustainable. Today the fishery is co-managed by these two countries' national authorities. The Portuguese sardine purse seine fleet has recently successfully applied for the MSC (Marine Stewardship Council) certificate.

3.4.1 The sandeel fishery in the North Sea

Sandeel in the North Sea is considered to consist of several geographically distributed sub-stocks. As the fisheries off the Scottish and English coast has been more or less closed in recent years we have concentrated on the Danish and Norwegian sandeel fisheries in the North Sea.

The sandeel fishery is an industrial fishery. As can be seen from Table 3.10 both spawning stock biomass (SSB) and catches have fluctuated significantly during the last decade. This is also the case for the catch per unit effort (CPUE), measured as kg catch per kWday (the CPUE numbers in the table are not corrected for technological progress). Technological progress and reorganisations in the fishery have reduced the input in the form of kW days, and the table shows that since 2003 there has been a significant increase in the CPUE.

Table 3.10 SSB and Catches in 1000 tonnes, and CPUE in the Danish and Norwegian sandeel fishery in the North Sea

	SSB, 1000 tonnes	Catches in 1000 tonnes	CPUE (kg catch per kWday)*
2000		670	71,6151303
2001		834	69,0366667
2002	350	808	89,8080192
2003	420	304	40,1594653
2004	200	336	42,7267819
2005	190	170	46,860338
2006	190	258	65,7373461
2007	350	196	71,8381593
2008	600	335	89,1620936

Source: ICES, database and Advice 2008, Book 6
* this is based on data from Denmark only

Sandeel is important as food for predators such as fish, marine mammals and seabirds. The management objective should ensure that the stock remains high enough to provide food for predator species and prevent depletion of local aggregations, particularly in areas of predator concentration. Due to the important role of sandeel as prey for sea birds, we now assume that a bird watchers' organisation (henceforth called NGO) obtain a say in the management of sandeel and thus can suggest an incentive scheme similar to that of the authorities to be used to regulate the effort used in the fishery, and thus the harvest. We assume that the NGO only holds environmental interests towards the sandeel fishery. Using the common agency model presented above and in annex 3 the results of an additional stakeholder in the management of the sandeel fishery is given below:

Let the incentive scheme of the NGO be given by $\tau_0 + \tau E_j$, whereas $t_0 + tE_j$ is the incentive scheme of the authorities. Further, let *w* denote the optimal tax/subsidy rate when the authorities manage the sandeel fishery alone. Then, when both the NGO and the authorities have a say in the management of the sandeel fishery, the tax/subsidy rates relates to w as shown in table 3.11.

Table 3.11 Optimal tax/subsidy rates when there are two principals to have a say in the management of the sandeel fishery relative to when the fishery is managed by the authorities alone

Variable	*t**	*τ**	*t*+τ**
Relationship	$t^* < w^*$	$\tau^* > 0$	$t^*+\tau^* > w^*$

Given the assumptions made about the interests of the fishers and the authorities it is obvious that the marginal tax set by the NGO is positive, i.e. $\tau^*>0$. This means that it is optimal for the NGO to punish all effort (harvest). Given this optimal strategy of the NGO it is no longer certain that it is optimal for the authorities to set a positive incentive parameter, i.e. tax effort. The higher the environmental interests of the NGO is, λ_1^{NGO}, the more likely it is that the incentive parameter of the authorities is negative, i.e. a subsidy. The reason is of course that high environmental interests induce the NGO to set a high tax on effort, and to moderate the detrimental effect of a high tax on the effort exerted in the fishery, the authorities set a low, and possible negative (subsidy) incentive parameter, w. This is due to their economic and social interests, which result in encouraging effort and thus harvest. On the other hand, high environmental interests for the authorities unambiguously contribute to a high incentive parameter, i.e. a tax on effort.

Compared to the regulation scheme when the authorities were the sole regulator it is easy to show that $t_1{}^* + \tau^* > w^*$, i.e. that with two regulators it is more likely that there will be a tax and that the tax will be higher compared to when there is only one regulator. This means that if it is optimal for the authorities to support effort, i.e. set a subsidy, the tax rate set by the NGOs is sufficiently high to outdo this subsidy and form a tax (punishment) which is higher than the tax the authorities would set were they the sole regulator. Hence, allowing environmental NGOs, as birdwatchers' organisations, to influence the regulations of the sandeel fishery implies higher costs in the sandeel fishery compared to if the authorities regulate the fishery alone.

The higher the environmental interests are, the more the principal aims at limiting effort, i.e. tax effort, and this is true for both the principals (authorities and NGO). Thus, the environmental interests draw in the same direction. The NGO, having no economic or social interests, unambiguously welcomes all measures which aim at limiting effort and has no interest in outdoing anything (positive) the national authorities put into the aggregate incentive scheme. The NGO is somehow "trapped" in a situation where setting an incentive parameter higher than τ_1^* implies that its pay off increases in effort, but at the same time a high incentive parameter limits effort, and thus the possibility to increase the NGO's pay-off. And vice versa. Hence, the best it can do is to "secure" the pay-off by making it independent of the authorities' incentive parameter, and of the effort to the fishers.

In equilibrium the participation constraint will be fulfilled with equality, implying that the fishers will have about the same pay-off from accepting both regulations schemes as of rejecting both (and this exceeds the pay-off of accepting only one incentive scheme). It is always optimal for the fishers to accept either both or none of the incentive schemes. This is reasonable as each of the principals has set their incentive schemes as an optimal response to the scheme of the other regulator. When it comes to the transfers in the incentive schemes, t_0 and τ_0, these can not be determined unambiguously. In reality this means that the two regulators must negotiate who shall contribute how much to secure that it is in the fishers' interest to implement the regulation schemes.

The sandeel fishery is already heavily regulated. On the input side the regulations encompass mesh size, limited licensing, seasonal and area restrictions and days at sea. On the output side TAC, group TAC, individual quotas and bycatch regulations count to the measures applied. In addition economic measures such as individual transferable quotas (ITQs) are introduced, and the fishery benefits from a general fuel tax exemption which covers all fishing vessels (see table A3.1 in annex 3).

Investigations show that the abundance of sandeel affects the regional distribution of sea birds' productivity (Fredriksen et al 2003, Furness and Tasker 2000). This means that at a local scale very low abundances of sandeel does not necessarily affect the productivity of the sea birds negatively as they either move to nearby locations or partly substitute the sandeel with other prey. However, when the sandeel disappear from larger areas this substitution becomes difficult, and in turn affect the birds' productivity negatively. This indicates that area restrictions (closing areas with low abundance of sandeel) is indeed an important regulation tool, and it may be necessary to take larger areas into consideration when opening and closing fishing grounds and to ensure that the sea birds' flexibility when it comes to change between locations for seeking food.

As an example, in spite of researchers' recommendation of closure of the Norwegian sandeel fishery the last 3 years due to very low abundances, the authorities have opened for a restricted, seasonal fishery on this species. It is not clear which issues the researchers take into consideration that are different to that of the authorities. One possibility is however, that the researchers take broader considerations e.g. by including the role of sandeel as prey for sea birds, whereas the authorities only take into consideration the stock's reproductive capacity when setting the regulations. In that case, including bird watchers organisations in the management of the sandeel would probably imply more restrictions on harvest, as predicted by the model above.

3.4.2 The nephrops fisheries in North Western Waters

As for sandeel, nephrops is considered to consist of several geographically distributed sub stocks, and this understanding of the stock dynamic implies that the catch area is divided into Functional Units (FU). The area under consideration encompass the following FUs; 11-17, 19-22. Due to lack of data on SSB for some FUs, we have not been able to present SSB for the area under consideration. Time series data on annual catches and CPUE are presented in table 3.12.

Table 3.12 Catches in tonnes and CPUE

	Catches, tonnes	CPUE (kg per hour)*
1995	23,765	37,3
1996	20,252	40
1997	23,098	39,85
1998	21,830	41,03
1999	24,018	39,85
2000	21,025	37,65
2001	19,972	41,2
2002	19,060	43,78
2003	19,219	32,83
2004	18,812	34,03
2005	16,028	37,28
2006	22,761	37,36
2007	27,040	43,6
2008		44,97

Source: ICES, database and Advice 2008, Book 6
* only Irish data

Regarding nephrops, the current management does not provide adequate safeguards to ensure that local effort is sufficiently limited to avoid depletion of resources in separate FUs. The current situation allows for catches to be taken anywhere in the ICES division and this could imply excessive harvest rates from some parts. Vessels are free to move between grounds, allowing effort to develop on some grounds in a largely uncontrolled way. Management at the FU level would address this problem. A continuing problem is the capture of juvenile haddock and whiting, which are discarded at a high rate and whose populations are presently much reduced (ICES 2008). Also juvenile cod is taken as bycatch, but this bycatch has been reduced the last years (Andrews et al 2009).

Though reduced, due to the small mesh size the nephrops trawl fishery still causes relatively large bycatches of small/juvenile cod, haddock and whiting, all of which are commercially exploited stocks. In an ecosystem based management this "externality" may imply that representatives of the mentioned fisheries get a say in the management of the nephrops fishery. We assume that this is a representative of the cod fisheries. In order to be able to solve the model analytically, we assume that the income in the nephrops fishery is a proxy for the activity in this fishery that cause the negative effect on the cod fishery, and that this negative externality increases linearly in the net income of the nephrops fishery.

Let $\rho_0 + \rho E_j$ be the incentive scheme of the cod fishers, whereas $v_0 + vE$ is the incentive scheme of the authorities. Then, when the cod fishers are allowed a say in the management of the nephrops fisheries, this results in optimal tax/subsidies rates, which compared to the single management rates are as given in table 3.13.

Table 3.13 Optimal tax/subsidy rates when there are two principals to have a say in the management of the nephrops fishery relative to when the fishery is managed by the authorities alone

Variable	v^*	ρ	$v^*+\rho^*$	
Relationship	$v^*<w^*$	$\rho^* > 0$	$v^*+\rho^*>w^*$	

Clearly, the cod fisher representative will forward a positive tax rate in its' incentive scheme, which implies that it will deter effort in the nephrops fishery. This is obvious as each unit harvest in the nephrops fishery implies bycatch of juvenile cod and thus smaller cod stocks, which in turn gives lower cod catches in the future.

Also, it is clear that compared to a situation when the authorities regulate the nephrops fisheries alone, they will now, in a situation where the cod fishers have a say, reduce the tax rate or increase the subsidy rate. The reason is that if the cod fishers' representative sets a high tax in order to limit the nephrops fishery effort, and thus harvest, then the authorities partly make up for this by setting a low tax, or even a subsidy (when $v^* < 0$). However, as the net incentive scheme, i.e. the aggregate of the two tax/subsidy rates exceed the tax/subsidy rate the authorities would set solo, they reduce the tax/subsidy rate with an amount that is less than the tax rate offered by the cod fishers' representative. As a consequence the aggregate tax burden on effort in the nephrops fishery (the net incentive scheme) will increase, which in turn implies that effort, and thus harvest, will decrease, compared to a situation where the cod fishers have no say in the management of the nephrops fisheries.

This conclusion holds regardless of the relative strength of the interests to the nephrops fishers or the authorities. Also, if we assume that the nephrops fishers have lower environmental interests and higher economic and social interests than the authorities, which should not be controversial, the net incentive scheme induces a tax upon effort in the nephrops fisheries. The tax increases in the economic interests of the cod fisheries, and decreases in the environmental interests of the nephrops fisheries.

As explained in the previous section, it is not possible to determine the lump sum transfers, ν_0, ρ_0 unambiguously. The nephrops fishers will always be kept on their outside option pay-off, i.e., when regulated by economic means any eventual resource rent will be taxed away. However, which of the regulators, the authorities or the cod fishers' representative, that shall be allowed to acquire how much, is to be decided in negotiations between the two. Probably, in a situation where the authorities are the main regulator and the cod fishers' representative is given a "consultative" role, the authorities are the principal who is allowed to acquire the resource rent, whereas the cod fishers' representative will not be given any economic gain (or loss) from the participation of the regulations.

The nephrops fisheries are regulated both on the input and on the output side. On the input side are mesh size, limited licensing and days at sea, whereas the output regulations encompass TAC, individual quotas, bycatch regulations and minimum landing size (see table in appendix 4).

Various efforts have been taken to reduce the bycatch of other commercial species in the nephrops fisheries. These have led to reductions in the bycatch especially of cod. Whereas for whiting and haddock the bycatch still amounts for 40-60% of the total harvest (measured in tonnes) the bycatch of cod is reduced to below 10%. The reduction of the cod bycatch is due to much emphasis on this species, as it is the most valuable of the bycatch species. Among these efforts are closures of FUs where the bycatch of juvenile cod is especially large, larger mesh size, and a demand to use selective bycatch devices, all of which increase the costs for the nephrops fishers, and thus limit effort. This is also just what the results from the model above shows. If the cod fisheries get a say in the management of the nephrops fisheries the costs of effort, and thus harvest, will increase.

There are two types of nephrops fisheries; the trawl fisheries and the creel fisheries. Only the trawl fisheries have externalities such as bycatch of commercially exploited species. On the other hand the share of the nephrops harvest caught with creels is only about 10% of total catches (measured in tonnes). An interesting question is then how costly the effort in the trawl fisheries for nephrops have to be in order for larger shares of the nephrops to be caught by creels. The model results indicate that the more stakes other commercial fisheries get in the management of the nephrops fisheries the more expensive will the trawling for nephrops be, and this will relatively favour the creel fisheries. However, there are of course also other reasons than purely economic for the creel fishery, and which contribute to explain the existence and size of this fishery. It is not a part of this work to go in detail into this.

3.4.3 The purse seine sardine fishery in the South Western Waters

After having experienced very low stocks and very high catches during the 1990s the EU authorities suggested to take over the regulation of the sardine fishery in the waters off the Iberian peninsula (Atlantic coast and Bay of Biscay). As an alternative to this solution, Portuguese and Spanish authorities took over the management of the fishery, and though catches have decreased during the last decade, the stock has stabilised. This is shown in table 3.14.

