Visual arts representations of marine science: in search of a participatory approach

Joanna Jane Henley

Submitted for Degree of Doctor of Philosophy
International Centre for Island Technology
School of Life Sciences
Heriot-Watt University
Orkney
Scotland
October 2004

ABSTRACT

This thesis explores ways in which arts-based representation and community engagement can enhance the accessibility and consensibility of marine science. To challenge conventional representations of science, innovative visual arts narratives were sought to communicate scientific information, data and models to the widest cross-section of society. A community arts project relating to a unique saline lagoon enabled the target audience to participate in creation marine arts and events, including an interpreted shore walk. A discussion forum between scientists and the Orkney Creel fishing community led to interpretation of shared research priorities, via application of elements of the artistic composition. Attempt to translate a mathematical narrative of fisheries stock assessment models, though visual notation emerged an alternative participatory approach to science communication.

Art was found to have the ability to increase the contemplation period of scientific fact and data, have a positive effect on observational consensibility and give tangible meaning to marine science. Better understanding resulted from arts interpretation than had the information been explained through orthodox scientific methods. Arts-based representation can increase accessibility, but requires scientific certainty, must be built on trust and the agenda set by the target audience of environmental stakeholders. The participatory approach arts interpretation of science must be promoted by science communicators on a global scale. Stakeholder participation in science via participation in art will lead to greater insight and understanding. The role for art is as a catalyst of the participatory approach.

DEDICATION

For my Father who first showed me the beauty of the natural world and for my Mother who has always believed in me.

ACKNOWLEDGEMENTS

Thanks are firstly given to Professor Jonathan Side, for allowing me to research such an excitingly unique field of science under his supervision. For tailoring a research project to my skills and interests I am extremely grateful. Thanks must also go to my former supervisor Dr Mark Baine, whom before moving to Papua New Guinea, provided much guidance and inspiration. I also thank Dr Sandy Kerr for agreeing to take his place.

I am thoroughly indebted to Mrs Effy Everiss for her unfaltering support, ideas, sewing skills and yoga positions, adding an element of calm to the last three years. I would also like to thank Mr Erlend Leslie for many hours scanning lobsters and crabs and de-bugging my computer.

Regarding the case study, Art in the Finstown Marine Environment, I must thank the community steering group from Finstown and the Firth Primary School for their time, support and participation.

Thanks to Mr Edwin Cooper for convincing me I could live on a small Scottish Island for another three years. Thanks to the fish for keeping me company. Finally, thanks go to my contemporary Ms Kate Johnson, without whom I would have got lost along the way. Apart from co-operation in Project Fisher, I thank her for her constant encouragement, brilliantly worded letters, glasses of wine and trips in the vehicle.

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LIST OF ABBREVIATIONS

AFME	Art in the Finstown Marine Environment
AFT	Abriachan Forest Trust
AGORA	Assessment of Group Option with Reasonable Accord
CBCRMP	Community-Based Coastal Resource Management Projects
CBRM	Community-Based Resource Management
CFP	Common Fisheries Policy
CoastNET	Coastal Network for the United Kingdom
COM	European Commission
DETR	Department of Transport and the Regions
ECO	Environmental Concern Orkney
EMEC	European Marine Energy Test Centre
EN	English Nature
ESRC	Economic and Social Research Council
FRS	Fisheries Research Services, Marine Laboratory, Aberdeen
ICES	International Convention on the Exploration of the Sea
ICIT	International Centre for Island Technology
IPR	Intellectual Property Right
IUCN	International Union for the Conservation of Nature
LCA	Length Cohort Analysis
MCS	Marine Conservation Society
MNCR	Marine Nature Conservation Review
NESTA	National Endowment for Science Technology and the Arts
NGO	Non-Governmental Organisation
NSCFP	North Sea Commission Fisheries Partnership
NTZ	No-Take Zone
OCEAN	Orkney Community Environment Awareness Network
OCFO	Orkney Creel Fishermen's Association
OFA	Orkney Fishermen's Association
OFS	Orkney Fishermen's Society
OIC	Orkney Islands Council
RAC	Regional Advisory Council
RIAS	Royal Institute of Architects in Scotland
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SNH	Scottish Natural Heritage
UNESCO	United Nations Environmental Scientific and Cultural Research Council
VMCA	Voluntary Marine Conservation Area
WWF	World Wildlife Fund

Chapter 1. INTRODUCTION

"One picture is worth ten thousand words"

Chinese proverb

1.1 Rationale of the thesis

This research is concerned with improving the communication of marine-based scientific knowledge by representation through visual arts narratives. More specifically, the research attempts to document if and how, stakeholder/community participation in this process is possible. Attempting to catalyse a participatory (science) process commencing at the agenda-setting stage, elements of visual artistic composition are used to increase the potential consensibility* of marine science. Generating discourse on science through a 'bottom-up' inclusive approach, real engagement of target audiences may be achieved if science communication is more visually accessible.

*Consensibility is a unique claim for scientific knowledge claiming it is attained by mutual criticism and intellectual co-operation, potentially resulting in a consensus of rational opinion over the widest possible field. It differs from consensuality, in that consensual statements are ones which have been fully tested and universally agreed (Malhotra, 1994). For further discussion of consensibility see section 2.10.1.

Elements of artistic composition discussed in the thesis will be purely visual in nature. Although it is understood that many arts forms (music, dance, drama, poetry, and multimedia applications etc.) have the potential to increase the consensiblity of science if incorporated into a inclusive participatory process of science representation, this research concentrates on the visual narrative (colour, contrast, shape, form, perspective and composition etc).

Working with such a rationale, it is understood that this thesis is atypical, in that, the research does not readily fit any intellectual tradition or does not exactly fit any typical academic practice. Not intended to read like a warning, this is purely statement of recognition that the research interplays between two distinct disciplines, art and science. Although what follows will highlight a large amount of overlap between the two fields, art and science are understood to treat their subjects in very different ways.

Art, being a subjective experience of the mind, it follows that any scientific study of art should perhaps be thought of as psychology. However, with urgent demands for radical reshaping of the public 'face' of science and presentation of all scientific research, more unconventional approaches such as this one, are necessary and should be more readily be incorporated into the knowledge.

1.2 Aims and objectives

A theoretical aim of this research is to determine if, and to what extent visual arts media can be used, to more effectively communicate marine scientific information. In other words, how response to observation (art) can aid in the acquisition of knowledge (science).

The research challenges art's potential to increase the accessibility and consensibility of marine environmental information, promoting insight and awareness amongst a wide cultural and socio-economic audience. With traditional science communication distinctly lacking in accessible and participatory vehicles for communication, a new mechanism of co-ordinated marine interpretation is sought through development of an innovative and creative visual narrative. The research attempts to challenge the antithetical nature of science and art and establish some universal, mutually beneficial ground. Replacing traditional methods of exchange of scientific information with visual artistic instruments, unconventional, more radical representations of science will be developed.

Furthermore, the research seeks to investigate the more insurmountable science-society information transfer barriers existing between the scientific community, and stakeholder groups displaying a more anti-science stance, both in terms of scientific fact and data and the motivations of scientists. With science classically viewed as paternalistic in such cases, a participatory method to forge societal links and challenge science elitism is sought.

Investigation will seek to broaden the boundaries of science for the non-scientist and diversify the captive audience, socially and culturally.

1.3 Research questions

Fundamental and related research questions arise as:

- Can visual arts representation increase the accessibility and hence of societal relevance of marine scientific information?
- Can the target audience directly participate in the creation of visual arts representation of science and if so,
- Will participation increase the knowledge transfer of marine scientific information to the target audience?
- Can artistic presentation methods provoke greater interest in marine science than traditional methods of scientific communication?

Divergent stakeholders, unwilling to participate in science, represent the most difficult barrier to scientific and societal concourse. For this reason, more specific research questions are as follows:

- Can visual arts representation aid the inclusion of a stakeholder group, notoriously unwilling to participate e.g. the fishing community in the scientific discourse?
- Can visual arts representation enhance the consensibility of complicated aspects of marine (fisheries) science for the divergent group stakeholder group?

More meaningful research questions are:

- Could the visual arts catalyse an alternative participatory approach to marine science communication?
- What are the implications for future directions of marine science communication and application to alternative interpretive scenarios?

1.4 Precede

With research aims and objectives clarified within a framework of primary research questions, the following chapters and related case studies seek to provide answers.

Chapter 2 reviews the available literature and existing knowledge pertaining to science, art and related links. Basic chronologies of the two disciplines are presented together with primary discussions of the relationship between knowledge (science) and the image (art). This summary of historical and current thought on building links between science and art will determine what gaps exist in the knowledge and provoke thought into future directions for science communication.

Chapter 3 represents an investigation into the origins of a method for the sociology of scientific knowledge. It summarises a selection of past and current initiatives, which display a rationale, in some respect similar to that of this investigation. The projects discussed will in some way use elements of art, in interpretation of information, scientific or otherwise, for a particular target audience. Termed as 'art for explanation' initiatives, related discussion of respective successes and failures will determine their relevance to this investigation. This discussion will provide a conceptual framework the more innovative case studies of this research.

Chapter 4 firstly sets the scene for proceeding chapters and related case studies, taking place during the period 2001-2004, in the Orkney Islands, Scotland. Introducing the islands as a suitable background for the research, target audiences for case studies will be outlined. Orkney will be discussed in terms of its communities, environment (natural, social and cultural) and its intrinsic links with art and culture. Secondly, the chapter discusses potential methods, particularly within a social science context, for surveying community perceptions of marine environments. Thirdly, the chapter outlines the involvement of the researcher in each of the case studies that follow.

Chapter 5 presents the first of two major studies, which comprise the thesis. Entitled 'Art in the Finstown Marine Environment', the study took place during the period 2001-2003 and involved conceptual design and development of and feedback from a community arts project. Involving the community of Finstown, a small Orkney village, central themes included sourcing locally relevant, desirable marine environmental information and presenting it to the community through a unique visual narrative. Direct participation of the community was key throughout the process and realised via consultation, discussion and creation of related art works.

Chapter 6 is the second of the major case studies, entitled Project Fisher. Taking place during the period 2002-2004, the study focuses on a participatory discussion forum set up between Orkney Creel fishers and a community of scientists. With an objective to place fishers in the driving seat for overseeing future research into the fishery, discussions and analysis sought to determine what priorities fishers had for this research. Information on preferences was presented and donated to fishers and other stakeholder groups through a visual and accessible narrative.

Chapter 7 follows on directly from 6, taking aspects of the results and applying a more diverse array of art-based interpretation techniques. This investigation, taking place in 2003 was triggered by a lack of understanding noted within stakeholder groups concerning the presentation of certain results of Project Fisher. With referral to and application of basic elements of artistic composition, the chapter searches for more frontier methods to present and evaluate scientific fact and data.

Chapter 8 is further subsequent to 6 and comments elaborated from Project Fisher. In particular, a request, for further information regarding fisheries stock assessment models and their associated limiting assumptions. Conducted in parallel to Project Fisher (2002-2004), this study attempts to rationally interpret more complicated, and often contrived, scientific information, in terms of the language used, to determine whether or not there is a limit as to what visual narratives can interpret. During this investigation, limitations of stock assessment models are discussed and art is used in the search for a participatory approach to science communication.

Finally, Chapter 9 represents a discussion of conclusions. The major case studies are compared and contrasted, individual research questions are answered and the most meaningful conclusions and contributions to the knowledge are discussed. Drawing on the lessons learnt in Orkney, with regard to the potential for art to increase the accessibility of science, relevance to alternative scenarios is discussed. Art and its implication for participatory science representation are re-defined.

Chapter 2. REVIEW OF THE LITERATURE

2.1 Introduction

This literature review seeks to outline the interplay between the disciplines of science and art, whilst observing fundamental contrast. Building on these lessons, the chapter summarises our existing knowledge and understanding of how science, in this case, marine science, may benefit from visual arts representations.

The chapter commences by asking philosophically 'can we define science and art?' In other words, can we reach a set of definitions, which rightly define what the reader might understand to be science and art? Once conclusions are drawn, basic schematic chronologies of the two disciplines are discussed, drawing on key references. These histories seek to establish when and where the paths of 'knowledge' (science) and 'the image' (art) cleave and converge.

With the historical background set, inherent characteristics of the disciplines are discussed. The nature of science is discussed in terms of the barriers that exist to our insight and understanding and the importance of the image in terms of the nature of the visual artistic composition. Subsequent discussion pertains to how science has in the past, relied on or 'used' art and conversely, how art often 'uses' science. The historical relationship between science and the image and famous 'scientists of art' are discussed respectively.

Further related discussions conjecture on the sociology of science and art asking the combined question, 'can science and art work in a social context?' With reference to science, discussions ensue regarding a need to preserve the pubic domain, or public information commons. In terms of the visual arts, commentary draws on more contemporary examples and recent public disenchantment with such a genre.

The proceeding section focuses on science and reasons on the need to enhance its consensibility. The discussion highlights studies of science conflict and their remediation. In keeping with the marine scientific theme to this research, such situations of conflict relate to marine resource and fisheries management. Discussions of consensibility also relate to more frontier 'post-normal' methods of enhancement.

The final section of the literature outlines current emphasis and justification for developing more visual narratives for science. Including discussion of the value of 'aesthetic education' and environmental interpretation, the stage becomes set for a more integrated approach to science and art.

2.2 Explanation and representation

2.2.1 Can we define science?

Karl Popper (1983) discusses science in the evolution of 'Objective Knowledge'. As, he claims, scientific knowledge always starts from observation, he describes the aim of science as i) the search for satisfactory observation, ii) discovery of the unknown by the known and iii) improving the degree of satisfaction in explanations. But according to Lukacs (2002), the ideals of scientific objectivity are antiquated and flawed. Lukacs (2002) suggests we be skeptical of such objectivism due to the previously accepted equivalence of 'objective' with 'scientific'.

Popper (1983) continues to define scientific theories. In this dialectic, he suggests that 'depth' of a theory would seem to be most closely related to its simplicity and also to the wealth of its content. Two ingredients, he suggests are required: a rich content and a coherence or compactness, of the state of affairs described.

Thomas Kuhn (1962) documents the historical and philosophical characters of science, representing a new phase in science ideology. Kuhn describes three aspects.

i) Realism. In that: science is an attempt to find out about one real world; that truths about the world are true, regardless of what people think; and that truth of science reflects some aspect of reality.

ii) Demarcation. In that there is a sharp distinction between scientific theories and other kinds of belief systems.

ii) The unity of science. In that, there should be one science about the one real world, less profound sciences are reducible to more profound ones: psychology is reducible to biology; biology to chemistry; and chemistry to physics.

According to Sagan (1984), science is a way of thinking much more than it is a body of knowledge, based on experiment and a willingness to change old dogma. In contrast, Lukacs (2002) would suggest science is more about understanding. In that, if understanding is a synthesis, science is a further and better result of accumulated and well-digested knowledge.

2.2.2 Can we define art?

According to Gombrich (1950), the acclaimed international authority on the history of art:

"There is no such thing as Art – only Artists"

Similarly in Routledge (2000), art is defined in terms of a relation between the activities of artists, the products that result and the audiences that receive them. Two types of definition result: i) the functional and ii) the procedural. The former sees as art, only that which serves the function for which we have art – providing aesthetic experiences. The latter, sees as art, only that which has been baptised as such, through an agent's application of appropriate procedures. But art has a historically changing character, holding that something is art if it stands in appropriate relation to previous art works (Routledge, 2000).

Routledge (2000) continues by association of art with truth, suggesting that works of art (similar to works of science) might be vehicles of truth about the actual world. A work will often get us to respond to what is portrayed in a way similar to our response to the real thing. However, if works 'portray' situations, we could reasonably believe the work true if we believed the portrayed reaction to a situation was a likely one (Routledge, 2000).

Whitehead (1946), in his discussions of science history, draws frequent reference to its art, describing both disciplines in terms of values. He defines art, in the general sense as 'any selection by which the concrete facts are so arranged as to elicit attention to particular values which are realisable by them'. In essence, he describes a 'habit of art' as 'enjoying vivid values'.

According to Read (1963) art remains permanent and indestructible, accumulative but ever free and on its immediate fringes, active and expansive. In this discussion, themes for a rich dialogue are set. Lippard (1997), for example, states art may be partially defined as 'an expression of that moment of tension when human intervention in, or collaboration with, nature is recognised'

2.2.3 Dismissing the terms 'art' and 'science

During discussions with my supervisor, potential definitions of art and science were negotiated and cogitated. For example, science could be thought of as the orthodoxy of scientific thinking, the province of science being objectivity. Science is reproducible, has defined boundaries and methods and is generally perceived as inaccessible (by the layman).

Art could be thought of as the orthodoxy of the artistic establishment, the subjective experience being the trade of the artist. Art is non-reproducible, has no defined boundaries or methods (any formulated laws of art were broken by the great masters) and is generally accessible.

Science represents our best attempts to understand or explain the world (Side, pers com, 2003). According to Smith (1995), the criterion of art, or the visual experience, is a copy or reflection of the world, producing images whereby the nature of reality is established. Therefore, artists also serve to make sense of the world. It follows that, if the world is a function of artistic representation, appearances are contingent upon representations, which in turn, underpins scientific explanations of what the world looks like (Smith, 1995). Science is explanation, inextricably linked to representation, which is the very nature of art. Determining which discipline is more about 'truth' is rather more difficult.

As suggested by Gombrich (1950), it is best to approach art with a fresh mind and infinitely better to know nothing about it than to have the kind of half-knowledge that leads to snobbishness. With this in mind, art and science are to be approached, in the following review, with such freshness. Can we ever find the perfect definition for those terms, we know as 'art' and 'science' and if even so, would every reader share these definitions? It is suggested otherwise. Therefore, original definitions of the terms are put forward by the review. Science is hereon referred to, where possible, as 'explanation' and where not, 'science' implies the acquisition of knowledge. Art is referred to, where possible, as 'representation', and where not, 'art' implies response to observation. NB. It is noted that although there is no such thing as non-representational art, not all representation is art.

2.3 Overlay: explaining and representing

In order to trace overlay (inextricable linkage) of the two disciplines and determine a comparative significance of explanation and representation, a review of historical events, pertaining to each is necessary. An overview of the two histories, 'the roots of explanation and representation' can be viewed in Figure 1. It is important to note here that the chronological start and end points of the important eras are somewhat blurred and subject to the particular perspective of the references. However, it is of a higher order to observe how fundamentally the roots of representation and explanation cleave and converge.

What follows are chronological accounts, which trace the paths of 'knowledge' (explanation) and 'the image' (representation). The mutual significance of observation to both disciplines and specific issues, including their fundamental departure from the confines of a religious and social policy, are documented.

2.3.1 The history of explanation

According to Lukacs (2002), the history of science is the history of scientists. He proposes subordination of science to history, the former being inevitably part of the latter and not the reverse. Science can be (and often is) a fashion of the times (Lukacs, 2002).

Figure 1. The roots of explanation and representation

The following condensed chronology of science through history revolves around two main texts: 'Science and the Modern World' by Whitehead (1946) and the more recent 'History of Western Philosophy' by Russell (2000). These two accounts effectively conjoint the realms of science and philosophy and seek to re-interpret these categories and their relationships to other disciplines. With useful reference to the spheres of religion and art, the transgressions of science through time and their relevance to modern thinking are succinctly expressed. This history is by no means a complete chronicle of explanation, but an account of the most significant periods.

The Middle Ages and Ancient philosophy

This period of history could be referred to as the first great period of science (Whitehead, 1946). The birth of a scientific scheme of thought can be traced back to the 6th Century BC, notably the Greek civilization where, generally speaking, the beginnings of the scientific movement were confined to a minority among the intellectual elite (Whitehead, 1946). Figures such as Pythagoras, Heraclitus and Parmenides stood at the forefront of scientific thought and the mathematical and metaphysical aspects of science were the important doctrines of the time.

Science and philosophy were born together in this era and consequently were rarely separated. For the Greeks, who were characteristically over-theoretical, science was merely an offshoot of philosophy (Whitehead, 1946). Furthermore, the Roman empires and its legislation were born of an ancient philosophy. Although the Greeks founded the scientific movement, they did not sustain it, as Europe would proceed to show the greater interest in the science/philosophy dialogue (Whitehead, 1946).

The theory of ideas

This period of scientific history was clearly dominated by three revolutionaries, in sequential order, Socrates, Plato and Aristotle. Although the extent of their influence on the future proceedings of science is ever clear, these three were famously members of the aristocracy. They believed the possession of knowledge would suppose to make a man govern wisely (Russell, 2000). The birth of Socrates saw the dawn of 'the theory of ideas' and his life was driven by the pursuit of theories of knowledge, wisdom and ethics.

A student of Socrates was Plato. Fundamentally a republican, Plato could be though of as the most influential of all philosophers (Russell, 2000). The Platonic world of ideas is essentially the revised edition of the Pythagorean doctrine, where number lies at the basis of the real world (Whitehead, 1946). Plato's theories delved into topics such as cosmology, knowledge and perception however, Plato is probably most famous for his theories of 'Utopia' and indeed his 'Republic'. Central themes of the 'Republic' were thesis, antithesis and synthesis.

Plato and Pythagoras stand closer to modern science than Aristotle does, whom, unlike his predecessors, related his theories to general principles. With ideas on ethics, politics and physics, Aristotle believed that invention stimulates thought (Whitehead, 1946). Such a philosophy can be observed more prominently in the proclamations of Aristotle's successors.

The rise of theology

At the end of this so-called '1st great period of science', philosophy was seen to be submerged by theology. The fall of Rome saw the Romans hand over the Christian religion and a consequent, rise in its popularity. In the period between the 11th and 14th Centuries, the Catholic Church dominated science and its philosophical reactions, with 'the Fathers' and 'the Schoolmen', such as Thomas Aquinas, taking the leading role.

The Reformation

Historical revolt was to be the dominant movement of the latter part of this period and is generally thought of as 'The '2nd great period' of the history of science. The Reformation of Christianity and the scientific movement were two aspects of this, collectively representing the birth of modern philosophy. In historical terms, the scientific scheme has lasted much longer than the theological but, throughout history, conflict has existed between the two categories (Whitehead, 1946).

Historically, there has always been notable conflict between religion and science, the former based on 'our intuitions' and the latter on 'our impulse for accurate and logical deduction'. Furthermore, in terms of similarities, both are developmental disciplines and both are based on human experiences (Whitehead, 1946).

The Italian Renaissance

Science has never shaken off the impress of its origin in the historical revolt of the later Renaissance, in the 16th Century. Although it represents no great achievement in philosophy, the Italian Renaissance famously broke down the rigid scholastic system of former periods. This effectively liberated the educated man with a consequent loss of spiritual authority (Whitehead, 1946). The famous scientific figures of the time combined the discipline with a variety of others, most notably, art. Leonardo da Vinci, for example, recognised the practical importance of science. Fine artists Michaelangelo and Machiavelli, amongst others, also figure greatly in the Renaissance period. See also section 2.7.1.

The Seventeenth Century

Termed as the 'Century of genius', the 'birth of modern science' or the '3rd great period of science' (Whitehead, 1946), the 17th Century recollects probably the most famous names of science past. Collectively, the 17th, 18th and 19th Centuries form the epoch of modern science, revolving around the issues of God, mind and matter. In proceeding centuries, science is observed to overshadow its categoric rivals, namely philosophy and religion.

The 17th Century exhibits a scheme of scientific thought framed by mathematics and cosmology as both disciplines regain their importance. With a scientific emphasis on direct observation and quantitative analysis, within a narrow scheme of scientific concepts, mechanical engineers and inventors dominate the period. The relevant historical figures were the experimental physicists including Galileo, Newton, Kepler and Copernicus.

With this undoubted emphasis on 'how things happen' and 'why things happen', a certain revival of philosophy can also be observed of the period. Proposing that 'knowledge is power', Francis Bacon figures highly in the 17th Century. With scientific thought on a similar theme, John Locke considered knowledge (intuitive, demonstrative and sensitive) and relative ideas of perception and human understanding.

