Centre for Transdisciplinary Environmental Research
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A social critique of the failings of management in the North Sea ecosystem

Subterranean North Sea Blues

Christian Tsangarides

Natural Resource Management, Governance and Globalisation
Master's Thesis 2007:21

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Abstract

The general decline of fish stocks in the North Sea has been observed, and efforts have been made by managers to combat this, they have however been unsuccessful. This thesis aimed to evaluate the resilience of the ecosystem, the effectiveness of management, and make recommendations as to how management could be improved. By doing so, the ecosystem services provided by the North Sea can be retained.

A qualitative literature review was used as a research method for this thesis. The North Sea is a well studied region, however, there is a lack of corroboration between epistemic knowledge communities, studying the ecosystem. A bridge between the literature bodies was required so as to amalgamate and reinterpret existing knowledge. This thesis aims to provide this function.

It was found that the problems affecting the North Sea ecosystem are more multifarious and complex than the problems which are managed for. The narrow focus of management has enabled the resilience of the ecosystem to be eroded significantly over time. When environmental drivers became more prominent, the ability of the ecosystem to buffer against change has not been strong enough. This has led to the regime shift that seems to be occurring at the moment.

Two outcomes seem likely for the future, fish stocks that are commonly found in the ecosystem, such as cod, could recover, or invasive species, such as the snake pipefish, could become more prominent and extensive. The third possibility of no fish is discounted because of the probable continuation of climate change and sea temperature increases, which will lead to northerly migration of fishes. Yet it must be borne in mind that the level of uncertainty surrounding both the data concerning stock sizes and the effect of the combination of systemic drivers means that all predictions must be qualified.

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Acronyms

CFP – Common Fisheries Policy

EU – European Union

FAO – UN Food and Agricultural Organisation

ICES – International Council for the Exploration of the Seas

MPA – Marine Protected Area

NFSC – Northeast Fisheries Science Center

SSB – Spawning Stock Biomass

TAC – Total Allowable Catch

Introduction

1.1 Introduction and Problem Statement

During the 20th century and into the 21st, fisheries across the globe have been characterised as largely being under stress. Changes affected by the advent of the Industrial Revolution, and subsequent developments have led to a global population explosion, an increase in dispensable income, and improvements in fishing technology which have enabled more fish to be caught for an ever-expanding market. Evidence of this is that, 25% of important fisheries are currently overfished (Walker and Salt, 2006) and at least 24% of Western fisheries have collapsed in the last 50 years (Mullon et al, 2005). Fish provide 2.6 billion people with at least 20% of their annual protein intake, with 93.8 million tonnes of fish being caught in 2006. Moreover, the industry represents an important contribution to many economies worldwide (UN Food and Agricultural Organisation (FAO), 2006).

Research on the North Sea fishery is important because it is an ecosystem that provides many ecosystem services to surrounding populations, and its productivity is threatened by multiple drivers, mainly overfishing and environmental/climatic factors (Cook et al, 1997; Drinkwater, 2005; Kell et al, 2005; Horwood et al, 2006; Planque and Frédou, 1999; Rindorf and Lewy, 2006). How this combination of systemic drivers is affecting the ecosystem is analysed alongside the role of management, and these two strata represent the main body of research in this paper. If fisheries continue to be exploited and managed in the 21st century as they have been in the 20th century, then their existence and constancy will come under increased threat, and more stock collapses would seem inevitable (Hutchings and Myers, 1994; Mercer, 2006; Roberts et al, 2005). This research paper hopes to aid the development of the North Sea fishery as a sustainable consumer of ecosystem services.

1.2 Research Aims

This paper has 3 main overlapping aims. Firstly, to reach an understanding of how the resilience of the North Sea ecosystem has changed over time. This will only focus on the 20th century, and predominantly on the latter part, because of the lack of data for bygone eras. Secondly,

the management of the ecosystem will evaluated. All areas of sea more that 12 miles/19 km from the coastline and responsibility for these is under the joint jurisdiction of the EU Council of Ministers and Norway (here on referred to merely as the EU), so this paper will analyse the effectiveness of their strategies and management plans. Finally, suggestions will be made relating to how management could build resilience. Provided the ecosystem is in a desirable state, then how can this be maintained and strengthened. These aims have led me to my research question; the resilience of the North Sea: how it has changed and the impact of management upon it.

1.3 Case Study Background

The North Sea is a marine ecosystem situated between Britain, Continental Europe and Norway (see fig 1, section IV). As a non-isolated marine system, species and resources are mobile, moving in and out of the system. Therefore, species will be able to react to changes in the ecosystem habitat relatively quickly, because they are generally mobile enough to migrate into other, neighbouring systems. There are 202 species and 81 families of marine organisms within the North Sea, which is shallower than 200m aside from a deep trench of 700m off the coast of Norway (Fishbase, 2007) (fig.2). The state of the North Sea ecosystem will be analysed through the lens of resilience theory. Existing research by organisations such as the EU and the ICES will be combined with scientific research on the ecosystem as a whole, species within the ecosystem and systemic drivers. While this method is imperfect because of its reliance upon secondary sources that do not always perfectly marry the needs of this paper, the volume of literature and resources used helps to increase the reliability and usefulness of this approach.

As with most ecosystems, changes to the North Sea are not only caused by what happens within the system itself. Rather, exogenous and endogenous drivers affecting other regions and ecosystems, for example carbon emissions and population increase in the UK, can have a cascade effect upon the North Sea (Elmqvist et al, 2003). The North Sea is by no means unique in being affected by changes in other ecosystems, however, it must be borne in mind that ecosystems change in relation to things that happen around them, and not merely because of what happens within them.

Ecosystems are complex, adaptive systems characterised by historical dependency, non-linear dynamics, and multiple basins of attraction (Levin, 1999). The North Sea is a complex adaptive system with emergent phenomenon arising from interactions between its parts (Naeslund, 2006). The system as a whole, and how it reacts to systemic drivers, is different to the sum of its

parts. Therefore, understanding how each individual species reacts to stresses and drivers will not inform us of the overall impact upon the ecosystem. It will provide us with a picture, however, this will be incomplete.

1.4 Ecosystem Services

The North Sea provides people living in and around its waters with many ecosystem services, which are here defined as the combined actions of the species in an ecosystem that perform functions of value to society, such as flood control and water purification (Walker and Salt, 2006). Marine ecosystems in general provide humans with a number of ecosystem services, the most important of which are food, biodiversity, nutrient cycling, atmospheric and climatic regulation and employment (Millennium Ecosystem Assessment, chapter 18, table 18.2, 2005), and the North Sea is symptomatic of this. Fish within the North Sea provide ecosystem services such as food, biodiversity and employment for people, however, the ability for cod to continue to do this is under threat, as their mortality levels increase and the spawning population decreases (Cook et al, 1997; Horwood et al, 2006; Longhurst, 2006)

From a human perspective, ecosystem services are a vitally important by-product of species interaction. Natural ecosystems, such as the North Sea, perform life-support services, without which humans would be unable to blossom. However, these are not always traded in economic markets (for example the value of biodiversity or pollination), they have no price tags which fluctuate in relation to their supply and demand (Daily et al, 1997). Hence, the economic value provided by the biodiversity within the North Sea is unknown, unmeasured and in all probability unmeasurable to any degree of pecuniary accuracy. Therefore, the value of preserving biodiversity and strengthening resilience within the North Sea shall not be understood here, merely in economic terms. Rather, more latent social benefits that contribute to the long-term sustainable usage of ecosystem services will also be incorporated (Adger, 2006; Daily et al, 2000; Elmqvist et al, 2003).

1.5 Motivation

The North Sea was chosen as my case study area because it is a well studied region, with much primary data accessed from the EU, the UN Food and Agricultural Organisation (FAO) and International Council for the Exploration of the Seas (ICES), relating to changes in the distribution, recruitment, mortality rates, and Spawning Stock Biomass (SSB) of important fish stocks within the

ecosystem. Alongside this data is a large body of secondary literature that mirrors the primary data, but also elucidates the reaction of fish populations to climatic change, overfishing and other systemic drivers.

While this data and literature is dense, it is also generally concerned with single species, rather than the ecosystem as a whole. In response to this, changes to cod within the North Sea will often be used as an exemplar of the ecosystem as a whole in this paper. Cod were chosen as they are a vitally important commercial fish stock and they were found to be the best studied species (Drinkwater, 2005). Unfortunately, changes to the cod population will not necessarily mirror changes in the ecosystem as a whole. For example, sea temperature warming may well increase the cod population while at the same time eroding the resilience of the North Sea ecosystem as a whole. However, these disparities will be highlighted when they arise.

Another motivation for this study is that the fishing industry is an important part of British culture and society, with 20,000 people employed directly in the industry as fishermen, and countless others relying on the industry in a more indirect sense (Guardian Unlimited, 2002). Protecting ecosystems and the environment as a whole has become an important political issue in Britain. But at the same time, protecting jobs and “traditional” industries, by which I mean primary production industries, has become politically sensitive since the Thatcher era and the mass closure of coal mines which created widespread social deprivation in the affected areas. Therefore, the North Sea is symptomatic of the need for governments to balance environmental sustainability with job protection and social vulnerability.

Given that the “Tragedy of the Commons” is a widely accepted outcome from commonly pooled resources with a lack of usage regulation, management of fishery ecosystems should strive to avoid the problem of resource over-usage (Dietz et al, 2003). My research aims were motivated by the fact that fisheries across the world have failed to preserve their resources, as exemplified by the statistics in section 1.1, and the application of resilience theory provides an original mode of management that has hitherto been untried in EU managed waters. Through an evaluation of the North Sea's resilience and its management it is hoped that meaningful improvements can be garnered as to how to improve the health of the ecosystem and build resilience, thereby managing the “Tragedy of the Commons.”

The North Sea is an excellent example of a mismanaged fishery that has yet to collapse, and

this mismanagement has been recognised by the EU fisheries department, who have implemented a recovery plan to rebuild endangered fish stocks there, and in 2001 adopted emergency measures to help the recovery of the cod stock. The resilience of the ecosystem has been eroded by consistently setting too high a quota or Total Allowable Catch (TAC), whose quantities have been based upon a political negotiation process rather than an ecological one (Cooper, 1999). However, there is only so much the EU can do while its management is based upon statistically measurable tools. Resilience theory encourages a more flexible and adaptive management process, that is not solely dependent upon such tools (Folke et al, 2005; Folke, 2006; Walker and Salt, 2006). Themes such as integrated and overlapping governance, stakeholder dialogue, and social capital are not present in the EU rhetoric, and so there is much scope for highlighting the differences between current management practices, and those encouraged by resilience theory.

In order to explain the managerial failure of the North Sea, Weber's bureaucratic nightmare, the “Iron Cage of Rationality,” and Granovetter's theory of embeddedness are applied so that a sociological perspective can elucidate the organisational failings of the EU. The motivation for this, is that resilience theory is particularly weak at explaining the social aspects that influence the ability for an ecosystem to absorb disturbances, so a more social approach was required as a complement. Weber argues that the rationalisation and bureaucratisation of society have led to the prevalence of rule-based control, which appears to be reflected in the management of the North Sea (Weber, 1947; Weber, 2001). This can thus be juxtaposed with resilience theory, for which rule-based control alone is insufficient in many cases to successfully preserve the functions of an ecosystem. Moreover, Granovetter argues that individuals and organisations are embedded in social networks and ongoing social relationships, and this constrains them from behaving in a rational way (Granovetter, 1985; Granovetter, 1995). The TAC process can certainly be characterised as irrational, and Granovetter helps to elucidate the social factors that facilitate its continuance. The motivation for incorporating these themes is that in order to fully evaluate the mismanagement of the North Sea resilience theory alone is insufficient, and Weber and Granovetter are able to plug a void.

1.6 Management Background

The North Sea is governed by the UN Law of the Sea Convention (1982), the UN Fish Stocks Agreement (1995), as well as rules set by the EU's Common Fisheries Policy (CFP). Fish

populations with EU waters are seen as “common property” and a “resource” which need 'rules to prevent overfishing by some to the detriment of all' (EU). These rules are set by the EU after dialogue and negotiations between the EU fisheries minister and the fishery ministers of each member state, with the advice of scientists being incorporated into the decision-making process (Cooper, 1999; Gray and Hatchard, 2003; Valatin, 2000). The involvement of stakeholders, such as fishermen, within the deliberative process is the prerogative of individual member states, and they tend to have differing approaches.

The “Tragedy of the Commons” is understood as a threat to jobs, ecosystems and fish populations (Dietz et al, 2003). In order to mitigate the associated problems, managerial regulation through rules and quotas is seen as the solution by the EU. Regulations are top-down bureaucratic measures, such as quotas (TAC), fines, restrictions on mesh size, moratoriums, and limits on the number of days per month trawlers are allowed out at sea. These are then enforced by a combination of member state policing and EU inspections. The EU uses top-down regulatory mechanisms to maintain the North Sea ecosystem in a perceived optimal state, in which fishing is plentiful and continuous. However, from a resilience perspective, this process fails to effectively manage the natural variability and flux that characterise complex adaptive systems, which can lead to regime shifts, because the focus is on maintaining fish stock supplies rather than aiding the capacity of the ecosystem to absorb systemic stresses (Longhurst, 2006; Walker and Salt, 2006).