Table 3.14 SSB and Catches in tonnes, and CPUE

	SSB, 1000? tonnes	Catches, tonnes	CPUE, catch per vessel (Portugal)	CPUE, catch per fishing day (Spain)
2000	270	85,786	351	
2001	310	101,957	372	
2002	450	99,673	385,8	
2003	458	97,831	371,5	5.84
2004	425	98,020	335,3	4.2
2005	369	97,345	301,2	4.85
2006	570	87,023	314,9	5.04
2007	525	96,469	391,6	
2008	460	92,000	448,4	

Source: ICES, database and Advice 2008, Book 6, IPIMAR (Helena Abreu)

The local/regional regulation of the sardine fishery in subareas VIIIc and IXa seems to have worked well. As the sardine fishery consists of large producer organisations both in Portugal and Spain the supply side is characterised by a monopoly situation, which they use to set minimum prices for sardines. Infrequently, it has been a problem to achieve this minimum price and then parts of the harvest is frozen for industrial processing or canning. The demand side consists mainly of domestic consumers. The limited domestic demand and problems of achieving the minimum price may explain why there is no pressure for higher quotas on the supply side, as the fishery struggles to be economically viable.

Though sardine is also a prey species, e.g. in the diet of common dolphins in Galician and Portuguese waters and other less common cetacean species, we have chosen a somewhat different approach to ecosystem based management for this species than for sandeel. The Portuguese sardine purse seine fishery has applied for, and at the end of 2009 achieved, the MSC’s (Marine Stewardship Council) certificate (ecolabel) for good environmental standard. According to the MSC their certificate has proven to secure contracts, access to new markets, potential price premiums, good reputation, improved relationships and economic stability to the certified units. Many of these characteristics are exactly what the sardine fishery units lack as of today.

It is a fact that MSC is an actor that fisheries and fishing companies to an increasing extent take into account when deciding their behaviour, including their effort. National authorities can choose not to take this into consideration when they set their regulations (incentive scheme) with regards to the fishers, or they can take it into consideration. Taking it into consideration can be interpreted as giving the MSC a say in the management of the certified fisheries, and adapt their regulations thereafter.

As a stakeholder in the sardine purse seine fisheries the MSC holds environmental and economic (and social) interests towards this fishery. The environmental interests are obvious, as the MSC primary aim is to promote sustainable fisheries. On the other hand, the fisheries which are MSC-certified pay quite large fees in two rounds for the certification process, and this is income to the MSC. Though operating as a non-profit organisation, the MSC is of course interested in the income originating from the certification process, and thus that any fishery which is a candidate for certification is profitable. Hence, one may assume that the MSC has an economic interest with regards to the fisheries they certify. It is less obvious that the MSC has social interests related to the fisheries, but for the sake of the symmetry (with the authorities) we assume that they hold this interest as well.

Then we have a situation with two symmetric principals, both aiming at individually and simultaneously regulating a specific fishery. Symmetry means that they both hold environmental as well as economic and social interests towards the fishery under consideration.

Let the incentive schemes of the two principals (authorities and the MSC) be given by $(z_0 + zE_j), (\varpi_0, \varpi E_j)$ respectively.

Then, when both principals take into consideration the existence of a second principal which also exert influence upon the effort applied in the specific fishery, their optimal tax/subsidy parameters will have the characteristics as given in table 3.15.

Table 3.15 Optimal tax/subsidy rates when there are two principals to have a say in the management of the sardine purse seine fishery relative to when the fishery is managed by the authorities alone

Variable	z^*	ω^*	$z^*+\omega^*$
Relationship	$z^* < w^*$	$\omega^S > \omega^* > 0$	$z^*+\omega^* > w^*$

where ω^S is the tax/subsidy rate the MSC would set had it not taken into consideration the authorities' regulation of the same fishery.

Table 3.15 shows that both principals moderate their tax/subsidy rate when they take into consideration that there is an additional principal regulating the fishery. However, the net incentive scheme is higher compared to what the authorities would have set were they the only principal.

When constructing their incentive schemes each of the principals "outdo" a share (less than one) of what the other principal put into her/his incentive scheme, before they make their own addition. This means that the incentive schemes are mutually dependent of each other. The two principals are now symmetric in the sense that they share all interests. The difference between the two them is their motivation to deter or promote effort. This is decided by the weights of the three interests in the principals' objective functions (the λs), and different weights imply different motivations to deter and promote effort. Each principal has to balance how much to deter and how much to promote effort in their own incentive scheme and at the same time take into account the effects on effort of the incentive scheme of the other principal. This is a trade-off between the costs of operating the incentive scheme and the pay-off the principals have from harvest (effort) from the fishery. In this trade-off both principals give and take, and they correct for differences in the weights of their interests, and thus different preferred effort levels, by taking out parts of what the other principal has put into the scheme.

The tax/subsidy rate of each principal increases in the environmental interests of the principals, and decreases in the economic and social interests. In contrast, it decreases in the environmental interests of the fishers and increases in their economic and social interests. These are reasonable results as the more environmentally concerned the fishers are the more they will restrict effort and thus harvest in order to fish sustainably, and then a high tax is not necessary to limit effort. On the other hand, when the fishers are mainly economically concerned they will have an incentive to fish a lot, i.e. apply much effort in order to increase income. Then a high tax on effort may be necessary to limit the effort, and thus harvest.

The transfers in the incentive schemes, (z_0*, ϖ_0*), can not be decided unambiguously. In contrast to the two other cases, where the "new" stakeholder to get a say in the management of the fishery under consideration was somehow "subordinate" to the authorities, the two principals in this case are symmetric, also in respect to their opportunity to "tax away" the fishers' resource rent. Hence, it is no longer obvious that the authorities are the only principal that can profit on regulating the fishery. The relatively high certification fees of the MSC show that this organisation also acquires a share of the resource rent. How the division of the resource rent between the authorities and the MSC is decided is a question for further research.

The sardine purse seine fishery is heavily regulated on the input side, encompassing regulations of mesh size, gear type, limited licensing, seasonal and area restriction and days at sea. On the other hand there are only a few output regulations, and to these count individual quotas, bycatch regulations and minimum landing size. The fishery benefit from the general fuel tax exemption, which encompass all fishing vessels.

The MSC is an organisation which to an increasing extent must be taken into consideration by fisheries around the world. It has been claimed that with increasing consumer focus on safe and sustainably harvested fish products it will in the future not be a question of whether the fish products should be ecolabelled or not, this will simply be a consumer demand (Jesper Raakjær, IFM, personal comment). Sustainable fishing activities are also the aim of the fisheries regulations in the CFP, set by EU and member state authorities. Hence, one could ask whether the MSC now does the job for the regulating authorities and that the regulations set by these authorities become superfluous? The analysis above indicates that when a new stakeholder, such as the MSC, enters the scene, the authorities will change their regulations and these will be more lenient with respect to punishing effort, and thus harvest. However, the aggregate of the regulations, including the MSC certification and authorities regulations, will imply a higher "regulation" pressure on the fisheries compared to before the organisation entered the scene. If it is right that certification will become a consumer demand directed towards all fisheries in the future then the costs of being certified (by any certifier) will come on top of other costs in the fisheries thus making effort and thus harvest more expensive.

3.4.4 Summary

One aspect of ecosystem based fisheries management is to let new stakeholders, affected by the activity of a specific fishery, get a say in the management of this fishery, in addition to the management executed by the authorities.

Applying a common agency model we have shown that introducing a second principal in the management of a specific fishery definitely changes the optimal regulations of the authorities compared to when they were the sole manager. When the new principal has interests that induces her/him to tax effort applied in the fishery, this always implies that the authorities reduce their tax rate (or increases their subsidy rate). However, the reduction in the authorities' tax rate is not as high as the tax rate introduced by the new principal, and hence the net incentive scheme (the aggregate of the two tax/subsidy rates) is higher compared to the tax/subsidy rate offered by the authorities alone.

As long as the new principal holds economic interests towards the fishery the optimal tax/subsidy rate of the authorities and the new principal are mutually dependent upon each other, which means that both principals take out a share of what the other principal puts into the tax/subsidy rate. When the new principal holds only environmental interests towards the fishery, he/she will set its optimal tax/subsidy rate independent of the tax/subsidy rate set by the authorities. The reason is that in this case the principal only has one motivation, which is to deter effort, and there is no trade-off between environmental and economic interests. As the action of the other principal, the authorities, will not change or affect the new principal's goal, he/she pursues this sole goal regardless of what the other principal does.

When the two principals cooperate, and both aim at limiting the fishers' effort, they forward a common incentive scheme to the fishers where the optimal marginal tax rate is higher the larger the weight of the new principal's objective function is in the common objective function of the two principals (given that the new principal hold stronger environmental interests than the authorities). Now the two principals maximise an (weighted) average of their objective functions. It is not possible to analytically decide how high the marginal tax rate is in this case compared to in the cases when the agents do not compete. However, the lower the weight of the new principal's objective function is in the common objective function, the more likely it is that the marginal tax rate is higher in the cases when the principals do not cooperate.

We have applied the common agency model to three case fisheries in EU waters; the sandeel fishery in the North Sea, the nephrops fishery in the Irish Sea and west of Ireland, and the purse seine sardine fishery off the Iberian peninsula (Bay of Biscay, and the Atlantic). New stakeholders in these fisheries would typically be bird watchers organisations in the sandeel case, as sandeel is an important prey for many sea birds, and representatives for the cod fisheries in the case of the nephrops fishery, as catching nephrops imply large bycatches of whiting, haddock and cod. The sardine purse seine fishery in Portugal has recently been MSC certified. For this case fishery we have asked what the consequences are for the national management if national authorities take into account the "regulating" effects the MSC certification has on the sardine fisheries behaviour.

In all cases we show that when additional principals are allowed a say in the regulations of a specific fishery the authorities react by "moderating" their original regulations. The more symmetric the two principals are when it comes to which interests they hold towards the fishery, the more mutually dependent are the optimal tax/subsidy rates the two principals set. When the new principal holds only environmental interests towards a fishery, it will set the tax/subsidy rate independent of the authorities' regulations.

4 The changing environment of fisheries policy in Europe

4.1 Background and introduction

The multitude of marine and maritime policies developed over the past decades has implications for fisheries management at both EU and national levels. The main underlying hypothesis of this report is that fisheries in EU waters are not only increasingly having to deal with other users and uses of the ocean but are also being confronted with a shift on the stage upon which marine policy is conceived. This shift consists of moving marine natural resource management away from National Fisheries ministries and DGMARE towards the environmental stage, resulting in more integration over activities and stakeholders and a more conservationist discourse. In addition, both as a strive in the revision of the CFP and as a result of implementation of marine environmental directives (such as the Bird, Habitat, Natura 2000, Water and Maritime directives) fisheries and marine ecosystem management evolves from the EU level and MS level to the regional level. A question that emerges is; what are the implications for EU and national fisheries policy from this change in management focus?

Hannesson states in his book "The Privatization of the Oceans" (2004) that "*The greatest threat to fisheries in the future may not be overfishing and depletion of fish stocks but rampant environmentalism*" (p. 178). Clearly environmental concerns for the oceans have increased over the last decades, especially exemplified by the focus on ecosystem based fisheries management. The question of interest is how does environmentalism enter into fisheries? Is it a threat that enters exogenously contrary to the fisheries interests, or rather endogenously via fisheries interests aligning to the environmentalists in some way? We suggest that the answer to this question is that environmentalism enters both in the exogenous and the endogenous fashion described above. Furthermore, the endogenous entrance of environmentalism is due to both a management and a market perspective. The former perspective is reflected in the fisheries stakeholders' vested interest in protecting ecosystems in order to maximise long term output. The market perspective is represented by the way environmental organisations make use of the changing preferences among consumers towards safe and sustainably harvested food. Hence the market promotes sustainable fisheries activity, with the most prominent example being the Marine Stewardship Council (MSC).

The exogenous way to affect the fisheries with regard to environmental concerns can be characterised as top-down and ruled by command-and-control regulations. It will often be ecologically effective but not necessarily cost effective and dynamically effective, as presented in section 2. Nontheless, it is usually politically acceptable to regulate fisheries in this manner despite potentially high implementation costs. The endogenous way to affect the fisheries with regard to environmental concerns can be characterised as bottom-up and ruled by carrot and stick. It is seldom immediately ecologically effective, but will be cost effective and dynamically effective. It is less applied and thus it is uncertain how politically acceptable it is. It is self fulfilling and often it is the agents themselves (fishers) who bear the implementation costs.

The aim of this paper is to explore the double pressure on the fisheries to take into account environmental/ecological aspect in their activity;

- through increased influence of other (environmental) policies and directives on the fisheries activity
- through environmental organisations' use of market mechanisms to promote environmental aspects

A part of the analysis will focus on the perceived 'triple role' of the ENGOs targeting authorities on national and international levels in order to influence the policies prepared and issued by these authorities as well as targeting the market through the consumers by utilising "green" preferences among consumers hence exerting pressure on the fishers directly and authorities indirectly to harvest sustainably, finally the NGOs can target the fishers directly for example by protest actions or by disputing fisheries activities in court. This is shown in figure 4.1.

Figure 4.1 also shows how international and EU environmental directives affect the CFP, but also the fisheries more directly for instance through the closing of physical areas previously open to fishing activity. It is also clear that the environmental directives through their more holistic focus on an array of activities in the oceans will affect the interaction between fisheries and other sectors operating in the seaLimitations regarding emissions from petroleum extraction or the rinsing of ballast tanks may also affect fisheries. Furthermore, national management of fisheries is affected by the more general international environmental directives. This is the case since the fulfilling of international obligations is important for relevant ministries in most countries.