René Descartes (1596-1650), often considered the founder of modern philosophy (Whitehead, 1946), was most responsible for highlighting the importance of a 'theory of knowledge' in the 17th Century. Concerned with a scientific 'idealism', Descartes and his followers saw in the deductive method of mathematics, the ideal scientific procedure. Mathematicians, they thought, could reason without having studied formal logic. Essentially, Descartes' methods and 'systems' were an attempt to combine theology and science, representing an individual road to philosophical 'truth'.

The Enlightenment

The philosophy of the Enlightenment, which played an important political role in the 18th Century, contained principal elements such as the mechanistic world view, empiricist epistemology and displayed a marked revolt against authority (Wedberg, 1982). The Enlightenment marked a period of skepticism, which challenged all that was metaphysical, including the divine rights of the sovereign.

The Romantic Movement

The real triumph of materialism occurred in the early 18th Century, with the sciences of dynamics, physical chemistry and the invention of electricity figuring highly. However, the latter part of the18th Century is probably most notorious for the developing Romantic Movement and a movement against industrialism. The two issues which characterised the period were that of nature and poetry. Both art and literature were used to absorb and define the 'beauty of nature' by famous names such as Wordsworth and Spinoza. In particular, English poetic literature was used to disconnect the aesthetic intuitions of mankind and the mechanisations of science. Scientists of a more modern philosophy, such as that of Kant, were still debating matters of physics such as space and time.

Nineteenth Century Idealism

The science of the 19th Century was characterised by a philosophic 'Idealism'. In this century, education became centred on science and the educators were no longer priests but scientists themselves. Finally, as the influence of mathematics deteriorated, a greater sense of liberalism proliferated in the scientific world, more concerned with matters of social organisation. Charles Darwin, whose ideas dominated the latter half of the Century, notably shocked both the religious and scientific sectors with his theories of Evolution and Natural Selection. An era of 'Darwinism' resulted. In addition, scientists such as Hegel debated complicated issues such as logic and reason.

However, the poet Byron was the first to display signs of contempt for mankind in his writings of the 19th Century. Indeed, with the eminent rise in power of Fascism and the Nazis, socialism became in itself a scientific discipline. Karl Marx was the most famous socialist of the period, with his own theories to criticise notions of scientific truth.

Modernism

Modernism entails an ecologically malignant anthropocentrism (O'Neill, 1993). Typical modernist writers believed science was the ultimate point of reference (Gare, 1995), providing answers to all questions. This approach is now referred to as 'logical positivism'. Immediately prior to and during the period, science was the ideology of the industrial society. The Industrial Revolution and increasing global capitalism predisposed an unquestioning belief in science, which could meet all societal needs. The characteristic belief of the time was in the ability of science to produce outcomes based on predictive models (Kerr, 2003). Nature was a commodity of sole use to humans and this separateness was strongly marked during the modernist period.

Postmodernism

The modernist 'illusion' of progress was crushed by the 2nd World War. Increasing poverty, social movements, military interventions and increasing environmental pollution and degradation showed that science was indeed fallible (O'Neill, 1993). It became obvious that scientific claims were revisable and often difficult to support. In particular, with the rising environmental crisis, the upcoming 'green movement' saw science as an unreliable ally. Hence, the postmodernist philosophy is that science is epistemologically unreliable, its observational basis open to too many discrepant interpretations (Yearlay, 1991).

Postmodernism is a direct challenge to scientific determinism, being characterised by scepticism (Hokesbergen, 1994). In this way it reflects the scepticism of 'The Enlightenment', claiming there be no grand meta-narrative, only narratives based on particular perspectives and viewpoints (Hokesbergen, 1994).

Postmodernism reflects the rise of a popular culture where politics is widely perceived as farce, where everyone is a cynical opportunist. A characteristic belief of the postmodernist is that the games of scientific language are now the games of the rich i.e. whoever is wealthiest has the best chance of being right (Gare, 1995).

Such widespread hostility is observed among green theorists and activists. Such groups put increasing faith in 'new sciences' (e.g. 'holistic' and 'organic' science) and paradigms (e.g. 'gaia', ecology and quantum mechanics) and less in the classical science which alienates society from nature (O'Neill, 1993).

It appears that until very recently, scientific experts were turned to, to resolve disputes, but now scientific truth has been severely questioned. This postmodern scepticism is a fundamental opponent to the logical positivism of the modernist era.

2.3.2 The history of representation

In the words of Schnasse (1842), art belongs to the necessary expressions of mankind. The art of every period is both the most complete and most reliable expression of the national spirit in question and human evolution, in general. The history of art originally consisted of the biographies of artists. This then transformed into the history of styles, or a collection of methodologies (Smith, 1995), ready to offer a key to the past and an index to society (Gombrich, 1999).

The following history of representation is taken primarily from *The Story of Art*, by Gombrich (1950), the internationally renowned authority on art history and author of many related texts. This is not to say that he is unsurpassed in accuracy, but he is referred to too universally to avoid. Furthermore, this historical account does not attempt to chronicle a complete story of representation, visual or otherwise, nor can it claim to be chronologically exact. Art history itself is a problematic concept. In the words of Smith (1995), all historical accounts of art are partial. There can be no such chronicle of everything – who would have time to read it? As an alternative, this chronology presents an overview of instances when, where and why, the power of observation and skill of representation figure highly in art history and the history of mankind, drawing in particular, on certain central examples (see also section 2.5 - The importance of the image).

Magic art: prehistoric

In prehistoric, primitive times, that is, in ancient America, art exhibited a belief in the universal power of picture making. Most notably cave paintings, in early civilizations, were connected with magic and religion (Gombrich, 1950). For example, animals that figured in such paintings were believed to succumb to an axe or spear if the painting itself was created with that implement. Indeed, cave paintings are widely thought of as the first form of written communication (see Figure 2).

Symbolic art: Egypt and Mesopotamia

Egyptian art was classically a narrative and primarily symbolic (Gombrich, 1999). The art of Egypt, aside from the great landmarks of the pyramids, was heavily focused on portraiture. What mattered to Egyptian artists was not prettiness or completeness, but the task of preserving everything as completely and permanently as possible (Gombrich, 1950), apparently evident in the preservation of the dead through the process of mummification.

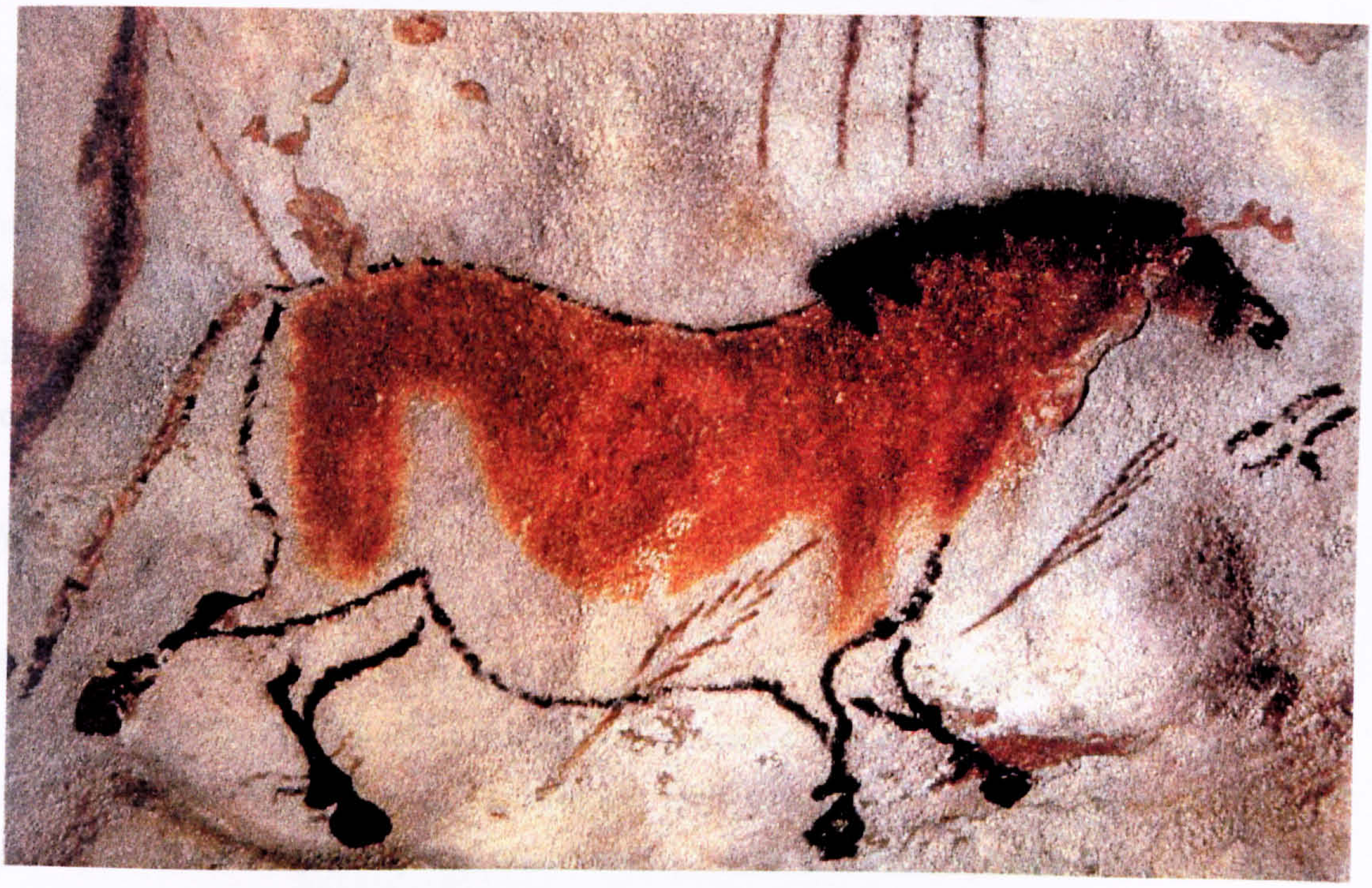

Figure 2. *The Horse*, Lascaux, France (15,000-10,000 BC) (Gombrich, 1950)

Unlike the artist of today, the Egyptian artist saw no problem with an almost child-like adherence to fixed rules and methods in their art. For example, everything was to be represented from its most characteristic angle. Accordingly, the head was always seen in profile, a full-face eye was planted in the side view of the face, the top half of the body was best seen from the front and the movement of arms and legs were seen sideways. That is the reason why the Egyptians in these pictures can often seem flat and contorted (Gombrich, 1950). Most famously, Egyptian artists encountered problems with the visualisation of feet from the outside. For this reason, both feet were pictured from the inside, giving the impression of two left feet (Gombrich, 1950) (see Figure 3).

Strict adherence to such rules created serious contention when in the period known as the 'New Kingdom' (after the invasion of Egypt), artists began to break many of the customs hallowed by age-old tradition. Refusing to pay homage to the many strangely shaped gods of the people (Gombrich, 1950), pictures emerged, less strict and rigid, portraits more flowing, with a new sense of movement. However, too many shocked audiences and the restrictive reign of Tutankhamun meant that this opening of Egyptian art did not last long.

Function and form: Greece and the Great Awakening

The Greek Masters went to school with the Egyptians and we are all pupils of the Greeks (Gombrich, 1950). The Greeks revolutionised art in the 6th Century BC. Whereas the basis for the art of the Egyptians was knowledge, used as a formula, the Greeks began to use their eyes (Gombrich, 1950). In other words, Greek art was responsible for the rise in powers of observation.

The Great Awakening saw artists become fully aware of their power and mastery. Though still looked upon as craftsmen, art took on its own function, no longer for the sake of its religious or political functions. The merits of a spectrum of methods, styles and traditions were now to be recognised. Referred to as the 'realm of beauty', with sculpture as the most prolific discipline, the Greek approach was to breathe as much life and animation into their creations as possible.

Figure 3. *Portrait of Hesire* (2778-2723 BC). (Gombrich, 1950).

During the Greek revolution, Greek Mythology was recited visually, through poetry and plays. These acts led Greek art to the observation of natural appearances, the rendering of expression, anatomy, space and light. Form followed function and, in contrast to the art of ancient Egyptian tombs etc., art now took on a physiological emphasis (Gombrich, 1999).

Observational art: Italy and the High Renaissance

The beginning of the sixteenth century is the most famous of Italian periods and one of the greatest periods of our time (Gombrich, 1950). It was the age of great discoveries, when for example, Italian artists turned to mathematics to study the laws of perspective and anatomy to study the structure of the human body (Gombrich, 1950) (see cleavage and convergence – section 2.3.3). Indeed, perspective presented an entirely new aspect of reality to human consciousness, debasing the artists' image to a naturalistic replica (Bill, 1949).

Image making was embedded in the social fabric of Renaissance Italy and famous artists of the period, regarded the true purpose of the painted image to be empathy (Gombrich, 1999). The art of observation was never more important than in the Renaissance period. Artists from hereon referred only to nudes and draped models to prepare pictures and statues, learnt to study plants and curious animals to include in their scenes and were grounded in the optics of perspective and use of colour. Furthermore, artists of the early Renaissance began to tackle the problems of perspective and depicted curves, by applying the principles of geometry (Goldstein DeVarco, 1997).

Artistic harmony was attained in this era and the compositions that resulted were thought to have conquered nature. Despite this, for all the grandeur of their representations of nature, figures often looked more like statues than living beings. One perspective on this fundamental observation is that artists of the High Renaissance aimed to leave something to our imagination (Gombrich, 1950). Two of the Great Masters of the Renaissance will be discussed in section 2.7.1 - Explanations of art.

Figure 4. *La primavera*. Sandro Boticelli (1478) (www.florenceguides.com)

Abstract art: Modernism

Early modern art was revolutionised by the introduction of perspective that occurred during the Renaissance. However, artists now discovered the challenge of abstraction and abandoned perspective. Whereas Renaissance artists established a one-to-one correspondence between object and representation, 20th Century artists strived to demonstrate the contrary (Koptsik, 1993).

Interaction between fine art and popular art has become one of the most important issues of contemporary art. According to Cox (1993), the aesthetics of pure form, geometric or abstract, represent the epitome of 'purist' modernism (see also Mathematical art – section 2.6.5).

Chaotic art: Postmodernism

In the 19th Century, the artistic movement characteristically challenged obsessive representationalism, and art became a fundamental expression of individuality. Such a movement was the origins of both modernist and postmodernist art.

Art in the now postmodern times is defined by the nature of the art market. For example, 'Chaos theory' art works, e.g. Fractals (see also section 2.6.5), figure highly in the realms of postmodern art, as does the theory of chaos in postmodernist science (see section 2.3.1). However, such works are the subject of contemporary art criticism due to their proliferation in mass media.

Smith (1995) explains she would be happier without both the terms 'modernism' and 'postmodernism', claiming they are merely categories defined by art critics. In her words, the two disciplines, best understood as styles of thought, have never been more than convenient ways of conceptualising an extraordinary outburst of iconoclasm and inventiveness within the arts.

2.3.3 Cleavage and Convergence – the Renaissance

With reference to the roots of explanation and representation (see Figure 1) we can observe three major periods which link the two chronologies. Firstly, the birth of modern science, in the form of mathematics and philosophy, took place during the Great Awakening in Greece, also the centre of art mastery of that period. Proceeding centuries continued to uphold the linkage between the two disciplines.

Secondly, in the rise of theology, art and science were inextricably linked to religion. However, the Reformation of the Christian Church meant that the boundaries between the priest and the scientist became less blurred and more distinct. Similarly in the history of art, portrayal of religious scenes, for example those in The Bible, lost their credibility as 'the only works of art', there being far more images in need of representation.

Thirdly, in terms of convergence, collaboration between artists and scientists can be no more obvious than during the Renaissance. It is well known that artists of the period received their training in an atmosphere of artists and mathematicians, studying and learning together. Scientists and artists shared the same tools, philosophies and canvases. Indeed at this time mathematics was the form of artistic expression (Emmer, 1993). After the Renaissance, one can observe the most marked cleavage in the paths of explanation and representation despite their continuous reinvention and reclassification (see Figure 1).

2.3.4 Observing similarities

Art and science have reflected similar values and used the same tools and methods throughout history[1]. Read (1963) does not distinguish between science and art, except as methods, believing that the opposition created between them in the past has been due to a limited view of both activities. More recently art, akin to science, is often perceived as inaccessible and only meaningful in artistic circles. Read (1963) continues to depict art as the representation, and science as the explanation, of the same activity. The only contrast is

[1] www.unesco.org/culture/creativity/education

that the artist strives to express his feelings rather than to record his observations (Read, 1963).

The Institute of Science in Society probes the issue further by discussing the feelings that the disciplines of art and science symmetrically generate amongst society. They suggest that human experiences of aesthetic feeling be not exclusively provoked by 'works of art' in the conventional sense, but also by 'works of science'. Indeed, that communion of shared experience through a universal ground constitutes the essence of both artistic and scientific creativity. Could it be said then, that the artist makes a better scientist than the analyst? (Ho, 2001).

Koptsik (1993) discusses central principles of the two disciplines in parallel. In science: law, order, symmetry and geometry; in art: harmony, beauty, style, rhythm and unity. According to Koptsik (1993) the meaning of these words differs very little. Cox (1993) adds that nature science and art are drawn together by this dialectic unity of concrete and abstract, aesthetic and theoretical.

Popper (1979), in his book, defends a theory of 'Objective Knowledge'. Popper makes use of his alternate theory of three domains. Firstly, World 1 - the world of physical objects and processes, secondly, World 2 - our psychological states and thirdly, World 3 - the world of abstract products of the mind that are not reducible to our psychology e.g. numbers, theories, designs, works of art, institutions. In this, Popper conjectures that science and art exist within the same domain. It is only through World 2 that World 3 objects can influence World 1 (Popper, 1979). In other words, public opinion is required to define both science and the arts.

2.3.5 Observing differences

According to Ashcroft (2000), though both art and science claim to seek to understand the world around us, their individual approaches are different. Scientists strive above all for clarity. Their papers aim to communicate their findings so they can be understood and reproduced. Facts and speculation are clearly distinguished. In contrast, the artist strives for subtlety, for metaphor and for multiple alternative meanings (Ashcroft, 2000).

As described by Ritchie (1950), there is a super idealistic view in the minds of artists. Artists' abilities to explain the world really require no material media for such artistic expression. In other words, artistic achievement has an autonomous, self-developing character. Lippard (1997) agrees that artists read, think and see from angles not often found by scholars. Perry (1993) leads this discussion into the realms of intuitions, which, although he suggests are excellent stimulations for both art and science, they are conceived from lack of information. The difference between the artist and the scientist, he suggests, is that the scientist uses intuition to look towards finding the facts, while the artist uses intuition to intrigue others. Loeb (1993) adds that visual art is a way of acting out our intuitions. Unless an artist is able to tell us the method by which he or she generated a pattern, one can only speculate about just how a work of art was generated.

Kuhn (1962) suggests that, whereas scientific communities are insulated from society, artists gain their education from exposure to the works of others. He describes scientific communities as the only professional communities in which individual creative work is so exclusively addressed and evaluated by other members of the profession. Accordingly, the scientist makes no use of an equivalent to the museum, and the result is sometimes a dramatic distortion of his discipline's past (Kuhn, 1962).

The International Society for Education through the Arts suggests that the research operations associated with creating art are quite different from the research activities of scientists. For example, research in both natural and social sciences relies upon measures that generate quantitative data, whereas artistic research is not concerned with either identifying or quantifying data. Moreover, artists rely upon their individual perceptions of the natural and social world[2].

Gross (1985), in more detail, distinguishes between "non-sign" (events we encounter in life which are interpreted 'transparently', without any conscious awareness of interpretative

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[2] www.instructional.castatela.edu/laa/research

activity) and "sign" events (events which evoke an interpretative process). In this way, science and art are both similar in that they represent sign events. However, a second distinction of Gross (1985) is between sign-events that are either natural or symbolic. Natural events, as he uses the term, are those, which we interpret in terms of our knowledge. Science would be a suitable example here. In contrast, symbolic events are those we assume were intended to communicate something to ourselves. Art implies meaning in such a way.

2.4 Barriers to insight and understanding

2.4.1 Conflict

Conflict in science, or 'science war', if about anything, it is largely about the power and authority of science (Sadar, 2000). Science and technology affect and are affected by the institutions and values of a society. Furthermore, public issues, anchored in scientific and technological applications to society often involve trade-offs between conflicting values[3].

Young (1976) observes two inter-related and self-justifying outcomes of science education in its present state. Firstly, mass scientific and technological ignorance of people in an increasingly technologically dominated society, who see themselves as dependent on experts in more and more aspects of their life. Secondly, he describes a community of scientists who see the knowledge for which they are responsible for producing and validating, as necessarily not available to the community (Young, 1976).

Popper (1983) discusses the problem with reference to induction. Without solving the problem of a lack of experience of science, he suggests we cannot decide between a 'good' scientific theory and the (bad) obsession of a madman. Central to this issue of what Popper terms as 'falsification', is the inability to test the validity of 'universal' statements and laws of science. Only experience of science, Popper (1983) suggests, can help make up our minds.

[3] http://www.ed.gov/databases/ERIC-Digests

Brush (1979) continues to suggest that society often sees little of the creativity of scientific inquiry and much of its mundane drudgery. Here lies the conceptual knowledge and information transfer barrier between science and society.

2.4.2 Stereotypes

Marsh (1998) leads the discussion into the realm of social stereotypes, highlighting the following:

"The scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle-aged and wears glasses. He may have a beard".

The classical social stereotype of the scientist is expressed.

Lukacs (2002) discusses the scholastic reputation of the scientist. In that, during the last four centuries of the Modern Age, 'scholar' meant a serious, modest and withdrawn man, whose interest and devotion to his, often unusual subject, was inseparable from the openness of his mind; a man of probity. Lukacs (2002) suggests this kind of respect has largely waned now, except perhaps here and there. There are too many so-called scientists, and there are all kinds among them – this is how many people are now inclined to see them. As in almost every other field of life, inflation has set in. Where there is more and more of something, it is worth less and less (Lukacs, 2002).

Brush (1979) refers to scientists as less socially desirable than the rest of society, with a notion of distance between self and stereotype. Furthermore, if stereotypes are built on generalisations derived from the actions of people in the stereotyped group rather than their true characters, it follows that new actions in a more human-orientated vein might successfully change public perceptions (Brush, 1979).

2.4.3 Institutionalisation

According to Lukacs (2002), when we consider the history of science, we are talking about the relationships of scientists amongst themselves with the scientists as human beings. However, this relationship is ever-increasingly not upheld. Lukacs (2002) believes equivalence of 'scientism' with 'humanism' is no more than a charming romantic dualism. Never the twain shall meet?

Homer-Dixon and Perkins (1982) note the apparent breakdown in the delivery, hence institutionalisation, of academic science as described by Marsh (1998). Many scientists who have made ground-breaking discoveries are little known outside their field, their work quietly assimilated and accepted into their general scheme or discipline (Marsh, 1998).

Over a century ago, science was purely the domain of the affluent gentleman and the university academic. Indeed, the activities of the Royal Institute of Science highlight this observation. Founded in 1799, popularisation of science was the Institute's mission. In 1827 the 'Christmas Lectures' were inaugurated, which still continue today. However, there was limited attendance due to expensive ticket pricing, suggesting attendance be a property of the privileged (Marsh, 1998). Of course, such restrictions on access to science, though evident, are no longer antiquated to such as degree.

More recently, the Brazilian Educator, Paulo Freire, in his revolutionary educational philosophy, maintains that freedom and the development of individuals can only occur in mutuality with others. Freire's views on education include transforming actions in aggregate, to announce an egalitarian, participatory and democratic social order, denouncing hierarchical, authoritarian and alienating systems of organisations. With specific reference to institutionalisation, Freire advocates dialogue and critical thought as a substitute for 'banking' education in which, riches of knowledge are deposited in the empty vault of a learner's mind[4].