1.7 Limitations of the Study

This study is limited primarily by the uncertainty over data that affects all fishery research, associated with gauging stock size, these problems are amplified (more so for mortality rates than SSB) when stocks are low, variable survey indices exist and catch data is inaccurate (Horwood et al, 2006). In this paper, no original primary data has been collected, so a reliance upon other literature and data has been fostered. While this research has been collated and compared, in order to generate accuracy and reduce uncertainty, data concerning sea temperature changes, fish population sizes, rates of recruitment, and the level of illegal fishing, can never be completely certain. Moreover, by integrating research relating to the impact of overfishing upon the North Sea ecosystem and fish populations, alongside the impacts of sea temperature changes further fuels the uncertainty of my results and conclusions. Responses to drivers within marine complex adaptive systems is characterised by non-linearity, which further increases the uncertainty of the results produced by

this study, however, by escaping single-species and single-driver studies and instead relying upon merely existent data this uncertainty is not further increased (Elmqvist et al, 2003; Naeslund, 2006).

In this paper, cod have been chosen as an individual species to exemplify some of the changes that have affected the North Sea ecosystem as a whole, as opposed to assaying every species within the ecosystem. This is because the latter would produce results that were too complex and incongruous to be meaningful, as different species have reacted differently to overfishing, for example. By using cod as an exemplar of change, albeit an imperfect one as discussed in section 1.5, consistent inferences can be made for the system as a whole, which could not be made were each species analysed. However, this study is limited by the fact that only one species has been chosen to exemplify the ecosystem as a whole, and this research would be improved by selecting three species and then contrasting the disparities between their responses to ecosystem changes.

When analysing the impact of climatic factors upon the North Sea, this study focuses upon sea temperature change, rather than significantly incorporating atmospheric and precipitation patterns, oceanic circulation changes, and wind field analyses. The reasons for this are two-fold. There is a relative lack of research in this area that ties in with impacts upon fisheries and marine ecosystems, and so without conducting original primary research a lack of detail would be present which would inhibit strong linkages from being developed. Moreover, the issue of space is apparent, and there are only so many drivers that can be discussed in detail within this paper. Sea temperature change and overfishing have been identified as the key drivers, and while this is not certain, in that the cascade effect driven by an increase in carbon dioxide emissions could become the most important factor afflicting the ecosystem, they are the most important drivers at the moment. Hence, while one of the aims of this is to have a more holistic analysis of the drivers of North Sea ecosystem change, not all systemic drivers could be looked at in requisite detail.

Theoretical Framework

2.1 Literature Summary

The majority of work written on the North Sea ecosystem and its management tends to be species-specific as opposed to analysing the ecosystem as a whole, this is done to reduce uncertainty and increase the credibility of conclusions and results. Within the literature unanimity exists concerning the decline in the North Sea cod population, and that there is a longevity to this problem, which has contributed to changes in the ecosystem as a whole. The EU funds ICES research, and uses their data, which indicates that the SSB has declined from a peak of 275,000 tonnes in 1971 to a historic low of 53,000 tonnes in 2006 (ICES, 2007). The recommended SSB for a healthy North Sea cod population is 150,000 tonnes, and below 70,000 tonnes the productivity of the stock is considered to be impaired (Horwood et al, 2006) (fig.3), these two figures are estimated under the auspices of the precautionary principle that is applied by the ICES for gauging whether a fish stock is within its 'safe biological limits.' The principles guiding this data are mirrored within the secondary literature, in which the decline of the cod stock is regarded as a serious problem which will lead to the stock collapsing were it to go unchecked.

Disparities within the literature exist as to the causes of this stock decline. Two main bodies of literature exist, one attributes blame to overfishing and the other to climatic factors. There is minimal overlap in the literature concerning these two systemic drivers, and bridges are required to create a more developed understanding of how and why the ecosystem has changed. Overfishing was seen as the key driver behind the reduction in the fish population of the North Sea by the 1997 Cook et al article, which borrowed from work by Hutchings and Myers on the collapse of the Newfoundland cod fishery, off the coast of Nova Scotia in Canada, in 1992. The work by Myers, Hutchings and Cook et al are used as references by much of the literature concerning the impact of overfishing upon the North Sea ecosystem, however, literature relating to the impact of climatic factors is predominantly exempted.

Poor and weak management is seen as the key factor behind overfishing, however, the EU fisheries policy reform of 2002 has created disjunctures over its effectiveness for helping ecosystem and species recovery (Adams et al, 2003; Cooper, 1999; Gray and Hatchard, 2003; Kelly and Codling, 2006; Mercer, 2006; Valatin, 2000). The question of when and if a stock collapse will

occur in the North Sea is not agreed upon, indeed a timeframe for collapse is not suggested because of the uncertainty of marine population dynamics. The collapse of the Newfoundland fishery off the coast, which is understood as having been caused by overfishing, is seen as a forewarning for the North Sea.

More uncertainty exists within the body of literature concerning the causes of climatic factors that have affected the North Sea and the impacts these have had. For example, sea temperature increase is both seen as having a positive or negative affect on the cod stock depending on the author of the study. The complex interaction between climatic fluctuations, wind pattern changes, phytoplankton blooming and sea temperatures is riddled with uncertainty. However, what is agreed upon is that an increase in phytoplankton leads to an increase in fish populations. The importance of sea temperature change and climatic factors in influencing the distribution of fish has been championed by Drinkwater, who has inferred from data on past warming periods what could happen within the North Sea and the Atlantic. Drinkwater, Horwood et al, Rose, Planque and Frédou, and Beaugrand et al all reference each other and create an epistemic knowledge community that is separate from the body of literature relating to overfishing.

2.2 The Role of this Thesis

This paper contributes to the field by synthesising these two bodies of literature. Some writers argue that the level of uncertainty surrounding any research on marine populations is so high that by maintaining a narrow focus, more accurate results can be uncovered. While there is certainly merit to this opinion, amalgamating what has already been written can reveal synergies that were previously hidden. The aim of acknowledging the level of uncertainty with this broader perspective is to guard against too concrete results being drawn, while still arguing for the benefits of bridging the gaps between the existing body of literature.

By bridging the literature concerning overfishing and that relating to climatic factors under a theoretical framework (resilience theory), that has largely not been applied to the North Sea, this thesis adds a new dimension to the existing body of research. Resilience theory can be used as an analytical tool for ecosystems that are undergoing change caused by systemic drivers. In the case of fisheries, Newfoundland demonstrates that thresholds can be breached and that these ecosystems have alternate states that can be entered after a regime shift. After the 1992 stock collapse, the Canadian government issued a moratorium on fishing in the area, and to this day cod stocks have

yet to replenish themselves (BBC, 2006; Guardian, 2006; Myers et al, 1996). In the case of the North Sea, the stresses upon the ecosystem may not be the same, but they do exude some similar characteristics, most notably levels of fishing which were regarded as excessive by scientists which were allowed to go unchecked. Where the North Sea differs is that the EU have changed their management strategy in response to suggestions by the ICES, albeit without implementing the recommended complete ban on fishing.

2.3 How this Thesis Can Improve Management

By acknowledging that some ecosystems provide services that do not have market values, but which are essential for human well-being and prosperity, the perspective of management can be changed (Daily et al, 2000). When the importance of these latent benefits becomes clearer, management can become more purposeful. Resilience theory can play an important part in making management more effective because there is a clear theoretical understanding of why regime shifts occur, how thresholds are breached, and how to avoid these two scenarios. One of the research aims of this paper is to suggest improvements to the current management framework, and it is argued here that by utilising concepts such as ecosystem services, regime shifts, and thresholds ameliorations can be made.

Embracing the concept of alternate ecosystem states, as resilience theory does, enables management to be directed toward either maintaining an ecosystem in a desirable state or driving an ecosystem from an undesirable state to a desirable one. The North Sea is currently in an uncertain state characterised by flux, in which the fishing industry is still prominent despite ever-decreasing quotas and SSBs, and ecosystem services such as food and employment are still provided. Therefore, management should be geared toward improving this ecosystem state by building resilience through encouraging both response diversity and biological diversity (Elmqvist et al, 2003) and preserving ecosystem feedbacks, while at the same time avoiding an alternative ecosystem state in which fish are not abundant (Folke, 2006). This thesis aims to critically reflect and improve upon North Sea ecosystem management by incorporating resilience theory alongside the work of Weber and Granovetter. Thereby evaluating what has been beneficial and problematic with the management regime, and advocating certain improvements.

Resilience theory allows ameliorations to the management process to be suggested, by providing a framework within which the ability for an ecosystem to maintain and reorganise itself

within a desirable state is put to the forefront. However, resilience theory is inadequate for critiquing managerial institutions themselves. Where are management thresholds? How does management reorganise itself? In order to critique the institutional failings within the EU management framework, the theories of Weber and Granovetter are used. Both theories critique the failures of individuals, institutions, and organisations in reaching their goals. The role of the EU is to maintain and increase fish stocks within the North Sea, however, it has failed in meeting this end. Bureaucratic inefficiencies and the inhibitive effect of constricted social networks have contributed to this managerial failure (Gray and Hatchard, 2003). This thesis aims to create an understanding of the reasons behind the institutional failing within the EU and fuse this with resilience theory to make conjectures as to how a sustainable fisheries programme can exist within the North Sea.

2.4 Definition of Key Concepts

Resilience: 'the amount of change a system can undergo (its capacity to absorb disturbance) and remain within the same regime-essentially retaining the same functions, structure, and feedbacks' (Walker and Salt, 2006).

Driver: 'any natural or human-induced factor that directly or indirectly cause a change in an ecosystem'. Endogenous drivers, such as increased affluence, overfishing and improvements in fishing technology, coupled with exogenous drivers like climate change, changes in wind direction, changes in phytoplankton blooming cycles and pollution have depleted North Sea stocks, thereby impacting upon present and future ecosystem services and functions (Nelson, 2005).

Collapse: 'a sustained period of very low catch values occurring after a period of high catch values' (Cooke, 1984). Stock collapse tends to occur once critical depensation has been reached, which is when a population biomass has reached such a low level that it is unable to sustain itself and replenish (Mullon et al, 2005).

Regime shift: 'when a social-ecological system crosses a threshold into an alternate regime of that system' (Walker and Salt, 2006). An example of this concept is a lake ecosystem, which has the potential to exist in alternate states such as a freshwater lake or a eutrophied lake, depending on the quantity of phosphates within the ecosystem. If the amount of phosphate goes beyond or below a certain level then a threshold is crossed and the ecosystem enters an alternate state.

Recruitment: 'the amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area. For example, the number of fish that grow to become vulnerable to the fishing gear in one year would be the recruitment to the fishable population that year' (Northeast Fisheries Science Center, 2007).

Embeddedness theory relates to how behaviour and institutions are shaped by social interactions. The premise is that people do not think and act in isolation, instead a complex web of interactivity drives, inhibits and directs behaviour, based loosely upon social networks. Much economic and political theory has underestimated the role that social ties play in shaping pattern of interaction, assuming that interactions are far more rational than they actually are. Granovetter argues that by acknowledging the role of social structure and social relations within economics, individuals will not be seen as atomised. Atomisation enables perfect economic markets to function because no information inequities exist between individuals, however, this is not how the real world works (Granovetter, 1985).

Embeddedness is understood as an initial preventer of certain patterns of social networking and interaction, however, once a social process begins then individuals become sufficiently “socialised”, so as to nullify its problems. Thus, if fishermen have been excluded from the decision-making process for a long-time, the initial step of creating new, functioning social networks is the most difficult to take (Granovetter, 1995). Embeddedness increases social capital between ingroup members, but decrease it with outgroup members, thus if greater dialogue and consensus is to be reached between stakeholder groups, they must become embedded within one another. Granovetter's theory enables a stronger critique of managerial failures, because the inequity of social interaction between stakeholder groups is one of the most pronounced differences within the North Sea management framework. By understanding and correcting some of the institutional failures, this paper aims to provide stronger recommendations as to how management can be improved.

Methodology

3.1 Methodology

In order to understand how the resilience of the North Sea has changed over time, to evaluate the management of the ecosystem and to make suggestions for how management can build resilience, my epistemological background has been rooted in social constructivism. The management process is based around social interactions between stakeholders, with values and norms informing the decision-making process. Social constructivism provides a perspective which acknowledges the importance of cultural relativism and the fundamentally social nature of knowledge production. Social constructs are embedded in culture, and this in turn influences the style of management of the North Sea ecosystem (Smith, 2006).

Qualitative research has informed the methodology of this paper. This approach has been utilised because it is an exploratory approach that is not reliant upon positivist science. Marine ecosystems are characterised by high levels of uncertainty, so inferring broad conclusions based upon statistics alone is unhelpful (Horwood et al, 2006). By utilising literature that relies upon both quantitative and qualitative research, and then amalgamating the results under a qualitative framework enables a more reliable discussion of the ecosystem and its management.

The critique of management pursued in this paper is solely qualitative because of the social nature of the decision-making process. In order to understand the managerial failures, the social process involved in value-formation must be analysed. A statistically-based quantitative research method was unused as it is too based upon empirical observation. The large amount of existing quantitative research, conducted by the EU, the ICES and independent scientific research, was felt to be sufficient in itself. So as to effectively understand how the resilience of the North Sea ecosystem has changed over time, and what effect management has had upon resilience, a qualitative perspective has been preferred as it enables greater flexibility and social critique, which is felt to be more appropriate for understanding these dynamics. By integrating existing quantitative research concerning population dynamics and fish distribution within the North Sea, alongside a qualitative critique of the management process enables this paper to more effectively understand the processes driving the state and resilience of the ecosystem.