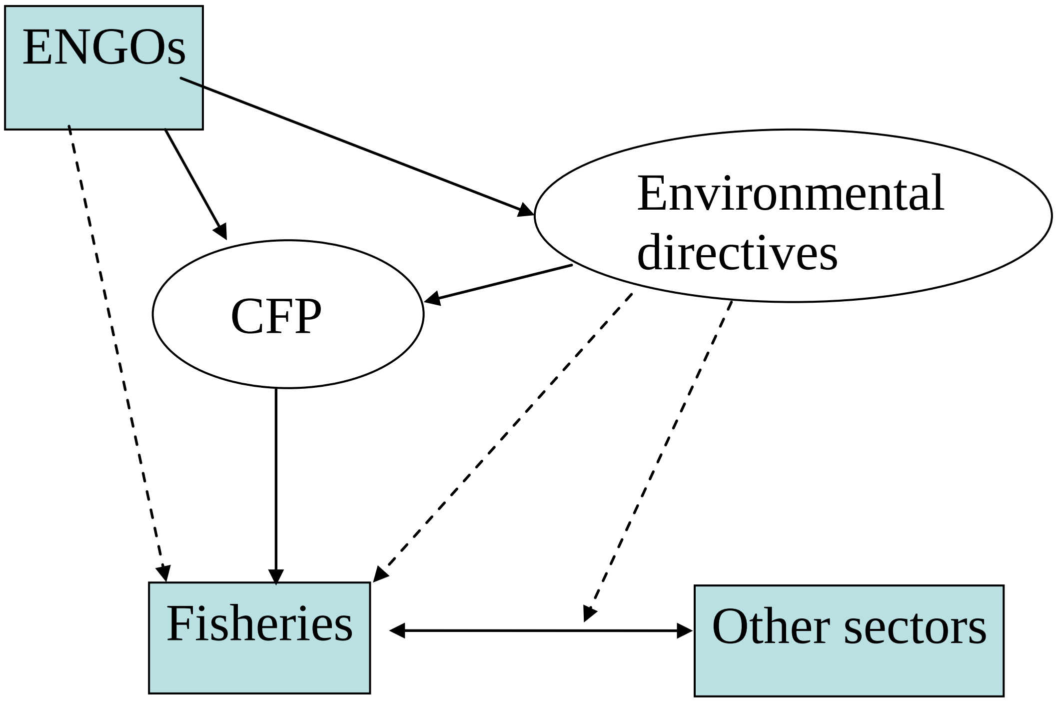


Figure 4.1. The relation between Environmental Directives and fisheries and fisheries management

In the following sections we present a brief overview of current global and EU policies governing directly or more indirectly the marine environment. How environmental issues also enter via the marketplace, as exemplified in the Marine Stewardship Council ecolabel, is presented in section three. In the final section we will analyse how this plethora of policies interact and what the perceived consequences are for fisheries management.

4.2 EU Marine policies and the management of fisheries

The institutional framework for the protection of Europe's seas and oceans has become highly developed over the last 35 years, including milestones like the 1972 and 1974 Oslo and Paris

Conventions (merged in 1992 into the OSPAR Convention on the Protection of the Marine Environment of the North-East Atlantic), the United Nations Convention on the Law of the Seas (UNCLOS), the 1992 Rio Agenda 21, the regional conventions for the protection of the Baltic Sea (HELCOM), the Black Sea, and the Mediterranean, and the Johannesburg Plan of Implementation (JPOI) of 2002. In addition, several international and EU initiatives focus on land-based sources of pollution with an impact on the marine environment such as the IPPC Directive and the REACH initiative. Extensive environmental requirements for shipping developed under the auspices of the International Maritime Organization (IMO), and the work under the Climate Change Convention is another important element (Kroepelien 2007).

Table 4.1 briefly describes the objectives of a number of directives and relevant marine/maritime policy documents, and their relevance for fisheries management.

Table 4.1 Policies and directives affecting the CFP and fisheries' activity

Directives and overarching policy	**Objective**	**Relevance for fisheries management**
Birds Directive (79/409/EEC)	Protect all European wild birds and their habitats	Bans activities that directly threaten birds. Designation of special protection areas (SPAs), possibly curtailing or prohibiting fishing
Habitat Directive (92/43/EEC) and Natura 2000 network	Ensure bio-diversity through the conservation of natural habitats and of wild fauna and flora	May prohibit some types of fishing activities in special areas of conservation (SACs)
Water Framework Directive (2000)	Establish framework for conservation and "good water status" of inland surface waters, transitional waters, coastal waters and groundwater.	May prohibit some types of fishing activities in the coastal zone, as "good water status" can be defined in terms of abundance of certain (fish) species
OSPAR	Implementation of ecosystems approach and sustainable management of the marine environment	Implements area closures especially in international waters
World Summit on Sustainable Development (2002)	Sets agenda for ecosystem based management and a representative network of MPAs established by 2012. Stocks should be at MSY levels by 2015.	Puts pressure on national and supranational fisheries management for the achievement of goals. In addition redefines the CFP reference points from the precautionary approach to setting fishing mortality at the lower F_{MSY} levels
Marine Strategy Framework Directive (MSFD)	Achieve "good environmental status" (GES) in EU oceans, through ecologically diverse, clean, healthy and productive oceans	The aim of a network of marine protected areas may have effects upon fisheries activities. In addition defining GES may well include indicators on specific (fish) species and impact on benthic habitats
Maritime Policy (MP)	Comprehensive integrated strategy for marine research, maritime surveillance, spatial planning and IUU fishing	Fishing is one of several sectors under scrutiny. Although fisheries are perceived as just one of the stakeholders it is seen as the activity with the highest impact on the marine ecosystem. The MP seeks to balance

		ecological and economic concerns over and across activities.

Natura 2000, the ecological network of protected areas in the territory of the European Union, unites the Birds Directive, which requires the establishment of Special Protection Areas for birds, and the Habitats Directive which similarly requires Special Areas of Conservation to be designated for other species, and for habitats. Although not primarily focused on the marine environment, Natura 2000 areas are found in the coastal zone. By taking a river basin approach Natura 2000 takes a spatial oriented focus and with its regional signature it emulates an international stage.

Closely related to the Natura 2000 areas is the MSFD. The main objective of the Marine Strategy Directive is to achieve environmentally healthy marine waters by 2021. This will be achieved by establishing marine regions and sub-regions, which will be managed by member states in an integrated manner based on environmental criteria. In drawing up marine strategies for the waters within each marine region, member states will be required to cooperate closely. As such, like Natura 2000, the MSFD has a regional and international stance. Natura 2000 and MSFD are both environmental directives, i.e. the Environmental DG is responsible, rather than DG Mare.

The Maritime Policy is clearly the new centre piece in marine and maritime management, encompassing the CFP fisheries management and the ecological MSFD. The MSFD has a clear environmental focus, while the MP is more encompassing and stresses the need for economic development as well as sustainability (Commission of the European Communities, 2007). The MSFD and MP can be seen both as a two pillar system (Mee *et al.*, 2007) and as two contrasting frameworks for Integrated Marine Management (Sissenwine and Symes, 2007). It concerns on the one hand a policy designed to maximise the economic benefits from the rational use of the marine environment and, on the other hand, legislation designed to conserve the flow of economic goods and services from marine ecosystems whilst maintaining their resilience and biodiversity (van Hoof and van Tatenhove, 2009a).

The above mentioned policies and direcitves are examples of the current environmental concern in international and European politics, as well as the increasing pressure from environmental interests on the fisheries' activity.

In the past decade, the European Commission has developed a suite of policies directly or indirectly affecting the governance of the sea and that of fisheries management. This has implied that the primacy of the CFP to regulate marine natural resource management is being challenged.

1) On one side with the establishment of the Natura 2000 agenda of bird and habitat directive and the establishment of the Marine Strategy Framework Directive (MSFD), marine environmental policies are being shaped outside the CFP.
2) On the other hand with the establishment of Regional Advisory Councils (RACs) and the Maritime Policy the arena for marine resource management is opened up to be more participatory and also opening up to more stakes and stakeholders.
3) Furthermore, the fisheries sector has become increasingly interested in securing that the management of their activity is sustainable, for instance in order to obtain MSC certification. Hence pressures from MSC, via the fisheries agents themselves are affecting national, regional and EU management strategies.

4) Also increasingly European Fisheries Policy is being determined outside the EU stage; for example the Johannesburg Summit on Sustainable Development, setting harvest levels at MSY (van Hoof and van Tatenhove, 2009b), and OSPAR and others encouraging the introduction of marine protected areas.

From a fisher's perspective these policies present a change in institutional setting; major policy measures no longer descend from the EU Common Fisheries Policy alone, but increasingly are derived from general environmental policy developments. In addition to a difference of emphasis on either ecological or economic aspects, from the perspective of policy arrangements, the rather novel integrative and participatory policy arrangement of the MP can be found next to the more classical neo-corporatist arrangement and inter-governmental structure of the CFP and under the same umbrella the etatist arrangement of the MSFD. Resolving the problem of mixed competences, and particularly the Commission's exclusive competence in matters relating to fisheries, and the question of primacy between the CFP and environmental Directives, will be crucial to ensuring the efficient and effective implementation of either strategy (Sissenwine and Symes, 2007).

The challenge put to the MP lies in its attempt to integrate over sectors and policies, with differing sets of stakes and stakeholders, with diverse sets of policy resources and discourses. For example, whereas in shipping, arrangements are made at an international level, in which individual member states are involved, the CFP is the exclusive competence of the EU (Commission) and implementation of the MSFD is devolved to the Member states. With the 2002 CFP reform the formerly rather enclosed stage of policy making in fisheries management between fishers, government and the EU was opened up to a more open and participative governance structure by the establishment of RACs. New stakes and stakeholders are also forced in through increased attention for environmental aspects such as through the MSFD. In this respect it is also noteworthy to focus on the fact that by establishing an MSFD, a directive with a sole environmental objective, it provides tools to some stakeholders to take control over the debate with the aid of the legal system: the directive will stipulate rules and regulations to which all have to adhere. It can be queried which policy will be leading when it comes to weighing environmental impact of fisheries versus the social and economic effects of fisheries on local communities (van Hoof and van Tatenhove, 2009a).

The CFP is placed on a new stage, away from the national neo-corporatist setting. Where in the past organised sectoral interest of fishermen could be brought to bear in the international discourse through the national corporatist structure, in the new era the CFP is embedded in a suite of other policies which implies negotiations increasingly shifting to the supra-national stage with different policy objectives (integration, environmental status) and different stakeholders (from DG FISH to DG MARE and DG ENV, from fishers to oil and gas extraction, shipping and environmental concerns). In addition market based influences, such as MSC and other ecolabelling and traceability requirements are shaping management and policy. Hence fisheries policy making is facing a general shift in stage from the national structures to the European and regional level, and a loss of competences with the introduction of other marine environmental policies. This breaking open of the fisheries arrangement is intensified by the already ongoing development of increased influence of spatial planning and environmental policy on fisheries policy. All these developments influence the CFP and raise the question whether there is still a niche for a specific policy aimed at managing fisheries.

4.3 The market, ecolabelling and fisheries management

The Marine Stewardship Council (MSC), initiated by World Wildlife Fund (WWF) and Unilever in 1999, has since its humble beginnings experienced a dramatic increase in interest. As shown in Figure 4.2, in the ten years of the MSC certification, the number of certified fisheries has reached 40, covering a total of almost 250.000 tons of harvested seafood, with a large part of this being fished in EU waters.

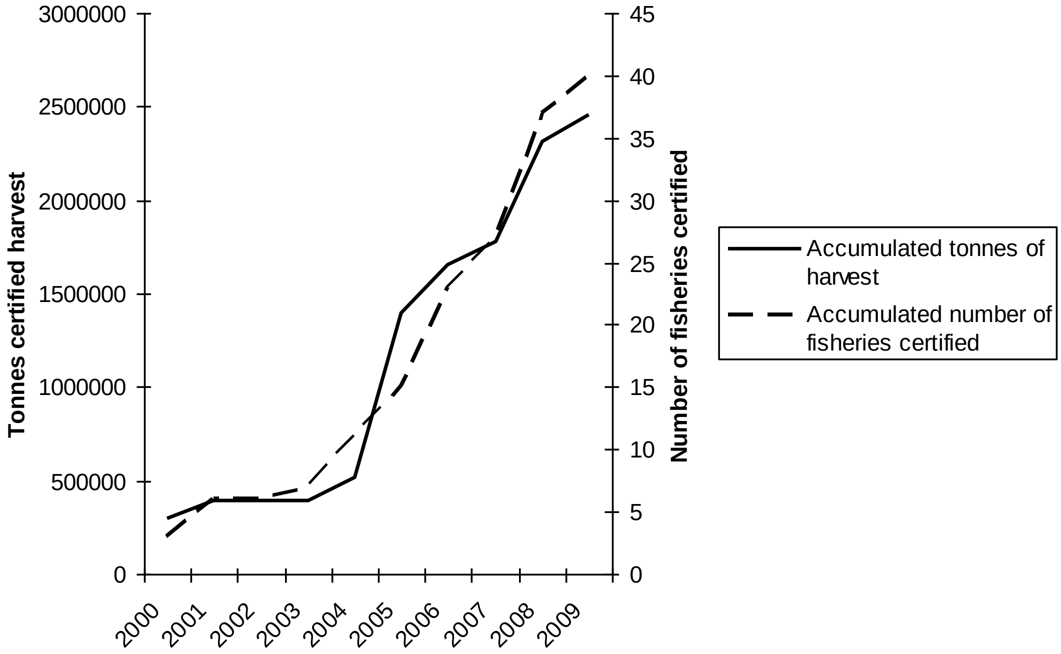


Figure 4.2 Development in number of fisheries certified in MSC, and tonnes of harvested of fish within the program.

The process of MSC certification is carried out initially by application for a specific fishery. The application is most often made by stakeholders; fisher organisations, producer organisations and the like, though ENGOs and local governments have also shared in the costs of certification. National managers have also been involved in paving the way for application through the implementation of management measures and recovery plans.

At the centre of the MSC is a set of *Principles and Criteria for Sustainable Fishing* which are used as a standard in a third party, independent and voluntary certification programme. These were developed by means of an extensive, international consultative process through which the views of stakeholders in fisheries were gathered. These Principles reflect a recognition that a sustainable fishery should be based upon:

- The maintenance and re-establishment of healthy populations of targeted species;
- The maintenance of the integrity of ecosystems;
- The development and maintenance of effective fisheries management systems, taking into account all relevant biological, technological, economic, social, environmental and commercial aspects; and
- Compliance with relevant local and national local laws and standards and international understandings and agreements

Purvis (2009) lists a vast array of advantages that certified fisher interests claim that the MSC certification has given their fishery; market access, price premium, reduced import tariffs, political influence, improved fisheries management and a raised profile. In some cases the social and political benefits are deemed to exceed the commercial gains. The introduction of the MSC certification raises a whole set of interesting perspectives, of which we will briefly discuss a few below.

As even more fisheries become certified, many of the advantages listed above, which typically can be described as ‘first mover’ advantages to the early MSC certified fisheries, can be expected to vanish. Over time we may end up in a situation where all serious fisheries must be certified in order to be able to sell their products (globally). This leads to another issue, namely the question of how this new management option affects management costs. As it is, the fisheries (companies and/or organisations) bear the costs of certification and of remaining certified. This implies that large parts of the management costs have been internalised, as they are now carried by the producers, and eventually transferred to the consumers by an increase in final price. If there are no significant increases in consumer prices the costs of being certified as a sustainable producer may have been covered by the potential creation of resource rent. Thus the certification can be seen as a way of confiscating parts of the resource rent, as a resource tax would also do. Whether the actual management costs are reduced or not is another question, but that parts of the costs of management are transferred from fisheries authorities to the fisheries agents (and thereby directly transferred to consumers, rather than indirectly over their taxes) may be expected.