[4] http://nlu.nl.edu/ace/Resources/Documents/FreireIssues.html

The paradigm of institutionalisation of science has become increasingly relevant with time. As suggested by Ramachandran *et al.* (2000), globalisation and internet commerce lead to science being more commonly viewed as a market good. Hence, science as public good is increasingly at threat (Ramachandran *et al.*, 2000).

2.4.4 Setting the agenda

Particularly within the field of marine conservation, the agenda for research into issues that affect the widest environmental community, remains one set unanimously by governmental organisations. For example, the Department for Transport and the Regions' conference (2000) into UK Biodiversity Research specified objectives as follows: to prioritise the research needed to support UK government commitments under the UK Biodiversity Action Plan; to facilitate the exchange of information about biodiversity research; and to raise the profile of and collaboration in biodiversity issues amongst research sponsors and the scientific community (UK Biodiversity Research Working Group, 2000). Thus, nowhere in this mission statement is there a mention of the need to set an agenda, relevant to local communities and environments or the consultation of those people affected by proposed research.

Despite claims of the assistance of non-governmental organisations (NGO's) and communities, it remains that systems of government alongside major global forums such as the International Union for Conservation of Nature (IUCN), are ultimately responsible for setting the agenda for the network of protected areas for conservation purposes. This partnership is also responsible for the creation of new protected areas and the direction of associated resources. Such designations, therefore, arise without local community consultation, with little/no prior knowledge.

2.4.5 Trust

The issue of trust in science centres around the basic epistemological question – is science reliable? (Ziman, 1978). According to Polanyi (1967), most writers on science of the time accepted the validity of science as unquestionable. Scientific truth was ultimately defined, as that which scientists affirm and believe to be true (Polanyi, 1967). However, today's sciences have frayed edges of truth. According to Perry (1993) there is far too much information to understand because: i) we are all too fraught with our own wishful theories or intuition, ii) we cannot wrestle with depths of concepts as iii) we have no real comprehension of the mathematics involved.

Kuhn (1962) was particularly concerned furthermore with the 'public face' of science. He states, whatever the internal problems of 'truth' of science, the public's belief in science as good and true has to be defended, for the social consequences of not doing so could be devastating (Sardar, 2000).

It is suggested, that with no knowledge of scientific principles, the public masses find scientific discoveries difficult to understand and frightening to contemplate (Marsh, 1998). Polanyi (1967) justifies this statement, suggesting a new contribution by science may not depend on the evidence of its truth, but takes place either at random, or in response to economic or political interests, or simply as dictated by accepted dogma.

However, Ridley (2001) suggests the mistrust and misapprehension of science's activities are not really its own fault. He suggests that decisions taken in the public's interests are not those of scientists, but of politicians and industrialists. However, when these groups claim they act according to scientific advice, the public believe science to be accomplice to the crime (Ridley, 2001).

Lack of faith in science is often further aggravated by a critical press, political mishandling and media overkill. Public catastrophes such as BSE and the threat of nuclear pollution have further eroded public trust and neglect the precautionary principle in search of quick, profitable technologies (Rose, 2003).

In a survey by the Scottish Office, of public attitudes to the environment in Scotland, over half the population surveyed felt that too little information was available and they wanted to know more. The research also highlighted central government as responsible for the majority of scientific mistrust, with environmental organisations and scientists held in much higher regard (Wilkinson and Waterton, 1991).

Analysis of scientific activity is subversive of science and is often resented as such (Sadar, 2000). Popper (1934) suggests 'falsification' (see also section 2.4.1) as the idea that science advances by unjustified, exaggerated guesses followed by unstinting criticism. Scientific theory is not only an instrument, but is generally required to be either true or false (Popper, 1979).

Ziman (1978) suggests a feeling has arisen that the evil factor is knowledge itself. In epistemological terms, science is characterised as 'a materialistic and antihuman force', especially when concerned with biological behaviour, social organisation and human emotion. However, the scientific message, he suggests, is not prescriptive. It is not an order from a social superior, or a moral imperative. The influence of knowledge over action arises, instead, from its powers of prediction (Ziman, 1978).

Somewhat contrasting, is the view of O'Neill (2003), who in her lectures on trust and transparency, suggests that global transparency and complete openness are not, as would perhaps be thought, the best ways to build or restore trust. O'Neill (2003) suggests we place and refuse trust, not because we have torrents of information but because we can trace specific bits of information and specific understandings, to sources whose veracity and reliability we question. Well-placed trust, she continues, grows out of active inquiry, not blind acceptance. When we can do nothing to check the credentials of sources, we often withhold trust and suspend belief. In this way, we need to think less about transparency and more about limiting deception. Fundamentally, if we are to restore trust, we need to start communicating in ways that are open to assessment (O'Neill, 2003)

2.5 The importance of the image

'Art for art's sake' is that which dominates the art of our time, according to Gombrich (1999) in his discussion of the social uses of images. However, such art obscures the critical element, which still remains that an image is expected to serve a function. As far as the demand for images is concerned, the invention and spread of photography offers the most dramatic example. Demand for a faithful, visual record, originally met by specialists in portraiture, topography or animal painting is now met more efficiently and cheaper by the camera (Gombrich, 1999).

2.5.1 Magic, myth and metaphor – historic uses

Myths are defined as systems of shared belief that hold a society together. The more we are in the grip of emotions, the more easily we feel tempted to regress the remnants of irrational belief which form part of our cultural heritage (Gombrich, 1999). Throughout our heritage, the image has had an amazing power to control such emotions.

The art of illusion

Pre 19th Century, the artist used illusion as a key feature of paintings on walls i.e. frescos (Gombrich, 1999). However, with the consequent rise of decorative painting, alternative methods of composition soon took preference over illusion. The decorators decried the vulgarity of illusionist tricks and resulting conflicts meant illusion rapidly lost its hold over the visual image.

Bill (1949) suggests that art can daily create images or symbols which suit the aesthetic and emotional needs of our time, like no other discipline can. Such a hypothesis was markedly proved in the widespread appearance of symbolic bestiaries. Bestiaries, traced back to the early Christian era, are defined as collections of illustrations depicting real and mythical animals and plants, accompanied by text (Baxter, 1998). The use of imaginary beings, strange creatures traced back through time and space by human imagination, was as an iconographic guide for animal imagery (Borges, 1967). Did a 'book of beasts' in medieval times represent a system of mythical zoology, or a serious work of natural history on which biological knowledge is founded? (Baxter, 1998). Commonly found within monastic manuscripts and decorating the cathedrals and libraries of the 12th Century, bestiaries were recognised by the church as a means of conveying religious instruction. However, the imagery was often subject to misinformation, with animals often confused for one another

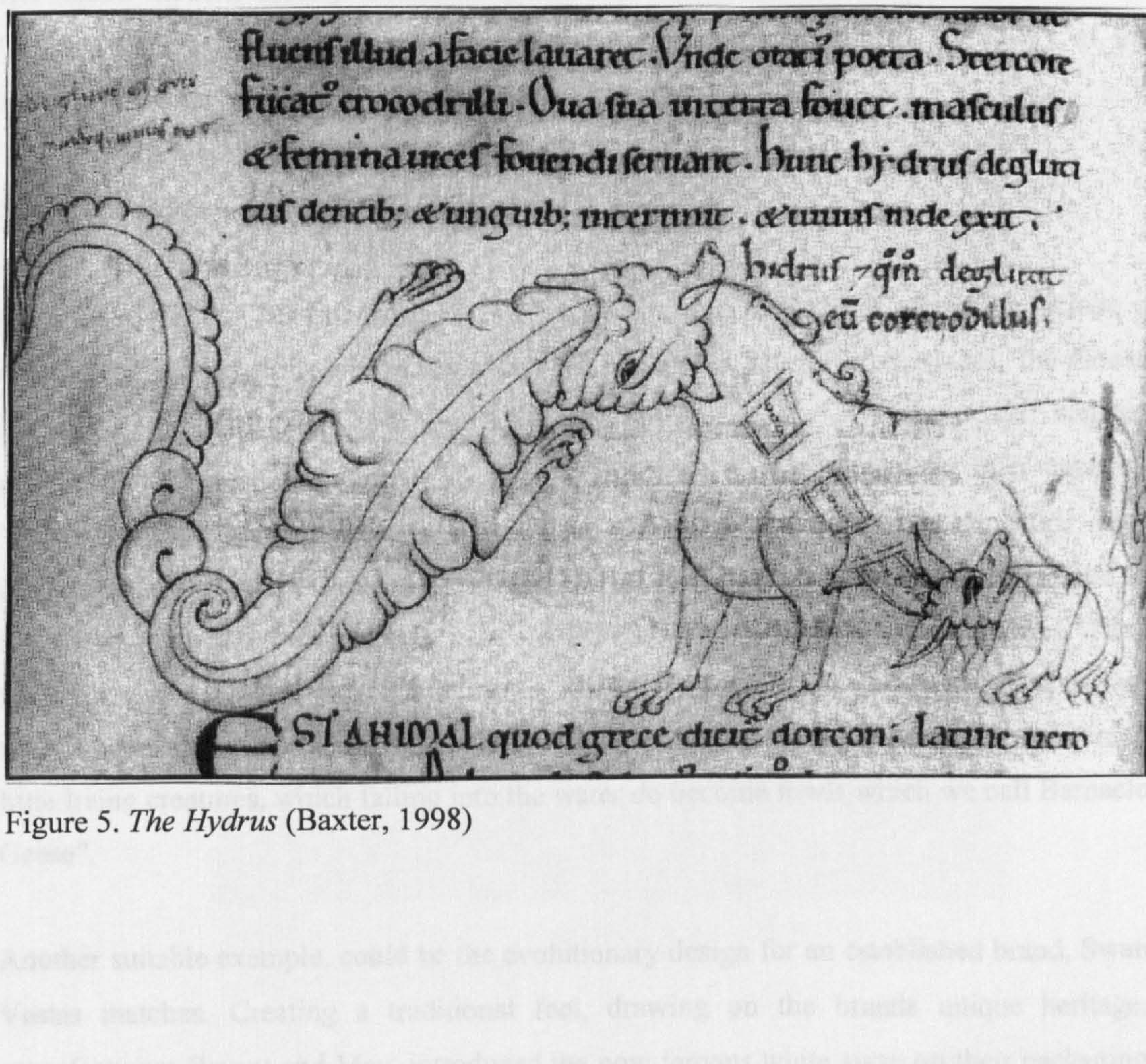

Figure 5. *The Hydrus* (Baxter, 1998)

(Baxter, 1998). And yet these animal images were intended to teach children, most importantly, to look at the real thing without fear, as a consequence of seeing it in a primal world of archetypes (Borges, 1967).

With mythical creatures including the Dragon (Eastern invention), Unicorn (Greek mythology), Fairies (Irish and Scottish folklore) and the Minotaur (Crete), the images served to fit man's imagination (Borges, 1967). In this way bestiaries have managed to transcend from a system of medieval, mythical beliefs to an iconographic status, that still fits within modern society. Bestiaries provide a historic example of the significance of images. Indeed, these powerful depictions have fundamentally shown the ability of the image to blur the boundaries of imagination and reality.

Similar examples

Other examples of the power of the image to blur the boundaries of reality include a common misconception among fishermen that a familiar family of crustacea, the Goose Barnacles is, in fact, not a family of barnacles, but goose eggs. Owing to their unusual pelagic existence, often attached to flotsam, driftwood for example, and their uncanny 'goose-like' appearance, many believe goose barnacles are something altogether very different. John Gerard's Herbal of 1597 (General History of Plants), makes reference to this barnacle as found attached to 'trees' and to its location in the Orkney Islands. "They are found in the north parts of Scotland and the islands adjacent called the Orchades, certain trees whereon do grow shells of a white colour tending to russet, wherein are contained little living creatures, which falling into the water do become fowls which we call Barnacle Geese".

Another suitable example, could be the evolutionary design for an established brand, Swan Vestas matches. Creating a traditional feel, drawing on the brands unique heritage, manufacturers Bryant and May, introduced the now famous white swan on their packaging in around the 1950s. The design originated from one man's encounter with a male swan whose feathers were distinctly ruffled in a display of aggression. Intriguingly, this design has come to represent many peoples, perceived ideas of what a swan 'should' look like, whereas in actual terms, such an appearance is rather unusual. However, the Swan Vestas

Figure 6. *Lepas anatifera*. Common goose barnacle (www.fathom.com/feature)

Figure 7. Swan Vestas matchbox (www.schlagenhaft.net)

advert has established 'period charm' and, in fact, the design of the matchbox is unchanged today.

Metaphor and political satire

A skilfully applied metaphor links the familiar with the unfamiliar and presents a fictional explanation of world events. Pictorial satire, most famously political satire, exhibits the capacity of entertaining fictions, which form part of an unchanging human nature (Gombrich, 1999). Pictorial satire serves the function of mockery, reinforcing stereotypes, and highlights the fact that images can be formidable weapons.

Essentially, satire derives effect from the use of metaphor to comment on topical reports of the day. Furthermore, it relies on a public that enjoys the wit of comparison which may not explain but sum up a situation (Gombrich, 1999).

Cartoons

It is fair to assume the majority of the population has experienced cartoons throughout their lifetimes. However cartoons particularly remembered are those, which express something already known, in readily available form. In other words, cartoons simplify what are often very complicated issues, down to very 'child-like' simple pictures. Hence, cartoons have the ability to provide a different perspective on rather serious issues and to rather reduce one's anxiety about that issue (Gombrich, 1999). A wide audience can therefore interpret cartoons.

Doodles

In the history of representation (section 2.3.2), art and its images display the ability, wherever possible, to repress strict discipline and go against any rigid formulas and standards. According to Gombrich (1999), it is when such standards are deliberately loosened, that artistic practice becomes permeable to that free play known as 'doodling'.

Of recent years, there has been extensive interest in these doodles, or absent-minded scribbles, made during moments of waiting or concentration. Indeed, there has been unexpected publication of these doodles in the history books of recent years, e.g. those of da Vinci, drawn in his search for geometrical laws. Doodles may be able to provide clues to an individual's true character and could be classed as a form of interpretation in their own right (Gombrich, 1999).

2.6 Representation of science- how science uses art

2.6.1 Science and image

In his book, 'Visualizations; the nature book of art and science', based on a lengthy series of articles appearing in *Nature*, Martin Kemp, from the Department of the History of Art, Oxford, introduces an appreciation that there are stimulating pieces of art, either by accident or design, in the content and presentation of much classic and modern science. Concerned with the artistic side of science, Kemp details a movement from an Enlightenment view of nature as a product to the modern view of nature as a process, evidenced by the more open-ended concerns of contemporary art and science (March-Russell, 2002). Samples of his discussions of the inextricable links between the two disciplines are contained within the following sections. Kemp (1998a-g) and (2002) refers to individual articles and reviews appearing in *Nature*, taken by Kemp to form the collective work.

2.6.2 Graphic Visualization

Visualisation has played an important role in the history of mathematics. For example, mathematicians use computer graphics to a) visualise known phenomena and b) solve unsolved problems. This unifying language between art and science is now referred to as the field of 'visual mathematics' (Emmer, 1993).

In his discussions of the parodies within scientific and artistic chronologies, Kemp (1998a) cites the diagram as the predominant conveyor of information. This centrality of illustration, he comments, remains constant within the scientific journals of our time. Most obviously he remarks, the use of line diagrams often greatly outweigh photographs and are generally preferred as a rule.

However, visual styles for the conduct of broadcasting of the sciences have undergone fundamental change (Kemp, 1998a). Bigger, glossier and heavier scientific periodicals display a far wider range of visual images. Indeed, colour now plays a key role, both decoratively and as a conveyor of information (Kemp, 1998a).

Ziman (1978) suggests that the basic conditions for visual communication can be met by mutual recognition of significant patterns. He terms such representations as 'maps'. According to Ziman (1978) there is good reason to believe that humans are neurologically and psychologically adapted to comprehend in map form, generating a good deal of information that is received and stored, readily made available as 'useful knowledge'. He continues that more information can be read from a map than was needed to construct it. Maps, adds Lippard (1997), are a visual science, which entails interpretation as well as direct observation.

Representing a surprising new form of graphic art, according to Kemp (1998b), are the rough sketches and jottings of scientists. Whereas artists' sketchbooks have been collectable since the Renaissance, scientists' notebooks generally attracted little attention until the nineteenth century, despite their central role in scientific and technological creativity. This difference, Kemp (1998c) suggests, speaks volumes of the historical gulf in attitudes towards creativity in art and science. It is now broadly accepted that informal jottings can provide fascinating insights into the varied nature of the processes of visualization, schematic thought, and an individual scientists' work (Kemp, 1998d).

Feynman diagrams

A picture suggests Ziman (1978), is a resemblance of reality, tells us about the world of our conscious experiences and is that from which science can be derived. Following such thought, Kemp (1998a) suggests that if a picture is worth a thousand words, a diagram can be worth many lines of complicated algebraic formulas. He discusses the work of Richard Feynman, renowned as the great authority on quantum electrodynamics and a communicator of difficult physics to nonspecialist audiences. Feynman developed the method still used today to calculate rates for electromagnetic and weak interaction particle processes. In Feynman's own words: "nobody understands quantum mechanics?" This, together with a concern that physical behaviour could be expressed in algebraic conventions without concrete visualization, led him to the development of the now ubiquitous 'Feynman diagrams' (Kemp, 1998d). Looking superficially like the simple graphics physicists have used for centuries, Feynman diagrams sidestep long-winded algebraic formulae, which contain electrons and positrons and using space-time co-ordinates, bring several equations together in one picture (see Figure 8). In essence, Feynman diagrams have achieved the graphic encoding of phenomena whose very nature means they cannot be subject to direct picturing (Kemp, 1998d).

As shown in Figure 8, Feynman's diagrammatic principles are very simple, but lead to increasingly complicated mathematical expressions, as increasing complicated diagrams are constructed[5]. Put together using such building blocks, diagrams become much more powerful than simple descriptions. Helping to conceptualize subatomic processes, Feynman diagrams are now an indispensable tool for calculation and communication in high-energy physics[6].

Buckminsterfullerene

Kemp (1998c) recognises the potential 'visual charisma' of scientific discoveries. The modern icon for chemistry that DNA has become for molecular biology could be thought of as the carbon cluster, Buckminsterfullerene. The impact of this perfectly symmetrical 60-atom cluster, a third allotrope of carbon, ancient and ubiquitous, transcends the historical or geographical significance of most named phenomena such as the mountains of the moon or

[5] http://www2.slac.stanford.edu/vvc/theory/feynman.html

[6] http://www.physics.carleton.ca/courses/75.364/pp-1html/node7.html

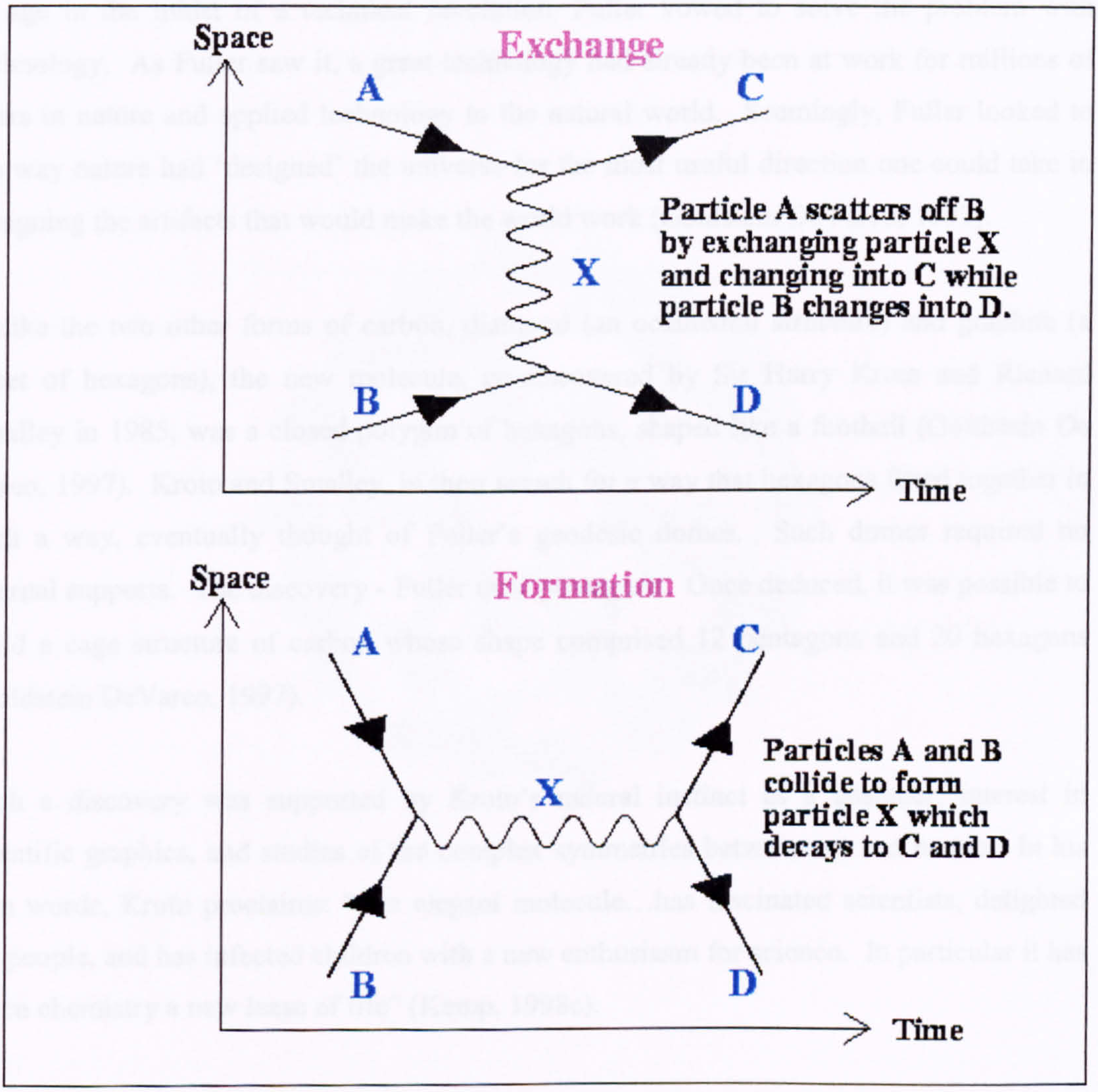

Figure 8. Feynman diagrams (www.nottingham.ac.uk/~ppzpc/feynman)

Antarctic peaks and ridges (Applewhite, 1995). Exhibiting molecular stability at odds with any diamond- or graphite-like configuration, colloquially referred to as the 'Buckyball', Buckminsterfullerence has unabashedly relied upon its visual charisma and media friendly appeal (Kemp, 1998c). Named after a geodesic dome-shaped American Pavillion at Montreal's Expo'67, the 'Buckyball' was a design of the architect, Buckminster Fuller. Fuller was an engineer, architect, machinist, philosopher, cartographer and poet. Coming of age in the midst of a technical revolution, Fuller vowed to solve the problem with technology. As Fuller saw it, a great technology had already been at work for millions of years in nature and applied technology to the natural world. Seemingly, Fuller looked to the way nature had 'designed' the universe for the most useful direction one could take in designing the artifacts that would make the world work (Goldstein DeVarco, 1997).

Unlike the two other forms of carbon, diamond (an octahedral structure) and graphite (a sheet of hexagons), the new molecule, co-discovered by Sir Harry Kroto and Richard Smalley in 1985, was a closed polygon of hexagons, shaped like a football (Goldstein De Varco, 1997). Kroto and Smalley, in their search for a way that hexagons fitted together in such a way, eventually thought of Fuller's geodesic domes. Such domes required no internal supports. The discovery - Fuller used pentagons. Once deduced, it was possible to build a cage structure of carbon whose shape comprised 12 pentagons and 20 hexagons (Goldstein DeVarco, 1997).

Such a discovery was supported by Kroto's natural instinct as a designer, interest in scientific graphics, and studies of the complex symmetries between art and nature. In his own words, Kroto proclaims: "this elegant molecule...has fascinated scientists, delighted lay people, and has infected children with a new enthusiasm for science. In particular it has given chemistry a new lease of life" (Kemp, 1998c).