3.2 Presentation of Data Sources

The primary data for this paper comes from two main sources, the EU and the ICES, both of whom provide analyses of fish stocks in the North Sea. The EU data is detailed, and its statistics focus on the TAC. Within this, the waters of the EU are divided up into 12 regions and 36 subsections, the North Sea is one region with three subsections, and for each subsection an annual quota for each species is set for each member state's fishing fleet. For example in section IV, the North Sea, French fishermen are allowed to catch 3799 tonnes of haddock in 2007 (EU, 2007). Moreover, the EU data contains the size of the fishing fleets of each member state. This data is useful because it is area-specific and supposedly accurate, because of the presence of EU and member state inspectors.

The ICES is a Danish marine research organisation that provides scientific advice on aquatic ecosystems in the North Sea, the North Atlantic and the Barents Sea. Assessments of North Sea cod are undertaken annually by the organisation. The EU uses much of their data concerning population sizes and the SSB of certain species, such as cod, and funds much of their research. In ascertaining whether a given fish population is within 'safe biological limits' the precautionary principle is applied, this means that where there are threats of serious or irreversible damage, lack of scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation' (ICES). The ICES is granted no power to govern over the North Sea ecosystem, however, it makes suggestions to the EU as to how management can be improved and adapted, on the basis of its scientific research. Using the ICES data is vital because it is a highly trusted organisation, as is shown by the fact that much of their data is analysed by the EU and incorporated in their decision-making process. Moreover, as it is an independent scientific organisation, it has an interest in maintaining objectivity for its credibility.

Within the secondary (academic) literature rendered from journals and books, there were two main bodies of work that related to the North Sea ecosystem, alongside another body critiquing the management of the ecosystem. The literature discussing the ecosystem can be divided along lines of systemic drivers, which on one hand discuss the impact of overfishing upon the ecosystem and specific species within it, and on the other discuss the effects of climatic changes. The overfishing literature derives its ideas about thresholds being breached and stock collapse from work by Hutchings and Myers on the 1992 collapse of the Newfoundland fishery, which they have

attributed to unrestricted overfishing. This influenced the work of Cook et al, who in a 1997 paper argued that if the level of fishing effort stayed constant, a collapse of the cod stock was inevitable. These writers are consistently referenced within the overfishing strata of literature, and form the base from which other work has spawned.

The importance of climatic factors upon the ecosystem has two strands, the most significant of which relates to the impact of sea temperature change upon the ecosystem and the species within it. The 1934 paper by Sæmundsson documenting sea temperature increases in the North Atlantic and the subsequent changes in species inhabiting these northerly waters, has generated an acceptance within this knowledge community that anthropogenic climate change, derived from carbon dioxide emissions, will have profound effects upon marine ecosystems. This work actuated that writers such as Drinkwater and Rose who have since hypothesised the impacts of climate change in the present day, with reference to the work of Sæmundsson. A smaller strand of literature relates to the impact of wind field changes upon the ecosystem, because of the effect on phytoplankton blooming. Heath et al and Beaugrand et al have discussed the complex interactions between atmospheric changes and the subsequent effect on fish stocks, with reductions in the quantity of plankton being understood as a serious bottom-up threat to fish species and the health of marine ecosystems.

No original, primary data was researched for this paper, because the plethora of information already available was adequate for answering my research aims. Research on the North Sea is funded by grants from the EU, and universities in Great Britain and Norway. These states and the EU have vested economic interests in the preservation of the ecosystem services provided by the area. Moreover, the North Sea is one of three main marine ecosystems that the ICES focuses on in its research. As so much raw data was available for analysis, conducting original primary investigations was not where research was best suited. Rather, an amalgamation of what has already been written seemed more appropriate, so that an innovative perspective could be added, thereby making existing research more valuable in preserving ecosystem services and building resilience. Given that it is already acknowledged within the research community that fish stocks in the North Sea are in decline, and the reasons for this have been narrowed down to a band of drivers that change the ecosystem habitat. Research was thus better geared toward generating an understanding of how the ecosystem has changed in response to these systemic drivers, and how these changes have been managed.

3.3 Critical Reflection of Methods

The qualitative approach used in this thesis, involving a literature review and an application of resilience theory and sociological studies by Weber and Granovetter limited this study because of the lack of interviews performed. Interviews would have enabled a greater understanding of the views and desires of stakeholders, some of whom are largely ignored by the literature and in the decision-making process, and others whose voices are represented within institutions rather than as individuals. Personal testimonies provide individual perspectives that could have improved this qualitative research by enhancing the material and information base from which results have been drawn (Booth et al, 2003).

Interviewing fishermen may have provided new and different insights into the failures of management than contained in the literature reviewed. Moreover, solutions to these problems could have been garnered that this thesis has failed to grasp. As well as fishermen, interviewing scientists and managers could have elucidated the difference between the managerial recommendations provided by scientists, and the decisions taken by managers. A greater understanding of the social aspects of the decision-making process could have come about through this process, which could have strengthened or changed the critique provided by this thesis.

Had a more quantitative focus and statistical analysis been pursued in this thesis, the foundations for this thesis may have been more certain, in a positivist sense. Rather than merely using quantitative research within a qualitative study, a more quantitatively based thesis may have generated more concrete results, in the sense of statistical falsifiability, which would have relied less on an interpretation of the social aspects of management and how this has impacted upon the ecosystem. Moreover, a quantitative analysis that combines the impact of both overfishing and climatic factors upon the SSB of North Sea stocks would generate results that are not found within the literature, and despite the uncertainty that would surround these results, would create new stock estimates from which the management critique could be drawn. This thesis is instead reliant upon the work carried out by other scientists studying the North Sea. However, the accuracy of these results is improved by corroboration with other literature, and from the wide array of sources used for understanding the ecosystem and its management. Moreover, the qualitative approach utilised does favour an interpretative social approach, which is felt to be more appropriate for understanding the social dynamics at play in the management of ecosystems.

3.4 Critical Reflection of Data Sources

The accuracy of the data provided by the EU is brought into question because no accurate information exists for the scale of illegal fishing or the quantity of non-declared catches, the amount of fish caught which have exceeded a trawler's quota, and so have to be thrown back into the sea. Since 2004 the ICES have incorporated their estimates of non-declared catches into their assessments of stock sizes, while this may have improved their accuracy the figures remain uncertain. No data exists on the amount of illegal fishing, which by its very nature is hard to quantify, yet it has been estimated that 40% of the British annual catch is illegal (BBC, 1997). Despite problematic facets associated with the data supplied by the EU it is essential to use the data that management decisions are based upon, if this management process is to be effectively evaluated.

The ICES has 20 member countries as well as another 6 affiliates, so while it presents itself as an independent intergovernmental organisation its impartiality could be impinged upon by those member states is relies upon for funding. This dependence could lead to advice being given so as to appease funding nations, however, this does not seem to be the case as they have consistently argued for reductions in fishing pressure across their study areas and a moratorium on cod fishing in the North Sea, which is not favoured by the ICES member states.

In this paper, resilience theory has been suggested as an alternative basis for management, and the theory is used to evaluate the impacts of systemic drivers upon the ecosystem. However, much of the literature used does not incorporate the theory in its analysis, so the results of other studies have been analysed, corroborated and then infused with resilience theory. This is potentially problematic because the methodology behind some of this research is dissimilar to that used in this thesis, and results may have been skewed so as to suit resilience theory. However, the qualitative approach used in this paper allows for a more exploratory use of data, which negates some of these problems. The diversity of sources referenced in this paper enables inferences based upon research using a different methodology. Articles can corroborate each other no matter their methodology or theoretical framework, it is just the mode in which results are found that differ.

News agencies were also used as a data source for this paper, and in order to maintain their credibility impartiality is an important facet of their work. However, the agencies sourced are all

British-based, because of the linguistic issues presented by using foreign sources. This could create imbalances because their news agenda is likely to be driven by nationalistic priorities, and are more likely to focus on how British interests are affected by events in the North Sea. While these sources are likely to be British-centric, Britain is the most populous nation bordering the North Sea, and British fleets are given the largest TAC, which gives tenability to the use of these sources.

Problematically, the data sources researched for this paper were inadequate to the extent that they failed to provide personal testimonies from fishermen and other lower-end stakeholders. Only news agencies provided information regarding the plight of fishermen, and so their preferences have been inferred. This could have been combated by interviewing stakeholders, however, the focus of this paper has been upon bridging the available literature rather than generating primary data. The literature tends to centre upon the ecosystem, scientists and managers, which leaves gaps around less powerful and influential stakeholders. However, this lack of research upon fishermen reflects their lack of influence in the decision-making process, and focussing upon them would not reflect the reality of their diminished role.

3.5 Methods Used to Find Data and Literature

In order to find data produced and used by the EU, the organisation's website www.europa.eu was used. Each department within the organisation is subdivided within the website, and in the fisheries subsection data can be freely accessed. Here, the aim of the CFP, and the reasons behind its creation, are clearly outlined alongside details of how to manage a common resource. The TAC map, with each member state's quotas for each fish species in each area of EU waters was the first port of call. It has a visual representation of Western Europe, in which the North Sea is labelled as Sections IVa/b/c. Thus the total tonnage of each fish species that can legally be caught per year by the fishing fleet of each member state was researched.

Within the EU fisheries department website archives, further research on the North Sea ecosystem can be found by either using the Search function and typing in key terminology or by manually surfing the site, clicking hotlinks within articles of interest and going on a knowledge thread. By entering keywords such as North Sea, cod, management, Norway, Great Britain, ICES, TAC, CFP, a combination of these keywords and by searching within the results produced by initial searches provided significant data. These keywords were chosen because of their relevance to the subject matter and case study area, and this was borne out by the results of these searches. Articles,

past and present management policies, graphs and charts relating to fishing mortality, recruitment and SSB, speeches, recovery plans and council regulations were all found. Alongside, the EU data, the ICES website was utilised as a corroboratory source. The ICES website has a specific section dedicated to the status of the North Sea, their action plan, and their advice on how to managed fish stocks. This is coupled with a search engine through which past documents, charts, statistics and information can be accessed by using keywords.

Search engines, databases and article catalogues were accessed through the Stockholm University library website, www.sub.su.se, so as to find articles written on the subject area. Fishbase was used to get specific statistical information concerning the North Sea, and the databases Libris and Web of Science were used as portals to academic journals. Typing the keywords mentioned above into these databases produces a list of literature that uses these keywords, which can then be sorted in terms of their relevancy, their recentness, and by the surname of the main author. These databases amalgamate articles that are written in academic journals, such as *fisheries research* or *nature*, so once a relevant article is found through a database, it links to the main journal which acts as a host. Journals were then searched using the same keywords that were employed for the EU archives and the databases listed, so as to ensure that potentially relevant literature were not exempted. Thus, the journals *Science*, *Fisheries Research*, *ICES Journal of Marine Science* were found to be a rich source of literature in the field of North Sea research.

Once a body of literature had been accumulated, bibliographies were scanned, and articles that were repeatedly referenced or had titles that related to the specifics of North Sea ecosystem change, resilience and management were then sourced from the relevant journal. This enabled epistemic knowledge communities to be uncovered, as bodies of literature cross-reference similar articles. Thus, collections of articles relating to specific systemic drivers could be developed and amalgamated, so as to generate a more complete understanding of their effects.

Internet search engines www.google.com and www.yahoo.com were used for finding websites, images and information that related to my case study. NGOs and study groups, such as the FISHINFONetwork and Greenpeace, were thus sourced, from which additional material relating to the ecosystem and its management could be accrued. Moreover, www.wikipedia.org was used as an encyclopaedic reference, providing information regarding the North Sea, trawling, the EU, and depensation. The Guardian, the BBC and the Independent are three British media outlets whose

websites were also scanned for news stories relating to the North Sea, thus providing alternative information sources relating to the case study. The already specified keywords were searched for within their archives to generate articles of interest.

3.6 Methodology Matrix

Base References	Category of Information	
EU Documents	CFP	
	Council Regulations	
	Recovery Plans	
	Speeches	
	TAC Data	
ICES Documents	Population Data	
	Scientific Advice	

Database Searches	Keywords	Identified Literature
Fishbase	North Sea	Population Data, Spawning Seasons and Species Information
Libris	North Sea, cod, fish, phytoplankton, ecosystem, management, TAC, CFP	Beaugrand et al, 2003. Cook et al, 1997. Hall and Mainprize, 2004. Kjesbu et al, 1996. Mercer, 2006. Mullon et al, 2005. Myers et al, 1996. Rose, 2005. Valatin, 2000.
Web of Science	North Sea, cod, fish, phytoplankton, ecosystem, management, TAC, CFP	Christensen et al, 2003. Cooper, 1999. Drinkwater, 2005. Drinkwater, 2006. Heath et al, 1999. Horwood et al, 2006 Kelly and Codling, 2006. Longhurst, 2006. Planque and Frédou, 1999.

Results

4.1.1 Overfishing

Since the 1970s the resilience of the North Sea ecosystem has undoubtedly been eroded by anthropogenic factors because the ability for the ecosystem to continue to absorb systemic stresses is under threat (Beaugrand et al, 2003; Christensen et al, 2003; Clark et al, 2003; Cook et al, 1997; Cooper, 1999; Drinkwater, 2005; Horwood et al, 2006; Hutchings, 1996; Kelly and Codling, 2006; Mercer, 2006; Planque and Frédou, 1999; Rindorf and Lewy, 2006; Rose, 2005). High mortality rates and poor levels of recruitment have meant that the SSB of fish stocks such as hake and cod have plunged to such an extent that the population biomass may no longer be able to sustain itself i.e critical depensation is a serious threat (EU, 2006; ICES, 2006). However, fish stocks such as haddock are healthy and abundant, therefore management has been species-specific rather than taking an ecosystem-based approach. At the same time, a sharp increase in the number of invasive species such as snake pipefish and octopus has been observed (Guardian Unlimited, 2006). These factors indicate that a regime shift is either approaching or is currently underway as the character of the ecosystem is fundamentally changing (Drinkwater, 2006).