Contrary to the directives presented in the previous section, certification (ecolabelling) represents a voluntary action for the fisheries. They can choose whether to be certified, and when certified it is in their own interest to keep to sustainable fishing practices. This shifts some of the management authority control from the state to the market, as compared to what is the case for the use of directives to affect the fisheries’ behaviour. This may be a cheaper way to achieve sustainable fisheries practices, and one can query whether market initiatives, such as ecolabelling, may reduce the need for the introduction of directives etc. in order to secure sustainable fisheries. Is there a trade-off between the two, or do they complement each other, such that both are necessary and operate best side by side?

4.4 A changing theatre

Across all the policy and market initiatives described above we see tendencies of an increase in integration, participation and regionalisation (van Hoof and van Tatenhove, 2009b). Integration in both the sense of integration over activities and sectors as well as in an integrated holistic view on the marine (eco)system. Participatory in the sense that representatives of the activities and sectors are obtaining formal positions in the policy cycle, as well as entering at many levels. Although it can be argued that in the current set up the RACs, with no formal decisive power within the institution and the fact that advice rendered does not necessarily become incorporated in the further policy making process, the establishment of the institution is a clear incorporation and formalisation of participation in the policy process. Regionalisation in the sense that explicitly in the Natura 2000 and MSFD a regional spatial approach has been chosen. But also that in the implementation of RACs it is clearly indicated that cooperation between states is required. And again, also the establishment of the RACs emulates a regional focus be it spatial (North Sea, Baltic, Mediterranean, North and South West waters) or on activity (Pelagic and Distant Waters RAC).

EU Fisheries management, in which the Commission has exclusive competence and the MS implement policies an the national level is a clear example of multi-level governance (MLG).

In general, MLG concerns the sharing of policy making competencies in a system of negotiation between nested governmental institutions at several level (supranational, national, regional and local) on the one hand, and private actors (i.e. ENGOs, producers, consumers, citizens, scientists) on the other (van Tatenhove, 2003). The concept of MLG in the European Union has largely been developed in response to dominant state-centred approaches. Adherents of a state-centred perspective in the EU tend to consider national governments as the key actors in the EU system, devolving only limited authority to supranational institutions to achieve specific goals. This is reminiscent of realist conceptions of international relations, focusing on the interaction between unitary state actors. National governments in this view are located in domestic political arenas, and their negotiating positions are influenced by domestic political interests (cf. Moravcsik, 1993. In the MLG perspective, in contrast, national governments no longer prevail in European policy making Hooghe and Marks, 2001;Jordan, 2001;Jachtenfuchs, 2001). European institutions like the European Commission, the Parliament and --more indirectly- - the Court of Justice each play a role on their own, and sub-national as well as private actors operate in both national and supranational arenas. In short, different types of actors at different levels share decision-making competencies.

Each of supranational and transnational arenas within the EU (van Tatenhove, 2003; van Tatenhove *et al.*, 2006) has its own characteristics in terms of participants, policy arrangements and procedures. In the inter-governmental and supra-national arenas, the role of codified institutions such as national governments and EU institutions is dominant. Member States play a prominent role in the European Council and the Council of Ministers. The supra-national arena, consisting of the European Commission (EC), the European Parliament (EP) and the European Court of Justice (EJC), gained more influence on collective decision-making, involving a significant loss of control for individual national governments Hooghe and Marks, 2001. These institutions are codified arrangements that provide the official setting of EU politics, such as: the institutionalised interrelations between European institutions and national governments and formal decision making procedures.

The transnational arena consists of a diversity of formal and informal institutions and organisations. Examples of formal institutions in the transnational arena are the diversity of committees and European Agencies. With the institutional reforms of the last decades, there was a growing need for co-operation between the sub-national, national and supra-national levels, especially concerning the implementation of EU policies. The institutionalisation of a diversity of committee structures in all stages of the policy process gave in to the need to establish fora in which policy ideas could be deliberated upon, policy proposals could be discussed, and policy implementation could be monitored (van Tatenhove *et al.*, 2006). These committees differ with respect to membership (Member State and EU representatives, non-state actors), with respect to their formal position and with respect to their competences.

In this respect it is noteworthy that the RACs introduced a new political level in EU fisheries management which meant there was, for the first time, a close one-to-one match between a level of management in the governance system and a biological, ecological scale in the natural system (Hegland *et al.*, 2009). The RACs create interaction between environmental and fisheries stakeholders in a setting that encourages consensus in the end product; namely policy advice. Hence this repeated learning process creates for the fisheries interests a more endogenous entrance of environmental regulation; i.e. the environmental concerns become integrated into the fisheries interests. This approach may be less threatening to fisheries interests than the more exogenously implemented environmental directives.

The push for MSC certification in specific fisheries also influences the fisheries stakeholders, and their interactions with national fisheries managers. These two approaches for inclusion of environmental concerns in fisheries may secure greater legitimacy and acceptance amongst fisheries interests with regards to regulations implemented.

The role of the ENGOs is of special interest. The ENGO community is a heterogenous community, reflected by the way they work in order to achieve marine environmental objectives. However, by focussing upon some types of fishing activities as having the most damaging effect upon the marine environment, these groups directly affect behaviour of the fisheries sector. Some ENGOs work solely at the level of policy makers, exerting pressure upon authorities in their formulation of directives, rules and regulations affecting the environment. These ENGOs have typically chosen an exogenous way in their effort to try to influence the fisheries environmentally. Other ENGOs utilise “green” preferences among consumers, expressed in a willingness to pay for sustainably harvested food and safe food, and organise campaigns directed towards consumers in order to induce them to boycott fish from for instance unsustainable fisheries. An alternative is that they offer fisheries, that fulfil conditions for sustainable harvesting, a certificate which is reliable in the market and thus secure higher prices and/or larger markets. The most prominent example here is the MSC. These are examples of how to affect the fisheries environmentally in an endogenous way.

Previously, in section 3, we identified three interests that stakeholder groups such as EU-authorities, national authorities, ENGOs and the fishers hold towards the fishery activity. These interests are;

- environmental (ecosystem health, healthy fish stocks, sufficiently large stocks)
- economic (profitability, efficiency, rent extraction)
- social (employment, community development)

Further, we assumed that each of these interest groups has an objective function or goal consisting of a weighted combination of the three interests, and where the weights typically will vary between the groups. We formulated such an objective function as follows:

$$U^g = \lambda_1{}^g ENV + \lambda_2{}^g ECO + \lambda_3{}^g SOC \qquad g = EU, MS, F, NGO \tag{1}$$

where U^g is the utility (well-being) of interest group g, ENV is the environmental interest, ECO is the economic interest, and SOC is the socio-economic interest. Assuming that $\forall g, \lambda_1{}^g + \lambda_2{}^g + \lambda_3{}^g = 1$, the parameters $\lambda_1{}^g$, $\lambda_2{}^g$, and $\lambda_3{}^g$ can be interpreted as the relative weight interest group *g* attaches to the environmental interests, to economic interests, and to social interests respectively.

Obviously, these interests and their relative weight do not only vary across different stakeholder groups, for one and the same stakeholder they probably also change over time.

One way to interpret such changes over time, at least for stakeholder groups as authorities and NGOs, is to observe which measures they take or use towards the fisheries in order to affect the fishers’ behaviour. In section 3 we presented the different measures most commonly applied in the CFP and by national authorities, and in section 4 we transformed all measures into economic terms, representing either a tax, which makes the use of effort more expensive and thus deters effort, or a subsidy, which makes effort cheaper and thus promotes the use of effort.

Another way of affecting the fishers' behaviour, although more indirectly, is by introducing directives. These may affect different aspects of the fishers' activity, such as safety, environmental concern and the choice of gear type. Above, we have concentrated on directives relating to environmental aspects which affect the fisheries' activity. The fact that authorities at different levels implement these treaties and directives can be seen as a signal, at least from the perspective of the fishers, that the authorities have increased the weight of their environmental interests in their objective function. At the same time fishers, more or less voluntarily, go into "environmental" agreements, which make their behaviour more environmentally friendly. This can be seen as if the fishers have increased the weight of the environmental interests in *their* objective function.

In table 4.2 we have systemised the treaties, directives and initiatives presented in this section, and indicated whose interests (and which interests) the adoption of these treaties, directives and initiatives may have changed

Table 4.2 Treaties, directives and initiatives systemised according to whose and which interests they affect

Interests **Interest groups**	**Environmental**	**Economic**	**Social**
EU-authorities	Bird, Water and Habitat directives, MSFD	Maritime Policy, RACs	Maritime Policy
National authorities	OSPAR, World Summit on sustainable dev		
ENGO	RACs, ecolabel	ecolabel	
Fishers	ecolabel, RACs	ecolabel, RACs	RACs

Some initiatives, such as the establishment of the RACs, will have effects up on all three interests. This is at least the case for the fishers, as this initiative, enabling different stakeholder groups at a regional level to meet, may give them opportunities to reach agreements which are both environmentally, economically and socially preferable to the existing solutions. The existing solutions are often determined at super-national levels and without participation by the actors that must adhere to or even implement them, and may as such have less legitimacy. Thus, establishing RACs may also have been an effort in trying to find solutions to the fisheries regulations that first and foremost are economically superior, both for the industrial actors and for the managers (EU-authorities). For this reason we have indicated that the establishment of RACs can mainly be seen as a strengthening of the EU-authorities economic interests towards the fisheries' activity.

Although the main motivation of the MSC to introduce the ecolabel was to promote sustainable fishing practices, the MSC on their home page now point to the good economic effects their ecolabel have had for the certified fisheries. Hence, applying for the MSC ecolabel is a signal from the fisheries not only of increased environmental interests, but also of increased economic interests. And there is always the possibility that it is the economic interests which are the main motivation for applying for certification. Also for the ENGOs offering such certification e.g. the MSC, one can not ignore the possibility that economic interests become an increasing motivation.

On a global level the initiatives relevant for the fisheries are mostly of an environmental character and mainly have as their aim to affect environmental aspects of the fisheries. International treaties and organisations, such as OSPAR, HELCOM, and the World summit on sustainable Development are implemented by national authorities, and the more eager the authorities are to implement such treaties, with mainly environmental perspectives, the higher will probably the weight of the environmental interests of the national authorities be perceived to be by the fishers.

On the EU-level, the Bird, habitat and Water Directives, are typical examples of initiatives which aim at increasing the environmental standard within their respective field, and thus must be interpreted as an increase in the weight of the environmental interests of the stakeholders. Also the MSFD has typically an environmental perspective, whereas the Maritime Policy Directive to a larger degree aims at coordinating the commercial users of the EU seas, and thereby secure the optimal economic use of a limited resource; the EU seas. This is the reason why we have placed the Maritime Policy Directive under economic interests, and not under environmental interests.

4.5 Conclusion

So, what are the implications for EU and national fisheries policy from a change in management focus from the exploitation of marine natural resources to a larger environmental context?

First, we have to take into consideration that this takes place at two levels; denoted exogenous and endogenous in section 4.1. International treaties, directives and initiatives formulated outside of a fishery context, and thus exogenous to the industry, have to an increasing degree implications for the fisheries’ activity. On the other hand, the fisheries also to an increasing degree actively seek new solutions to the environmental challenges, i.e. their adjustment to the environmental challenges is endogenous (decided by themselves). The question to what degree these two approaches to finding solutions to environmental challenges for the fishery sector are compatible remains to be discussed.

Second, there is the division between policy and market. Environmental concern becomes profitable. Issues such as ecolabelling and traceability are proof of that. Then the question emerges, to what degree can the solutions found through the market substitute parts of the legal (command-and-control) management regime? This is also a question which remains to be discussed.

Third, there is the geographic dimension to this discussion. Whereas many of the treaties, directives and initiatives come from super-national levels, such as the UN and the EU, there is the tendency towards a regionalisation of the fisheries management, exemplified by the establishment of the RACs within the CFP. This is the topic of WP4.

Annex 1: Questionnaire for expert opinion amongst MEFEPO partners

We wish to give an assessment of the different tools applied in fisheries management. We would like to get your assessment in order to set up an expert opinion regarding these tools. The management tools we study and their aims are set up in Figure 1 below. The aims are focussed within the tradition of single species management, though we also include bycatch issues related to other commercial species. Habitat issues are not included

Table 1 Tools and their intended aim.

Tool	Aim
Mesh size	Limit the catch of undersize fish
Gear type	Limit catch or type of catch
Limited licensing	Limit catch, or number or vessels
Engine size	Limit catch
Seasonal restriction	Limit catch or type of catch
Days at sea (individual)	Limit catch
Area restriction	Limit catch or impact other species/age groups
Bycatch devices	Limit catch of non-target species/size
TAC	Limit total catch
Group TAC	Limit or secure catch of certain vessel group
Individual quotas	Control of harvest and improve economic performance
Bycatch regulations	Limit catch of non-target species/size
Minimum landing size	Limit catch of undersize fish
Subsidies	Encourage certain behaviour
Taxes/fees	Discourage or reduce certain behaviour. Reduce catch
Individual transferrable effort	Secure efficient effort allocation
Individual transferrable quotas	Secure efficient quota allocation

In order to assess these tools, we use the following criteria, which are often used to assess measures applied to reach goals within the management of environmental and natural resources:

e) politically acceptability
f) cost effectiveness
g) ecological effectiveness
h) dynamical effectiveness

Political acceptability will often vary both geographically and between different interest groups. We are however interested in the political acceptance of the *decision makers* (e.g. bureaucrats or politicians) in fisheries management in your country. The prevalence of a measure does to some degree indicate the acceptance, though lack of presence does not necessarily imply lack of political acceptance[14]. Clearly over time political acceptability of tools may change and we are interested in the *current* political acceptability in your country.

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[14] Even though the implementation of a policy may be controversial among some stakeholder groups, the fact that it is implemented implies that it is politically acceptable. Furthermore, some of the tools presented may not have been implemented, not due to lack of political acceptance, but rather because they are either incompatible with existing measures, or are superfluous.

I.e. do you believe that the management tool is politically acceptable for your fisheries management decision makers today?