According to Goldstein DeVarco (1997), Buckminster Fuller's explorations of synergetic maths, derived from experience, bear similarities to many artists and scientists before him such as Pythagoras, Dürer, da Vinci, and Kepler. Emerging in the broad intersection between art and science, these masters looked individually at the architecture of the

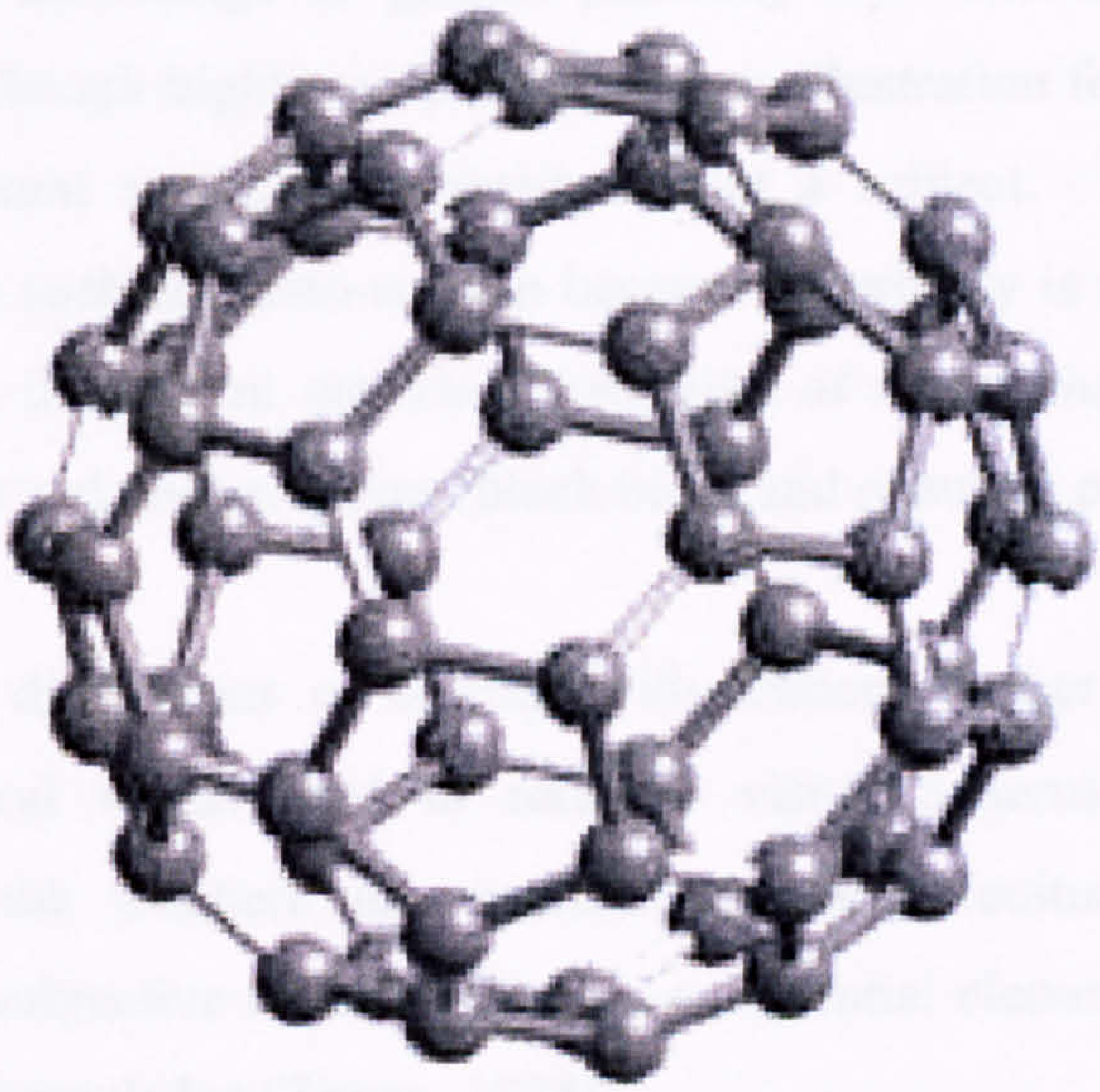

Figure 9. 'Buckyball' (www.thescientist.com)

universe and stand out in the history of geometrical explorations of symmetry, harmony and balance.

2.6.3 Scientific Illustration

In historical terms, the portrayal of scientific discoveries has a lengthy history. In the development of scientific knowledge, the study of illustration provides a retrospective view of the conduct of research (Ford, 1992).

Essentially, scientific knowledge is gained primarily by observation (Ziman, 1978). Scientific illustration, though highly representational, is illustration for which the objective is to accurately represent specific information about a subject. It differs from other representational genres such as photo-realism because its priority is not necessarily that it 'look real'. Scientific illustration includes illustration of maps, charts, and diagrams of natural science subjects and unseen things (black holes and quantum particles etc.)[7].

Ziman (1978), in his discussions of scientific illustration, further discusses biological illustration as 'technical words used to refer to visual patterns' and 'a perceptual consensibility across the frontiers of unconnected human culture'. Indeed, visual perception, by its intersubjective consensibility, is an essential element in the creation and validation of scientific knowledge (Ziman, 1978).

Botanical Illustration

The goal of botanical illustration is not art, but scientific accuracy. However, in the hands of a talented botanical artist, the illustration goes beyond its scientific requirements and becomes a thing of beauty in its own right[8]. Koptsik (1993) would, in fact, suggest that drawings of flowers and birds etc. are almost an excuse for artistic creativity in science.

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[7] www.Scientifiillustrator.com
[8] www.lib.udel.edu/ud/spec/exhibits/hort

According to the botanical artist, Brooker (2001), botanical illustration aims to describe in the clearest way, the structure of plants, the patterns of growth, colours and textures, and aspects of plant life-cycles. It is not about personal responses, impressions or individual touches. Instead, botanical illustration displays objective facts, described using certain conventions, in order to transparently communicate information. The individual art lies in the balance between artistic and technical values to produce an integrated whole.

Brooker (2001) states that, whereas a photograph can only depict one view, a drawing can: show different aspects simultaneously, depict a theoretical stereotype, show ranges of variation and can enhance or diminish features selectively. In taxonomy, a schematic drawing in three dimensions is generally deemed superior to the best photography. The draughtsman, by the trick of line and scale, can show with total ease, a combination of structures in one plane of view. When necessary to give significance to a specimen on the systematic (taxonomic) level, it is always necessary to schematise, to highlight certain details and to exclude other ones. Few species can be determined so readily from a photograph[9].

A large volume of scientific discoveries have been made through illustrative means and incorporated into the body of knowledge. From ancient herbal texts to medieval medical books, from accounts of the great exploratory voyages of the 15th Century to the chronicles of cosmic journeys of the 20th Century, scientific illustrators have helped elucidate the secrets of the natural world (Bolz, 1996).

There is a much debated issue of whether the illustrator should show one particular specimen, 'warts and all', or a synthesis of many specimens in such a way as to represent the archetypal form. In turn, this raises the question of whether scientific drawing should be gradually, if not wholly, surpassed by photography (Kemp, 2002). Furthermore, the discipline has commonly been subject to plagiarism and deliberate misappropriation. This has resulted in generations of perpetuated errors and compounded misinformation, precipitating at times, a decline in professional standards (Ford, 1992). Despite these negative aspects, scientific illustration remains the most refined art of picturing natural history (Bolz, 1996), even in this technological age.

2.6.4 Taxonomic Art

Scientists display an irresistible urge to list and classify, establishing categories according to observed similarities. Indeed, the history of natural history centres on the acts of naming and classification, most obviously the case in the Linnaean and Darwinian eras. Apparently, with the proviso of a scientific mind, you only show, with a fair interpretation, what you see, don't alter the detail and don't become 'artistic'[9].

The artworks of Dutch artist, Herman de Vries, is one attempt to display how nature defies such attempts at a fixed order (Kemp, 1998e). De Vries exhibits and collects natural things of 'a kind', for example shells, flowers, leaves, branches, herbs and varieties of earth, displayed in a fashion that avoids any form of denomination. In contrast, such art involves the quiet contemplation of nuances, challenging any relationship to standard taxonomic categories, such as those in the herbaria on which he has worked (Kemp, 1998e).

2.6.5 Mathematical Art

As described by Cox (1993), the use of mathematics has been important to art discourse for hundreds of years. From Renaissance architecture to graphic arts, mathematical forms have evolved into important cultural icons. In this way, the beauty of mathematics has become more accessible to mass culture today (Cox, 1993).

The idea that mathematical ideas can exhibit beauty and, more specifically, that pure geometrical form exhibits aesthetic perfection at the highest level has an ancient history. With the ultimate goal of an 'intuitive visualization of theorems', the advantage that artists working in the mathematical field possess is the ability to exploit suggestion and visual allusion in a way that is not generally acceptable in a scientific or geometrical diagram (Kemp, 1997).

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[9] http://www.microscopy-uk.org.uk

According to Hardy (1940), the mathematicians' patterns, like the painters' or the poets', must be beautiful; the ideas, like the colours or the words, must fit together in a harmonious way. Beauty, he defines as the 'first test' stating that there is no permanent place in the world for ugly mathematics.

Emmer (1993) discusses geometric plane shapes and solid forms i.e. those possessing regular features of proportion and symmetry. With reference to the 'platonic solids' or 'regular solids' (cube, tetrahedron, octahedron, isosahedron and dodecahedron), classic shapes of geometry are hailed for their conceptual beauty and were/are used by famous artists including Leonardo da Vinci and Albrecht Dürer.

Fractals

As defined by their creator, Benoit B Mandelbrot (1993), fractals are an art for the sake of science. Representing a new art 'form', they redefine the boundary between 'invention' and 'discovery' and artists are becoming more excited by the recognition that fractalisation, in some sense, is art[10].

Fractals were first defined in the 19th Century and ever since they have been referred to as bizarre. A fractal, in mathematical terms, is a geometric shape that is complex and detailed in structure at any level of magnification. Often fractals are self-similar; that is, they have the property that each small portion of the fractal can be viewed as a reduced-scale replica of the whole. One example of a fractal is the 'snowflake' curve constructed by taking an equilateral triangle and repeatedly erecting smaller ones on the middle third of the progressively smaller side[11] (See Figure 10).

Most famously, Mandelbrot defined a fractal, to be 'any curve or surface that is similar independent of scale'[11]. Considering, fractal patterns can be observed throughout the natural world as signs of dynamic activity, Mandelbrot, suggested that mountains, clouds,

[10] http://home.iprimus.com.au/ajwalker/mh/nature
[11] http://life.csu.edu.au/complex/tutorials

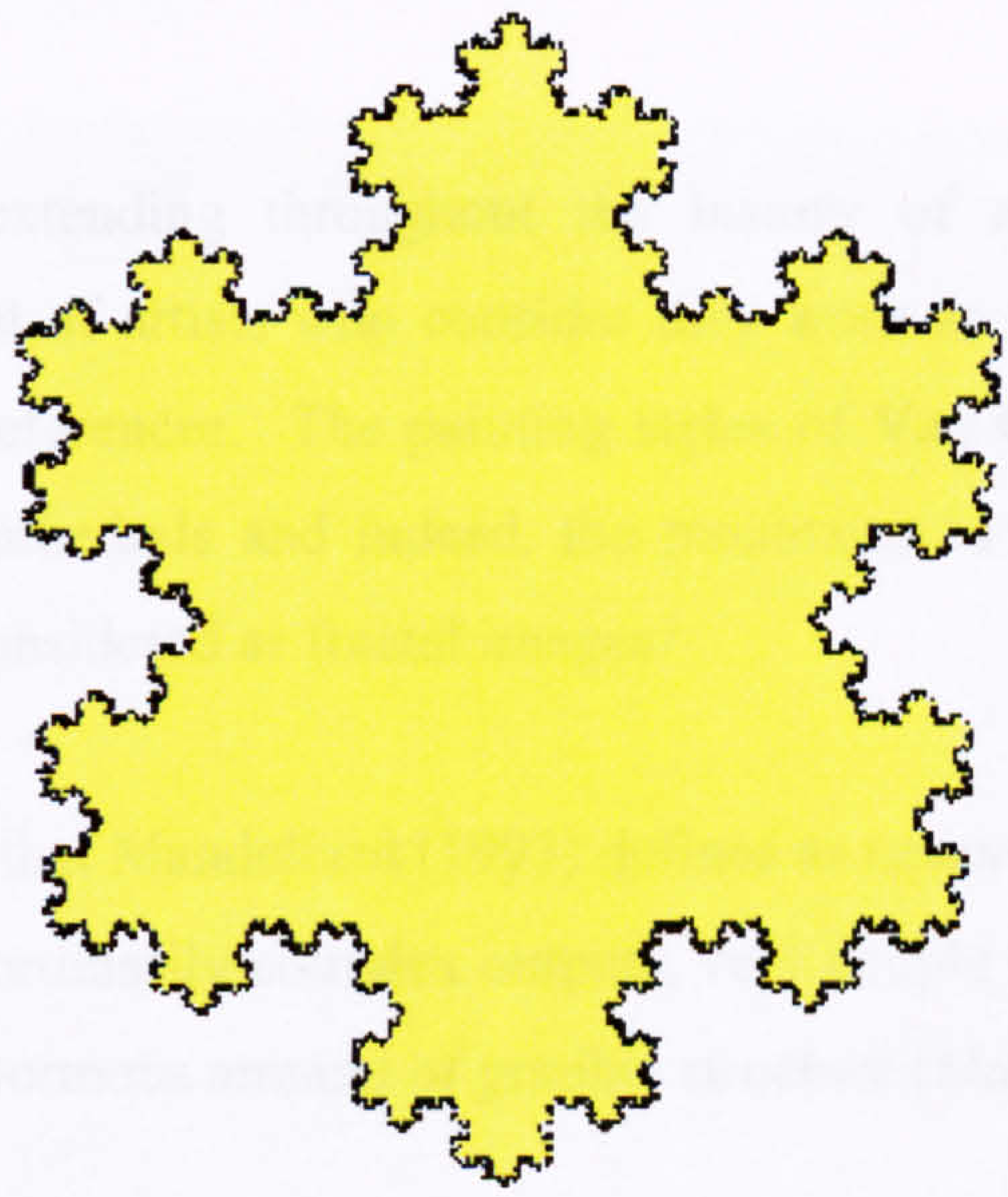

Figure 10. A Fractal (www2.math.uic.edu)

aggregates, galaxy clusters and other natural phenomena are all fractal in nature[11]. In this way, fractals and their geometry is a rapidly expanding field in terms of scientific application.

Mandelbrot was responsible for a turning point in the study of fractals in the 1970s with the discovery of fractal geometry. Fractal geometry is a body of thoughts, formulas and pictures which could be referred to as either 'geometry of nature' or a 'geometric language' (Mandelbrot, 1993).

Fractals in art

Claiming a heritage extending throughout the history of art, the contemporary arts movement boasts a host of artists who consider they work as fractalist in nature. Certain artists make fractalist references. The painting styles of Van Gogh and Jackson Pollock, the design of Gothic cathedrals and indeed, the mountains in ancient Chinese landscape paintings could all be considered as fractal images?

It is the fractal formula that Mandelbrot (1993) defines as necessary to create the art. With simple inputs and extraordinarily complex outputs, very simple mathematical formulas can be 'pregnant' with an enormous amount of graphic structure (Mandelbrot, 1993).

Veltman (1993) suggests perspective remains one of the most fascinating expressions of the links between mathematics and art. With this in mind, he states the rise of fractals has made us aware that scale is a factor to be taken into account with regards to perspective.

Being 'orderly to excess', Mandelbrot (1993) suggests that fractals interplay between too much symmetry (objectionable) and hidden symmetry, in other words, order and surprise. Furthermore, he suggests they are half way between representational and non-representational art. Indeed many fractalist patterns had no intended meaning, nor were meant to represent anything. They have, as stated by Mandelbrot (1993) 'plastic beauty'.

The 'beauty' of fractals has made them a key element in computer graphics and multimedia applications[10]. Indeed, computer generated fractal geometry proliferates globally on coffee

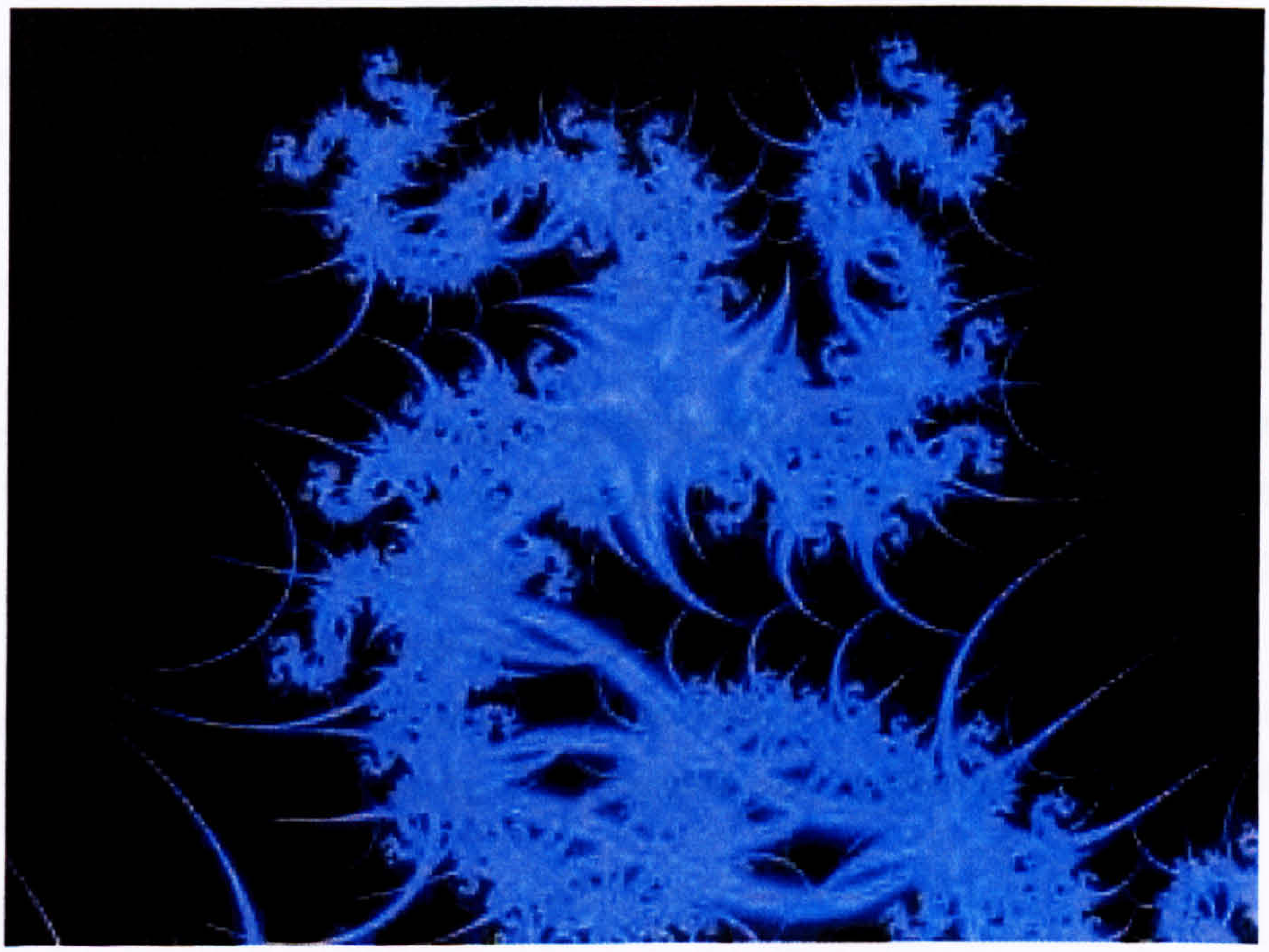

Figure 11. Fractal art (www.fractaldomains.com)

tables, music videos and posters globally (Mandelbrot, 1993). The qualities of fractals that lend towards this artistic endpoint would be their self-similarity, simultaneous order and chaotic dimension. However, the repetition of the fractal set is often deemed a little too habitual for the majority of the art world. Considering speculation that great, historical works of art resist the brains' tendency towards habituation, the worth of fractals as an art form in their own right remains to be clarified. (For scepticism of fractals, see also section 2.9.4).

2.6.6 On Growth and Form

"For the harmony of the world is made manifest in Form and Number, and the heart and soul and all the poetry of Natural Philosophy are embodied in the concept of mathematical beauty.........Moreover, the perfection of mathematical beauty is such that whatsoever is most beautiful and regular is also found to be most useful and excellent".

D'Arcy Thompson tells us in the epilogue to his composition *On Growth and Form*, an analysis of biological processes and their physical and mathematical aspects, that he understands something of the use and beauty of mathematics. The primary purpose of this famous text was 'to show that a certain mathematical aspect of morphology...is helpful...to the proper study and comprehension of Growth and Form'. Indeed, that no organic forms exist, save such as are in conformity with physical and mathematical laws (D'Arcy Thompson, 1961).

D'Arcy Thompson discusses several mathematical approaches to form. *On magnitude* represents D'Arcy Thompson's discussion of the Galilean principle of similitude, defining that, "no organism can grow beyond a certain size while retaining natural proportions". The central argument however, is that surface/volume ratios must decline as organisms grow in size. D'Arcy Thompson leads this discussion onto issues of the physical forces, which shape organisms directly. Moreover, small creatures are the product of surface forces, large creatures of gravitational (volumetric) forces (Gould, 1961).

Potentially the most fundamental and influential idea that D'Arcy Thompson presents is that complex prototypes of organisms and their transformations to related forms may be expressed as simple co-ordinates (Gould, 1961). Drawing on such natural formations as those found within the body shapes of fishes and skulls of mammals, outlines of species are transferred via a network of co-ordinates to a manifest representation of closely allied species. Perhaps not perfectly regular deformations, the examples are indeed symmetrical to the eye and provide an adequate and satisfying picture of the processes of deformation and the directions of growth (D'Arcy Thompson, 1961). Perry (1993) credits the work of D'Arcy Thompson as 'the bridge from real life to art', displaying, he states, the inherent beauty and interest in primary forms e.g. the spiral, the pyramid and the cube, so often expressed elsewhere in architecture and adornment.

2.6.7 Outsider Art

The origins of the term 'Outsider Art' can be traced back to the first book written on the subject by Roger Cardinal in 1972. In an attempt to meaningfully translate the term 'L'Art Brut', thought to be 'outside art', he defined it as being outside society, or socially excluded. In other words, outsider art pertains to individuals from a variety of backgrounds whose visual images are not given the term 'art' (Laing, 2000). Also referred to as 'Art Extraordinary', examples of such art are commonly produced by people with special needs, both physical and mental.

As discussed by Ashcroft (2000), there has always been a synergy between painting and the science of vision. Our perception of art, she suggests, and its derangement in patients with eye or brain defects, has illuminated our understanding of the emotional state of the brain. Ashcroft (2000) also emphasises that the paintings of schizophrenics alter before and after an attack. On a similar theme, there has been widespread usage of art, in recent years, as a therapy for many such physical and mental disabilities.

2.7 Explanation of art – how art uses science

2.7.1 Scientists of art

Of all the men who contributed to the revival of artistic and intellectual achievement that occurred in the High Renaissance, none were more remarkable than Leonardo da Vinci. Master of any discipline he practiced, Leonardo had a high degree of curiosity about the physical world, which was to be the foundation of modern science[12].

For Leonardo da Vinci, art and science were inseparable; both based on insightful observation. Leonardo's perspective was that 'the most praiseworthy form of painting is one that most resembles what it imitates'. A leading anatomist, inventor and phenomenally acute observer, his skill as an illustrator enabled him to notice and recreate the effects he saw in nature. Curious as well as observant, he constantly tried to explain what he saw[13].