Essentially, the basic structure and function of the North Sea is changing, and the fact that the ecosystem is supporting different forms of life in different proportions to only 30 years ago suggests that new emergent properties will come about through new interactions within this complex adaptive system (Naestrom, 2006). As the stock size of fish such as cod decreases their schools become concentrated in smaller areas, simultaneously, new invasive species provide alternative competition for phytoplankton and other food sources. Therefore if fishing pressure is not reduced then the chances of survival for “indigenous species” are further reduced (Mercer, 2006).

In 1997, 96% of cod recruits aged 1 died before reaching age 4 (Cook et al, 1997). This high mortality rate not only impairs the chances of the current generation of fish to survive, but also future generations. Cod are able to live until age 25, and as they age they lay more eggs, which are larger and more buoyant, this is a three-pronged incentive for reducing their mortality rates, because having more older fish will lead to having more new recruits (Kjesbu et al, 1996 and Longhurst,

2006) (fig.4). Since 2001, the EU has reduced cod quotas from 48,600 tonnes to 23,200 tonnes in 2006 (EU, 2007). The mortality rate has fallen from the dramatic figure in 1997 to 65% in 2006, which indicates that management of the fish stocks has managed to decrease the amount of fishing, however, the SSB of cod has continued to decline from approximately 75000 tonnes in 1997 to the current figure of 53000 tonnes (ICES, 2006). Which indicates a managerial failure that goes deeper than merely controlling mortality rates. The long-term effects of overfishing and high levels of mortality is borne out in the population of recruitments, which have fallen dramatically from 900 million in 1971 to just 90 million in 1996 (ICES, 2004). This drastic decline is symptomatic of a dramatic change in the character of an ecosystem's regime, whose resilience can be said to be eroded (Walker and Salt, 2006).

In the Newfoundland fishery collapse, high mortality rates were attributed as the sole cause of the stock crash (Myers et al, 1996). A subsequent 15 year moratorium has failed to allow the population to regenerate, because critical depensation has been reached and the SSB is too low to self-perpetuate (Mullon et al, 2005). Mullon argues that a stable level of catch over several years conceals the risk of a sudden collapse, because depleted stocks become congregated in ever-smaller areas which makes them more susceptible to overexploitation. Fish populations do not necessarily behave as they have done in the past, because the size of future populations is not related to linear and incremental changes (Walker and Salt, 2006). Rather, complex adaptive systems are characterised by non-linearity, which means that basing the annual TAC upon the success and quantity of the previous years catch is not ideal (Naeslund, 2006).

The nature of the TAC means that if ships exceed their catch quotas, or catch fish they were not permitted to catch, this excess must be thrown back into the sea as bycatch (Catchpole et al, 2005). In the North Sea, 71,000 tonnes of offal and 109,000 tonnes of discards are either consumed by seabirds or settle to the bottom and decompose. This has led to large increases in seabird populations and disrupts seabird communities (Kaufman and Dayton, 1997). Changes in food supplies and fluctuations in the populations of species are indicators of regime shift within ecosystems. The effect of the TAC has been to change seabird dynamics within the North Sea ecosystem. The quantity of discard from trawler fishing impacts upon interactions between parts of the ecosystem, and this increases the potential for a threshold being breached. If unchecked, the changed population dynamics in the ecosystem that are brought about by trawler fishing will lead to a situation in which the food supply of higher trophic level fishes is taken away from them by a combination of fishing pressure and increased seabird competition (Christensen et al, 2003;

Elmqvist et al, 2003).

4.1.2 Managerial Responses to Overfishing

In 2002 following pressure from scientists the EU issued a Green Paper designed to improve the effectiveness and success of its management. The EU acknowledged that its CFP needed "re-thinking" so that ideas of conservation and sustainability became more focussed upon. The EU's stated aim was to promote sustainable fisheries and secure an economically viable and self-sufficient fisheries sector that has a long-term future (Gray and Hatchard, 2003; EU, 2002).

The EU identified fishing mortality rates as the key factor behind the decline of fish stocks. Too many fish were caught too young, thereby seriously hindering the renewal of fish stocks (Cook et al, 1997; Rose, 2005). In order to escape from this "spiral of decline" the EU argued that the continent's fishing fleet was too large for the amount of fish that should be caught. The ex-EU fisheries commissioner, Franz Fischler, suggested that the EU fishing fleet should be halved and that current subsidies should be redirected into compensation for scrapping vessels and providing social aid for fishermen (Guardian Unlimited). Shrinking economic returns in the fishing industry have perversely encouraged the industry to fish harder in order to maintain their levels of profit and catch. However, this not only increases the vulnerability of the ecosystem and the species within it, but also those employed within the industry (Adger, 2006). Between 1990 and 1997 employment in the catch sector (fishermen) went down by 19% and 10% in the processing industry (EU, 2002). Henceforth, the EU attempted to reduce fishing pressure, have greater involvement of stakeholders in the decision-making process, and create balanced marine ecosystems.

Alongside reducing the size of the fishing fleet, the EU implemented a wide-range of bureaucratic measures designed to reduce mortality rates. Since 2002 the EU has either frozen or reduced the TAC in the North Sea, in order to prevent exacerbation of the overfishing problem (EU, 2007). In 2004 the EU set a target level of 150,000 tonnes for the cod population, as recommended by the ICES, in a regulation that is binding for all member states. Rules implemented in 2003 concerning the mesh size used by fishing trawlers were designed with this target in mind. Vessels using equipment with minimum mesh size >100 mm were restricted to 9 days at sea per month, netters to 16 days, beam trawlers to 15 days, and the 70-99 mm sector to 25 days per month (Horwood et al, 2006). Linking mesh size to the number of days per month fishing trawlers are allowed out at sea, economically incentivises fishermen to use meshes that target their catch better.

This policy in turn is designed to reduce the number of younger, smaller fish caught and to reduce bycatch, thereby limiting the amount of fish thrown back into the sea. This would allow the population time to recover, thereby increasing biodiversity and encouraging redundancy (different ways of performing the same function within an ecosystem), thereby building the resilience of the ecosystem (Folke, 2006; Walker and Salt 2006).

The 2003 Green Paper also led to the EU making more of an effort to decrease the amount of undeclared catches, illegal fishing and trawlers exceeding their quotas by increasing the level of monitoring (BBC, 2007). Vessels fishing for endangered species such as cod that carry more than one tonne must inform the authorities of their member state the port at which they will dock, their estimated time of arrival and the quantity of fish on board at least 4 hours in advance of their arrival. Moreover, ships carrying more than two tonnes are only permitted to dock at pre-specified ports (EU, 2003). These measures are coupled with a policy that prevents endangered species such as cod being allowed to mix with other marine organisms, thus enabling the quantity of catch to be more accurately measured. These legislative measures are designed to ensure the TAC is not exceeded, however, the potential for corruption is not removed. While bribery of officials is merely a hypothetical situation it remains a possibility because of the economic gains that could be made. EU monitors roam ports and make unannounced visits to ensure that regulations are not flaunted, however, their presence is ephemeral and they too are not incorruptible. In order to ensure member states comply with EU rules on monitoring, the European Court of Justice is able hand out fines. In 2005, France was fined 20 million euros for failing to carry out systematic inspections of nets and the unloading of fish, in accordance with EU rules, which led to undersized fish being sold. Failure to comply with the EU rules would then lead to France being fined 57.8 million euros every six months (BBC, 2007).

4.1.3 Critique of EU Management

The fundamental dilemma highlighted in game theory is known as “the Tragedy of the Commons,” in which it is argued that resources which are freely accessible and not covered by private property rights will be overexploited unless an effective mode of management is agreed upon and enforced by resource users (Dietz et al, 2003). In order to decrease the probability of “tragedy” occurring, management should aim to create an environment in which resource users interact with one another in order to increase social capital and mutual trust through reciprocity,

idea exchange, rules, norms and sanctions (Pretty, 2003). Social interaction leads to connectedness within networks, and this social process fosters both horizontal and vertical integration between different levels of resource users and resource managers (Granovetter, 1985) (see fig.5 for diagram of management structure).

Dietz argues that dialogue between interested actors, within complex, redundant and layered institutions benefits the management process, however, Cooper states that this is not how the CFP operates. Social interaction between stakeholders in the North Sea is characterised by unevenness. At the lowest level are fishermen, between whom there is a distinct lack of horizontal collaboration (Cooper, 1999), no EU-wide fishery trade union exists, and neither do member states such as the UK have a trade union exclusively for fishermen or those operating within the fishing industry. Moreover, the role of fishermen in the decision-making process can be described as limit at best, as they are largely ignored by the EU, despite the 2002 CFP reforms (Gray and Hatchard, 2003). Instead, the responsibility for incorporating fishermen falls to fisheries ministers of member states, and disparities from country-to-country are marked, where the Netherlands' policy of high stakeholder involvement is identified as an exception rather than the rule (Guardian).

The lack of involvement of stakeholders at the lower end of the management scale can be better understood by applying Granovetter's theory of embeddedness. A distinct lack of institutions exist which foster social interaction between fishermen and ministers at the national and European level, which leads to no social networks being formed through which ideas can be exchanged (Cooper, 1999; Valatin, 2000). Without the formation of social networks, managers will have a limited scope of information, and decisions will be made based upon only what they know and hear, thus the desires of stakeholders who do not have social relationships with decision-makers will be ignored (Granovetter, 1985). Hence, the high levels of illegal fishing and quota excessions can be understood by the powerlessness and disinteractivity of fishermen.

In contrast to the plight of fishermen, scientists have a rather more prominent role in the management process, and are actively sought out and funded by the EU and member states. Their advice and expertise are seen as vital in understanding the changes afflicting the ecosystem, and the monitoring which they participate in is highly valued. Technical expertise are seen as a vital component for generating understanding of the ecosystem and the changes occurring to fish stocks (EU; ICES; Mercer, 2006). However, the focus of scientists tends to be upon single-species rather than the ecosystem as a whole because of the increased uncertainty that comes with analysing a

larger field of study.

As the CFP is a centralised, bureaucratic institution it should come as no surprise that the involvement of scientists is seen as a priority whereas fishermen are not. Weber argues that bureaucratic institutions tend towards technical, rule-based solutions based upon rational predictable outcomes (Weber, 1947). However, as complex adaptive systems behave in non-linear patterns, this may partly explain the failure of the CFP (Naeslund, 2006). All of the measures implemented by the EU for managing the ecosystem are statistically measurable rules. The TAC fishing quotas, mesh size, days per month at sea, designated docking sites, and reducing the size of the fleet are all top-down regulatory mechanisms of the sort that Weber suggests are favoured by bureaucratic institutions. The 2002 CFP reforms were designed to increase stakeholder participation and decentralise authority, however, Gray and Hatchard have argued that the EU only paid lip-service to these reforms, and that the reality of the top-down structure has not materially changed. It should be borne in mind that Grey and Hatchard critiqued the 2002 reforms only one year after their implementation, so their article would be more prescient had it given more time for changes to materialise, especially bearing in mind the 2003 Green Paper and 2004 recovery plan for cod and hake in the North Sea. However, as Weber has argued, centralised organisations tend toward rule-based control rather than decentralised management, and the EU fit this pattern (Bauman, 1989). Moreover, as Granovetter has suggested, social networks become embedded in patterns of behaviour that are determined by the social interactions that take place between their members (Granovetter, 1995). Without increased vertical collaboration, a decentralised decision-making process will be difficult to pursue (Hahn et al, 2006).

At the top level of management, strong horizontal collaboration exists (Cooper, 1999). Fishery ministers from each member state all meet together with the EU fisheries commissioner at least once a year to compile the annual TAC (EU). Moreover, these quotas are not settled merely on the basis of one meeting. Negotiations between national fisheries ministers are continuous and the collective bargaining process is based upon trade-offs that are made between states. There is a certain degree of “I'll scratch your back and you scratch mine” that culminates in the TAC. Cooper argues that the CFP is highly politicised, which leads to environmental concerns often being put on the backburner behind concerns over jobs and the need to reciprocate favours. Social relationships are seen as a key driver of the negotiation process, which in turn leads to environmentally irrational quotas being set. The EU has sought to reduce the effect of this by making management more decentralised, but as has already been stated, the success of this has been limited at best (EU, 2003;

Gray and Hatchard, 2003)).

Management of the North Sea is fraught with difficulties because different species are under threat to different degrees, and while the meshes used by trawlers can distinguish between different sized fish, they cannot distinguish species. A balance must be struck between protecting endangered species while enabling healthy stocks such as haddock to be fished (Horwood et al, 2006). The EU pursues a policy of protecting merely the endangered species rather than an ecosystem-based approach, the thinking behind this is that healthy fish stocks will result in balanced ecosystems which can sustainably be exploited. While there is merit to the thinking behind this policy its results indicate that the policy has been unsuccessful. The scale mismatch between the CFP and the problems it is designed to solve prevents success, and seems to be an ineffective institution for solving the problems of the North Sea (Cooper, 1999; Cumming et al, 2006). Rather than merely protecting certain species and exploiting others, a more holistic approach is required.