Cost effectiveness is secured in two possible ways; 1) when there is an aim of improving the economic performance of a given fishing fleet, and some improvement may be expected to take place and/or 2) when the aim of the management tool is to conduct the fishery as whole in the most cost effective way. In the first case, limiting the number of vessel, for instance using limited licences may improve the economic performance of a vessel group, at least in the short run. In the second case, an individual transferable quota regime aims at securing that a limited quota is harvested by those that are willing to pay the highest price for the rights. The most efficient agents are willing to pay the most, and hence the most cost effective harvesting takes place.

Ecological effectiveness is characterised by the measure reaching some ecological goal, for instance securing the stock size at some level, or ensuring that only fish over a certain size is caught.

Dynamic effectiveness is the securing of the *ecological* goal over time. I.e. can the management tool be expected to sustain its ecological aim over time? Note that a tool may not be ecologically effective instantaneously, but may be so in the long run. In this case it is not ecologically effective but dynamically effective. There may also be examples of vice versa.

The symbols used for the four assessment criteria are as follows;
Politically acceptable △
Cost effective □
Ecologically effective ○
Dynamically effective ⬭

We measure the four assessment criteria of the tools according to a "traffic-light" method:
Red: no
Orange: may be
Green: yes
White: irrelevant

A red circle indicates *no* ecological effectiveness, an orange circle indicates that there *may be* ecological effectiveness in some form, a green circle implies that the ecological goal of the tool *is* reached, while a white circle states that ecological aims are *irrelevant* for the tool in question.

In Table 2 we have measured the expected outcomes of the four assessment criteria for each tool[15]. The assessments of the expected outcome of the management tools in table 1 are made based on the intended effect or aim of the tools[16], and are (we think) logic combinations of the description of the intended effect and the definition of the efficiency/acceptability criteria.

Intended effect and theoretic assessment of management tools may not coincide with the *actual* effects of the applied tools. One reason for this, especially relevant within the CFP, is

[15] A closer description of our thinking as regards the choices of the traffic lights chosen as the "Expected outcomes" for the four criteria for the different tools is attached in the separate Appendix.
[16] One exception is the political acceptance. The expected outcome here is mainly based on the EFEP study of stakeholder opinions and prevalence of a number of different management tools.

that a series of tools are applied simultaneously. Another reason is that the tools may depend on additional controls or monitoring that is not sufficiently present or possible. This makes it necessary to discuss actual (empirical) outcomes of the application of the management tools. We will do this by using your expert opinion. Hence the actual assessment of the tools will be based on the experiences from EU fisheries amongst our MEFEPO members.

If you *disagree* with whether the aim and actual functioning of the tools are the same as the intended effects regarding our four measures of assessment (political acceptability, cost, ecological and dynamic effectiveness) in your country, please indicate this by filling in your opinion in the relevant criteria boxes under **Expert opinion** in the table below.

For instance;

- write R for red in the Ecol box if your opinion is that the tool is *not* ecologically effective in your country.
- write O for orange in the Ecol box if your opinion is that the tool *may be* ecologically effective in come instances in your country.
- write G for green in the Ecol box if your opinion is that the tool *is* ecologically effective in your country.
- write W for white in the Ecol box if your opinion is that ecologically effectiveness is irrelevant for this tool in your country.

For instance, if you feel that mesh size limits are not politically acceptable in your country, you put an R under Pol in the table below. If you find no reason for assuming that the expected outcomes are different to the actual in your country, leave the boxes unchanged. If you would like to comment on your choices, please write in the comment box on the side. Any other comments to the text are also gratefully received.

Annex 2 Game Theory – a short introduction with relevance for the work in this report

Game theory is an analytical tool to systematically analyse strategic actions between agents. It can be divided into cooperative and non-cooperative game theory. The former is characterised by the ability to meet binding agreements, i.e. there exist an authority with the power to enforce the agreement, whereas the latter is characterised by the absence of such a power. Hence, in non-cooperative game theory all agreements must be self-enforcing, which means that it must be in the agents own interest to fulfil the agreement. Any agreement between these agents has to be self-enforcing as none of them has the authority to enforce any regulation upon the other. Hence, the interactions between the fisheries interests and the ENGOs and also the one between the EU authorities and the national authorities may most properly be analysed by non-cooperative game theory. On the other hand, the interactions between fishers and authorities on different levels can just as well be analysed by the use of cooperative game theory. However, as the models applied by the two divisions of game theory vary significantly, we have chosen the non cooperative approach. Another reason for this is the argument that self-enforcing agreements may be easier to implement, and have a higher degree of acceptability.

In game theory one takes into consideration that the action of one group affects the preferred action of other groups, and this affects the preferred (equilibrium) actions of all groups. This is also denoted *strategic actions*. The game theoretical analyses within economics aim at defining the optimal action, also called best reply, to take for one agent (or group of agents) given the actions of all other agents, and this is done for all agents. This set of mutually optimal actions are characterised by the fact that if no agent change their action, it is in no other agent's interest to change her/his action, which is the definition of equilibrium. When there is full information between the agents, this is called Nash equilibrium, and with asymmetric information it is called Bayesian-Nash equilibrium.

In economic game theory all negotiations and trade-offs between agents are explicitly modelled. On the one hand this limits the analysis models with regard to how many and which aspects of human interactions they can handle. On the other hand it makes the models very concrete and explicit, and the relationship between one specific action taken by one agent to the reaction of another agent takes the form of a logic (and rational) procedure.

Empirically there are several examples showing that independent actions often result in sub-optimal (Nash) equilibria for transnational public goods and externalities. Hence, to foster cooperation, the international community has devised institutions (Arce and Sandler 2001). Sometimes these have evolved as a result of common interest of all actors. They then typically are stated as standards or conventions. In other respects more or less enforceable treaties have been met. This is especially the case within environmental and security matters. Understanding the relationship between the introduction of a regulation, e.g. in the fisheries, and eventual changes in the fishers' behaviour implies an ability to predict the action of specific stakeholders or groups of agents given a change in the action by another stakeholder group or group of agents. Economic game theory provides the analytical tools for that end.

Adaptive management and stakeholder participation imply that the stakeholders and agent groups at the political level takes into account the interests of the different stakeholders and agent groups at the societal and industrial level when developing regulatory measures. The development of effective regulations, e.g. in the form of incentive schemes, can be studied by the use of so-called principal-agents models, which is a sub-group of non-cooperative game theoretic models. Principal-agent models analyses how one principal (regulator) should compose regulations or incentives in order to induce one agent to behave as the regulator wants her/him to behave without using direct enforcing power and to the lowest possible costs to the principal (regulator). Principal-agent models can be extended to models of so-called common agency, where several (normally two) principals try to regulate one (group of) agent.

In a Commission Working Document on reflections on further reform of the Common Fisheries policy (CFP) the problems of the present incentive structure is addressed. It is underlined that “industry incentives need to be turned around from the present set-up.” (p 8). There is a large economic literature on incentive systems. Some of it addresses the problems of “the multiprincipal” nature of government (see e.g. Martimort 1996). This is especially relevant for the EU as a union of independent states because it implies that there are different authority levels which regulate one and the same agent. Translated into a game theoretic language this means that two or more principals try to regulate one single agent. When these principals have competing interests when pursuing the regulation their optimal incentive scheme will be inefficient in the sense that the agent will under-provide the good regulated, i.e. a sustainable use of marine resources (which means that they will harvest more than what would otherwise be optimal). This result is in general valid when the principals are symmetric, and it works even stronger when there is a hierarchy of principals, as in the EU-system. Assuming a Stackelberg game between principals, e.g. with the EU Commission as the Stackelberg leader and national or regional authorities as the follower, it can be shown that the inefficiency of the regulation schemes (incentive schemes) are even larger compared to under symmetric principals (Martimort 1996). In a static setting it can be shown that it is always profitable for the principals to coordinate their actions towards the agent (Dewatripont and Maskin 1990, Dewatripont and Tirole 1992). On the other hand, if we take into consideration the dynamic aspects of regulation, i.e. that the regulated units (agents) repeatedly has to decide how to adjust to the regulator (principal) this conclusion may change. Then there is a trade off between the static inefficiency of a decentralised agency and dynamic gains in the form of reduced information rent to the agent due to many principals (Olsen and Torsvik 1995).

Though of interest, we will in this work keep to a static analysis and not take into consideration the effects of regulations in the form of incentive schemes over time. This might be a topic for future research.

Annex 3 The principal-agent and common agency models

A3.1 The basic model

We look at one specific fishery. Let the short run production function relating the catch in member state *j*, G_j, to the stock of the main targeted species of that fishery, *x*, and effort, E_j be given by $G_j = G_{ij}(x, E_j)$. We look at one specific fishery, encompassing all fishers in member state j participating in that fishery, and in the following presentation we suppress the subscript denoting the fishery, i. However, as one and the same fishery may be executed in many member states we keep the subscript j. Summing over j then gives aggregated harvest of the fishery for all member states participating in that particular fishery.

We assume the short run production function to have the following properties; $\frac{\partial G_j}{\partial E_j} > 0$, $\frac{\partial^2 G_j}{\partial {E_j}^2} \leq 0$, and $\frac{\partial G_j}{\partial x} > 0$, $\frac{\partial^2 G_j}{\partial x^2} \leq 0$. This implies that the marginal product of effort is positive and non-increasing and that the marginal product of stock size is positive and non-increasing. This production function implies that when we know the harvest and the stock size, which are usually publicly available data, we are able to, by the use of the production function, to calculate the effort.

Note, this is not the bio-economic equilibrium harvest function, which gives the maximum sustainable yield over time. Applying the above harvest function implies that a given stock, *x*, and effort E_j will provide a harvest equal to G_j. The harvest function does not say anything about the size of the stock in equilibrium.

In the short run, the individual harvesting costs are related to effort only, and for vessel type *i* in member state *j* it is given by $C_j = C_j(E_j)$. We assume that the cost function has the following properties: $\frac{\partial C_j}{\partial E_j} > 0$, and $\frac{\partial^2 C_j}{\partial {E_j}^2} > 0$. This implies that the marginal costs are positive and increasing. In contrast to data on harvest and stock size, cost data are not necessarily publicly available. Some countries, among them Norway, makes annual surveys of costs for vessel types, and the results of these surveys are publicly available.

According to Jewitt (1988) the properties of the production and cost functions above enable us to apply the 1.order approach when solving the principal-agent models later in the paper. These properties are that G is increasing concave and C is increasing convex in effort.

Finally, let $F(x)$ be the natural growth, net of natural mortality, function for a stock, which implies that the net growth depends on the size of the stock, x. When the stock is harvested the change in the stock over time is given by $\frac{\partial x}{\partial t} = F(x) - \sum_j \sum_i G_j(x, E_j)$.

In order to make the application of the production and cost function in the following analysis simpler we concretise them as follows (Andersen 1979):

$$G_j(x, E_j) = qxE_j \qquad q > 0 \tag{1}$$

$$C(E_j) = aE_j^{\ 2} \qquad a > 0 \tag{2}$$

Equation (1) states that production (harvest) is a positive, linear function of effort, *E*, and the stock size, *x*. The parameter *q* is defined as catchability, and it denotes how easily accessible the fish harvested is. The higher the catchability is the higher is the harvest for given stock and effort. Equation (2) states that production (harvesting) costs are a positive, exponentially increasing function of effort, and *a* is a parameter indicating how strong the connection between effort and costs are. The lower *a* is the less the costs rise due to a rise in effort.[17]

Now, by the use of the above functions and formulations, we can translate the three interests the actors hold towards the fisheries activity; environmental, economic and social, into formal (mathematical) expressions.

We use the definition of sustainable harvesting as an expression for the environmental interest. Sustainable harvesting implies that the aggregated harvest does not exceed the natural net growth of a stock. Formally, this means

$$\frac{\partial x}{\partial t} = F(x) - \sum_j (qxE_j) \geq 0 \tag{3}$$

When the expression is fulfilled with inequality it means that the natural growth of the stock is higher than the harvest and thus that the stock increases. For given effort, the solution to (4) does not necessarily give maximum sustainable yield (MSY) or maximum economic yield (MEY). For stocks, which are at a sufficiently high level to secure MSY (or MEY), sustainable harvesting means that (4) is fulfilled with equality.

We use the resource rent as an expression for the economic interests. The resource rent, π, is defined as

$$\pi_j = pG_j(x, E_j) - C_j(E_j) \equiv pqxE_j - aE_j^{\ 2} \tag{4}$$

where *p* is the unit price of the species constituting the stock *x* harvested in the fishery under consideration. Defining the cost function as all costs including a "normal" return on invested capital, production multiplied with price for the fish minus these costs gives the resource rent, which is the economic "super" profit from the fishing activity, due to the fact that we harvest a resource that is freely available. The resource rent can thus be regarded as the value of the fish. A positive resource rent is an assumption for an economically sustainable fishery, and often maximising the resource rent is seen as an aim of fisheries activities (Hannesson 1978).

An indicator for the level of fisheries activity is the effort deployed by the fleet. If we assume a constant relation between effort and catch the effort determines the catches realised. From a societal point of view an aim might be to maximise effort, in the form of persons employed in the fishery, for a given quota or harvest level. In an open access fishery fishers will enter the fishery until the resource rent is exhausted. Denote E_j^M the effort which exhaust the resource

[17] Note, however, that due to the convexity of the cost function a is not the marginal cost of effort. This is given by 2aEj.

rent, i.e. $\pi(E_j^M) = 0$. If an aim is to maximise effort for a given harvest level then effort less than this level will provide negative utility because all employment possibilities is not exhausted in the fishery. Hence, a proxy for the social interest (SOC) might be

$$(E_j - E_j^M), \tag{5}$$

This proxy implies that effort lower than the maximal level enters the objective function with a negative sign, whereas effort beyond the maximal level enters the objective function with a positive sign. The latter might seem strange, as this indicates effort levels for which the resource rent is negative. On the other hand, many present fisheries operate at this scale surviving only thanks to indirect subsidies and continual restructuring. From a societal perspective, though not from an economic and environmental, this has a positive impact.