While his paintings have brought him most fame over the years, the full range of his talent can best be seen in his drawings. The bases for much of modern scientific illustration, especially in the field of anatomy, his drawings were a means of exploration of human functions. Based on actual dissection, Leonardo's greatest contribution to anatomy lay in the creation of a system of drawings for anatomists and physicians to transmit findings to their students[14].

Leonardo's most famous anatomical drawings included the Embryo in the Womb. Although faulty in some respects, it is so expertly drawn that can still be used in medical textbooks. However, a topic of more obsessive fascination for da Vinci was that of the human heart. Furthermore, Leonardo's ability to extricate himself from authoritative theological beliefs and scientific methods may explain how he was able to come to a number of new conclusions regarding the nature and function of the heart[14]. Such deductions included: the muscular nature of the heart; it being the most powerful muscle in the body; the presence of upper chambers (referred to as 'auricles'); importance of the

[12] http://www.geocities.com/CollegePark/1070/leonardobibliography
[13] http://www.mos.org/sln/Leonardo/Leonardosperspective
[14] http://www.stanford.edu/~mgorman/essays/Rekha/leo

independence of these chambers, residing above ventricles; and the ability of these chambers to expand and contract at separate times. Furthermore, Leonardo's anatomical studies of the heart (see Figure 12), together with his geological and physical studies of the earth, resulted in a mutually influential dialogue. He further deduced an analogical relationship of how the property of heat endows and transmits life to the earth and the human[13].

Da Vinci never believed in science for the sake of science, saying once "From science is born creative action, which is of much more value". However, Leonardo stood only on the threshold of the scientific revolution. Moreover, accused of sacrilegious practices, Leonardo was banned from doing anatomical drawing by Pope Leo X and thus, his 28-year anatomical career came to an abrupt, rather undignified end[14].

Albrecht Dürer (1471-1528), the German renaissance printmaker and biological illustrator, was the first of his kind to teach the methods of perspective. Dürer shared with Leonardo da Vinci the quest for an art that would be 'universal'- one that constructs representations of all forms in nature on the basis of a profound understanding of natural philosophy in all its relevant facets. So, when portraying human beings, the mental and physical constitutions of each individual were to be expressed in terms of the Renaissance theories of psychology and physiology (Kemp, 1998f). Dürer believed that art should be based on careful scientific observation[15], and his works lay testament in equal measure to these religious and intellectual allegiances (Kemp, 1998f).

Some say that Dürer had more effect on the visually based sciences than any 'scientist' of his day (Kemp (2002). Particularly, Kemp (2002) highlights that Dürer's writings on human proportion and geometry have remained points of reference for centuries and that as both artist and scientist, he was widely influential on three-dimensional geometry and those sciences that sought geometrical foundations.

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[15] http://www.arts.ufl.edu/art/rt.room@rtrivia3/durer

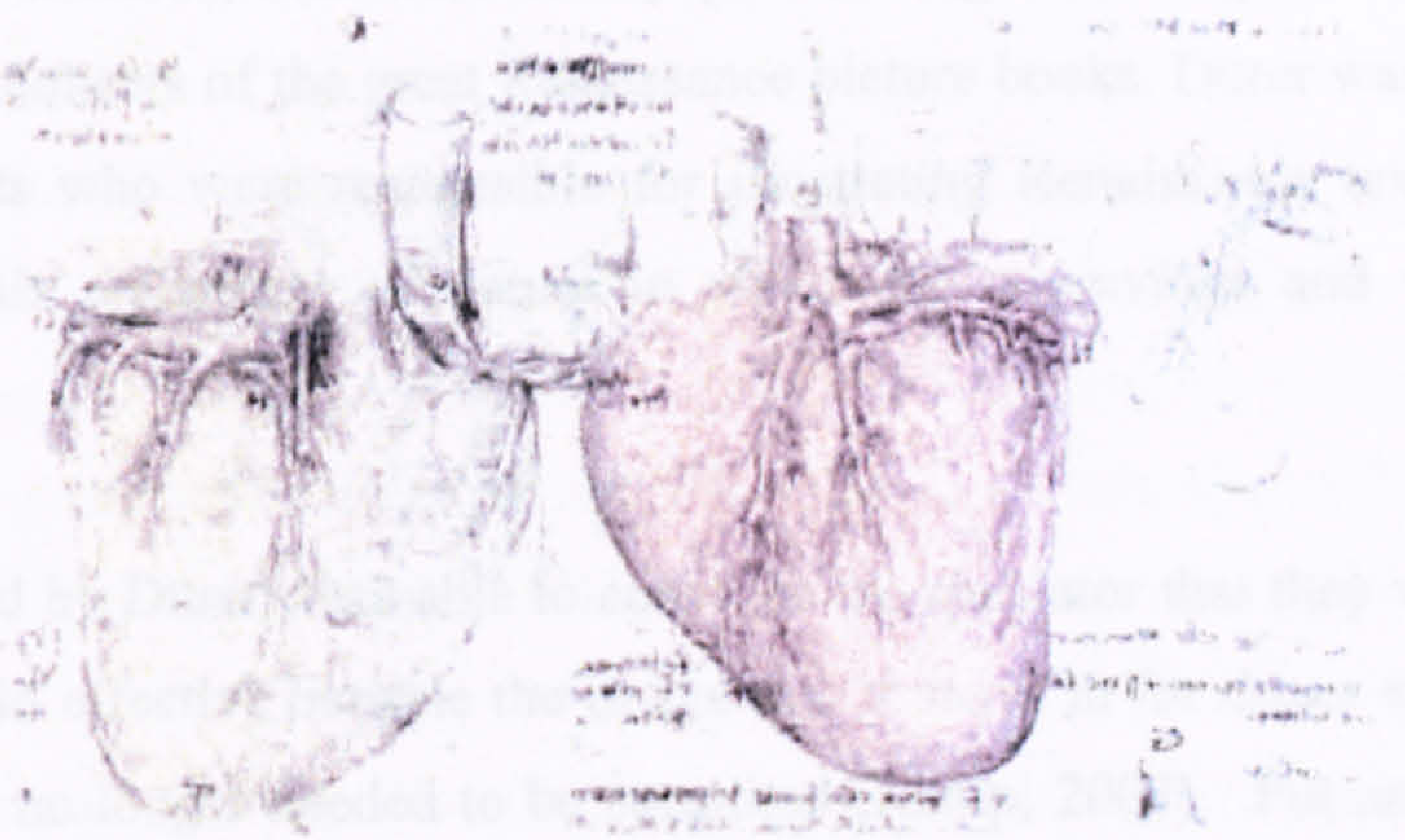

Figure 12. *The Heart*. Leonardo da Vinci (1452-1519) (www.wsu.edu)

Figure 13. *Hare*. Albrecht Durer (1502) (www.gallery.euroweb.hu/art/durer)

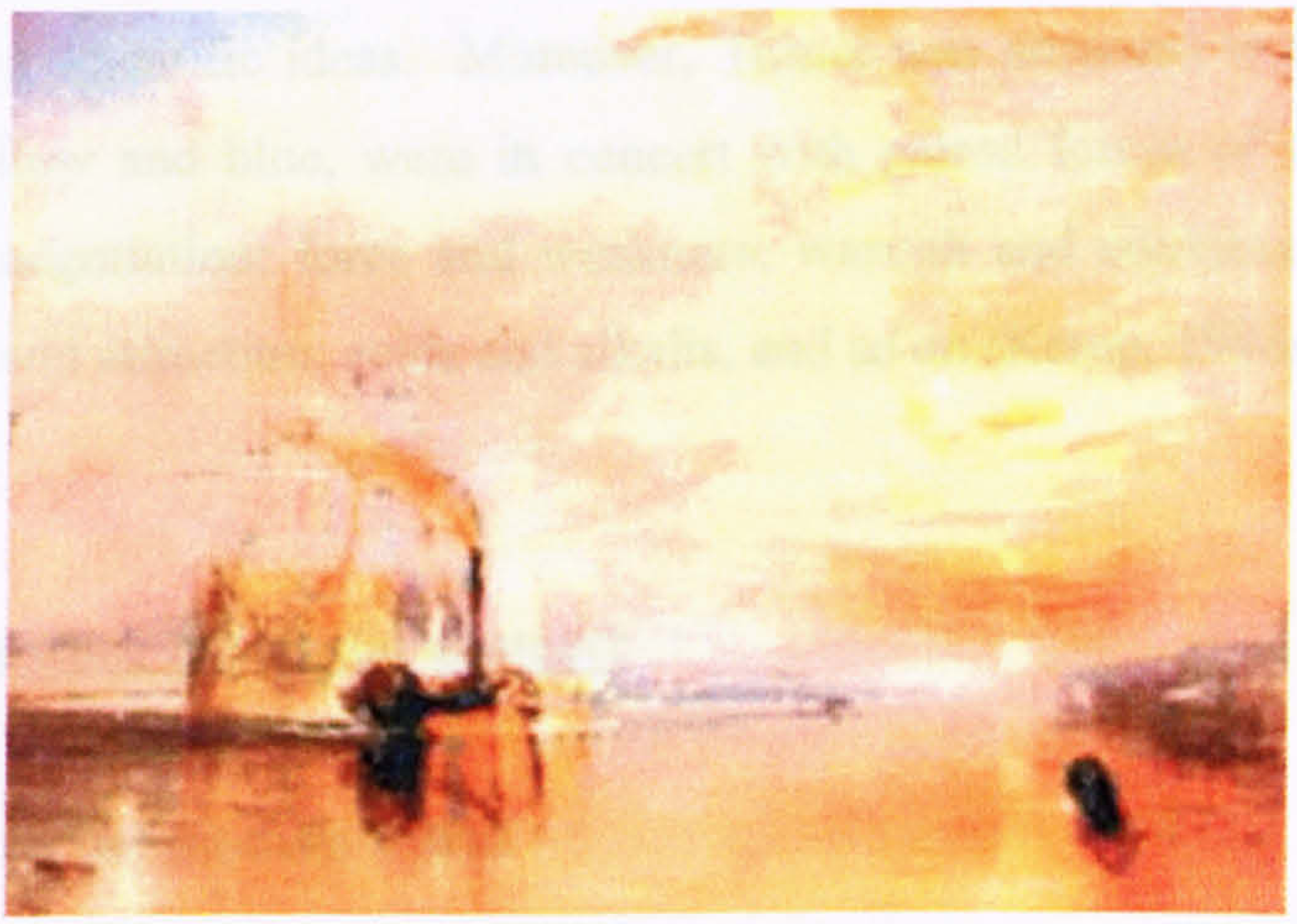

Figure 14. *The Fighting Temeraire*. John Turner (1838) (www.j-m-w-turner.co.uk)

Dürer could be regarded as the true father of naturalistic illustration. The potential for the illustration of those sciences, that were newly proclaiming their empirical foundations, became clear to the pioneers of the great Renaissance picture books. Dürer was involved in the training of artists who were responsible for illustrating Renaissance texts, setting a precedent through his renderings of nature in woodcuts, engravings and watercolours (Kemp, 2002).

Techniques pioneered by Dürer were able to convince the spectator that they were looking at the 'real thing'. So effective became the image that it stood in for direct experience of the specimen, which no longer needed to be consulted (Kemp, 2002). For an example of Dürer's reality, see Figure 13.

John Turner, well known, as the supreme exponent of Romanticism in British art, is lesser known as a student of the science behind that art. Scientific insight for Turner, was never a matter of 'restrictive rule', but provided access to the awesome powers of nature. Turner is famous as a master of the use of primary colours to depict light in painting, which exemplifies his fascination by the magnetizing properties of light (see Figure 14). More importantly this triad of colours, comprising the traditional 'primaries' of all painters of the era, was founded on scientific ideas. Moreover, Turner was attracted to the way the two 'polar' colours, yellow and blue, were in concert with paired forces of nature: plus and minus; action and negotiation; force and weakness; warmth and coldness; proximity and distance; repulsion and attraction; acids and alkalis, and so on (Kemp, 1998g).

2.8 Can science work in a social context?

2.8.1 Knowledge in the modern world

The history of explanation (see section 2.3.1) has much bearing on the modern scientific world we see today and certain remnants of science past still figure highly in the current framework of scientific research. Historically, we see science has prevailed solely by intrinsic appeal to reason. Representing a piecemeal and partial authority, the pronouncements of science in recent years are made tentatively, liable to modification through time (Russell, 2000).

The philosophical situation expressed by Descartes still exists in modern scientific thought. That is, 'everyone is an individual and exists independent of others'. In fact, such a philosophy is the basis of a method of scientific research. However, such thinking has led to complex moralistic issues in the modern world. Indeed, society now suffers from this previously limited, selfish moral outlook (Whitehead, 1946).

According to Whitehead (1946), the old foundations of science are now becoming unintelligible. The ideas of time, space, matter, electricity, mechanism, organism, structure, pattern, function, all require reinterpretation. Moreover, Whitehead (1946) believes science to have started its modern career by taking over ideas derived only from the weakest sides of the philosophies of Aristotle's successors.

The discoveries of the 19th Century were in the direction of professionalism, leaving no expansion of wisdom and with a greater need for it. Indeed, the modern world at present, seems to be heading towards a situation like that of antiquity; a social order, imposed by force, representing the will of the powerful rather than the hopes of common men (Russell, 2000).

2.8.2 Preservation of the public domain

The public domain is proposed to be the cultural space in which we share information, creativity and ideas. This 'information commons' grows, not only with the breadth and depth of its holdings, but also the number of citizens who use it. However, knowledge that belongs in the information commons which should theoretically, be accessible as part of our shared heritage, is rapidly being privatised into proprietary 'product'[1].

Ravetz (1996) states scientific knowledge is amenable to sociological inquiry, dictating a need for a method for sociology of scientific knowledge. According to Walford (1985), an intellectual understanding of human society is incompatible with ignorance of science. In the 1990's the process of globalisation, privatisation and corporatisation of research and attendant issues of intellectual property rights (IPR's) and proprietary information led to negotiating research priorities in a broader social context. As a result, new models of the innovation chain and new paradigms of the science-society contract have emerged (Ramachandran *et al.*, 2000).

Science and industry are otherwise suggested as paternalistic in their societal approach, with an ever-increasing trend of science elitism. Therefore, an imperative need for science pluralism (Ramachandran *et al.*, 2000) presents itself.

Ramachandran *et al.* (2000) state that scientific prescription with no historical ecological data has very little value for management. Such information lies with people who have no formal training in scientific endeavour. Here lies another knowledge system, which needs to be recognised, with people made partners in the new science-society contract. In this new social contract for sciences, people must be given a greater role in managing and monitoring resources (Ramachandran *et al.*, 2000).

Historically, Harold Wilson realised the importance of science and scientists to the economic and social growth of the British nation. Furthermore, his ideas helped reinforce the need for science teaching in schools (Harlen, 1992). In parallel, The Science in Society project, a curriculum development scheme of the Association of Science Education, was initiated in 1976, a time of rapid growth and activity in various aspects of the social study of science. It defined policy statements in a concerted effort to redirect the focus of science away from elitism and a class-structured society (Walford, 1985).

To support the argument, Homer-Dixon and Perkins (1982) define scientific and technological research as human activities, subject, therefore, to moral appraisal. No citizen can avoid the responsibility of trying to keep informed of the performance of elected officials, in this case scientists, and no elected official can avoid the responsibility of looking after the public good (Homer-Dixon and Perkins, 1982).

To integrate science in society, Philippart (1980) suggests that society must be either: a) diachronic i.e. follow the developments of research and scientific policy, adjusting to it; or

b) synchronic i.e. consider all the data known or accessible at any given time. However, the pressure and time elements of scientific research may induce people to overlook the diachronic or the synchronic aspect, or indeed, neglect both (Philippart, 1980).

It is suggested that authoritative sources of information on developments in science can bridge the gaps among scientists, policy-makers and the public in order to advance science and science education. Equal access to the fund of scientific knowledge is important in order to more fully understand and appreciate the global society in which we live (Marsh, 1998).

However, to respond effectively to an ever-changing environment, society needs more than a knowledge base. The use of innovative philanthropy and catalytic leadership to develop an information literate society is essential to preserve a large and robust public domain[16] as a consequence. Martins (1992) suggests pragmatic knowledge, derived from social expectations to inform decisions about pedagogic interventions within a 'science and society' approach

2.9 Can art work in a social context?

2.9.1 Public art

Like science, art has a social function and significance (Lippard, 1983). However, purely visual art is increasingly unable to communicate the complexities of the contemporary world. Therefore recommended is a 'hybrid' form of communication, a mixture of many media as signifiers of context (Lippard, 1997). In her short definition of public art, something that was defined as recently the 1960's (Becker, 2002), Lippard (1997) defines 'accessible art of any species, that cares about, challenges, involves and consults the audience for or with whom it is made, respecting community and environment. The 'public' in public art she states, can be read in two ways – passive or active - as private art

[16] www.centreforthepublicdomain.org

in public spaces or as art intended to be understood and enjoyed, or even made by, 'the public' (Lippard, 1997). Such public art should have the following criteria:

- Specific: enough to engage people on the level of their own lived experiences.
- Collaborative: seeking information, advice and feedback from the local community.
- Generous and open-ended: accessible to a wide variety of people, not withholding information.
- Appealing: enough visually or emotionally to catch the eye and be memorable.
- Simple and familiar: enough not to confuse or repel potential viewer participants.
- Complex and unfamiliar: enough to hold people's attention once attracted.
- Evocative: enough to recall related moments, places or emotions.
- Provocative and critical: enough to think of issues beyond the scope of the work (Lippard, 1997).

Becker (2002) suggests that innovative collaborations and independent initiatives in the 1970's and 80's paved the way for a large number and diverse array of artists to move out of the studio and into a much larger arena. With expanded options for delivering their creative expressions artists were given opportunity to connect with audiences on their terms. From the 1990's until the present day, this public art field encompasses place-making, environmental activism, cause-related art, interdisciplinary performance events, a wide variety of community-based initiatives and much more (Becker, 2002).

Whether owned by the community or existing in private places, Adams (1999) describes public art as a cultural investment, creating a different perspective on our view of heritage. It can enhance local identity, contribute to the development of a sense of place and be used to improve environmental quality. In this way, public art requires artists to adopt new ways of working, to extend the role of the artist and to redefine the function of art in society (Adams, 1999).

As highlighted by Binks (1999), working with artists in all media has become much more commonplace for countryside managers and rural community workers. Indeed, there has been a strong revival of interest in using art and artists in processes such as urban regeneration, environmental improvement and community development (Binks, 1999).

However, Lippard (1997) comments that rural public art is very different from the prevailing notion of public 'land' art as it involves, not art tourists, but local people for whom farmland, coastlines etc. are not exotic. Indeed, local people may need help in reading the images, or education of what to look for outside their own experience (Lippard, 1997).

2.9.2 Environmental art

In a general sense, environmental art could be described as art that helps improve our relationship with the natural world. The majority is ephemeral, site-specific and involves collaborations between artists, scientists, educators and community groups[17].

Some environmental art:

- interprets nature, creating artworks that inform us about natural processes or environmental problems we face;
- is concerned with environmental forces and materials, creating artworks powered by wind, water, lightning etc.;
- re-envisions our relationship to nature, proposing new ways in which to co-exist with our environment;
- reclaims and remediates damaged environments, restoring ecosystems in structural and often aesthetic ways[17].

2.9.3 Contemporary examples

Patrizio (1999) discusses contemporary Scottish sculpture in terms of a 'lyrical conceptualism'. He suggests that public life in general, has become a complex problem to be scrutinised in relation to our sense of community and use of communications technology. Sculpture therefore, inherits the problems associated with this wider context.

[17] http://www.greenmuseum.org

Sculpture is currently being brought into new constituencies, with its 'private languages' now within the common public domain. This enables an exploration of open-ended issues of context in relation to art production and dissemination (Patrizio, 1999), in other words, a 'lyrical conceptualism'.

A recent example of artists bringing environmental sculpture more fully into the public domain, is the work of environmental artists Matthew Dalziel and Louise Scullion. Graduating from the Glasgow School of Art, exhibiting nationally and internationally, they have produced an impressive body of work that engages their ongoing interest in our contemporary relationship with nature. Their art is intended to express a shared interest in the environment and the growing urbanisation of the population. Their sculpture, together with work in film, video and photography, encourages us to look anew at our habitat, questioning what significance our increasing estrangement from nature will have on our collective future. Frequently working alongside scientists, for example ecologists and botanists, they aim to convey scientific information about the reality of our environment and challenge the way we respond to it.

Land artists

In his dialogue, Patrizio highlights the contemporary artist, Andy Goldsworthy. Aware of the collaborative nature of what he does, Goldsworthy aims to make sculpture which reasserts humankind's sense of connection to its surroundings, rather than underscoring the differences (Patrizio, 1999). In this way, Goldworthy is a representative of the movement of the 'environmental' or 'land' artists.

A more recent addition to this movement is Chris Drury, referring to himself as a land artist or 'someone who works with art and nature' (Drury, 1998). His aims to produce work which: explores nature and culture, inner and outer; fits the needs of the community; is an integral part of the landscape; draws attention to something outside the work itself and is

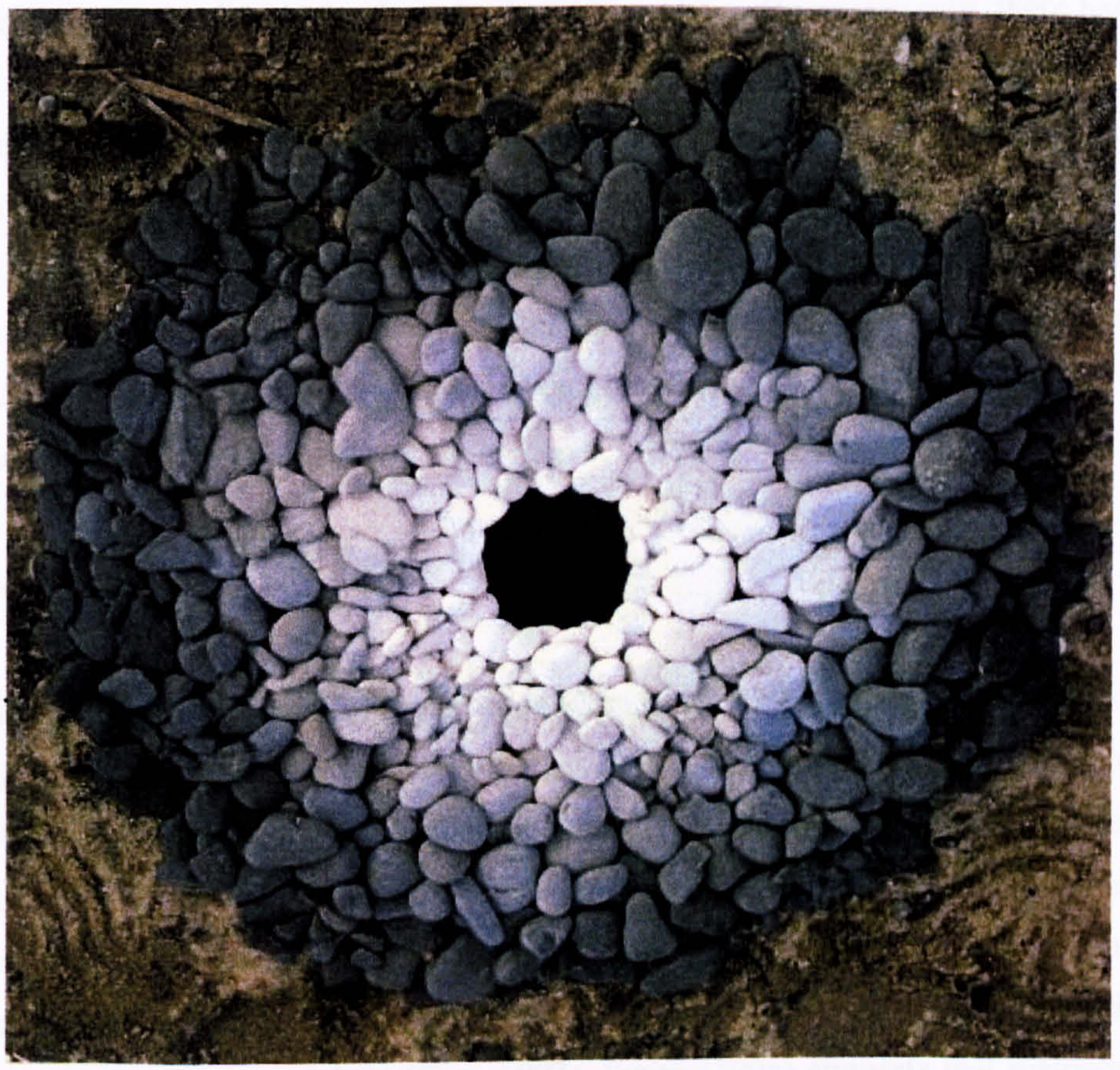

Figure 15. *Pebbles and Hole*. Andy Goldsworthy (1987) (www.absolutearts.com)

not self-referential[18]. For an example of Drury's work see Figure 19 (section 3.1.3).