In 2001, the EU implemented a 10 week moratorium on fishing to gauge how speedily stocks would recover with no fishing. Unsurprisingly, given the short length of the policy, its success was negligible (Horwood et al, 2006). However, the idea of banning fishing in certain areas has proved successful elsewhere. Marine Protected Areas (MPAs) give fish stocks the opportunity to congregate and spawn in areas where they will be able to survive, which is especially important when their SSB is low (Roberts et al, 2005; Stefansson and Rosenberg, 2005). In order for MPAs to be effective, they must have two key characteristics, firstly, they must be off limits to all kinds of fishing, thus providing complete and permanent protection for the species within them (Roberts et al, 2005). In conjunction with this, MPAs must be large enough to ensure stock renewal (Stefansson and Rosenberg, 2005). Too many MPAs are either too poorly regulated or too small in size to achieve their aims, thus failing to aid the population recovery of a stock. However, if correctly applied they can provide a haven for endangered species while at the same time allowing fishing pressure to continue unabated in non-excluded zones.

The components of an ecosystem interact and create emergent properties that are not easily predicted (Elmqvist et al, 2003; Naeslund, 2006). In conjunction with this, stock collapses can occur suddenly in spite of reduced mortality rates, therefore increased vertical collaboration is required in order to prevent overexploitation, minimise illegal fishing, and increase social capital (Mullon et al, 2005; Ostrom, 1990). In order to do this, bridging organisations could be introduced so that a discursive forum in which ideas are exchanged and consensus is built, this concept will be

further discussed in the discussion section (Hahn et al, 2006).

4.2.1 Climatic and Environmental Factors

Climate change is recognised within the literature as a serious threat to the health of stock sizes within the North Sea. The effects of the post-1950 exponential increase in carbon dioxide emissions into the atmosphere are multifarious, and will impact upon marine ecosystems. The resultant increase in mean air temperatures leads to an increase in evaporation and precipitation, which in turn have led to changes in wind patters and oceanic hydrographic properties, however, the complexity of this non-linear but interlinked process means that cause and effect are skewed and hard to measure (Drinkwater, 2005). What is certain is that the mean bottom temperature of the North Sea is increasing, albeit by non-agreed upon figure, and this is affecting the ecosystem and its species in four ways (Clark et al, 2003; Drinkwater, 2005; Horwood et al, 2006; Planque and Frédou, 1999). The spatial distribution of many “indigenous” species is shifting northward, spawning sites are and may increasingly gravitate northward for certain species, invasive species are become more numerous and an increasingly common feature of the ecosystem, and the growth rates and speed of maturity of fish are increasing (Drinkwater, 2005; Rose, 2005; Rindorf and Lewy, 2006) (fig.6). All of these factors are profoundly affecting the composition of the North Sea, and further support the idea that a regime shift is either occurring or approaching (Cook et al, 1997; Drinkwater, 2006; Mercer, 2006).

Much of the scientific analysis concerning the effect of sea temperature warming upon the North Sea is derived from a severe warming period from roughly 1920-1940. The causes of this are poorly understood, but an increase in North Atlantic sea temperatures of 3-4ºC was observed (Sæmundsson, 1934). While this data applies to the North Atlantic strong inferences can be made with the North Sea because of the proximity of the two neighbouring waters and the similarity of fish species that inhabit both areas. During this warming period many colder water species such as cod expanded northward, while continuing to populate their more southerly grounds, and became abundant in new waters, most notably along the coast of Iceland where new fisheries were established, which were subsequently shut one the sea temperature fell during the 1940s (Drinkwater, 2006; Rose, 2005). Rindorf and Lewy have argued that since the late 1990s, cod have not only become less abundant in the North Sea, but their centre of distribution has also shifted northward, as a result of warmer winters accompanied by southerly winds during their egg and larval phases. As a result of this, juvenile cod are increasingly common in more northerly latitudes,

and tend to stay there for their lifetime, rather than migrating southward during cooler winters, thus new spawning sites become ensconced in the ecosystem and change its composition (Kjesbu et al, 1996; Rindorf and Lewy, 2006). However, it should be noted that not all species will be affected equally be changes in sea temperature, and this is often related to the depth at which they inhabit the sea. Halibut and other deepwater species are less affected by ecosystem changes, and can be understood as more resilient species, whereas cod and flounder are more sensitive to changes in temperature and phytoplankton availability (Rose, 2005).

Establishing new spawning sites for fish enables centres of distribution to significantly shift within a matter of generations. It is hypothesised that by 2100 the North Sea will have warmed to such an extent that the cod population will be negligible, and that around the northerly climbs of Greenland, Labrador, the Barents Sea and even along the Arctic continental shelf, cod will be far more common (Drinkwater, 2005). While this prediction is riddled with uncertainty, given the long time-lag between prediction and eventuality, it is emblematic of the changes observed by Sæmundsson and then extended to incorporate the further warming that is anticipated by 2100, thus providing some credibility.

While “indigenous” species such as cod, eelpouts and flounder are forced northward by their habitat becoming increasingly warm, invasive species became more frequent and numerous in the 1920s and 1930s, and are doing so again today (Rose, 2005). Sæmundsson noted an increase in the tuna population and this has been mirrored in the North Sea of late, where species as unusual as turtles have been found (Guardian Unlimited). As new species become established and carve out niches, the characteristics of an ecosystem alter and its resilience is eroded, as a threshold is approached (Walker and Salt, 2006). Drinkwater argues that the changes in the 1920s and 1930s constituted a “regime shift” because of the drastically altered ecosystem composition. The fact that the habitat supported different species, produced new ecosystem services (new fisheries), and had new predator/prey relationships constituted a regime shift. Given the changes currently occurring within the North Sea, it seems that a regime shift has not yet been completed. Fishing of traditional species continues, and thrives in the case of haddock, predator/prey relationships have not been radically distorted, but at the same time the sea is warming (ICES). Therefore, the system can be understood to be in an insecure state, one in which certain stocks of fish are still plentiful while others are in danger of collapsing and at the same time the proportion of invasive species is increasing.

While overfishing reduces the population of many fish species in the North Sea, and sea warming pushes cold-water fish northward and invasive species into the ecosystem, sea temperature increase has a paradoxical positive impact upon certain fish species, such as cod, which may aid their survival against the many threats to their existence (Rose, 2005). For every 2°C rise in in mean bottom temperature, the age of cod maturity decreases by approximately one year (Drinkwater, 2005). Moreover, where mean bottom temperature does not exceed 12°C, cod production usually increases with temperature (Dutil and Brander, 2003). Considering that the mean bottom temperature of the North Sea was 8.6°C in the period 1960-1992, there is certainly scope for sea warming to lead to higher recruitment levels for cod, which would thereby increase their SSB (Planque and Frédou, 1999). Unfortunately, the level of overfishing clouds the impact that sea temperature increases are having upon fish species, and it is feasible that without the accelerated levels of maturity brought about by sea warming the impact of overfishing would only be exacerbated further (Kjesbu et al, 1996; Mercer, 2006).

Modifications in wind patterns also have a profound impact upon the ecosystem, and are caused by wider environmental factors that are often hard to predict because of the non-linearity between the causes of change and the changes themselves. Plankton blooms, which provide a large proportion of the food supply for the entire ecosystem are affected by wind fields, and fluctuations in their quantity have a knock-on effect upon fish recruitment (Beaugrand et al, 2003). Cod recruitment has been in general decline since the early 1970s, which coincides with a steady abatement in the incidence of north-westerly winds (Heath et al, 1999). Heath argues that changes in wind fields have been coupled with changes in deep water circulation, which has reduced the significance of the Spring invasion of phytoplankton, thus providing a smaller food supply for fish, which has translated itself in declining levels of recruitment in fish such as cod. Again, the overarching importance of overfishing as a driver of change makes it difficult to fully comprehend the influence of a decline in plankton blooming upon fish stocks. However, this bottom-up driver of change, coupled with the top-down overfishing driver could have been working in tandem to severely reduce the SSB of fish stock. Moreover, in the last 5 years, the TAC has consistently been reduced and yet the SSB has continued to decline, albeit at a slower rate, which is indicative of other drivers of change, such as wind fields and plankton blooming, also afflicting North Sea fish stocks (Beaugrand et al, 2003; EU, 2007).

4.2.2 Management of Climatic and Environmental Drivers

The current EU management mantra is to reduce fishing mortality within the North Sea, thus solving the problems caused by overfishing (EU, 2003). The EU has recognised that fisheries within its waters are overfished, and this has left many stocks outside 'safe biological limits,' and so in order to get out of a 'spiral of decline,' measures were introduced to further reduce the quantity of fish caught, to target fish better so as to reduce bycatch, and to increase the monitoring of trawlers to ensure the legality of their catch. However, environmental drivers and the impacts they have are completely exempted from the EU literature and their management programme. Carbon dioxide emissions, wind field changes, and plankton blooming may not be controllable my the EU fisheries commission, but their impacts can be discussed, recognised and managed (Drinkwater, 2005; Heath et al, 1999). Currently, these drivers are either ignored or not understood, while the EU focuses on managing those facets of the ecosystem which it can directly affect, most notably the TAC.

In monitoring the North Sea, the ICES noted that during the fourth quarter of 2006 was unusually warm, with temperatures ranging 9-12ºC in December. However, they do not discuss the impact that a prolonged warming phase could have upon the ecosystem, merely just noting that the change occurs. The ICES have had a policy since 2001 of recommending a significant decrease in fishing pressure within the North Sea, and a complete ban on cod fishing to ensure that the SSB does not remain below 70,000 tonnes. Yet, the EU have been unable and unwilling to implement this because of the economic and social costs that would no doubt follow such a measure (BBC; EU). The unpredictability of the impact of climatic drivers, especially when coupled with overfishing makes management an unenviable and difficult task (Horwood et al, 2006). Having to balance the short-term needs of the fishing industry and those employed within it against the long-term requisites of the ecosystem is problematic, especially when the future impacts upon the ecosystem are debatable. However, the lack of a strategy used by the EU in relation to climatic drivers seems risible. While changes to the management of overfishing have been implemented they have not been an unmitigated success, consequently, the ignorance of climatic factors should not continue if management is to succeed in its goals of reducing fishing mortality and renewing fish stocks (Catchpole et al, 2005; Cooper, 1999; Gray and Hatchard, 2003; Kelly and Codling, 2006).

4.3 Bridging the Divide

Within the literature, two distinct epistemic knowledge communities have been formed, these relate to overfishing and environmental drivers. Referencing of other literature tends to be

exclusively from the same sphere of research, and the lack of overlap between the two prevents a more complex understanding of the reasons for ecosystem change being formed. Overfishing, sea temperature variation and changes in wind direction all have a profound impact upon the ecosystem, and potentially will have a detrimental effect on fish stocks. Therefore, the literature in this field needs to become less embedded within specific fields of knowledge.

The impact that overfishing has on certain stocks in the North Sea is well understood, and from research on Newfoundland there is knowledge about alternate ecosystem states (Hutchings and Myers, 1994; Myers et al, 1996). However, these two ecosystems are not perfect parallels, and research from Newfoundland cannot be directly transposed onto the North Sea. Within the North Sea, climatic drivers do have an impact upon stock sizes and the long-term sustainability of fishing for species such as cod and hake (Clark et al, 2003; Drinkwater, 2005; Horwood et al, 2006; Rose, 2005). Moreover, there is a history of climatic variation in the North Atlantic and North Sea which, in the past, have led to profound changes in the characteristics of ecosystems and the distribution of fish stocks (Sæmundsson, 1934). However, in order to fully understand the impact that exogenous drivers like climatic changes will have upon the ecosystem, the effect of endogenous drivers such as overfishing must be critically evaluated. Without this collaboration, research on the ecosystem is further riddled with uncertainty. For example, a reductionist piece of research on the impact of a reduced TAC upon the cod population of the North Sea may well hypothesise that this will lead to an increase in the SSB of the fish stock. However, if climate change research indicates that sea temperatures in the North Sea will rise by 4ºC in the next five years, then the research on TAC reductions will be rendered useless, as a regime shift will almost certainly occur leading to a revamp in the fish species occupying the North Sea and a northward migration of the cod population.

The lack of overlap and collaboration within these two spheres of research is only compounded by the EU, who fail to manage or discuss the impact of climatic variation upon the North Sea. The EU does fund ICES research on the North Sea, and this includes studies into changes in wind fields, which affect phytoplankton blooming, however, this research is not subsequently connected to the body of work relating to overfishing. For management to be more effective, corroboration between the combined impact of climatic factors and overfishing upon the ecosystem is required. It is argued that combining these two strands of research leads to too much uncertainty over the results produced (Rindorf and Lewy, 2006; Rose, 2005), however, more uncertainty is surely garnered by isolating these drivers, because the impact of overfishing upon the

ecosystem could be completely overridden by climatic factors and vice versa.