The objective function for each of the four interest groups, EU-authorities, national authorities, fishers, and NGOs, can now be expressed as follows:

$$U^g = \lambda_1^g \left[F(x) - NqxE_j\right] + \lambda_2^g \left[pqxE_j - aE_j^2\right] + \lambda_3^g \left[E_j - E_j^M\right] \qquad g = EU, MS, NGO \tag{6}$$

$$U^F = \lambda_1^F \left[F(x) - qxE_j\right] + \lambda_2^F \left[pqxE_j - aE_j^2\right] + \lambda_3^F (E_j - E_j^M) \tag{7}$$

N is the number of member states participating in the fishery. All interest groups except the fishers take into account the total harvest on a stock, which is the aggregate of all member states harvest. We assume myopic fishers, which mean that they only take into account national fishers harvest on a specific stock x. Though being a super ordinate authority we assume that the EU optimises the effort for each member state (and thus for all member states, as we have assumed homogenous member states). National authorities (MS=member states) and the fishers (F) care only about the resource rent to the national fishers participating in the specific fishery. NGOs can be either international, e.g. Greenpeace, or national, e.g. Norges Naturvernforbund, and as a point of departure we have assumed national NGOs, which mainly take national resource rent and employment into consideration. For an NGO it might very well be the case that they only hold environmental interests, which implies $\lambda_2^{NGO} = \lambda_3^{NGO} = 0$.

The national authorities in different member states may diverge when it comes to the weight of the interests, and the same is true for fishers. As a point of departure, and to keep things simple, we start out by assuming homogenous member states and fishers, i.e. one representative national authority and one representative fisher.

Often, there will be a relationship between effort and harvest and/or effort and harvest costs, which is known only to the fishers, and not to the other three interest groups. This type of asymmetric information can be introduced in different ways, e.g. by a stochastic term with an expectation only known to the fishers, or by assuming that q or a is private information to the fishers. As a first approach to the analysis of agency drift and optimal regulations (incentive scheme) we assume symmetric and complete information.

The variable the authorities seek to control is effort executed by the fishers. The pay off, expressed by the nominal value of the objective functions, to an actor regarding her/his social and economic interests are higher the higher the effort (and thus harvest) is, whereas the pay off to an actor due to her/his environmental interests are higher the lower the effort (and thus harvest) is. Hence, regulating the fisheries the authorities (and NGOs) face a trade off between the positive effects of effort, represented by the economic and social interests, and the negative effects of effort, represented by the environmental interests. Hence, if the authorities hold strong economic and social interests and weak environmental interests they will typically choose to implement a high effort level. High environmental interests will induce the authorities to implement a low effort.

A3.2 Agency drift

Assuming rational actors each interest group maximise its pay-off from the fisheries' activity w r t effort, and this decides the optimal effort level as seen form the perspective of each group. The optimal effort levels are given by

$$E_j^g = \frac{(\lambda^g)}{2a\lambda_2^g} \qquad g = EU, MS, F, NGO \tag{8}$$

where $(\lambda^F) = -\lambda_1{}^F qx + \lambda_2{}^F pqx + \lambda_3{}^F$, $(\lambda^g) = -\lambda_1{}^g Nqx + \lambda_2{}^g pqx + \lambda_3{}^g, g = EU, MS, NGO$.

Agency drift occurs when the optimal effort level, as seen from the perspective of the EU-authorities differ from that of the national authorities. Whenever $\lambda_1^{EU} \neq \lambda_1^{MS}$ agency drift will occur.

We have argued that the EU authorities hold stronger environmental interests than do national authorities, and that national authorities hold stronger economic and social interests. All these characteristics draw in the same direction, namely that $E_j^{EU} < E_j^{MS}$. This means that the optimal effort, and thus harvest level for the fishery in country j as seen from national authorities is higher than the corresponding variable as seen from the perspective of the EU authorities. In practice this may imply that the national authorities, in implementing e.g. the quota set at the EU-level, have an interest in allowing a higher effort level than what is compatible with the fixed quota.

A3.3 Incentive schemes

There are different ways to deter agency drift. We shall concentrate on economic mechanisms, and we assume that the authorities have the possibility to tax and subsidise the fishers and also impose upon them fees/licences and compensate them for "unexpected" costs. We concentrate on agency drift between national authorities and fishers, i.e. the fishers have a higher optimal effort level, which means higher harvests, compared to national authorities. Then, in order to align the effort, and the harvest, of the two groups, the authorities formulate a scheme with (economic) rewards and punishments. Formally, we talk about an incentive scheme of the form $w_0 + wE$, where E is effort, w is an incentive parameter, which influences the fishers' behaviour w r t the decision on E, and w_0 is a fee on or a compensation to the fishers. Each of w and w0 may be positive or negative. A positive w works like a tax on effort, which makes effort more expensive and thus the fishers will apply less effort and take a lower harvest. A negative w works like a subsidy, which promotes effort. The lump sum transfer (compensation/fee), w0, secures that the fishers have the possibility to remain in the fishery though regulated by the incentive parameter w. When w is positive w0 will often be negative, implying a compensation to the fisher for reduced effort and thus harvest, and the vice versa. Without this parameter the regulations would have to be enforced by the use of command-and-control.

A principal applies an incentive scheme in order to secure that that the agent acts in accordance with the principal’s interests, without the principal needing to use enforcing power. This demands that

$$U^{F}(x, E_{j}, w_{0}, w_{1}) \geq U^{F0} \tag{9}$$

where U^{FO} is the pay-off the fishers can achieve outside the fishery (outside option).

Assuming symmetric and complete information, this regulation problem can be solved by the so called first order approach. This implies that the authorities maximise their pay off from the fisheries activity given the participation constraint, and taking into consideration the relationship between the fishers’ decision w r t effort and the incentive parameter. Formally, this can be formulated as follows:

$$\begin{aligned} &\max U^{MS}(w_{0}, w_{1}, E_{j}) \\ &\text{s.t.} U^{F}(w_{0}, w_{1}, E_{j}) \geq U^{F0} \end{aligned} \tag{10}$$

and given that $$E_{j}^{F} = \frac{\lambda_{1}^{F}pqx - \lambda_{2}^{F}Nqx + \lambda_{3}^{F} - \psi w_{1}}{2a\lambda_{1}^{F}} \tag{11}$$

(11) is found by maximising the fishers’ pay-off w r t E when they are regulated by an incentive scheme as the one given above. We see immediately that the incentive parameter contributes to reduce the optimal effort level if it is positive, i.e. a tax, and increases the optimal effort level if it is negative, i.e. a subsidy, $w_1<0$.

Inserting (11) into the authorities pay-off function and adding the incentive scheme, the authorities objective function can be formulated as follows:

$$\begin{aligned} U^{MS}(w_{0}, w) &= \mu w_{0} - \lambda_{3}^{MS}E_{j}^{M} - \left[\frac{\psi(\psi\lambda_{1}^{MS} + 2\mu\lambda_{1}^{F})}{4a\lambda_{1}^{F2}}\right]w^{2} + \left[\frac{(\lambda^{F})(\lambda_{1}^{MS}\psi + \lambda_{1}^{F}\mu)}{2a\lambda_{1}^{F2}} - \frac{\psi(\lambda^{MS})}{2a\lambda_{1}^{F}}\right]w + C^{MS} \\ C^{MS} &= \lambda_{2}^{MS}F(x) - \left[\frac{(\lambda^{F})(\lambda_{1}^{MS}\lambda_{1}^{F}pqx + 2\lambda_{1}^{F}(-\lambda_{2}^{MS}Nqx + \lambda_{3}^{MS}) + \lambda_{1}^{MS}(\lambda_{2}^{F}Nqx - \lambda_{3}^{F}))}{2a\lambda_{1}^{F2}}\right] \end{aligned} \tag{12}$$

Correspondingly, the fishers’ pay-off function is given by

$$U^{F}(w_{0}, w) = -\psi w_{0} - \lambda_{3}^{F}E_{j}^{M} + \frac{\psi^{2}}{4a\lambda_{1}^{F}}w^{2} + \left[\frac{\psi(\lambda_{2}^{F}Nqx - \lambda_{1}^{F}pqx - \lambda_{3}^{F})}{2a\lambda_{1}^{F}}\right]w + C^{F} \tag{13}$$

$$C^{F} = \lambda_{2}^{F}F(x) + \frac{(\lambda^{F})^{2}}{4a\lambda_{1}^{F}}$$

Using the 1.order approach the Kuhn Tucker two first-order conditions gives for the maximisation problem in (10) gives are:

$$\frac{\partial L}{\partial w_0} = \frac{\partial L}{\partial w} = 0$$

$$\frac{\partial L}{\partial \gamma^S} \geq 0 \qquad \text{and} \qquad \left(\frac{\partial L}{\partial \gamma^S} = 0 \quad \text{if} \quad \gamma^S > 0; \qquad \frac{\partial L}{\partial \gamma^S} > 0 \quad \text{if} \quad \gamma^S = 0\right) \tag{14}$$

where L denotes the Lagrange equation. Solving for the Lagrangian multiplier, γ^S, and equating gives

$$\gamma^S = -\frac{\dfrac{\partial U^{MS}}{\partial w_0}}{\dfrac{\partial U^F}{\partial w_0}} = -\frac{\dfrac{\partial U^{MS}}{\partial w}}{\dfrac{\partial U^F}{\partial w}} \tag{15}$$

Rearranging, we obtain the equality of the marginal rates of substitution between *w* and w_0 of the national authorities and the fishers.

$$\frac{\partial w_0}{\partial w}\bigg|_{U_1=\bar{U}_1} = \frac{\dfrac{\partial U^{MS}}{\partial w}}{\dfrac{\partial U^{MS}}{\partial w_0}} = \frac{\dfrac{\partial U^F}{\partial w}}{\dfrac{\partial U^F}{\partial w_0}} = \frac{\partial w_0}{\partial w}\bigg|_{U_2=\bar{U}_2} \tag{16}$$

Solving for *w* provides the following solution to the optimal tax/subsidy rate;

$$w^* = \frac{\lambda_1^{MS}(\lambda^F) - \lambda_1^F(\lambda^{MS})}{\left(\psi\lambda_1^{MS} + \mu\lambda_1^F\right)} \tag{17}$$

Solving for the Lagrangian multiplier gives

$$\gamma^S = -\frac{\mu}{-\psi} \equiv \frac{\mu}{\psi} > 0 \tag{18}$$

The inequality holds if we assume that the incentive scheme influences the pay-off to both the principal and the agent.

This implies that the participation constraint is binding, and thus

$$U^F(w_0, w, E_j) = U^{F0} \tag{19}$$

Inserting for w* in (13), we can solve for the lump sum transfer:

$$w_0^* = \frac{\psi}{4a\lambda_1^F} w_1^{*2} - \left[\frac{\left(\;\right)^F}{2a\lambda_1^F}\right] w_1^* - \frac{\lambda_1^F E_j^M}{\psi} + \frac{C^F}{\psi} - \frac{U^{F0}}{\psi} \tag{20}$$

where C^F is given above.

A3.4 New stakeholders and common agency

We keep to the application of linear incentive schemes and the assumption about symmetric and complete information. Previously, Chortareas and Miller (2004) and Campoy and Negrete (2008) have analysed the regulation of a central bank by two principals; the government and an independent interest group. They use a linear incentive scheme, as the one derived by Walsh (1995) and discusses how the introduction of a second interest group (industrialists) affects the optimal incentive scheme of the government, and the net incentive scheme, i.e. the aggregate of the incentive scheme offered by the two principals. As far as we know, a common agency model has never been applied to fisheries regulations.

A3.4.1 Cooperating principals

Formally, the formulation and resolving of the model with cooperating principals coincides with that of a single principal. The only difference being the principals' common objective function. This function is now given by

$$U^C(c_0,c_1) = \theta c_0 - \lambda_3{}^C E_j{}^M - \left[\frac{\psi(\psi\lambda_1{}^C + 2\theta\lambda_1{}^F)}{4a\lambda_1{}^{F2}}\right]c^2 + \left[\frac{(\lambda^F)(\lambda_1{}^C\psi + \lambda_1{}^F\theta)}{2a\lambda_1{}^{F2}} - \frac{\psi(\lambda^C)}{2a\lambda_1{}^F}\right]c + C^C \tag{21}$$

$$C^C = \lambda_2{}^C F(x) - \left[\frac{(\lambda^F)\left(\lambda_1{}^C\lambda_1{}^F pqx + 2\lambda_1{}^F(-\lambda_2{}^C Nqx + \lambda_3{}^C) + \lambda_1{}^C(\lambda_2{}^F Nqx - \lambda_3{}^F)\right)}{2a\lambda_1{}^{F2}}\right]$$

$$(\lambda^C) = \lambda_1{}^C pqx - \lambda_2{}^C Nqx + \lambda_3{}^C$$

where θ is the costs to the two principals of formulating and implementing the common incentive scheme, and $\lambda_i{}^C = \alpha(\lambda_i{}^{MS}) + (1-\alpha)\lambda_i{}^{NGO}, i = 1,2,3$. This implies that the weights of the interests in the common objective function, $\lambda_i{}^C$, are now weighted averages of the weights in the objective functions of the two principals.

Applying the same procedure as in the single principal case, we find the optimal tax/subsidy rate to be

$$c^* = \frac{\lambda_2{}^C(\lambda^F) - \lambda_2{}^F(\lambda^C)}{(\psi\lambda_2{}^C + \theta\lambda_2{}^F)} \tag{22}$$

Setting α=0,5, and assuming that the NGO has higher environmental and lower economic and social interests compared with the authorities, we get that $\lambda_1{}^C > \lambda_1{}^{MS}$, $\lambda_2{}^C < \lambda_2{}^{MS}$, $\lambda_3{}^C < \lambda_3{}^{MS}$. These characteristics contribute to make both nominator terms on the right hand side of (22) lower, and the denominator lower compared to w* given in (17). Keeping the assumption from above that the fishers hold lower environmental and higher economic and social interests combined with the above inequalities, it can be shown that the optimal tax/subsidy rate will increase as a consequence of an additional principal with strong environmental interests, given that this principal cooperates with the original principal. This means that the principal will set a higher tax or a lower subsidy on effort.

The less the interests of the new principal, the NGO, counts in the common objective function the smaller is the change in c relative to w. In other words, the less influence the NGOs get the smaller will the increase in taxes or decrease in subsidies on effort be.