2.9.4 Public disenchantment with art

The public face of science and scientists are markedly subject to regular criticism, with objections and a lack of faith clearly voiced within society. Comparatively, there has been observed a deep-seated ambivalence about the nature, purpose and relevance of art in contemporary society (Smith, 1995). Mass media interest and a modern, relentless quest for the artist to challenge and provoke lead frequently to the disillusionment of the target audience. It is the view of Smith (1995) that, as we create, it is necessary to adapt to what we have created. The danger, she states, is that the artist, responsible for representation of the world as we see it, may create a world beyond the restraints of our intelligence - a world we cannot see.

Graphic and mathematical art

Cox (1993) defines two spheres of the art of modern times: i) 'high art'- works which focus on the significance of their contribution to the history of art and ii) 'low art' – works prevalent and appreciated by mass or popular culture. Mathematical and scientific imagery for example, have current popular appeal, partly due to their celebration of natural structures. However, contemporary art criticism condemns work that focuses on the aesthetics of pure form. Indeed, the fine art market ignores most works of graphic art, relegating them to 'non-serious' art (Cox, 1993). Smith (1995) suggests that mathematical truth is not the same as pictorial truth. Above all, it happens continually that geometry says one thing and our mind says another.

Koptsik (1993) continues to suggest that prejudice against the use of scientific methods for studying artistic phenomena have not been overcome amongst artists. This prejudice is based on the idea that even acknowledgement of scientific laws in art might in some way

[18] http://www.chrisdrury.co.uk

interfere with the direct perception of artistic compositions. Koptsik (1993) suggests this is fundamentally incorrect, but mass public opinion on such an issue is unclarified.

Loeb (1993) suggests that if art is 'something that extends an accepted tradition of icons and images, restating the inherited beliefs of our culture', then visual mathematics *is* art. It is a reflection of our culture, enthralls a small audience and produces new and widely shared styles. Ultimately, some would disagree.

The artist Damien Hirst

A twelve-foot tiger shark in formaldehyde, a cow and her calf sawn in two, cabinets of pharmaceutical bottles filled with controlled substances, spinning canvases, spot paintings, cigarette butts: this is the unmistakable sphere of Damien Hirst's work (see Figure 16). One of the most controversial artists of his generation, Hirst possesses an unflinching view of modern life and an original talent for making images that fearlessly communicate the urgent themes of our time (Burn, 1997).

Fundamentally designed to shock, provide controversy and provoke intrigue, Damien Hirst's art easily achieves this goal as demonstrated by his name being a staple of feature pages and media columns (Burn, 1997). However, in the artists own words this art is merely 'idea art', revolving around 'the idea of trying to understand the world by taking things out of the world'. Perception of the art by the viewer, whether in excitement or disgust, it could be said, matters not when normality has been challenged and notice taken.

2.10 Enhancing consensibility

2.10.1 Consensibility and consensus

Ultimately, the goal of many (perhaps all) scientists is a consensus of rational opinion over the widest possible field. Similarly, the aim of a professional scientific education is to develop the ability to live at ease within the current scientific consensus (Ziman, 1978). Scientific researchers labour towards the goal that their peers will ultimately reach a

Figure 16. *Waste*. Damien Hirst (1991) (Burn, 1997)

consensus on the importance and reliability (truthfulness) of their work, incorporating it into the core. Until this consensus has been reached, frontier work is regarded as very tentative work that may be legitimately criticized. Ziman (1978) further suggests that consensibility is a necessary condition for any scientific communication, whereas only a small proportion of the whole body of science is undeniably consensual at a given moment (Ziman, 1978).

Ziman (1978) defines consensibility in terms of 'the social model of science', as 'not obscure or ambiguous'. In this way, the recipient can give either whole-hearted assent or offer well-founded objections. Consensibility is, however, limited by the majority of science being comprised of mainly esoteric data (Kuhn, 1962). Those who ask the question 'is this a matter on which science is to be believed?' must be given an answer that takes into account their own biographical experiences and powers of comprehension (Ziman, 1968). Prejudice and value systems influence even the 'purest' science (Sardar, 2000). Although scientific philosophers such as Thomas Kuhn (1962) would believe that unlike members of other fields, scientists are able to reach a firm consensus, ineffective dissemination of scientific proclamations, to a community of stakeholders, may be its ultimate flaw.

Schalk (1998) states that a close collaboration, or consensus, between scientists and policy-makers, will be needed if the value-loaded problem of a responsible use of the Earth's resources is to be tackled. Only with a common accessible knowledge base can alternative approaches for more responsible use of exploitation can be outlined (Schalk, 1998). For this, the greatest impediment to a consensus is translating social concerns into well-defined goals (Homer-Dixon and Perkins, 1982).

2.10.2 A case for Post-normal Science

A large body of Kuhn's work details what he defines as 'normal science'. As described by Kuhn (1962), normal science is the activity on which most scientists inevitably spend all their time, predicated by the assumption that the scientific community knows what the world is like. Much of the success of the enterprise derives from the community's willingness to defend that assumption, if necessary at considerable cost. Sadar (2000) continues that normal science isolates the scientific community from the outside. Therefore, in high-risk environmental situations, with facts uncertain, value in dispute, stakes high and decisions urgent, normal science is non-valid (Functowicz and Ravetz, 1990).

Post-normal science, first defined by Functowicz and Ravetz (1990), in contrast, provides a coherent explanation of the need for greater participation in science-policy processes. The phenomena of life, society and now the environment, cannot be captured, nor their problems managed by sciences, which assume that the relevant systems are simple. Indeed, anyone trying to comprehend the problems of 'the environment', might well be bewildered by their number, variety and complication. Despite the natural temptation to reduce them to simpler elements, post-normal science has been developed as the appropriate methodology for complex systems[19].

A restricted corps of insiders only can no longer perform scientific assessment. The dialogue on quality, along with that on policy, must be extended to all those who have a stake in the issue, that is to the extended peer community (Funtowicz and Ravetz, 1997). In this way, the community can imagine solutions and reformulate problems in ways that the accredited experts do not find "normal" within their professional paradigms (Functowicz and Ravetz, 1993). When persons with no formal qualifications attempt to participate in the process of innovation, evaluation or decision, their efforts have tended to be viewed with scorn or suspicion. Post-normal science endeavours to correct this sort of mindset leading to a focus on mutual respect and education[19]. In particular, it requires the gap between scientific expertise and public concerns to be bridged in a full, democratisation of science (Functowicz and Ravetz, 1990).

In summary, the world of "normal science" still has its place in the study of the environment, but it needs to be supplemented by awareness of the post-normal nature of the problems we now confront (Funtowicz and Ravetz, 1993). In other words, science must evolve in response to the changing needs of the community (Functowicz and Ravetz, 1990).

[19] http://www.website.lineone.net/-jerry_ravetz/pages/pns

2.10.3 Scientific revolutions

Kuhn (1962) continues his discussion of normal science in his book 'The Structure of Scientific Revolutions'. In the text, he suggests normal (science) research does not aim to produce major novelties, conceptual or phenomenal. Invention of alternatives is what scientists seldom undertake, retooling an extravagance to be reserved only for the occasion that demands it (Kuhn, 1962). Scientific revolutions, conversely, are extraordinary episodes in which a shift of professional commitments occurs, shattering the traditions of normal science. Although, revolutions, large or small, produced within one scientific community will not necessarily extend to the others as well (Kuhn, 1962).

As mentioned, much of the discussion into the historical and philosophical backgrounds of scientific progress relates back to Darwinian principles. Kuhn's (1962) 'Structure of Scientific Revolutions' is exemplary of this. Like many theological predecessors, he relates science to the process of natural selection: it has no pre-defined goal; and science is the net result of a set of revolutionary selections (Kuhn, 1962). On a similar theme, Karl Popper highlighted the analogy between scientific progress and genetic evolution by natural selection (Dawkins, 1989).

Richard Dawkins, holding a Professorship in Public Understanding of Science, discusses the evolutionary aspect of science, with reference to his personally devised concept of 'memes'. Where genes are a replicating entity, biological in nature, memes, Dawkins (1989) proposes, are another kind of replicator, cultural in nature. Memes are stories, songs, habits, skills, ideas and ways of doing things that replicate via imitation. Dawkins (1989) suggests we can only explain human nature by evolutionary theory when we consider memes as well as genes. Furthermore, analogous to the survival of genes in a gene pool, Dawkins (1989) discusses the survival of memes in a meme pool. For example, ideas, he suggests, propagate by psychological appeal, works of art by aesthetic appeal and scientific ideas by how acceptable they are to the population of individual scientists (or how many times replicated in scientific journals).

Of most significance, however, is the statement of Dawkins (1989) that the survival value of a meme, in this case a scientific idea, is dependent on it being easy to understand. In other words, ideas that are more comprehensible will last longer and therefore, be more readily incorporated into the public information commons. However, it is perhaps important to note that ideas move differently in the scientific world compared with other worlds. Acceptance by scientists is dependent on elements of logic, reproducibility and proof. Furthermore, such ideas and their acceptance often change according to the fashion of the times.

2.10.4 Case studies of conflict and consensus

With a view to enhancing consensibility, it becomes necessary to draw on suitable examples. Of particular relevance to this research are case studies within the field of marine resource management. Firstly, it is important to document scenarios where issues of conflict, regarding the deliverance of science, have impeded effective resource management and secondly, where co-operation and consensus have been central to the resolution of conflict. In searching the literature, the most relevant examples pertain to issues of fisheries management, related discussion being abundantly significant to future chapters.

Conflict

According to Mitchell (1997), four basic causes of conflict concerning decisions about environmental and resource management exist. With more than one of these often co-existing, they are defined as follows:

i) Differences in knowledge and understanding. In that, different groups may be using different models, assumptions and/or information;
ii) Differences in values. In that, disagreement can centre on the nature of the problem, the means to resolve it and most notably the ultimate endpoint to be sought;

iii) Differences about distribution of benefits and costs. In that, conflict could relate to who will be the beneficiaries and who will carry the burden of costs; and

iv) Differences due to personalities and the circumstances of interested parties. In that, conflict may result from historical differences, personal bitterness and/or a lack of trust.

The Canadian Atlantic Fishery Collapse

Growing complexity, interdependence and uncertainty of environmental issues and the rapid rate at which environmental situations change aggravates such situations of conflict. Furthermore, there is a growing public expectation of participation in resource management, and less willingness to accept that the experts necessarily know what's best (Mitchell, 1997).

Exemplary of such a set of circumstances was the 1992 collapse of cod stocks off the East Coast of Newfoundland, a paradigm of how a relatively sophisticated management programme, based on scientific information, can go drastically wrong. Formerly the most productive cod fishing area in the northwest Atlantic region, the introduction of destructive fishing methods such as 'factory-trawlers' and 'dragger' technology, combined with the increased effort by distant-water fleets, had a disastrous effect on this 'northern cod' fishery.

Concerns of the Canadian (and US) government that stocks were being reduced considerably led to legislation passed to extended their jurisdiction to 200 nautical miles, banishing foreign fleets to the 'high seas'[20]. Catches naturally declined in 1978, at which point the fishery should have been capped. Instead, in the 1980s, the Canadian government displayed a permissive approach to fisheries development, promoting further investment.

In the early 1980s and contradictory to scientific data and reports by scientists, traditional inshore fishermen in Newfoundland began to notice declining catches. By 1986, scientists realised the same, though despite recommendation that the total allowable catch be cut in

[20] http://archive.greenpeace.org/~comms/cbio/cancod.htm

half, the federal government delayed action. By 1992, the biomass for northern cod was so low that the Minister of Fisheries had no choice but to declare a ban on fishing for cod and a number of other groundfish species[20]. This Northern Cod Moratorium was responsible for the loss of an estimated 40 thousand jobs and the devastation of several hundred Newfoundland communities. Most heavily, the blame for this ecological disaster lies with the federal government for its overly optimistic reliance on science in predicting a large increase in cod stocks in the 1970s and 1980s[20].

The interplay of such a set of circumstances is commonly known as 'the ratchet effect'. In the initial stages of exploitation of a fishery, investment and harvesting rates increase rapidly, stabilizing at excessive, unsustainable levels. When yields start to decline, scientific information and improved knowledge necessitate calls for reduction in catches. However, appeals from industry are made for help or special consideration, owing to investments and jobs now at risk. In such circumstances, governments typically delay decisions, pending the results of further scientific research[20]. Such processes can often take several years.

The Canadian Atlantic fisheries collapse illustrates how a fishing community, moreover, society at large, can become the long-term losers of fisheries science, backed by government support and private investors. Despite heavy investment by government and industry in the scientific process, the costs of accompanying irrational behaviour are undoubtedly socialised[20].

Consensus: local knowledge systems

The knowledge of people who live and work in an area is usually referred to as traditional, indigenous or local, to differentiate it from knowledge based upon science or formal study. Indeed, traditional accumulated understanding of the environment often cannot be explained in scientific terms. Such awareness and understanding has led to the acceptance of the participatory approach to environmental management (Mitchell, 1997).

A prime example of an indigenous assemblage of people would be fishers. Indeed, it is essential for community organizers to understand and take into account the perceptions and suggestions of local fishers to achieve successful solutions in fisheries management (Van Mulekom and Tria, 1997).

Participation

Some of the key aspects of sustainable environmental development are empowerment of local people, self-reliance and social justice. Indeed, drawing upon many groups of people should help achieve a balanced perspective relative to an issue (Mitchell, 1997). Such 'participation' has certain key elements to its success:

- compatibility between participants, often based on respect and trust;
- benefits to all participants;
- equitable representation and power;
- communication mechanisms;
- adaptability;
- integrity, patience and perseverance (Mitchell, 1997).

Co-management

Co-management arrangements reflect one means of achieving the participatory approach. Co-management agreements between government and fishing interests have arisen out of crises caused by rumoured or real stock depletion, or from political pressure resulting from claims that the government's ability to manage is insufficient to handle specific problems (Mitchell, 1997).

Pomeroy (1998) defines fisheries co-management as 'a partnership arrangement in which government agencies, the community of local resource users and other resource users (fish traders, boat owners, business people etc.) share the responsibility and authority for the management of a fishery'. Furthermore, he describes community-based co-management as fisheries management with a central theme of empowerment, which maintains that control should rest with the people who will bear the consequences. Such management strategies involve resource managers equally with the community and stakeholders, thereby, developing a trust between actors who participate and integrate.

Recognizing the need to decentralize the management of coastal resources to local governments and resource users and to increase the participation of resource users in management, a number of locally- and foreign-funded projects have been initiated in the Philippines by government and non-governmental organizations (Pomeroy et al., 1996). These projects employed strategies of Community-Based Resource Management (CBRM) and co-management and relevant examples are outlined as follows.

Kuperan et al. (1999), in their discussion of the implications of fisheries co-management in San Salvador Island, Philippines, suggest the lack of knowledge of marine ecosystems and the long-term effects of destructive fishing methods could have led to irreversible damage, were it not for the intervention of external agencies. In particular, one volunteer, working with the Bureau of Fisheries and Aquatic Resources, spent a year assessing the level of environmental awareness of village residents, of the state of coral reefs around the island. Initiating dialogue between village officials, the municipal mayor, non-governmental organizations (NGOs) and the Bureau, in the process, support was gained for rehabilitating the fishery resources of San Salvador (Kuperan et al., 1999). Such endeavour resulted in a 'Marine Conservation Project' for San Salvador, which adopts a prosperous community-based approach to management.

Katon et al. (1998), discuss the effects of a 'Mangrove Rehabilitation and Coastal Resource Management Project' in Cotong Bay, Philippines. One major driving force for the shift from open access to communal property rights for mangrove areas was the heightened environmental awareness as a result of information campaigns and community organizing efforts. The example further highlights how conflicts between environmental resource users can be effectively overcome by collective arrangements.

Such examples of CBRM projects represent a vast pool of untapped information with regard to promoting consensus. Though there has been little quantification of the comparative value of such projects, lessons learnt from the individual projects offer guidelines for similar coastal resource management projects in the future (Pomeroy, 1996).

Positive and negative impacts

As explained by Pomeroy et al. (1997), impact indicators of levels of success and sustainability of Community-Based Coastal Resource Management Projects (CBCRMP) can be based in large part on participants' reactions to a project. Pomeroy et al. (1997) state if there is an interest in understanding project success and sustainability, it is essential to understand community perceptions of the present and possible future impacts of these projects.

According to Kristiansen and Poiosse (1996), a beach seine net fishery in Mozambique, suitably highlights beneficial side effects of co-management such as a stronger sense of community and individual responsibility towards a common good. One of the measures employed was creation of an assemblage of fishers to discuss matters involving their interests (Kristiansen and Poiosse, 1996). Originally, it was the responsibility of the District Administrator to call meetings, but in 1981, a Fishermen's Association was set up, primarily to discuss issues such as closed seasons. Greater compliance with regulations was observed if fishermen were given the opportunity to express their preferences. The central place it occupies in the social, as well as economic, life of the members of the fishing community heightened the success of this management strategy (Kristiansen and Poiosse, 1996).

Pomeroy et al. (1997) outlines that successful CBCRMP offer individual fishers a sense of empowerment, in that they have more information with which to make decisions and improve their life. Moreover, Luttinger (1997) maintains that community awareness through education, of the impacts, economic and social links and pre-existent policies of a community-based management project is the most essential element responsible for building a consensus of support.

However, complete success of community based management initiatives is not always obtainable. Baruah et al. (2000) highlight a study carried out in India, where fishers abide by the Indian Fisheries Act, 1897. Despite a need for conservation of aquatic biodiversity through community participation and a number of existing fisher cooperatives, there is no meaningful function for fishers. In particular, the members of such groups are often ignorant about their rights and roles (Baruah et al., 2000).

Dahl (1997) discusses the difficulty of applying original concepts of community participation in resource management within an island context. He maintains that the social conditions on islands, where people live in relatively small, cohesive communities, makes resource management all the more relevant despite its limitations.

Conclusions

From the compiled case studies of conflict and resolution via consensus, key concepts can be extracted and built upon. Firstly, it can be observed that situations of conflict within the domain of marine resource management arise predominantly from differences in interests of the stakeholders concerned. Most frequently, those often most disadvantaged by conflict are those groups with the least representation and infastructure, for examples the fishing community. However, the advantages of incorporating aspects of local knowledge systems into debates over resources can be seen to decentralise management, develop a more participatory approach, and build trust and confidence amongst stakeholder groups. Such 'co-management' is exemplary of how agreement and participation, can be key to a sense of equity and potential acceptance of science.

2.11 Visual arts representation of science

"Since both science and the modern visual arts share the belief they are not fully understood by the public, perhaps by working together they might help solve that problem"

Ashcroft (2000)

We are long overdue a revision of our notions of creativity, not only with regard to science but with the visual arts also (Smith, 1995). Goodman (1985) suggests that effective representation and description (explanation) require invention. They are both creative, they inform and they form, relate and distinguish objects.

To know is to represent accurately and prior to representation, there was no way of distinguishing things. It is pictures rather than propositions, metaphors rather than statements, which determine most of our philosophical convictions. Smith (1995) continues that pictures are readily to hand whereas neural connections are not. It is also one view of that art be the centre of any investigation of the world in that no scientist would work without some idea of what the world looks like. For this reason, the visual arts are crucial to our grip on reality because images are the means whereby those aspects of reality are established (Smith, 1995).

2.11.1 Aesthetic education

According to Smith (1995) art and education are all too similar. In simplistic terms, they are both consumer items, commodity not utility, product not process. But the artistic discipline has far more subtle complexities. Works of art can decorate, educate, flatter, entertain, impress and persuade (Koptsik, 1993). Historically, much has been written of the benefits of an aesthetic education. Plato, for example, termed an aesthetic education as 'the only education because it can operate in childhood and is the only instrument that can penetrate the recesses of the soul'. Similarly, Schiller (In: Read, 1963) states "until man has been accustomed to the laws of beauty, he is not capable of perceiving what is good and true, and he is not capable of spiritual liberty".

As described by Read (1963), aesthetic education can be defined as 'the education of those senses upon which consciousness and ultimately, the intelligence of the individual are based'. He determines its scope to include the following: the preservation of the natural intensity of all modes of perception and sensation; the co-ordination of the various modes of perception and sensation in relation to the environment; the expression of feeling in a communicable form; the expression of mental experience, which would otherwise remain partially or wholly unconscious; and the expression of thought in a required form.

The United Nations Environmental Scientific and Cultural Research Council (UNESCO) suggests the need to promote arts education in both formal and non-formal settings is becoming increasingly felt throughout the world. Despite the need to extend the boundaries of creativity, there is a growing trend to decompartmentalize different disciplines and to build links between them and, in particular, between science and art.

Becker (2002) proposes that more experimentation between and among artists and audiences will yield more effective means of delivering creative expressions or social messages, with greater emotional impact and cost effectiveness. Acknowledging their peripheral role in society, Lippard (1983) suggests artists are repossessing the means of communication by going directly to their audiences. There is, in her opinion, the possibility, when art is accessible for a cross-cultural, cross-class audience. Certain viewers will be so touched by the experience that they will be forced to make aesthetic, personal, or political statements of their own.

According to Lippard (1983), the modern artist is seeking collective forms to justify and/or liberate him/herself. Such artists are rebelling against reductive purism and an 'art-for-art's-sake' emphasis on form and image alone, with a gradual upsurge of mythical and ritual content related to nature and the origins of social life. Many artists are trying to overcome false dichotomies between nature and culture and the universality of art, by resurrecting lost connections within a contemporary framework (Lippard, 1983).

Lawton (2001b) argues that the stronger the creative input, the more likely an exhibit or presentation will rise above ordinary factual information, on a cognitive level, to become a more inspiring and effective piece of communication. By stripping away layer upon layer of superfluous information (Lawton, 2001b), artists can more powerfully communicate important issues with a higher longevity of impact.

Whitehead (1946), in his discussions of science history, refers to historical links with art in terms of objectivity. He suggests that 'once you understand all about the sun, the atmosphere and the rotation of the earth, you may still miss the radiance of the sunset'. Accordingly, he maintains there is no substitute for the direct perception of the concrete achievement of a thing in its actuality. This he refers to as 'aesthetic apprehension' and, a way to foster creative initiative towards the maintenance of objective values. Whitehead (1946) further suggests an objectivist philosophy as capable of bridging the gap between scientific and artistic intuition.

Bill (1949) suggests that art could be a unique vehicle for the transmission of ideas, because expression by pictures leads to no danger of their original meaning being perverted. He suggests that although Archimedes and Einstein remain our authority on many contingencies, Raphael and Seurat produced works that characterised several epochs, since their days, the orbit of human vision has widened. It is art that has annexed these fresh territories.

Romantic pedagogy

Elder (1998), leads the discussion into the realms of environmental conscience, essentially a more romantic pedagogy, in other words, love. According to Elder (1998), a successful education has the power to make the world strange again. In other words, experience can raise an educational community to a new level of attentiveness. He explains that, everything looks different, including the meaning of education, when we bear in mind that the world is beautiful. Carson (1965) connects such values in a similar way with the following statement. 'Once the emotions have been aroused - a sense of the beautiful; the excitement of the new and the unknown; a feeling of sympathy; pity; admiration or love - then we wish for knowledge about the object of our emotional response'.