4.4 Results Matrix

Source	Species	Ecosystem Perspective	Temperature	Wind / Phytoplankton	Overfishing
Beaugrand et al, 2004	Many	Yes	Yes	Yes	No
Catchpole et al, 2005	Many	Yes	No	No	Yes
Christensen et al, 2003	Many	No	No	No	Yes
Clark et al, 2003	Cod	No	Yes	No	No
Cook et al, 1997	Cod	No	No	No	Yes
Cook, 1998	Cod	No	No	No	Yes
Drinkwater, 2005	Cod	Yes	Yes	Yes	No
Drinkwater, 2006	Many	Yes	Yes	Yes	No
Heath et al, 1999	Plankton	Yes	No	Yes	No
Horwood et al, 2006	Cod	Yes	Yes	No	Yes
Hutchings and Myers, 1994	Cod	Yes	No	No	Yes
Kell et al, 2005	Cod	No	Yes	No	No
Kjesbu et al, 1996	Cod	No	Yes	No	No
Mercer, 2006	Many	Yes	Yes	Yes	Yes
Myers et al, 1997	Cod	No	No	No	Yes
Perry et al, 2005	Many	Yes	Yes	No	No
Planque and Frédou, 1999	Cod	No	Yes	No	No
Rindorf and Lewy, 1999	Cod	Yes	Yes	Yes	No

Roberts et al, 2005	Many	Yes	No	No	Yes
Rose, 2005	Many	Yes	Yes	No	No
Stefansson and Rosenberg, 2005	Many	Yes	No	No	Yes

Discussion

5.1 Review of Problem Statement and Research Questions

The increased stress that fisheries have been placed under globally, as a result of societal changes rooted in the Industrial Revolution, threatens the ability of marine ecosystems to provide humans with ecosystem services, such as food, biodiversity and employment (Walker and Salt, 2006). In the North Sea, a consequence of an increase in fish consumption, mortality rates, and a changing habitat, is that the ecosystem is increasingly unable to provide these ecosystem services (Cook et al, 1997). In response to this, the management of the ecosystem has sought to protect it from over-usage so as to foster long-term sustainable exploitation (EU, 2003). However, the aims of management have not been able to stem the tide of ecosystem change; an increase in the frequency of invasive species, rising sea temperatures, changes in the blooming cycles of phytoplankton, and the impact of long-term overfishing have led to changes in the interactions between the parts of the ecosystem, which in turn have eroded resilience (Beaugrand et al, 2003; Drinkwater, 2005; Heath et al, 1999; Guardian; Rindorf and Lewy, 2006).

Management has been unable to counter these systemic drivers because too limited a scope has been pursued. The preference for using tools such as the TAC, mesh size regulation and inspections fails to counter the overarching problems caused by climatic factors (Lequesne, 2000; Valatin, 2000). As Weber argues, bureaucratic organisations utilise rational and predictable, rule-based tools in order to implement change. These ideals are rooted in the Enlightenment mentality, in which knowledge derived by science is the only means of uncovering facts. Hence, the use of the ICES and scientists and the absence of fishermen are lower level stakeholders, in the decision-making process, must be understood within this sphere of rationality (Bauman, 1989; Weber, 2001).

The failings of the EU managerial philosophy must be seen through the prism of the capitalist economic system. The mandate of the EU is to promote economic growth within its borders my removing barriers to trade and movement, increasing efficiency, and promoting interconnectivity between states, the corporate sector and citizens (EU). Weberian theory states that bureaucracies operate in a disciplined and unemotional manner, in which goals are pursued in a

systematic, calculated and predictive manner (Weber, 1947). The underlying principle for this is instrumental rationality; where clear goals are set and then pursued in the most efficient possible manner, utilising rule-based tools. In line with Weberianism, the EU seeks to manage the North Sea ecosystem by only controlling clearly measurable variables. However, because the effects of systemic drivers in complex adaptive systems manifest themselves in non-linear results, the effectiveness of management driven by instrumental rationality is limited (Bauman, 1989). To manage unpredictable ecosystems, which are imperfectly understood, management needs to be based upon looser principles. This is not to say that rule-based management is useless, rather, that it must operate within a framework that does not assume that ecosystems can be controlled. Ecosystems adapt and change over time, attempting to manage for stasis is futile because disturbances will always occur, be they anthropogenic or environmental (Elmqvist, 2003; Folke, 2006; Walker and Salt, 2006). Therefore, applying ideals rooted in resilience theory, namely that management should be geared toward enabling ecosystems to absorb shocks and disturbances, would help the EU to achieve their aim of creating sustainable fisheries and securing employment in the industry.

The EU management process has also been inhibited by the decision-making process itself, which is embedded in social networks, thus making the aims of management subservient to social relationships. Social interaction is framed within institutional patterns of behaviour centred around TAC negotiations. These meetings and discussions are exclusive, in that the ministers meet without the presence of fishermen and lower-end stakeholders. Thus this type of institutional organisation leads to embedded patterns of behaviour, fostered by ritualised interactions. Which in turn frames the rhetoric of discussion within narrow bands, that exclude the opinions of some of the stakeholders using the North Sea. The separation of stakeholders fails to build social capital, and a lack of bridging organisations further distances different stakeholder groups (Granovetter, 1985; Granovetter, 1995; Pretty, 2003).

The social aspect of EU negotiations prevents purely rational outcomes, which in turn leads to instrumental rationality being imperfectly implemented. Goals of sustainability are set within the CFP framework, however, the need to negotiate the TAC between strongly horizontally integrated stakeholders leads to a collective bargaining process in which irrationalities occur, which skew the aim of fostering a sustainable fishing industry (Cooper, 1999). This organisational failing is heightened by social networks failing to sponsor vertically integrated collaboration, which is necessary for the problem of overfishing to be effectively countered (Ostrom, 1990; Pretty, 2003).

Merely legislating for change, without incorporating those needed to implement change in the decision-making process has been a key failing of the management of the North Sea. However, this failing is aided by the lack of institutions fostering organisation between low-end stakeholders. The lack of an EU-wide fishermen trade union or a discussion forum has prevented their voice from being heard. Greater collaboration between these stakeholders would enable greater interaction with the EU, thus enabling the management process to become less embedded within a small social network comprised of officials and ministers (Hahn et al, 2006).

5.2 The Role that Social Capital (Doesn't) Play

Social capital helps to explain how people come together for their collective benefit using relationships and networks to develop bonds. Mutual trust helps to enable actors to work for not only private benefit but also for collective benefit. Trust that reciprocal relationships can be developed and enforced through rules and institutions means that networks can become more interconnected, with further horizontal and vertical collaboration coming as a result of this. Trust helps to prevent the “Tragedy of the Commons” by preventing resource over-usage through institutionalised reciprocity, tightened information feedbacks between stakeholders, and dissuasion of self-interest and greed, which aids self-regulation of common property (Dietz et al, 2003; Pretty, 2003).

The lack of vertical collaboration is symptomatic of and exemplifies the lack of social capital between the stakeholders of the North Sea. Illegal fishing, in terms of exceeding quotas and catching undersized fish, continues to occur within EU waters and this can be partially explained in terms of a lack of social interconnectedness between stakeholder groups (BBC, 2007; Payne, 2000). In order to get stakeholders working together for the long-term benefit of the ecosystems, forums in which interaction and trust-building can take place are required (Pretty, 2003).

Hahn argues that bridging organisations lead to collective preference formation and better collaboration because they enable greater consensus between stakeholders, than is provided by top-down bureaucratic rule-based regulations. By creating an institutionalised sphere of interaction, more stakeholders become a proactive part of the process of management, rather than just being affected by the decisions of managers (Ostrom, 1990). Increased trust has been acknowledged as a product of stakeholder participation, this encourages greater respect for rules and fosters resource self-regulation. Moreover, dialogue leads to greater knowledge generation and knowledge sharing

between stakeholders, which can better inform management decisions (Hahn et al, 2006). As has been discussed, the embeddedness of stakeholders within social networks can lead to irrational decision-making. If stakeholders share knowledge and better understand each others views and positions, then a more rational and inclusive decision-making process is likely to be the outcome. However, a lack of social interaction and social capital inhibits this process from occurring.

5.3 Post-Normal Science and the Management of Ecosystems

The North Sea ecosystem is characterised by high systemic uncertainty and the man side by high decision stakes. High uncertainty exists around stock sizes (Horwood et al, 2006; Rose, 2005), and where ecosystem thresholds are, and high decision stakes are exemplified by the collapse of the Newfoundland fishery (Cook et al, 1997; Mullon et al, 2005; Myers et al, 1996). Funtowicz and Ravetz argue that where facts are uncertain, values in dispute, stakes high and decisions urgent, post-normal science should be invoked, these characteristics are readily identifiable within the North Sea management discourse.

Post-normal science is a problem-solving strategy, which is useful in situations where decision-makers have imperfect information and urgent action need to be taken. A dialogue among stakeholders is advocated, regardless of their expertise, so that “extended facts” can be brought to the process. This democratisation of science is designed to overcome the problems of uncertainty and underline the fact that knowledge is a social product (Funtowicz and Ravetz, 1992). Through this process, social capital is likely to increase and the irrationality of embeddedness may be overcome as it enables the development and spread of social networks, through which new epistemic knowledge communities can emerge.

In order for “extended peer communities” to emerge, bridging organisations are emblematic of the arenas that are necessary for such a discursive approach to function. If expertise are to be democratised, then a physical space in which dialogue to take place is necessary, this does not currently exist, and considering the number of stakeholders involved in the North Sea and the distance between them, many difficulties can be seen (Folke et al, 2005; Hahn et al, 2006). The impracticalities of every fisherman, scientist and bureaucrat meeting are self-evident, so this paper advocates a pyramid system of organisation, in which many knowledge communities exist at the bottom level and these congregate toward a lesser number at the top. The top of the pyramid is already in place, however, it is weakly supported, so greater vertical collaboration is necessary

between fishermen, scientists and bureaucrats, and more horizontal collaboration is required between fishermen and scientists. Bridging organisations which operate specifically for the purpose of linking stakeholder groups would serve the purpose of nullifying some of the problems of scale between stakeholders that inhibit knowledge feedbacks (Adams et al, 2003; Hall and Mainprize, 2004).

An additional way of fostering greater collaboration, social capital and self-regulation is through an approach advocated by Ostrom. Currently, the monitoring of fishermen is conducted by the EU and by member states, however, Ostrom argues that monitoring should be overseen by resource extractors or at least accountable to them, as this empowers those whose interests are most affected by resource over-usage. Giving greater control of the management of an ecosystem to its users would enable long-term sustainability to become a greater priority, instead of the current situation where a ban on fishing could be implemented by the EU with negligible discussion with those who would be directly affected. This in turn would reduce the incentives for illegal fishing and catching undersized fish, and lead to greater respect for the legislative process (Ostrom, 1990).

By interconnecting fishermen and monitoring, linkages between managers and resource users would emerge. Such linkages are evidently lacking in the current management process, and are not encouraged by top-down regulatory measures. A post-normal science based discursive approach operating within the framework of bridging organisations between stakeholder groups would acknowledge the inherent uncertainty surrounding the North Sea ecosystem, and move the management process away from its current trajectory (Funtowicz and Ravetz, 1992). By combining this approach with a monitoring programme that was accountable to fishermen, management would become disembedded from bureaucrat-based social networks and unbounded from the Weberian tragedy of rule-based rationality (Bauman, 1989; Ostrom, 1990; Weber, 1947). The problem with allowing fishermen to control the monitoring process is that there are currently a lack of institutions lack interlink them across nations. In order for greater responsibility to be given to fishermen, an organisational framework would have to be in place that prevented corruption and ensured that effective monitoring was carried out. Therefore, it is likely that monitoring undertaken by fishermen would best be utilised as complementary to the existing monitoring undertaken by member states and the EU. This process would provide checks and balances upon each party, thereby inhibiting corruption and encouraging further dialogue between the parties.

Moreover, the mix of languages spoken by fishermen presents a problem, because although

the majority of resource users in the North Sea are British or Scandinavian, any fleet registered with a member state is entitled to fish there if the annual TAC provides for them. However, this is a surmountable problem as within the pyramidal organisational structure previously suggested, local stakeholder groups could communicate in indigenous languages and bridging organisations could also provide the function of communicating across these barriers. Presumably because of the location of the North Sea, English would emerge as the overarching language, and this is understood by most of the resource users.

5.4 Climatic Drivers

While the strength of the impact of climatic factors upon the North Sea ecosystem is debatable, it is undeniable that sea temperature changes and wind variation do have an effect, and have the potential to devastate the ecosystem (Heath et al, 1999; Horwood et al, 2006; Mercer, 2006). However, preventing an increase in sea temperature and ensuring that phytoplankton blooming remains constant are not immediately remediable. The first step in enabling the ecosystem to handle these wider environmental changes is to acknowledge the fact that there is a threat, but the EU has yet to begin managing for these problems.

5.5 Visions for the Future

In addition to strengthening linkages between and within stakeholder groups, empowering fishermen by handing over the responsibility of monitoring to them, introducing large MPAs, and the creation of national and Europe-wide fishermen trade unions, three further recommendations will be made for improving the management of the North Sea ecosystem. Firstly, more focus needs to be given to the temporal aspect of fishing. At the moment, regulations focus upon the number of days per month fishing is allowed to take place, this leads to continuous fishing because the days fleets are out at sea are merely spread over the course of the month. A more effective strategy for increasing the SSB of fish stocks would be to control fishing in relation to spawning seasons, thus reducing the mortality rate of spawning fish and increasing the population of new recruits. Instead of merely focussing on reducing the mortality rates of endangered species, allowing spawning to take place without interference would likely aid stock replenishment. This strategy would likely increase unemployment within the industry as the fishing season would become more condensed and competitive, however, as the ex-EU fishery minister has acknowledged, the industry is already oversized and the fleet should be shrunk to enable sustainable fisheries to exist.

Cod, haddock, whiting, plaice and herring are 5 of the 7 most fished species in the North Sea (EU TAC, 2007). Were fishing to be restricted between the months of January and May, the spawning cycles of these species would be far less interrupted, and would enable higher levels of recruitment as well as a reduction in mortality rates. In the North Sea, cod spawn from December through May, haddock spawn from March through June, whiting spawn from January through September, plaice spawn from January through June, and herring spawn from January through April (Fishbase, 2007). Therefore, as significant overlap exists between the spawning seasons of the most commercially important species in the North Sea, it seems sensible to limit further the days per month fishing is allowed during the early part of the year compared to the latter months.