The optimal lump sum transfer is now given by

$$c_0{*} = \frac{\psi}{4a\lambda_1{}^F} c^{*2} - \left[\frac{\psi(\;)^F}{2a\lambda_1{}^F}\right] c^{*} - \frac{\lambda_1{}^F E_j{}^M}{\psi} + \frac{C^F}{\psi} - \frac{U^{F0}}{\psi} \tag{23}$$

The only variable in (9) which has changed compared to the expression for w_0* is the incentive parameter, c*. When $0 < c^* < 1$ increased incentive parameter implies that the lump sum transfer decreases, and that it is more likely that it is negative, i.e. a transfer to the agent. Hence, giving the NGOs a say in the fisheries management most likely implies stronger incentives on effort (higher tax or lower subsidy) and to compensate for this increase in costs of the fishing activity the expected compensation (lump sum transfer) to the fishers must be higher.

A 3.4.2 Competing principals

The incentive scheme of the national authorities has the same structure as in the single principal-agent relationship and in the cooperative game, but not to confuse the optimal tax rate for the national authorities between the different games, this scheme is now given by $t_0 + t_1 E_j$. The NGO, which does not have the same opportunity to tax or subsidise the fishers, may still incur costs or benefits upon this group of actors. As an example, they may call on the public to boycott products from the fishery under consideration when harvest, and thus effort, exceeds a specific level (this level may typically be the harvest ICES recommends for the species caught in the fishery). On the other hand, they may also promote sustainable fisheries, i.e. fisheries where the harvest is below or at the quotas recommended by ICES, by publicly certifying it as a sustainable fishery. In the public this will have a positive effect on demand, and thus price (ref…). Hence, a boycott can be interpreted as a tax on the fishers, i.e. on effort, whereas certification can be interpreted as a subsidy. For simplicity we assume that the tax/subsidy is continuous in Ej, and not only take place above/below a certain effort level. Then the incentive scheme forwarded by the NGOs will have the following structure; $\tau_0 + \tau_1 E_j$. Due to the participation constraint τ_0 will contribute to regulate the total effect of the incentive scheme.

As will be demonstrated the formulation of the incentive schemes and how they are perceived by the principals does matter for the optimal reaction functions between the principals, but not for the net incentives towards the agent.

When the fishers are "regulated" by two independent principals simultaneously their objective function is given by

$$U^F = \lambda_1{}^F\left(F(x) - \sum_j qxE_j\right) + \lambda_2{}^F\left(pqxE_j - aE_j{}^2\right) + \lambda_3{}^F\left(E_j - E_j{}^M\right) - \psi(t_0 + t_1E_j) - \beta(\tau_0 + \tau_1 E)) \tag{24}$$

where β is the cost of the NGOs incentive scheme for the fishers.

Maximising the objective function in (24) with respect to E_j gives the optimal effort to exert for the fishers given that they face two principals with incentive schemes:

$$E_j^{\,a} = \frac{\lambda_2^{\,F} pqx - \lambda_1^{\,F} Nqx + \lambda_3^{\,F} - \psi t_1 - \beta\tau_1}{2a\lambda_2^{\,F}} \tag{25}$$

Inserting the optimal effort into the objective functions of the principals and the agent, we get:

$$U^{MS}(t_0, t, \tau_0, \tau) = \mu t_0 - \lambda_3^{\,MS} E_j^{\,M} - \left[\frac{\psi(\psi\lambda_2^{\,MS} + 2\mu\lambda_2^{\,F})}{4a\lambda_2^{\,F2}}\right] t^2 + \frac{\beta^2\lambda_2^{\,MS}}{4a\lambda_2^{\,F2}}\tau^2 +$$
$$\left[\frac{(\lambda^F)(\lambda_2^{\,MS}\psi + \lambda_2^{\,F}\mu)}{2a\lambda_2^{\,F2}} - \frac{\psi(\lambda^{MS})}{2a\lambda_2^{\,F}}\right] t_1 + \left[\frac{\beta(\lambda_2^{\,MS}(\lambda_3^{\,F} - \lambda_1^{\,F} Nqx) - \lambda_2^{\,F}(\lambda_3^{\,MS} - \lambda_1^{\,MS} Nqx))}{2a\lambda_2^{\,F}}\right]\tau - \tag{26}$$
$$\frac{\beta(\psi\lambda_2^{\,MS} + \mu\lambda_2^{\,F})}{2a\lambda_2^{\,F2}} t\tau + C^{MS}$$

$$U^{NGO}(t_0, t, \tau_0, \tau) = \eta\tau_0 - \lambda_3^{\,NGO} E_j^{\,M} - \left[\frac{\beta(\beta\lambda_2^{\,NGO} + 2\eta\lambda_2^{\,F})}{4a\lambda_2^{\,F2}}\right]\tau^2 + \frac{\psi^2\lambda_2^{\,NGO}}{4a\lambda_2^{\,F2}} t^2 +$$
$$\left[\frac{(\lambda^F)(\lambda_2^{\,NGO}\beta + \lambda_2^{\,F}\eta)}{2a\lambda_2^{\,F2}} - \frac{\beta(\lambda^{NGO})}{2a\lambda_2^{\,F}}\right]\tau + \left[\frac{\psi(\lambda_2^{\,NGO}(\lambda_3^{\,F} - \lambda_1^{\,F} Nqx) - \lambda_2^{\,F}(\lambda_3^{\,NGO} - \lambda_1^{\,NGO} Nqx))}{2a\lambda_2^{\,F}}\right] t -$$
$$\frac{\psi(\beta\lambda_2^{\,MS} + \eta\lambda_2^{\,F})}{2a\lambda_2^{\,F2}} t\tau + C^{NGO} \tag{27}$$

where $(\lambda^{NGO}) = (\lambda_2^{\,NGO} pqx - \lambda_1^{\,NGO} Nqx + \lambda_3^{\,NGO})$

$$U^{F}(t_0, t, \tau_0, \tau) = -\psi t_0 - \beta\tau_0 - \lambda_3^{\,F} E_j^{\,M} + \frac{\psi^2}{4a\lambda_2^{\,F}} t^2 + \frac{\beta^2}{4a\lambda_2^{\,F}}\tau^2 + \left(\frac{\psi\beta}{2a\lambda_2^{\,F}}\right) t\tau -$$
$$\left[\frac{\psi(\lambda^F)}{2a\lambda_2^{\,F}}\right] t - \left[\frac{\beta(\lambda^F)}{2a\lambda_2^{\,F}} + \beta E_j^{\,0}\right]\tau + C^F \tag{28}$$

and where C^{MS}, C^{NGO} and C^F are given by

$$C^{MS} = \lambda_2^{\,MS} F(x) - \left[\frac{(\lambda^F)(\lambda_1^{\,MS}\lambda_1^{\,F} pqx + 2\lambda_1^{\,F}(-\lambda_2^{\,MS} Nqx + \lambda_3^{\,MS}) + \lambda_1^{\,MS}(\lambda_2^{\,F} Nqx - \lambda_3^{\,F}))}{2a\lambda_1^{\,F2}}\right]$$

$$C^{NGO} = \lambda_2^{\,NGO} F(x) - \left[\frac{(\lambda^F)(\lambda_1^{\,NGO}\lambda_1^{\,F} pqx + 2\lambda_1^{\,F}(-\lambda_2^{\,NGO} Nqx + \lambda_3^{\,NGO}) + \lambda_1^{\,NGO}(\lambda_2^{\,F} Nqx - \lambda_3^{\,F}))}{2a\lambda_1^{\,F2}}\right]$$

$$C^F = \lambda_1^{\,F} F(x) + \frac{(\lambda^F)^2}{4a\lambda_2^{\,F}}$$

Applying the same optimisation procedure as in section 3.2.2 we get the following pair of reaction functions for the two principals:

$$t^R = -\frac{\beta\lambda_2^{MS}}{\psi\lambda_2^{MS} + \mu\lambda_2^{F}}\tau_1 + \frac{\lambda_2^{MS}(\lambda^F) - \lambda_2^{F}(\lambda^{MS})}{\psi\lambda_2^{MS} + \mu\lambda_2^{F}} \tag{28}$$

$$\tau^R = -\frac{\psi\lambda_2^{NGO}}{\beta\lambda_2^{NGO} + \eta\lambda_2^{F}} t_1 + \frac{\lambda_2^{NGO}(\lambda^F) - \lambda_2^{F}(\lambda^{NGO})}{\beta\lambda_2^{NGO} + \eta\lambda_2^{F}} \tag{29}$$

where t^R is the reaction function of the authorities and τ^R of the NGOs, β and η are the costs of formulating, implementing and obeying to the incentive scheme of the NGOs for the fishers and the NGOs respectively.

Solving for the two reaction functions simultaneously gives the following first best solutions to the tax/subsidy rates:

$$t_1^* = \frac{-(\beta\lambda_2^{NGO} + \eta\lambda_2^{F})(\lambda^{MS}) + \beta\lambda_2^{MS}(\lambda^{NGO}) + \eta\lambda_2^{MS}(\lambda^F)}{\eta\psi\lambda_2^{MS} + \eta\mu\lambda_2^{F} + \beta\mu\lambda_2^{NGO}} \tag{30}$$

$$\tau_1^* = \frac{-(\psi\lambda_2^{MS} + \mu\lambda_2^{F})(\lambda^{NGO}) + \psi\lambda_2^{NGO}(\lambda^{MS}) + \mu\lambda_2^{NGO}(\lambda^F)}{\eta\psi\lambda_2^{MS} + \eta\mu\lambda_2^{F} + \beta\mu\lambda_2^{NGO}} \tag{31}$$

The net incentive scheme is now given by

$$t_1^* + \tau_1^* = \frac{((\beta+\psi)\lambda_2^{NGO} + \eta\lambda_2^{F})(\lambda^{MS}) - ((\beta+\psi)\lambda_2^{MS} + \mu\lambda_2^{F})(\lambda^{NGO}) + (\mu\lambda_2^{NGO} - \eta\lambda_2^{MS})(\lambda^F)}{\eta\psi\lambda_2^{MS} + \eta\mu\lambda_2^{F} + \beta\mu\lambda_2^{NGO}}$$
(32)

With two principals, the agent has (in theory) the possibility to accept, one, two or none of the incentive schemes forwarded.

If $U^{F0}>0$, implying that it is better for the agent to accept at least one incentive scheme than reject both, then $U^F(t, t_0, \tau, \tau_0) = U^F(t, t_0, 0, 0) = U^F(0, 0, \tau, \tau_0)$. This means that there must exist a vector (t_0, τ_0) which fulfils the following three conditions:

$$\psi t_0 + \beta\tau_0 = -\lambda_3^F E_j^M + \frac{\psi^2}{4a\lambda_1^F} t_1^{*2} + \frac{\beta^2}{4a\lambda_1^F}\tau_1^{*2} + \left(\frac{\psi\beta}{2a\lambda_1^F}\right) t_1^* \tau_1^* +$$
$$\left[\frac{\psi(\lambda_2^F Nqx - \lambda_1^F pqx - \lambda_3^F)}{2a\lambda_1^F}\right] t_1^* + \left[\frac{\beta(\lambda_2^F Nqx - \lambda_1^F pqx - \lambda_3^F)}{2a\lambda_1^F} + \beta E_j^0\right]\tau_1^* + C^F - U^{F0} \tag{33}$$

$$\psi t_0 = -\lambda_3{}^F E_j{}^M + \frac{\psi^2}{4a\lambda_1{}^F} t_1{}^{*2} + \left[\frac{\psi\left(\lambda_2{}^F Nqx - \lambda_1{}^F pqx - \lambda_3{}^F\right)}{2a\lambda_1{}^F}\right] t_1{}^* + C^F - U^{F0} \tag{34}$$

$$\beta\tau_0 = -\lambda_3{}^F E_j{}^M + \frac{\beta^2}{4a\lambda_1{}^F} \tau_1{}^{*2*} + \left[\frac{\beta\left(\lambda_2{}^F Nqx - \lambda_1{}^F pqx - \lambda_3{}^F\right)}{2a\lambda_1{}^F} + \beta E_j{}^0\right] \tau_1{}^* + C^F - U^{F0} \tag{35}$$

Unless either t* or τ* equal zero, which we have shown that they do not do in equilibrium, the three conditions can not be fulfilled simultaneously, and thus it can not be the case that $U^{F0}>0$ in equilibrium.

If $U^{F0}=0$, implying that the agent is indifferent between accepting one or both of the incentive schemes, then $U^F(t, t_0, 0, 0) < 0, U^F(0, 0, \tau, \tau_0) < 0$.

This means that there must exist a vector (t_0, τ_0) which fulfils the following three conditions:

$$\begin{aligned}\psi t_0 + \beta\tau_0 = {} & -\lambda_3{}^F E_j{}^M + \frac{\psi^2}{4a\lambda_1{}^F} t_1{}^{*2} + \frac{\beta^2}{4a\lambda_1{}^F} \tau_1{}^{*2} + \left(\frac{\psi\beta}{2a\lambda_1{}^F}\right) t_1{}^* \tau_1{}^* + \\ & \left[\frac{\psi\left(\lambda_2{}^F Nqx - \lambda_1{}^F pqx - \lambda_3{}^F\right)}{2a\lambda_1{}^F}\right] t_1{}^* + \left[\frac{\beta\left(\lambda_2{}^F Nqx - \lambda_1{}^F pqx - \lambda_3{}^F\right)}{2a\lambda_1{}^F} + \beta E_j{}^0\right] \tau_1{}^* + C^F - U^{F0}\end{aligned} \tag{36}$$

$$\psi t_0 \le -\lambda_3{}^F E_j{}^M + \frac{\psi^2}{4a\lambda_1{}^F} t_1{}^{*2} + \left[\frac{\psi\left(\lambda_2{}^F Nqx - \lambda_1{}^F pqx - \lambda_3{}^F\right)}{2a\lambda_1{}^F}\right] t_1{}^* + C^F - U^{F0} \tag{37}$$

$$\beta\tau_0 \le -\lambda_3{}^F E_j{}^M + \frac{\beta^2}{4a\lambda_1{}^F} \tau_1{}^{*2*} + \left[\frac{\beta\left(\lambda_2{}^F Nqx - \lambda_1{}^F pqx - \lambda_3{}^F\right)}{2a\lambda_1{}^F} + \beta E_j{}^0\right] \tau_1{}^* + C^F - U^{F0} \tag{38}$$

Trying to solve for the lump sum transfers simultaneously show that these are indeterminate, which means that any combination of t_0 and τ_0 which fulfils

$$\begin{aligned}U^{F0} = {} & -\psi t_0 - \beta\tau_0 - \lambda_3{}^F E_j{}^M + \frac{\psi^2}{4a\lambda_1{}^F} t_1{}^{*2} + \frac{\beta^2}{4a\lambda_1{}^F} \tau_1{}^{*2} + \left(\frac{\psi\beta}{2a\lambda_1{}^F}\right) t_1{}^* \tau_1{}^* + \\ & \left[\frac{\psi\left(\lambda_2{}^F Nqx - \lambda_1{}^F pqx - \lambda_3{}^F\right)}{2a\lambda_1{}^F}\right] t_1{}^* + \left[\frac{\beta\left(\lambda_2{}^F Nqx - \lambda_1{}^F pqx - \lambda_3{}^F\right)}{2a\lambda_1{}^F} + \beta E_j{}^0\right] \tau_1{}^* + C^F\end{aligned} \tag{39}$$

and at the same time fulfil (37) and (38) are optimal responses to each other, and thus candidates to the equilibrium values of the fixed parts of the incentive schemes.