At this stage, one could refer to the famous essay of Aldo Leopold, 'The Land Ethic', where he says: "It is inconceivable to me that an ethical relation to land can exist without love, respect, and admiration for land, and a high regard for its value". In itself, the evolution of 'The Land Ethic' is an intellectual as well as emotional process (Leopold, 1949).

Elder (1998) continues to revere the scientific method, with its effort to arrive at unbiased and reproducible results and its quest for a universal language. He suggests that the highest and most trustworthy science arises when the scientist is also capable of expressing in a personal voice, the love that motivated his or her lifetime pursuit of knowledge. Opposed to the more classical, deductive approach to scientific education, a romantic, or inductive, approach assumes that the capacity to recognise natural patterns and the power of creative expression, are innate. Education's function then becomes exposing people to a new range of possible relationships and giving them the language and models to explore and express such affiliation within a vivid community of values (Elder, 1998).

2.11.2 The tools of artistic composition

The following discussion relates to the specifics of visual narratives and has particular relevance to Chapter 7. According to the late Robert McKnight, sculptor, designer and theoretician of art, the evolution of art included the development of a 'visual notation system' or 'alphabet of art'. This notation system for visual design, he proposed is made up of 'Elements' and 'Attributes', elements representing the things the artist or designer works with and attributes being defined as the qualities the art or design conveys to the observer[21]. This system also considers the concept of composition – the total effect of the use of elements and attributes, and represents a means by which comparisons of art and design can be made.

Some of McKnight's elements of art are discussed in the proceeding sections. With reference to the attributes of an artistic composition, McKnight suggested all works of visual art convey qualities to the observer. He proposes three categories of viewer response to a composition, dependent predominantly on the personal and cultural characteristics of the viewer: Emotional; Aesthetic; and Spatial, in order of increasing complexity of response. To elaborate, the emotional attribute is simply the emotional response "I like it" or "I don't like it", depending purely on the temperament of the viewer. The aesthetic attribute requires the ability to comprehend the difference between the dynamic and decorative qualities of the composition. Similarly, the spatial attribute requires a technical observer, or critic, who understands the interplay between elements of the composition[21]. Accordingly, the latter two attributes require greater experience of the elements of art to formulate a rational response to the composition.

[21] http://www.guidancecom.com/alphabet

Colour

Lyons (1995), defines colour in the following way:

"Colour is the property of physical entities and substances that is describable in terms of hue, luminosity (or brightness) and saturation and that makes it possible for human beings to differentiate between otherwise perceptually identical entities and substances. More especially, between entities and substances that are perceptually identical in respect of size, shape and texture". The three components of colour, are alternatively proposed to be hue, chroma and value. Hue refers simply to the name of the colour (red, blue etc.), chroma to the intensity of colour (weak, strong etc.) and value as the brightness or dullness[21].

However, colour means very different things to different people from the sciences to the arts. For example, to the physicist, colour is determined by the wavelength of light, dating back to Newton's first experiments with a glass prism that showed light to be composed of a spectrum of colours. To the physiologist and psychologist, our perceptions of colour involve neural responses in the eye and brain. To the naturalist, colour is not only a thing of beauty, but a determinant of survival. Last but not least, to the artist, colour provides a means of expressing feelings and makes possible the creation of a work of art. Yet, the painter, in whose hands colour has enormous potential (Riley, 1995), has two quite different systems of colour. Firstly, perceptual colour, i.e. colour that is perceived by the observer and secondly, pictorial colour i.e. the use of pigments from the artist's palette (Lamb and Bourriau, 1995).

Although colour is undoubtedly in the mind of the beholder, all concepts of colour are expressed in our language and culture (Lamb and Bourriau, 1995). For example, temperature, specifically the polar contrasts of 'hot' and 'cold' are still widely endorsed in the characterisation of colour. Colours seem 'warm' (e.g. red) or 'cool' (e.g. blue) only metaphorically of course, whereas in actuality, the short wave, high-frequency energy of the blue-violet end of the spectrum signals the greatest capacity to heat, and the long-wave, low frequency red end, the least (Gage, 1995).

Gage (1995) argues that responses to colour go back to archetypal human experiences of black night, white bone, red blood and so on. But it is the most 'basic' sets of 'simple' or 'primary' colours that are the greatest gift to structuralists and interpreters owing to a modern colour-order or language they are able to convey. Yet it was the experimental psychology experiments of van Gogh's time that showed the love of strong, saturated primary colours was not the preserve of primitives or children, but was also common among educated adults. A suitable example within the history of art would be Piet Mondrian, who used nothing but primary colours in his art, divided by vertical and horizontal lines (Davis, 1973) (see Figure 17). This type of philosophy has gone hand in hand with the development of a range of bright synthetic pigments and dyes (Gage, 1995).

Contrast

Contrast compares the differences between (things) or observes a difference, which is clearly seen when compared. It can also be used to describe a degree of difference between colours and tones (Collins, 1994). In other words, the more different or opposite something is in comparison with something else determines the level of contrast e.g. black ink against a white background is the highest level of contrast available in art.

The key element for artists working with contrast is to make sure the differences are obvious. Common methods of creating contrast are by using differences in size, value, color, and type. More specifically in terms of colour, harmonizing, complementary, and opposite colours are used to create contrast.

Shape and form

Shape and form can both be used to refer to visual appearance, perceptual structure, possession of spatial attributes, configuration of something or mode in which a thing manifests itself[21]. Shape is an enclosed space, a definite or proper form (Readers Digest, 1994), defined by other elements of art. Geometry is the mathematical science of shape. These shapes can be divided into naturalistic and geometric shapes. For example, landscape paintings often contain both naturalistic shapes, such as trees, and geometric shapes, such as houses. More specifically, geometric shapes are more decorative and their multiple or repeated use, can increase their decorative effect.

Form is an element of art that is more three-dimensional and encloses volume, with cubes, spheres and cylinders being examples of various forms. In more philosophical terms, an 'art form' is a form of artistic expression, where form can be used to describe the design, structure or pattern of a work of art (Readers Digest, 1994). Artists have always been concerned with the pursuit of the perfect form, following the central argument 'does form follow function or function follow form?' i.e. does the end determine the means?

Cubism

In Europe, Cubism was a movement which developed between about 1908 and 1912, in a collaboration between the artists Pablo Picasso and Georges Braque. With immediate influences said to be Tribal Art, the movement itself was not long-lived or widespread, but it began an immense creative explosion with resonated throughout the 20th Century art[22]. The key concept of Cubism is that the essence of objects can only be captured by showing them from multiple points of view simultaneously (see Figure 18). The subject matter is broken up, analysed and reassembled in an abstracted form[23].

Cubism is also inextricably linked to geometrical structure. It was the artist Paul Cézanne, who, in 1904, claimed artists should treat nature "in terms of the cylinder, the sphere and the cone". Furthermore, co- founder Braque scorned (more natural) form and in his art, reduced objects, sites, figures and houses, to geometric schemas and cubes[23]. Colour was also a fundamental concept to the cubist movement. Landscapes with simplified, interpenetrating forms were described using a limited variety of colours. Indeed, colour was used with force around 1912, when the creation of 'papiers collés' or collages, was used to dissociate colour and form[22].

According to Davis (1973), the predominant credit for the triumph of modernism in Western Art should be given to Cubism. Indeed, Cubists thought of themselves as

[22] http://www.artcyclopedia.com
[23] http://www.artlex.com

visionaries, 'in absolute devotion to newness' (Davis, 1973). Cubism represented a complete denial of classical, conceptual beauty. It was in contrast, a geometrically analytical approach, shattering the object in focus into sharp-edged, angular pieces. Distrusting 'whole' images, Cubism attempts to mimic the mind's power to abstract and synthesize its different impressions of the world into new 'wholes'[24].

Symmetry

Symmetry is a characteristic of geometrical shapes, equations and other objects; we say that such an object is *symmetrical* with respect to a given operation if this operation, when applied to the object, does not appear to change it. The three main symmetrical operations are reflection, rotation and translation. Such functions of symmetry occur in geometry, mathematics, physics, biology, art and literature[25]. Symmetry most commonly exists between similar shapes but can also refer to pattern, in other words, an arrangement of repeating or corresponding parts.

As described in section 2.6.5, symmetry is commonly seen as aesthetically attractive, and symmetry in art, traditional or modern, has generally been a favourable characteristic to behold. A symmetrical composition is balanced and has an overall equality of size, shape, texture, and colour. However, the question is whether the early artists had symmetry in mind when they created their art or whether they created their art and then people discovered the symmetry in it[25]?

Some art or pieces of art are pleasing to the eye because they are symmetrical in a mathematical sense. However, symmetry is also used mathematically to effectively exhibit pattern, repetition and agreement with mathematical formulae. Fractalist art is popular for such reasons (see Figure 19)(see also section 2.6.5).

[24] http://www.huntfor.com/arthistory

[25] http://www.ezresult.com/article/Symmetry

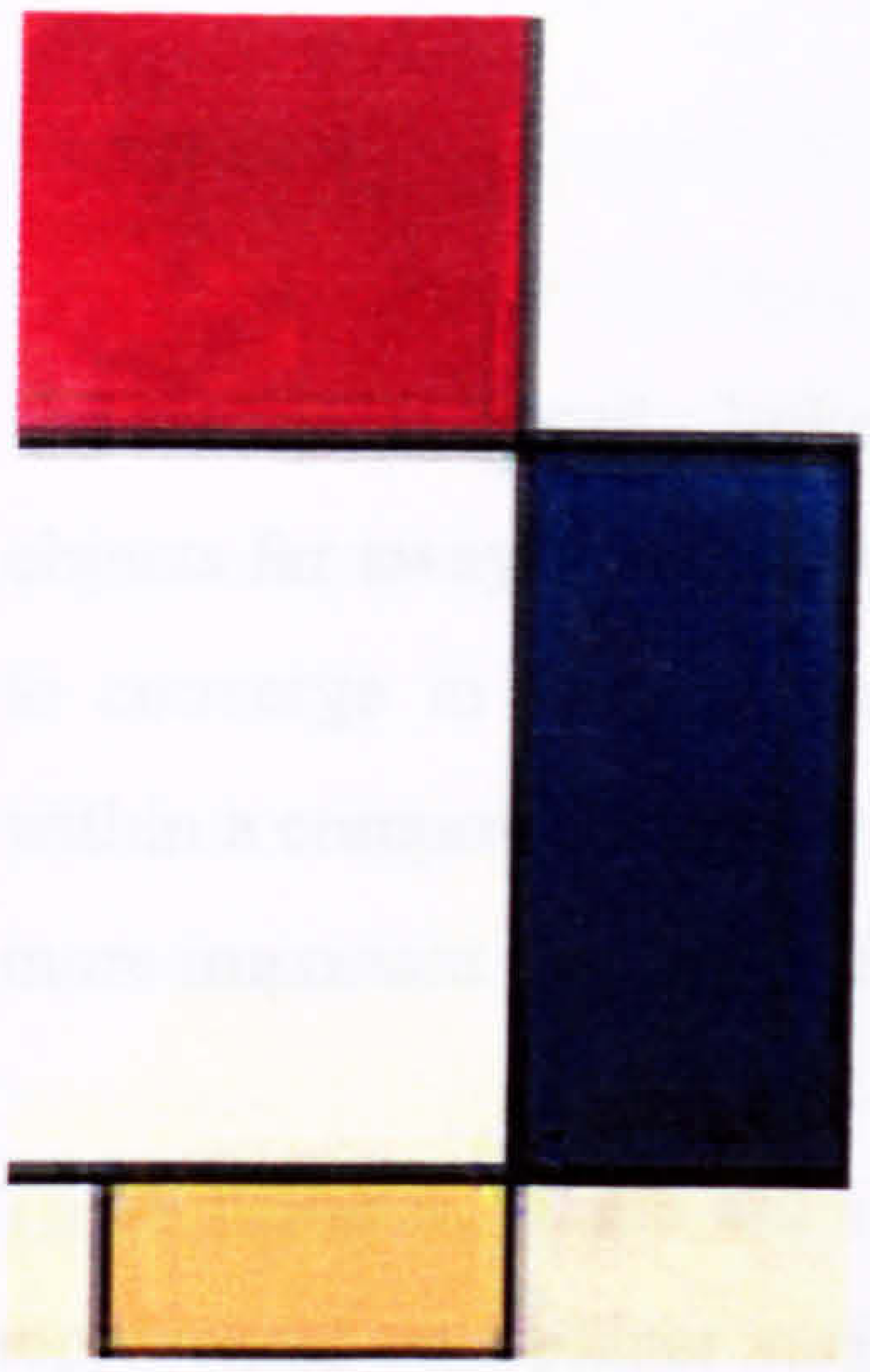

Figure 17. *Composition with red, yellow and blue.* Piet Mondrian (1922) (205.126.22.50/art/terms)

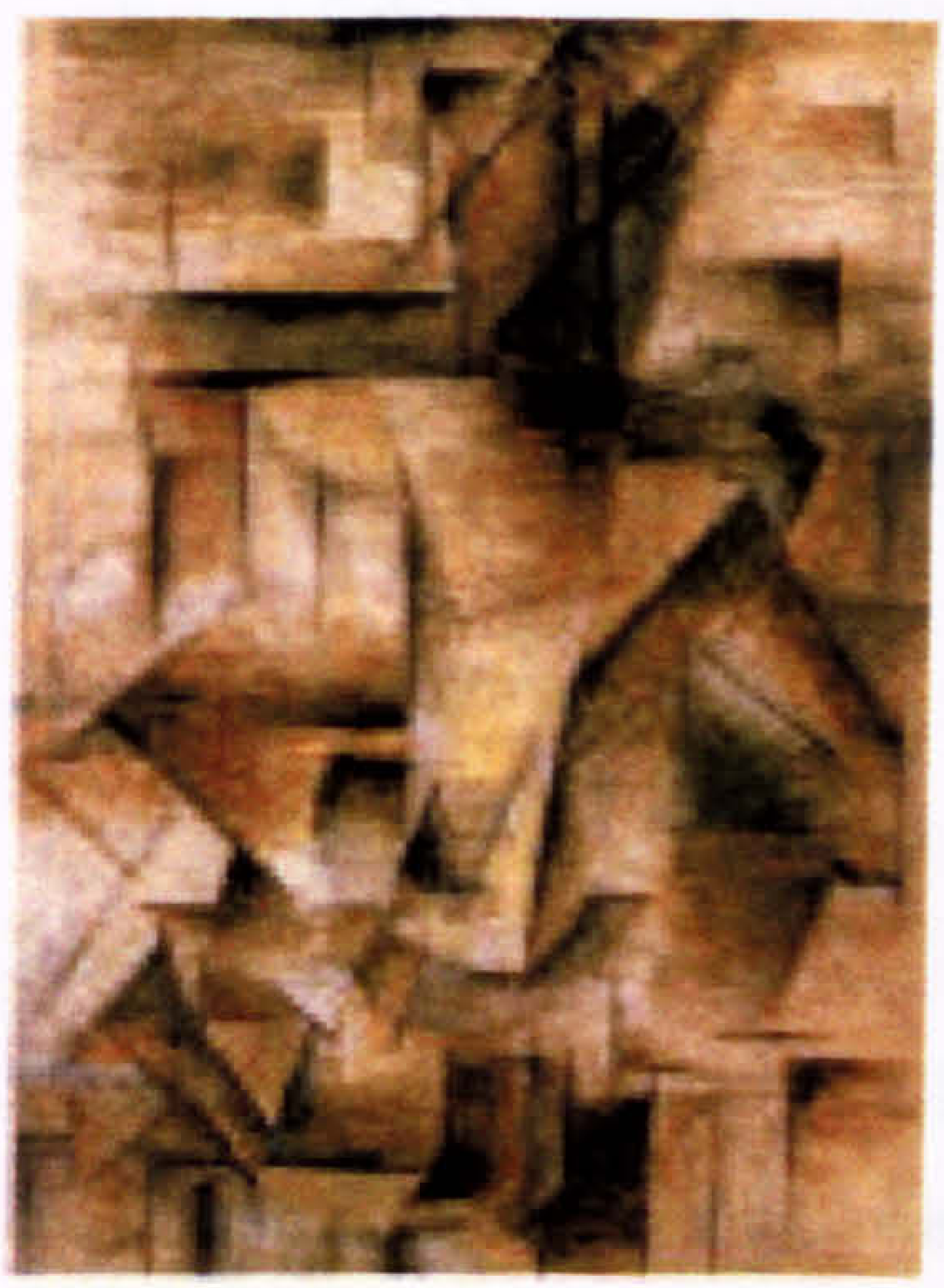

Figure 18. *The Guitar Player.* Pablo Picasso (1910) (www.abstractart.20m.com)

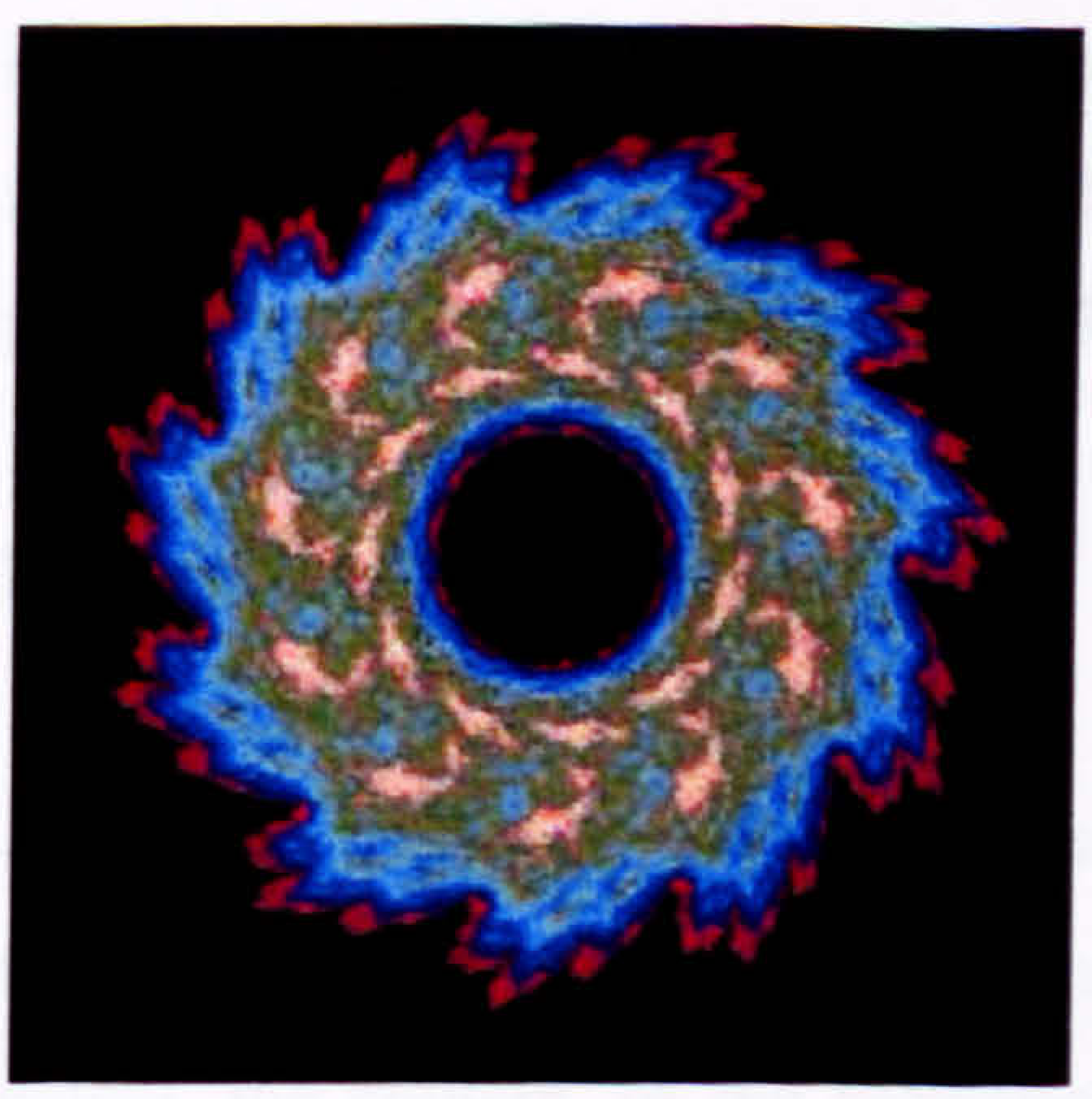

Figure 19. *Saw* - a Symmetric Fractal with 11-fold rotational symmetry (http://nothung.math.uh.edu).

Dimension

Dimension is heavily linked with the idea of perspective. Familiar are the concepts that objects far away from us appear smaller than they actually are and that parallel lines appear to converge in the distance. The relative size of shapes, often affect their significance within a composition by the effect on perspective. Large size makes things appear near and more important and small size, things far away and less important[21].

These features, which are a standard part of the way that 3-dimensional objects are usually represented on a planar surface, were not fully understood before the Renaissance. It is now common to refer to artists as using 'perspective' (or linear perspective) to increase the realism of their representations[26]. Art forms with a 3-dimensional element are numerous and diverse including: sculpture; ceramics; jewellery making; collage; flower arranging; dance; and drama.

2.11.3 Interpretation

Interpretation is defined as 'explanation provided by the use of original objects and/or visual display material' (Collins, 1994). Designed to provide meaning and motivation, coordinated interpretation frequently uses arts media, more often than not to trigger aesthetic responses in the target audience. If interpretation is to further encourage a conservation ethic, it must grow from an 'emotional' attachment and commitment as well as an academic understanding. With this in mind, 'the arts' have become a widely accepted part of interpretation work (Carter, 1999).

Environmental interpretation

According to Ziman (1978), science requires a necessary 'language medium'. It follows that, the available language of human communication determines the form and to some extent, the content, of the messages that make up scientific knowledge. To achieve the

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[26] http://www.ams.org/

ultimate goal, consensibility of science, it must be capable of expression in an unambiguous language, with a maximum degree of clarity and expression (Ziman, 1978). Indeed, a particular method, style and approach to nature will often prove to be more influential than the actual results established by their exercise (Gjertsen, 1989).

Scottish Natural Heritage (SNH) states that public skepticism about damage to the environment has arisen from an historical overstatement of the case (SNH, 1996). In response, environmental interpretation will not aim to provide all the answers to society's questions but will seek to provoke interest and raise new questions (Lawton, 2001a).

Lawton (2001a) continues to propose that one of the main benefits of environmental interpretation is 'the potential to elicit in the viewer high levels of intellectual understanding, alongside the wider range of emotional and spiritual responses'. More importantly, as experienced by SNH on a local scale, with this understanding comes appreciation and with appreciation comes protection and wise use (SNH, 1996).

A review of current interpretative facilities for the marine and coastal environment was conducted in Scotland, on behalf of SNH in 1996. The report elucidated a general lack of such facilities and said that which did exist lacked co-ordination and rationalisation. Moreover, a lack of interpretative planning was observed both regionally and locally (SNH, 1996).

With such large market potential, the opportunity to communicate messages to the public concerning the marine environment is vast. Indeed, marine interpretation is becoming more widely attractive to private operators. However, with the increased proliferation of large interpretative centres, this mission may have little/no significance, with financial gain the prime objective (SNH, 1996).

The Marine Conservation Society (MCS), in a practical guide to coastal and marine interpretation, cite the most successful method, of engaging public support as aesthetic appreciation e.g. by way of leaflets, portable guides, viewpoint interpretation etc. Moreover, that people are more likely to retain information if it is presented to them in ways which have the following characteristics:

- use and encourage active involvement;
- show the relevance of the information;
- make the experience enjoyable;
- generate curiosity and interest, stimulating desire for further information;
- use personal contact (Welton and Heeps, 1999).

SNH states that the assignation of environmental value to a particular situation also provides essential underpinning to interpretation. If the basis for value identification is quantified, defence of environmental values, which reflects the outlook of all users, will be achieved (SNH, 1996).