A modification of the TAC is also necessary to ensure that the aims of management are more successfully reached. Currently, quotas are set for the fleets of each member state that relate to the quantity of each species caught in each area of sea. In 2007, the TAC for cod caught in the North Sea was 19,957 tonnes, of which 7773 tonnes were designated as British, whereas the TAC for haddock was 54,640 tonnes, of which 36466 tonnes was British. (EU, 2007). However, as the European Commission fisheries spokeswoman Mireille Thom states, it is not possible to catch an abundant fish such as haddock without catching cod as well, in spite of mesh size regulations (BBC, 2007). The problem of bycatch is inevitable because meshes cannot target specific fish species, however, the current TAC does not help matters. Moreover, the TAC further alienates fishermen as they have to throw back any excess catch, despite the fact that this does not actually aid the ecosystem or stock recovery (Catchpole et al, 2005). It is merely a punitive measure designed to limit fishing pressure, yet it is too rigid and fails to acknowledge that not all excess catch is intentional. A more progressive approach would be to allow limited overcatch, and if this is repeated too often then fines could be implemented. Self-regulation by fishermen needs to be fostered so that responsibility for the health and resilience of the ecosystem is in the hands of those who have the most vested interest in its sustainability yet also cause the most damage (Daily et al, 2000; Dietz et al, 2003; Pretty, 2003).

The TAC could be improved upon by not encouraging the fishing of targeted species, when current fishing technology is not developed enough to target specific species. The current mode of setting quotas fails to incorporate the fact that both the quantity of fish caught and the species caught are not entirely predictable (BBC, 2007). Thus, a system whereby fishing boats do not specify the type of catch, but merely the quantity would better reflect the kind of fishing that is

done. With fishermen in control of the monitoring process, knowledge feedbacks as to the type and quantity of catch would be much tighter, and would enable a more flexible system of fishing to emerge, that would not require annual fishing quotas. Without displacing top-down controls such as quotas, mesh regulations, and fines, which are still helpful in seeking to prevent ecosystem damage, so long as they are respected and adhered to. A more reflexive system of management that utilises the knowledge of resource users to better understand the changes afflicting an ecosystem would help quotas be set in relation to the current state of the ecosystem (Hall and Mainprize, 2004). Currently, the TAC fails to adapt to ecosystem changes in a short time period, quotas are set for a whole year, and this does not necessarily help to build the resilience of the ecosystem. A system whereby fishermen are able to cutback on fishing rapidly in response to the results of their own monitoring would help the ecosystem to absorb systemic disturbances, as anthropogenic drivers such as overfishing could be prevented from exacerbating environmental shocks, such as sea temperature increases.

The recommendations made here encourage a more interactive process of management, however, this should not be in sake of a top-down regulatory framework. These two fields must complement each other, rather than be seen as alternatives. The disparate nature and interests of stakeholder groups, as well as the huge distances between their locations inhibits the practicality of discursive-based management. The deliberative framework suggested within post-normal science and the critique of EU management provided here has a role to play in building social capital and social networks that will make top-down legislation more palatable, consensual and applicable (Funtowicz and Ravetz, 1992). Moreover, having tighter knowledge feedbacks will enable decision-makers to take more informed and accommodating choices (Walker and Salt, 2006). Yet problems of scale are likely to emerge when managing an ecosystem of such size and use, and having a highly decentralised managerial structure could inhibit far-sighted policies from being implemented (Cumming et al, 2006). Thus it is argued that deliberation and stakeholder involvement must fuse with bureaucratic top-down management. The EU is an institution with power and influence that has the ability to regulate and enforce its policies with fines and quotas, but this only functions to a certain extent, because without social capital the process is undermined. Consequently a delicate balance must be struck between devolution and centralisation, and this must become the focus of future CFP reforms.

5.6 A Resilient Ecosystem

For the ecosystem to settle into a resilient and desirable state, the effect of systemic drivers needs to be stemmed. A combination of a rule-based management structure designed to negate overfishing, whose principles are adhered to by resource users through improvements in dialogue and social capital must be combined with action geared toward alleviating the negative impacts of environmental drivers. An ecosystem approach to the management of fishing needs to incorporate both of these principles, rather than isolating single species whose stocks are in decline and trying to restore these alone.

Ecosystem resilience can be garnered by firstly raising the SSB of all stocks to a minimum level that is above that which the recruitment and productivity of stocks is not impaired, in the case of cod this is 70,000 tonnes (ICES, 2006). This thereby ensures that the biodiversity which is essential to a resilient ecosystem is not lost. Without biodiversity, ecosystems are more prone to collapse and regime shift as there are less parts of the ecosystem which can interact with one another, and the healthy functioning of an ecosystem is, in the long-run, dependent on this (Walker and Salt, 2006). Recognising the interconnectedness of the parts of the ecosystem enables policies that foster biodiversity maintenance and increase to flourish (Naestrom, 2006).

The adaptive capacity of the North Sea ecosystem can be strengthened by inhibiting the decline of its biomass and biodiversity. Therefore, for overfishing to be regulated and brought to sustainable levels, an ecosystem approach would have to strengthen the social relations within and between resource users and managers. Increased social interaction, through which commonly thought out and agreed upon policies are developed, is essential for coherent strategies (Pretty, 2003). However, this alone is not enough. Strong leadership that provides a vision which is shared by the stakeholders involved is also necessary for rules to be co-opted by resource users (Hahn et al, 2006). Centering the importance of biodiversity and biomass within this vision would enable an ecosystem approach to management to work toward maintaining and increasing the resilience of the ecosystem and its ability to absorb systemic disturbances. At the moment, environmental and anthropogenic drivers and shifting the ecosystem ever-closer to a threshold in which the species that inhabit the North Sea are vastly different to those that exist today (Christensen et al, 2003; Cook et al, 1997).

Conclusions

6.1 Summary of Findings and Conclusions

The North Sea ecosystem seems to currently be undergoing a regime shift, caused by a combination of overfishing and environmental factors. Fishing intensity increased from the 1950s onward and this eroded the resilience of the ecosystem, because it caused a reduction in biodiversity. As a result of overfishing, the ecosystem has been lesser able to effectively buffer environmental disturbances, namely sea temperature increase and wind field changes, and its ability to continue to do so in the future is impaired. The increase in sea temperature has led to changes in the species composition of the ecosystem with invasive species successfully finding niches, becoming more prevalent and increasingly permanent, but had the resilience of the ecosystem been strengthened, these species may not have been able to successfully invade the ecosystem (Folke, 2006; Guardian; Walker and Salt, 2006). Moreover, the increase in bird populations as a result of ever-increasing levels of bycatch is symptomatic of the regime shift that is currently occurring (Catchpole et al, 2005; Kaufman and Dayton, 1997). However, this regime shift will not necessarily mimic that of Newfoundland, much depends on the level of sea temperature increase, and the availability of phytoplankton (Drinkwater, 2006; Heath et al, 1999). If a significant food supply perpetuates the ecosystem could well thrive in a different regime, one in which warmer water fish are far more prevalent than today. Yet, if phytoplankton blooming declines dramatically, then the ability for fish stocks to replenish themselves could become permanently and even irreversibly damaged. It seems likely that the ecosystem will be comprised of different species (parts) in the future which will lead to different interactions and new and unpredictable emergent phenomenon (Naestrom, 2006).

Management of the ecosystem has failed to build resilience because for too long its focus was on protecting the profitability of the fishing industry and jobs within it rather than on building a sustainable industry (Gray and Hatchard, 2003). The TAC was a political process, informed by economics, rather than an ecological-minded one (Cooper, 1999). In spite of the reforms from 2002 onward, the ecosystem seems to be continuing to undergo a regime shift, however, if the reforms are implemented effectively the possibility exists that the regime shift can be reversed. The

alienation of fishermen from the decision-making process has increased the level of illegal fishing and bycatch, and this has also eroded the resilience of the ecosystem (BBC, 2007; Guardian, 2004). From 2002, the EU's stated aims have included greater co-operation and dialogue with fishermen, however, this has largely been merely a change in rhetoric rather than behaviour, consequently, the existing problems have continued unabated.

Managerial failures persist because of a failure to factor environmental drivers and their effects into plans for stock recovery. The EU policy of merely managing clearly measurable variables ignores the wider environmental changes that are affecting the ecosystem, and have caused a regime shift in the past, as exemplified by Sæmundsson. Therefore, if management is to succeed in preventing a regime shift and creating a sustainable fishing industry, then environmental drivers too must be managed for.

6.2 Summary of Recommendations

For management of the North Sea ecosystem to be improved, a more co-operative process must be implemented with increased liaising between stakeholder groups. A lack of vertical collaboration between stakeholders can be overcome with bridging organisations providing forums in which discussion could take place, thereby increasing levels of social capital and consensus over the decision-making process between stakeholders (Hahn et al, 2006). MPAs, changes to system of monitoring, gearing the fishing timetable around fish spawning seasons, the creation of an EU-wide fishermen trade union, tightening knowledge feedbacks, modifications to the TAC, and managing the ecosystem as a whole rather than single species are all alterations that are recommended for building ecosystem resilience (Hall and Mainprize, 2004; Ostrom, 1990; Roberts et al, 2005; Walker and Salt, 2006). Moreover, in order to manage for the impacts of environmental factors, managerial decisions cannot be so top-down and rigid. A more flexible system, rooted in a discursive process, is required for managing the inherent uncertainty surrounding the interconnectivity of systemic drivers within the North Sea (Dietz et al, 2003; Funtowicz and Ravetz, 1992; Pretty, 2003).

This critique of management has been rooted in post-normal science, Weberianism and the theory of embeddedness, however, it should be noted that these recommendations lead to a system of management very similar to that of adaptive co-management. Increased stakeholder involvement, forums for discussion and the building of social capital are mirrored in both theories (Folke et al,

2005). This adds to the validity of these conclusions, because whether management is critiqued from a sociological or ecological perspective, many of the solutions are the same .

6.3 Future Research

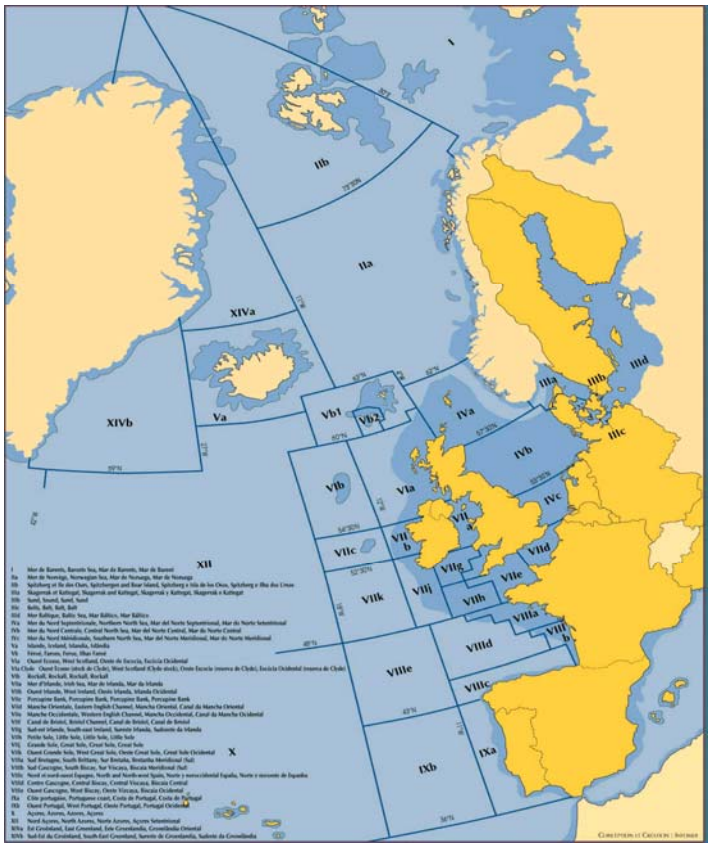
In order to extend and improve upon this study, interviews with stakeholders would provide an additional information source which would add to the critique of the management process and bestow greater validity and feasibility on the recommendations suggested. Interviews would enable greater understanding of the reasons for a lack of stakeholder dialogue, the level of illegal fishing, and the social aspects of the decision-making process. Moreover, the extent to which managerial problems are seen as being rooted in institutional failures could be investigated further by interviewing EU bureaucrats, whose arguments could be juxtaposed against those provided by scientists, fishermen and other stakeholders.

Further research could also be conducted to create new SSB estimates and fish population data with regard to the combination of environmental drivers and fishing pressure. Current data fails to sufficiently account for environmental factors, which in turn limits the effectiveness of management. Uncertainty surrounding the extent and effect of environmental factors and their relationship with fishing pressure is the key factor that prevents more holistic research. However, integrative research is required if greater data accuracy is to be achieved. Incorporating the impacts of more systemic drivers upon the ecosystem will lend greater cogency to the literature, and for this study to be extended, quantitative research that utilises this approach is needed.