When the NGO only holds environmental interests, and we assume that it has no "income" from taxing the fishery, its objective function reduces to

$$U^{NGO}(t_0, t, \tau_0, \tau) = \eta\tau_0 - \left[\frac{\beta\eta}{2a\lambda_1^{\ F}}\right]\tau_1^{\ 2} - \frac{\psi\eta}{2a\lambda_1^{\ F}} t_1\tau_1 + \left[\frac{\eta(\lambda^F) + \lambda_2^{\ NGO} Nqx\beta}{2a\lambda_1^{\ F}} - \eta E_j^{\ 0}\right]\tau_1$$
$$+ \frac{\psi\lambda_2^{\ NGO} Nqx}{2a\lambda_1^{\ F}} t_1 + C^{NGO} \tag{40}$$

where C^{NGO} is given by

$$C^{NGO} = \lambda_2^{\ NGO} F(x) - \frac{\lambda_2^{\ NGO} Nqx(\lambda^F)}{2a\lambda_1^{\ F}}$$

The authorities' and fishers' objective functions are still given by (26) and (28). Applying the first order approach and following the procedure from section A3.3 the Kuhn Tucker conditions gives the following reaction functions:

$$\tau_2^{\ R} = \frac{\lambda_1^{\ NGO} Nqx}{\eta} \equiv \tau^* \tag{41}$$

$$t_2^{\ *} = -\frac{\beta\lambda_2^{\ MS}}{(\psi\lambda_2^{\ MS} + \mu\lambda_2^{\ F})}\tau_2 + \frac{\lambda_2^{\ MS}(\lambda^F) - \lambda_2^{\ F}(\lambda^{MS})}{\psi\lambda_2^{\ MS} + \mu\lambda_2^{\ F}} \tag{42}$$

As can be seen, the reaction function of the authorities does not change, whereas the reaction function of the NGO now does not depend on the authorities and is thus no reaction function but rather a best reply solution to the NGO's optimisation problem.

Inserting for (41) in (42) the optimal incentive parameter for the national authorities is now given by

$$t^* = -\frac{\beta\lambda_2^{\ MS}\lambda_1^{\ NGO} Nqx}{\eta(\psi\lambda_2^{\ MS} + \mu\lambda_2^{\ F})} + \frac{\lambda_2^{\ MS}(\lambda^F) - \lambda_2^{\ F}(\lambda^{MS})}{\psi\lambda_2^{\ MS} + \mu\lambda_2^{\ F}} \tag{43}$$

The optimal incentive parameter for the national authorities decrease in the environmental interests of the other principal, and this is intuitive. The higher this weight the higher is the aggregate incentive parameter, and thus the lower can the national authorities set their incentive parameter in order to also serve their economic and social interests.

The aggregate incentive parameter is now given by

$$t^* + \tau^* = \frac{\lambda_1^{\ NGO} Nqx\left(\lambda_2^{\ MS}(\psi - \beta) + \mu\lambda_2^{\ F}\right)}{\eta(\psi\lambda_2^{\ MS} + \mu\lambda_2^{\ F})} + \frac{\lambda_2^{\ MS}(\lambda^F) - \lambda_2^{\ F}(\lambda^{MS})}{\psi\lambda_2^{\ MS} + \mu\lambda_2^{\ F}} \tag{44}$$

The lump sum transfers are found as shown above.

Annex 4 Case studies

Table A4.1 summarises the tools applied in each of the fisheries case studies.

Table A4.1 Measures applied to regulate the fishery

		Sandeel	Nephrops	Sardine	Comment
Input reg	Mesh size	X	X	X	
	Gear type			X	
	Limited licensing	X	X	X	
	Engine size				
	Seasonal restr	X		X	
	Days at sea	X	X	X	
	Area restr	X		X	
	Bycatch devices				
Output reg	TAC	X	X		
	Group TAC	X			
	Individual quotas	X	X	X	
	Bycatch reg	X	X	X	
	Minimum landing size		X	X	
Economic measures	Subsidies	X	X	X	
	Taxes/fees				
	Ind transf quota	X			
Other					

Source: CEFAS, MI, IEO, IPIMAR, IFM, UiT

A4.1 The sandeel fishery

This case study can be formally analysed by the model given in section A3.4.2, when the new principal hold only environmental interests.

A4.2 The nephrops fishery

The new principal's objective function when it has a say in the management of the nephrops may be formulated as follows:

$$U^{FC} = -\lambda_2{}^{FC} pqxE + \gamma(v_0 + vE) \tag{45}$$

The objective function of the nephrops fishers and authorities are given by (7) in Annex 3, with the additional term $-\beta_1(v_0 + vE)$ and ψ is substituted by ψ_2, and in (1) μ is substituted by μ_2 as the costs of the authorities of regulating the nephrops fishery and w_1 is substituted by w_2 as the incentive parameter in the scheme. Assuming that both national authorities and the cod fishers can formulate an incentive scheme which are forwarded to the nephrops fishers, applying the common agency model we get the following reaction functions:

$$w_2{}^R = -\frac{\beta_1\lambda_2{}^{MS}}{(\psi_2\lambda_2{}^{MS} + \mu_2\lambda_2{}^F)}\nu + \frac{(\lambda^F)\lambda_2{}^{MS} - (\lambda^{MS})\lambda_2{}^F}{(\psi_2\lambda_2{}^{MS} + \mu_2\lambda_2{}^F)} \tag{46}$$

$$\nu^R = \frac{\lambda_2{}^{FC} pqx}{\beta_1 \gamma} \equiv \nu * \qquad (47)$$

Whereas the equilibrium incentive parameter for the cod fisheries is given in (33), the corresponding variable for the authorities is found by inserting (33) into (32). This yields;

$$w_2 * = \frac{\lambda_2{}^{MS}(\lambda^F) - \lambda_2{}^F(\lambda^{MS})}{\psi_2\lambda_2{}^{MS} + \mu_2\lambda_2{}^F} - \frac{\beta pqx\lambda_2{}^{FC}\lambda_2{}^{MS}}{\gamma\left(\psi_2\lambda_2{}^{MS} + \mu_2\lambda_2{}^F\right)} \qquad (48)$$

The sign of (48) can not be determined unambiguously. If the cod fisheries are strongly negatively affected by the nephrops fisheries, i.e. $\lambda_2{}^{FC}$ is high, $w_2{}^*$ will be low. The reason is that a high $\lambda_2{}^{FC}$ contribute to a high tax set by the cod fisheries, then in order to limit the deterring effect on effort in the nephrops fisheries the authorities set a low tax, or even a subsidy, that is $w_2{}^* < 0$. High economic interests on behalf of the authorities, $\lambda_2{}^{MS}$ has (partly) the same effect, as this means that the authorities are interested in promoting effort.

The net incentive parameter, i.e. the aggregate of the two incentive parameters, is given by

$$w_2 * + \nu * = \frac{\lambda_2{}^{MS}(\lambda^F) - \lambda_2{}^F(\lambda^{MS})}{\psi_2\lambda_2{}^{MS} + \mu_2\lambda_2{}^F} + \frac{\lambda_2{}^{FC} pqx\left(\lambda_2{}^{MS}(\psi_2 - \beta_1) + \mu_2\lambda_2{}^F\right)}{\gamma\left(\psi_2\lambda_2{}^{MS} + \mu_2\lambda_2{}^F\right)} \qquad (49)$$

The reaction functions show that whereas the authorities take the incentive scheme (parameter v) of the cod fisheries into consideration when fixing its incentive parameter, the same is not true for the cod fisheries. When the cod fisheries get a say in the management of the nephrops fisheries they set the incentive parameter independently of the authorities' regulations, and from (33) it is easy to see that they set a tax on effort (v*>0). The authorities, on the other hand, in formulating their incentive scheme they first outdo some of what the cod fisheries have put into the scheme. This means that compared to a situation where the cod fisheries had no say in the management of the nephrops the authorities now reduce the incentive parameter. The reason is that the authorities in addition to having interests that imply to deter (tax) effort, they also have interests that imply to promote effort (economic and social interests). In order to moderate the effect of the cod fisheries' tax on effort they reduce their incentive parameter, which means either a lower tax or a higher subsidy, or a higher likelihood for subsidising the nephrops fisheries. They do this motivated of their economic and social interests.

A4.3 The sardine purse seine fishery

The objective functions of the authorities, fishers and MSC are now given by (7), where w is now substituted by w_3 and μ by μ_3, (2) has got an extra term given by $-\beta_2(z + zE)$ and ψ is substituted by ψ_3. The objective function of the MSC is given by

$$U^{MSC} = \lambda_1{}^{MSC}\left(F(x) - qxE\right) + \lambda_2{}^{MSC}(pqxE - aE^2) + \lambda_3{}^{MSC}(E - E^M) + \rho(z_0 + zE) \qquad (51)$$

Solving the model given by (1), (2) and (16), with the corrections above, as a common agency gives the following reaction functions for the incentive parameters:

$$w_3^{\,R} = -\frac{\beta_2\lambda_2^{\,MS}}{\psi_3\lambda_2^{\,MS}+\mu_3\lambda_2^{\,F}}\,z + \frac{\lambda_2^{\,MS}(\lambda^F)-\lambda_2^{\,F}(\lambda^{MS})}{\psi_3\lambda_2^{\,MS}+\mu_3\lambda_2^{\,F}} \tag{52}$$

$$z^R = -\frac{\psi_3\lambda_2^{\,MSC}}{\beta_2\lambda_2^{\,MSC}+\rho\lambda_2^{\,F}}\,w_3 + \frac{\lambda_2^{\,MSC}(\lambda^F)-\lambda_2^{\,F}(\lambda^{MSC})}{\beta_2\lambda_2^{\,MSC}+\rho\lambda_2^{\,F}} \tag{53}$$

From (52) and (53) we see that when constructing their incentive parameter each of the principals "outdo" a share (less than one) of the incentive parameter formulated by the other principal, before they make their own addition. The two principals now share all interests, of which the environmental interests imply to deter (tax) effort and the economic (partly) and social interests imply to promote effort. The difference between the two principals is their motivation to deter or promote effort. This is decided by the weights of the three interests in the principals' objective functions (the λs), and different weights imply different motivations to deter and promote effort. Each principal has to balance how much to deter and how much to promote effort in their own incentive scheme and at the same time take into account the effects on effort of the incentive scheme of the other principal. This is a trade off between the costs of operating the incentive scheme and the pay off the principals has from harvest (effort) from the fishery. In this trade off both principals give and take, and they correct for differences in the weights of their interests, and thus different preferred effort levels, by taking out parts of what the other principal has put into the scheme.

Solving for (52) and (53) simultaneously we get the equilibrium incentive parameters, given by

$$w_3^{\,*} = \frac{\rho\lambda_2^{\,MS}(\lambda^F)+\beta_2\lambda_2^{\,MS}(\lambda^{MSC})-(\beta_2\lambda_2^{\,MSC}+\rho\lambda_2^{\,F})(\lambda^{MS})}{\psi_3\rho\lambda_2^{\,MS}+\beta_2\mu_3\lambda_2^{\,MSC}+\mu_3\rho\lambda_2^{\,F}} \tag{54}$$

$$z^* = \frac{\mu_3\lambda_1^{\,MSC}(\lambda^F)+\psi_3\lambda_2^{\,MSC}(\lambda^{MS})-(\psi_3\lambda_2^{\,MS}+\mu_3\lambda_2^{\,F})(\lambda^{MSC})}{(\psi_3\rho\lambda_2^{\,MS}+\beta_2\mu_3\lambda_2^{\,NGO}+\mu_3\rho\lambda_2^{\,F})} \tag{55}$$

This means that the net incentive scheme, which the fishers face is given by

$$z^* + w_3^{\,*} = \frac{(\lambda_2^{\,MS}(\beta_2-\psi_3)-\mu_3\lambda_2^{\,F})(\lambda^{MSC})+(\mu 3\lambda_2^{\,MSC}+\rho\lambda_2^{\,MS})(\lambda^F)+(\lambda_2^{\,MSC}(\psi_3-\beta_2)-\rho\lambda_2^{\,F})(\lambda^{MS})}{(\psi 3\rho\lambda_2^{\,MS}+\beta_2\mu_3\lambda_2^{\,MSC}+\mu_3\rho\lambda_2^{\,F})} \tag{56}$$

When assuming that the costs to the sardine fishers of being regulated by the authorities does not differ much from the costs of being regulated by the MSC, i.e. $\beta_2 \approx \psi_3$, the first and the last right hand term have a negative sign. Given the definition of $(\lambda^g), g = MS, MSC$ (see appendix), this implies that the net incentive scheme increases in the environmental interests of the principals, and decreases in the economic and social interests. In contrast, the middle right hand term shows that the incentive scheme decreases in the environmental interests of the sardine fishers and increases in their economic and social interests. These are reasonable results as the more environmentally concerned the fishers are the more they will restrict effort and thus harvest in order to fish sustainably, and then a high tax is not necessary to limit effort. On the other hand, when the fishers are mainly economically concerned they will have an incentive to fish much, i.e. apply much effort in order to increase income. Then a high tax on effort may be necessary to limit the effort, and thus harvest.

As in the two other cases, the transfers in the incentive schemes, $(w_{30}*, z_0*)$, can not be decided unambiguously. As it can be shown that the participation constraint is binding we have that $U^F(w_3, w_{30}, z, z_0) = \overline{U}$. Thus, all vectors (w_{30}, z_0) fulfilling the mentioned equality are possible equilibrium solutions to the lump sum transfers in the incentive schemes. How the principals distribute the necessary lump sum transfer to (form) the fishers between them can e.g. be decided through negotiations.

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