Figures

Fig.1

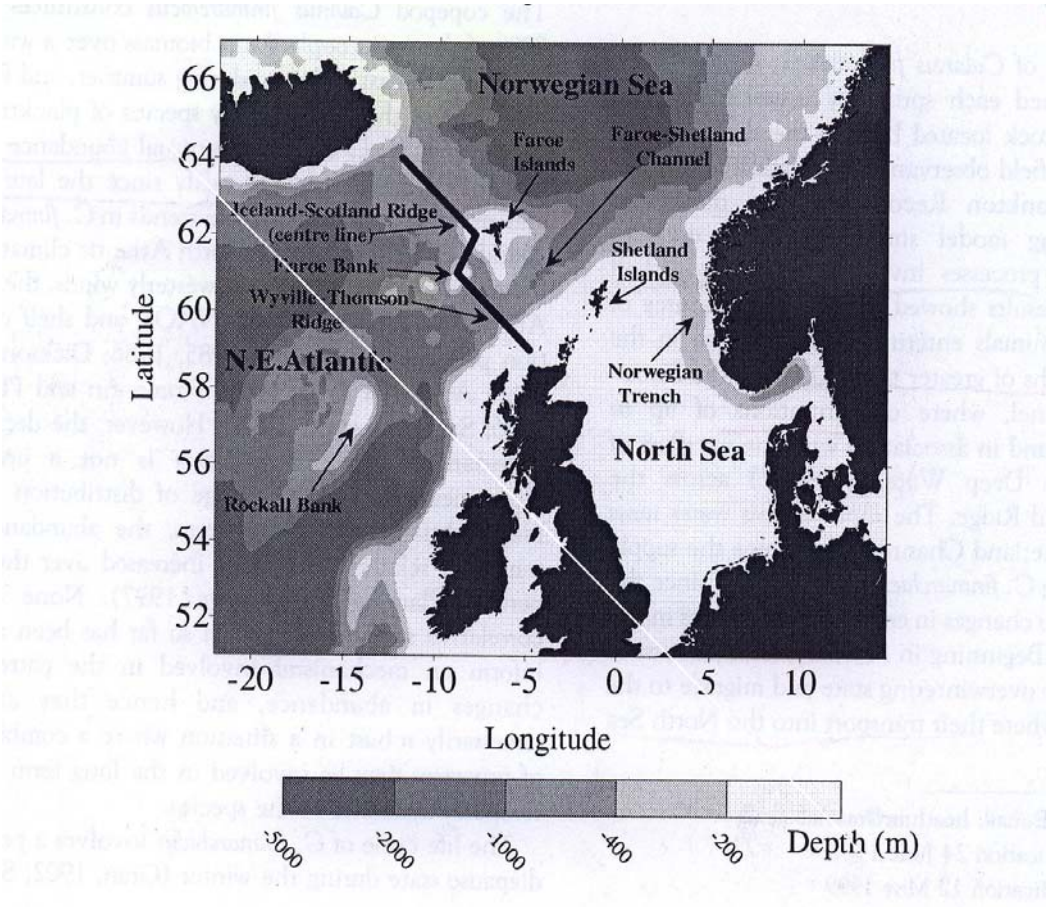
North Sea is labelled sections IVa, IVb, and IVc



Source: EU, 2007. Map of 2007 TACs and quotas

http://ec.europa.eu/fisheries/publications/maps_en.htm

Fig.2



Source: Heath et al, 1999

Fig.3

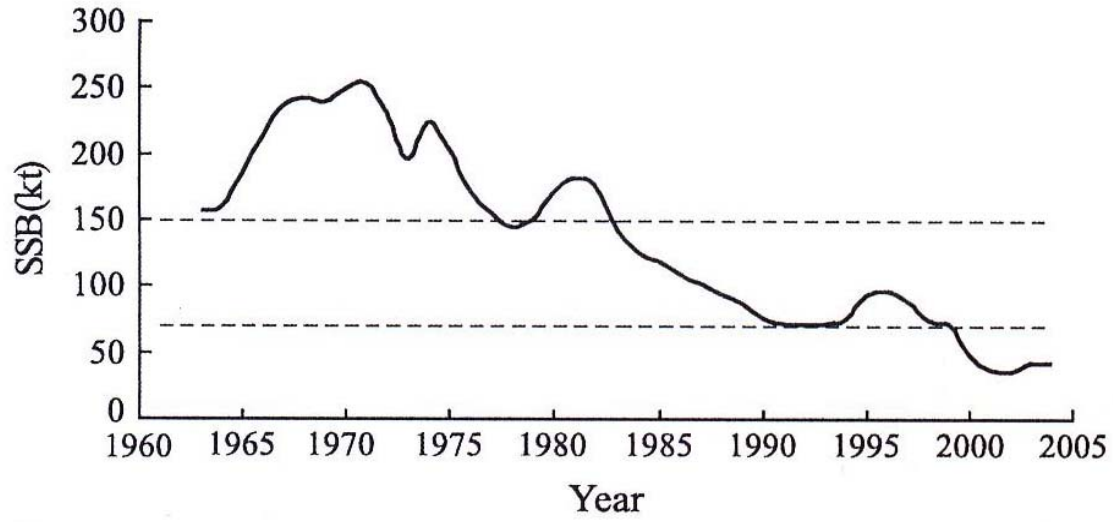


Figure 1. The spawning-stock size (SSB, '000 t) of North Sea cod. ICES limit (70 000 t) and precautionary (150 000 t) stock reference levels (B_{lim} and B_{pa}) are also included.

Source: Horwood et al, 2006

Fig.4

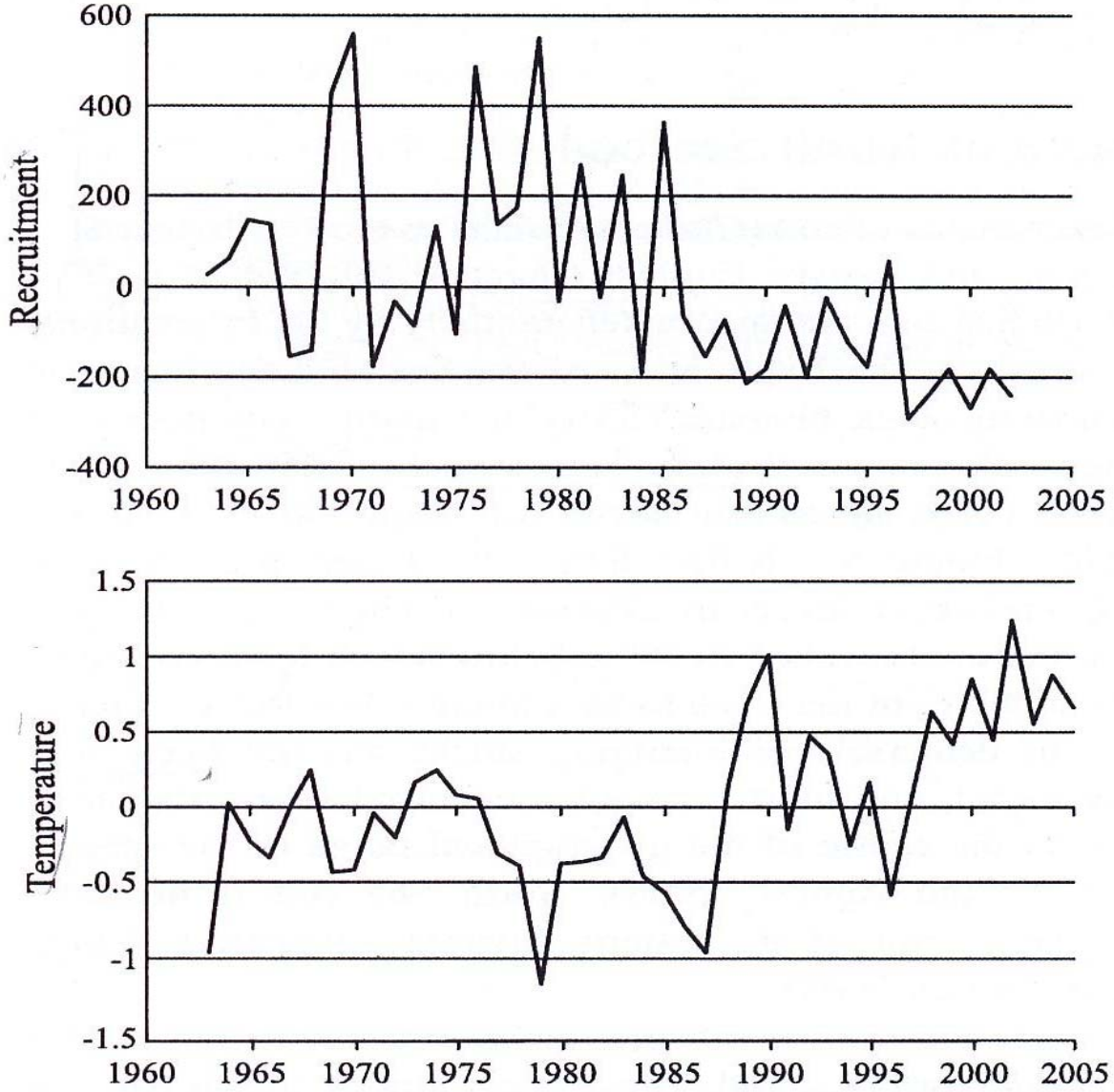
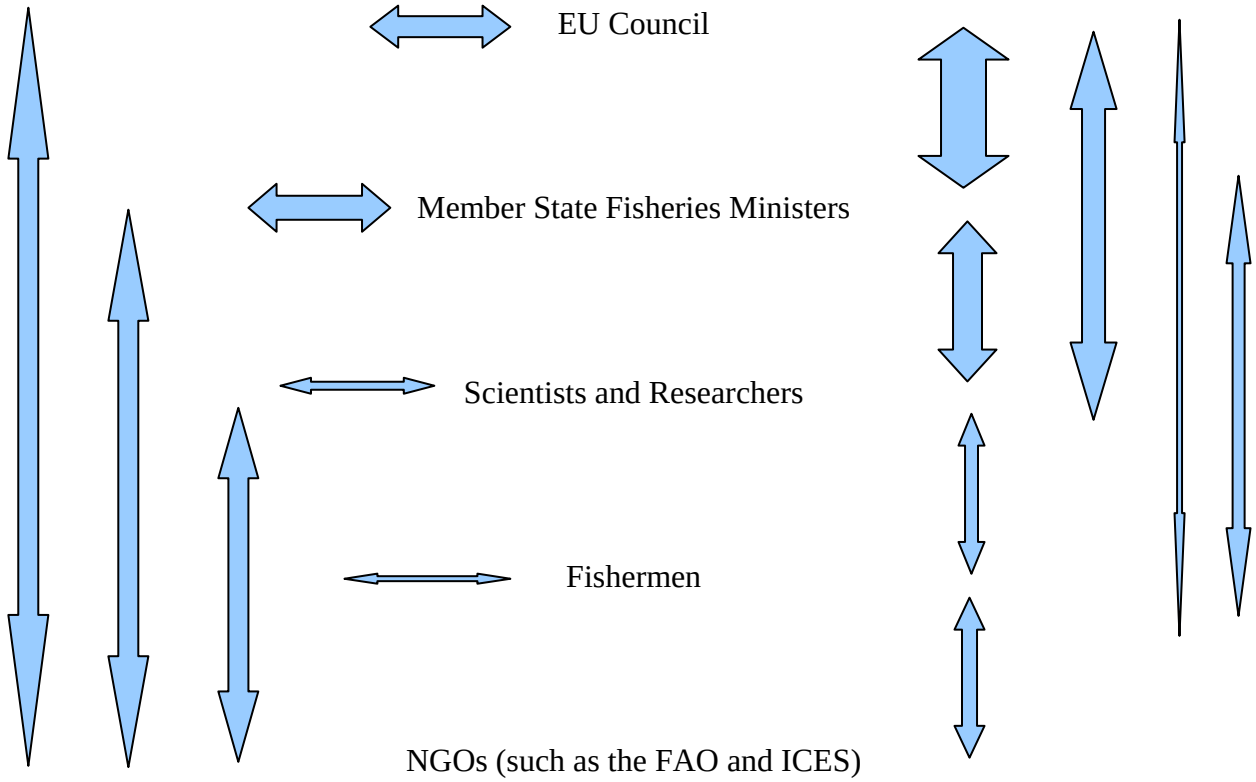


Figure 3. Post-1963 North Sea sea surface temperature anomalies in °C (bottom panel) and cod recruitment anomalies in millions (top panel) showing the earlier colder period of larger recruitment and the later warmer period of smaller recruitment.

Source: Horwood et al, 2006

Fig.5



The width of each line represents the strength of collaboration between the stakeholder group.
All lines are merely general representations of relationships are should not be taken as indicative of specific bonds.

The strongest connection is between the EU Council and Member State Fisheries Ministers. These parties meet regularly both in formal and informal settings to produce the annual TAC. This structured, routinised relationship leads to social bonds and networks forming. Both of these bodies are also strongly horizontally collaborated which enables coherent strategies to be pursued.

Scientists have strong connections with both the EU Council, Member State Fisheries Ministers and NGOs. However, the closeness of these relationships vary between individual scientists and organisations. The relationship with fishermen is unclear and highly variable. Scientists working within the North Sea ecosystem were found to have strong horizontal collaboration when researching similar drivers or species within the ecosystem. However, horizontal collaboration was found to be very weak between disparate areas of research.

Fishermen are not strongly connected to any one group, and this is primarily because of their status as well as low horizontal collaboration between fishermen.

NGOs represent a large body, segments of which are actively sought out by other bodies to collaborate with. They are connected to all the other stakeholder groups. No information concerning levels of horizontal collaboration was used in this paper.

Fig.6

Northward migration of coldwater species such as cod

Invasive species, such as the snake pipefish, enter the North Sea from warmer waters as sea temperatures rise

Source: http://www.thebestlinks.com/images/a/a2/Nseamap.gif

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