2.12 Future direction

This review of the literature has crucially summarised our existing understanding of the philosophical and historical relationship between explanation of science and visual arts representation. It has further identified instances where the two disciplines have had, and continue to have, mutual influence and shared experience. The sequential next step is to identify what practical lessons marine science (in particular) has already learnt from the visual arts. This will potentially provide insight into a conceptual methodology for producing an arts-based narrative to extend the accessibility and social context of marine scientific information.

Chapter 3. <u>ART FOR EXPLANATION INITIATIVES</u>

Prior to testing any new vehicles for the presentation of marine scientific information it is clearly necessary to summarise existing practical experience via a survey of similar initiatives, past and present. These initiatives will, to some extent, reflect the unique agenda of this research into visual arts representations of marine science. In searching through literature, various initiatives have been compiled under the headings: community arts initiatives; public art initiatives; and interpretation initiatives. Project examples are discussed in terms of their level of science base, marine focus, use of art, and target audience/community involvement. Preceding discussion of initiatives grouped in this way, one particular case study is presented and discussed at length (section 3.1). This one venture describes a comprehensive collection of initiatives, incorporating community arts and interpretation, pertaining exclusively to marine affairs. A conceptual framework for this research will then be outlined.

3.1 <u>Taigh Chearsabhagh – a case study</u>

Visited November 2002. Study based on assimilated resources and interview with: Norman Macleod (Centre Manager), Anne Mackenzie (Arts Officer) and Fiona Pearson (Arts Teacher).

Taigh Chearsabhagh or 'house by the wrong bay', although an internationally acclaimed Museum and Arts Centre, is essentially a community initiative. Located in Lochmaddy, on the island of North Uist, Outer Hebrides, it is the dynamic focus of this small coastal town, providing access to education as well as a visitor attraction. Last year alone some 30,000 visitors passed through its doors. Manager Norman Macleod estimates over 95% of locals have visited the centre at some point, many returning to view exhibitions, take a class or use studio space. Representing not only a cultural venue but also a community hub, Taigh Chearsabhagh also houses the local Post Office, café and craft shop.

The local historical society and the Uist Art Association, with funding from the Western Isles Council and the Scottish Arts Council, developed the centre. In 2001, a £500,000 lottery grant funded a further extension to the premises. The centre now houses not only the original local printmakers but also a high-quality dark room, an arts studio and extensive exhibition space.

3.1.1 Aims

The aims and objectives of Taigh Chearsabhagh are as follows:

- present an integrated programme of exhibitions and related practical workshops offering the best in contemporary arts practice;
- provide opportunities for people to explore their creativity through a variety of art forms such as music, poetry, film, multimedia and creative arts;
- develop creative collaboration between the Uist Arts Association and Comman Eachdraidh Uibhist a Tuath;
- develop international links; and
- document current and recent arts activities for educational use using new technologies.

Specific educational objectives are as follows:

- provide a range of arts activities for children and young people in Uist and Barra responding to their input;
- provide challenging opportunities for young people to explore their creativity through arts activities; and
- create strong links between the arts and education programmes.

Aims in terms of cultural events are as follows:

- programme a range of cultural events to suit the venue in response to demand; and
- seek to promote the Gaelic language through its culture.

3.1.2 Exhibitions

All recent and current exhibitions at Taigh Chearsabhagh have a marine significance, displaying the heavy reliance of Hebridean communities on their seas. Some of the most poignant examples are as follows.

i) An Seol-Mara- 'The Ebb and Flow of the tide'

An Seol-Mara depicts a maritime island story and recently represented the main exhibition at Taigh Chearsabhagh. The project carefully blends oral history of Gaelic culture, objects, photographs, sound and marine life to trace a pattern starting from human activity on the Hebridean Isles, through the tidal zone to the natural environment of the sea. Taigh Chearsabhagh runs this display in conjunction with the voluntary group, Comann Eachdraidh Uibhist a Tuath, as a means of research into local history and an outlet of maritime stories and images.

ii) Comann na mara -'Society of the Sea'- proposed marine education and research centre

Comann na mara has the broad aim of bringing a better understanding and use of the marine environment to people. The centre is proposed as a Western Isles resource for the education of the public, fishermen, visiting students, school pupils and tourists concerning the sea, its shore and adjacent land throughout the area. The concept arose from frequent community meetings, of a small multi-interest group at the time of a developing Scottish Natural Heritage (SNH) application to achieve Special Area of Conservation (SAC) status of Lochmaddy Bay under European legislation.

Loch Maddy (Loch nam Madadh), the most complicated fjard in the European Union and its large number of isolated saline lagoons are a composite proposed SAC under the Habitats Directive. Its two qualifying features are a) large shallow inlets and bays and b) lagoons. Further conservation status relates to the presence of reefs, sandbanks, mudflats and otters. This information was determined via extensive habitat and associated species mapping, carried out by SNH according to the Marine Nature Conservation Review (MNCR) (Entec, 1996). Management of the Loch nam Madadh European Marine Site is carried out by stakeholders and regulatory bodies, following debate and regular review, to assist in the continuation of public awareness of one of the most significant areas of marine nature in Europe.

It was decided that, in addition to confirming local support for Comann na mara that area, national and international marine interested educational and research institutes should be contacted and their support for the centre sought. Universally, organisations responded positively, with supporters including: North Uist Community Council; Scottish Crofters Foundation; Western Isles Fisheries Trust; the local Fisheries Officer; local fishermen; SNH; Scottish Environmental Protection Agency; and Universities including that of St. Andrews, Wales, Glasgow, Helsinki and Iceland. In this way the cross-section of consultation and participation is fundamentally diverse and highlights an unbiased, non-selective approach. Local interests are observably a firm priority for achieving the centre's objectives.

In terms of events to date, a marine exhibition with small aquarium is housed at Taigh Chearsabhagh, representing one third of the main exhibition. In addition, some time has been purchased from the Southern Isles Amenity Trust's countryside ranger, who has led coastal walks around the bay, organised otter tours and escorted boat trips to neighbouring outer islands. Positive results of this rangering service have already been observed via increasing the number of visitors who want to be shown aspects of the local, natural heritage and environment. Environmental interpretation material has also been produced including locally relevant leaflets and interpretive panels following successful local fundraising.

Future developments of the Comann na mara venture, after applications for National funding are made include the renovation of a privately owned property to contain a student laboratory, demonstration area, fish tanks, electronic library, administration offices and meeting rooms.

3.1.3 Community-based Sculpture

Probably the most famous strain of Taigh Chearsabhagh's arts and events programme is its sculpture trail. With community's ideas and aspirations central to the venture, Taigh Chearsabhagh is a driving force for 'art in the community' projects. Furthermore, with a heavy marine significance noticeable in many of the composite sculptures, the environmental messages are clear.

The first two sculptures constructed, in close proximity to the arts centre, are poignant reflections of the maritime history of the local area. Approached via a viewing platform, the first is a giant mosaic of a mackerel. Created out of locally found materials: quartz; black basalt; blue mussel shells; and worn down glass, the structure is designed to withstand the most violent Uist storms. The idea of the fish, particularly a mackerel, pays significant homage to the death of the fishing industry in the islands and the decline of fish in the seas.

The second sculpture was installed to reflect Taigh Chearsabhagh's closeness to the sea and its dramatic tidal surge. Standing close to the site of a salt factory, the sculpture further incorporates a local historical aspect. The simple conical form encrusted with particles of glass to resemble salt alludes to the moon and its effect on the tides. Furthermore, with an entrance at its base to allow in the tidal surge, water is then projected out the top, to resemble salt escaping from a salt-seller.

Development of the remaining sculpture trail, extending from North Uist, through to the islands of Barra and South Uist commenced in 1997, when Land artist Chris Drury spent a month in North Uist building a sea-sky chamber known as 'Hut of the Shadows' or 'Both nam Faileas'. This particular work has proved to be enormously popular with visitors to the island. The success can be attributed to many factors: the skill of the artist; its location; sensitivity to the surrounding landscape; local community involvement; and local craftsmanship in particular dry stone walling. Hut of the Shadows is essentially a camera obscura encased in a stone walled chamber. Angled towards the sea and a scattering of small outer islands, this image is reflected on to the internal chamber wall. This remarkable moving image of sea and sky, combined with the sound of wind and waves, offers a unique visual experience.

A total of seven unique artworks have now been created throughout the islands, both conceptual and traditional in approach. In particular, the 'Roadends Project' (1998-2000) saw four pieces of sculpture installed at the end of little-used roads on the island. After asking members of the community whether they would like a sculpture on their land, the reception was overwhelming. According to Macleod, the reasoning behind the venture was to draw people into the landscape and to put the community and artists together. He

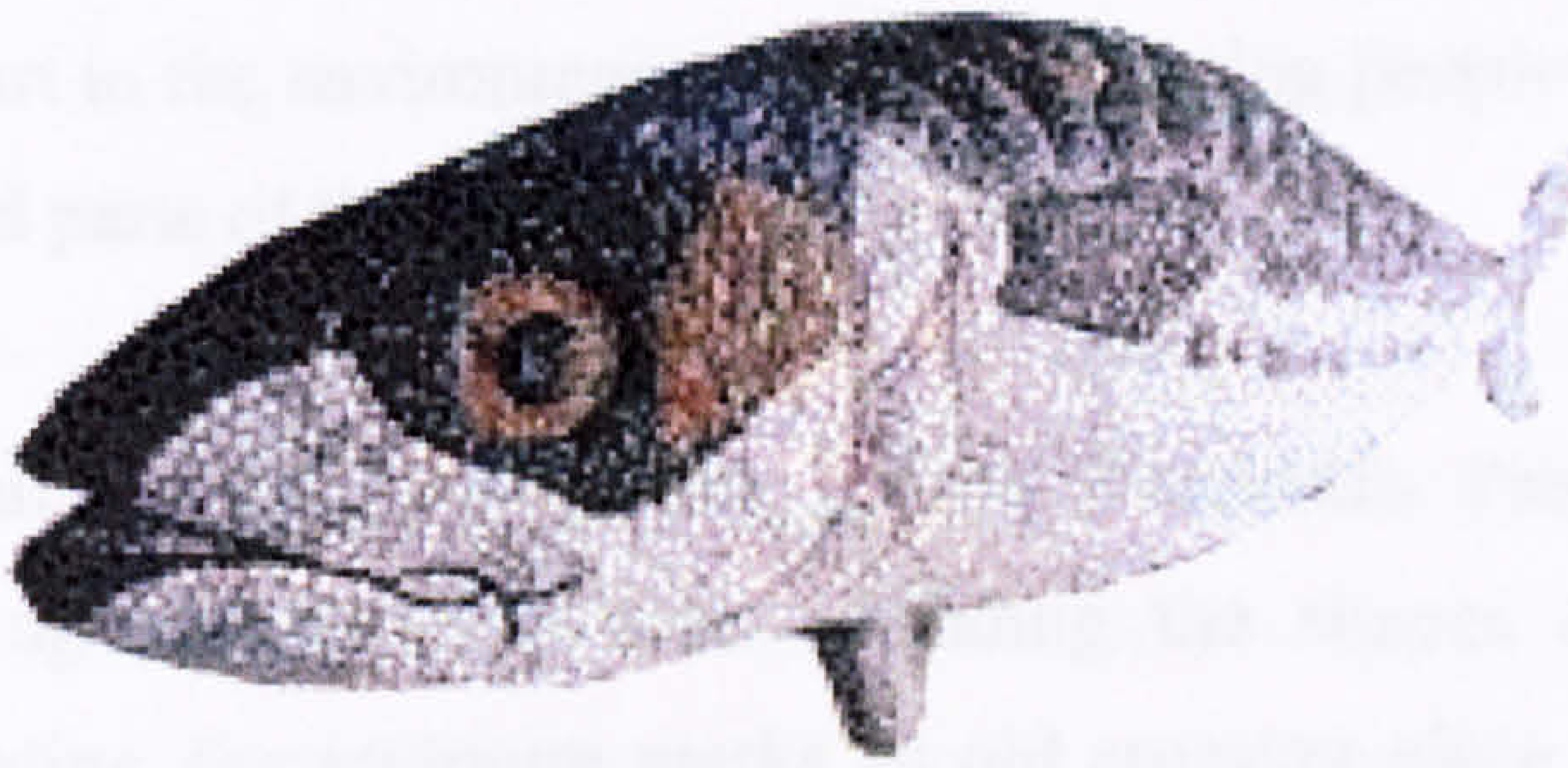

Figure 20 *Mosaic Mackerel*. Rosalind Wates (1996)
(www.taighchearsabhagh.org)

Figure 21. *High Tide Low Tide*. Christine Boshier (2000)
(www.taighchearsabhagh.org)

Figure 22. *Hut of the Shadows*. Chris Drury (1997)
(www.taighchearsabhagh.org)

comments "most importantly, the communities provided a location, ideas and in many cases, assistance in terms of the construction itself. In this way, the project set out to widen people's experience of art in the environment, while encouraging people to explore some of the beautiful, less-visited parts of the isles".

One of the most locally popular sculptures of the Roadend's Project is known as 'Reflections', a sweeping ceramic tiled seat. Echoing the shapes and colours of its surrounding sandy shoreline, the sculpture marks an old crossing place for sheep before a causeway was constructed. The artist, Colin Mackenzie, assisted local children and adults who participated by making their own relief tiles for the seat during a workshop.

3.1.4 Ongoing projects

i) Grimsay Boat Project

The Grimsay Boatshed Trust is cooperating with Taigh Chearsabhagh on the rescue and refurbishment of a disused fishing boat, the Morning Star. An important part of local history, the boat fished out of Lochmaddy until the 1990's. Using Heritage Lottery funding, the construction of a boatshed outside the Centre will permit the renovation of the boat, eventually be used as an educational vessel or as a permanent display ashore. Local participation in the project is considerable according to Macleod, with strong aims to save local skills, help the local fishing community, reflect a way of life and be a useful resource for future Uist communities.

ii) Uistory

According to Macleod, this multimedia venture of Taigh Chearsabhagh highlights in most detail how the community's involvement and participation in arts projects is of paramount importance to the Centre. With schools and indeed adults, involved from throughout the Isles, Uistory was concerned with the depiction of the folk stories and legends of North Uist. The project culminated in the production of an interactive CD-ROM and booklet.

iii) Into the Oceanic

This project began in 1998, when Edinburgh based artist Elizabeth Ogilvie was invited to contribute to a 2-year arts programme at Taigh Chearsabhagh. With a working theme of 'the sea and beyond', the project was inspired by the constant presence of the ocean and it's impact on island life, historically, economically and socially. With family originating from the Outer Hebridean Island of St. Kilda, the significance of working with the sea was yet deeper for Ogilvie. In collaboration with Douglas Dunn, a leading figure in the poetry field, the idea was to combine the disciplines of literature and art. The installation created at Taigh Chearsabhagh transformed the gallery space into a quiet place where the audience could explore their own responses to the work. Comprising slender perspex panels, inscribed with verse, suspended over pools of water, the installation reflects a 'moment of time' in the Uist landscape.

3.1.5 Other Centre activities

Based at Taigh Chearsabhagh is an 'Arts for All' Officer as well as an Arts Education Officer. Furthermore, an imaginative partnership between Lewes Castle College and Taigh Chearsabhagh provided opportunities for study in art and design and both further and higher level by way of the Diploma in Art and Design or the Higher National Certificate. More importantly, Taigh Chearsabhagh can now boast one of the first college-accredited arts courses to be held in a public arts centre.

The facilities not only permit an art summer school for local people but arts and activity classes for children. 'Feis Tir An Eorna', a most popular children's workshop, is extremely important locally in the opinion of arts teacher, Fiona Pearson, who stated "the cultural, economic and social benefits to our community are diversely felt and these workshops provide a strand of education, presently outwith the formal education system". A wide range of artistic endeavour is under further development away from the centre, with classes being run as far South as Eriskay with plans to extend to the island of Barra.

A new web-site, www.flotsam.org.uk, is under development, designed to raise local awareness of marine litter in the coastal and marine environment. The site will further co-ordinate local beach clean-ups and report sea mammal sightings.

In 2001, the Centre won a 'Dynamic Place Award', recognising the extent to which it has provided training and skills development for people from the Uists. In addition, it won a Grampian Television Environmental award as part of the 'Enjoying the Natural Heritage' category.

3.1.6 Conclusions on Taigh Chearsabhagh

Most obviously, Taigh Chearsabhagh represents a major economic boost for the North Uist. Moreover, serving as a social centre for discussion, interaction and appreciation of the arts and associated events, its cultural role is also clear.

The marine and historical significance, particularly of the Uist Sculpture Trail, is highly evident. However, the level of scientific information to be retrieved from the collective activities of Taigh Chearsabhagh is rather limited. This said, current development of Comann na mara, or the Society of the Sea, promises to be of great significance in terms of accessible marine environmental information for the local fishing community, tourists, local adults and children alike. Therefore, the success of this venture should be closely monitored and critically appraised in the future. Centre manager Macleod, recalls one project, which although unpublicised, in his opinion, best reflects a scientific agenda. Based in St. Kilda, the most Westerly Hebridean Island, one artist released a total of twenty 'message-in-a-bottle's'. Despite only a few being washed ashore, the main objective of this community-based arts project was to track the tidal patterns of the Atlantic Ocean.

When asked to what extent he feels Taigh Chearsabhagh and its collaborations truly 'cross the boundaries of art' through to other disciplines, Macleod commented on the organisational structure of the centre. With a network of directors, artists and indeed community members that feed into the core activities, Macleod maintains that this diversity of interests and backgrounds can only entail that it impacts on a multitude of disciplines.

'Community' is observed to be the very essence of the activities of Taigh Chearsabhagh. Few other such ventures in the literature highlight how the ideas and aspirations of a community can become recreated into very public declarations of a sense of place. Celebrating not only local history, but also natural heritage, the sculpture trail, internal exhibitions and indeed workshops display strong environmental messages at their core.

Currently, there would appear a very obvious trend or fashion for communities to become involved in public arts projects. However, universally, these most commonly appear to be the vision of either some form of regulatory body or the artist themselves. Contrastingly in Lochmaddy, members of the communities themselves have approached the artists and organisers, in other words, they have set their own agenda. Such direct and practical involvement is relatively unsurpassed elsewhere and the consequent sense of ownership of the installations is a fundamental mark of the arts centre's success. In addition, local disagreements over issues such as land-ownership and private places, which are more common in larger coastal communities, do not appear to affect Lochmaddy, perhaps a consequence of its small-scale nature.

Collectively, the Western Isles represent an amalgam of environment, culture and amenities where sense of community has a pivotal role, and this is most apparent in North Uist. With community participation in public arts projects a buzzword in the current environmental arts climate, Taigh Chearsabhagh is rather different to many rival arts centres. However, with the small and isolated nature of this island community, the scale of its conceptual application to other areas in the UK is unknown.

3.2 Other initiatives

Science and art (commonly known as 'SciArt') collaborations are becoming more widely used in the quest for improving the language of science. Indeed, many scientists are beginning to understand the creative promise of such an interdisciplinary approach. In the UK, organisations such as Arts Catalyst, the British Council for the Arts, the National Endowment for Science, Technology and the Arts (NESTA) and the Wellcome Trust have all supported a variety of artists, scientists and technologists in innovative collaborations. Such projects explore diverse fields including, ecology, mental health, space, artificial intelligence, genetics, virtual reality and neuroscience to name but a few[27].

The proceeding sub-sections outline a number of initiatives and interpretation approaches, regional (small-scale) through to international (large-scale), each of which in some way, use art to translate scientific, and where possible, marine information to the general public. Individual initiatives are discussed in terms of the following criteria: subject/focus of interpretation; stakeholders involved; specific aspects of the work involved; benefits to communities/target audience (local or otherwise); and faults/distinctions e.g. bias towards certain stakeholders. A summary table, or qualitative assessment of their worth as separate interpretation initiatives, including the Taigh Chearsabhagh case study, is presented at the end of this chapter.

3.2.1 Community arts initiatives

'Mountains to the Sea' represents a collaboration and integration between scientists and artists in the Motueka River catchment area of New Zealand. The project, led by the organisation Landcare Research, explores ways of conveying ideas about the environmental and social interconnections that shape the local area. A collaborative workshop sponsored by Landcare Research in 2002 saw the genesis of the Mountains to the Sea proposal. This involved initial investigation of a potential arts and science dialogue pertaining to environmental understanding and creativity. The project involves biophysical and social science researchers from Landcare Research and two independent artists and draws on environmental research undertaken in the Motueka catchment. The aims of this project are twofold: i) to better understand how those from different disciplines can successfully work together and ii) to produce collaborative work that conveys and promotes an understanding of the integrated nature of the River environment[28]. Aspects of the work include a shared web-based ideas dialogue between group members and a 'Travelling River' exhibition.

[27] www2.britishcouncil.org/home/arts
[28] http://icm.landcareresearch.co.nz

The latter involves visual, audio, tactile, static and mobile media, potentially incorporating community-based interpretations of the river environment and a range of interrelating scientific knowledge. Although some facility for community participation in the project has been provided for, the main dialogue of the project can be observed to take place largely within a community of experts i.e. scientists from Landcare Research and respected artists. In other words, there remains no community driving force for the project and no allowance for audience participation at the ideas stage.

'A'Chraobh'- the tree, or 'Celtic Spiral Wood', is a community arts project, located in Sutherland, North Scotland. Launched in the year 2000, and run by the Millennium Forest for Scotland, stakeholders in the project were essentially the local communities of the towns of Bettyhill, Atnaharra, Melvich and Tongue and particularly local schoolchildren. The project comprised the design, construction and plantation of a small forest, incorporating pieces of stone sculptural work, based around the Gaelic alphabet (Sutherland, 2000). Following a series of arts workshops on the subject of trees native to Scotland and their leaves, a selection of children's' drawings on the subject were sandblasted onto stone. Each leaf design corresponded to a Gaelic letter, being the first letter in the trees' name. Following plantation of the trees in question, the stone tablets were distributed, predominantly in a spiral design, centrally in the forest. Reflecting local heritage and celebrating the Gaelic language, the project is regenerative and benefits the local communities concerned through a continued sense of ownership. However, there is no marine significance of this project.

Forest and its preservation is also central to a project designed and run by the people of Abriachan, a scattered rural community of about 120, set high above the shores of Loch Ness, Scotland. The Abriachan Forest Trust (AFT) was set up in 1996, bringing into community ownership 534 hectares of planted forest and open hill, which had been placed on the market by Forest Enterprise. At that time, there was no mention of continued access and the results of a community consultation process had been ignored. The community responded and a local interest/steering group was formed. Assistance in the purchase of the forest was provided by a number of grant making authorities including SNH, the Scottish Office Rural Challenge Fund and the Highlands and Islands Enterprise, making it the largest community-owned forest in Scotland. The principal objectives of AFT are to ensure

Figure 23. Design for the Celtic spiral wood *A'Chraobh – The Tree* (Dornoch Studio, 2000)

continued public access to the forest, respect and enhance the environmental value of the area, assist in re-afforestation and be a catalyst for a whole range of community-based activities, especially those involving the younger generation. An example of one such activity took place to celebrate the Millennium, in the development of 'family trees', in other words tagging and naming of trees to represent each local resident.

With the majority of the community supporting the project and participating in such community Activity Days, the potential has developed for a timetable of future arts and events. This includes workshops the community can attend on conservation management, creating paths and orienteering trails, bird hides, sculptures, a series of interpretation boards and educational field studies courses. Although this project demonstrates a strong community driving force and organisation to reach a set of defined goals, the direction and co-ordination of interpretation and community arts falls to outsiders, not the community themselves. The project relates more to a community's response to a 'crisis' situation to ensure continued public access. Scattered arts-based initiatives have developed only as subsequent projects, with no community participation in design and type of information. Again this project does not concern marine affairs.

'Science in Salamanca', Tasmania is a festival of science and the arts. Bringing together Marine Researchers, the University of Tasmania, local students and artists, the festival aims to highlight the aesthetics of science and scientific data, relating to five central themes: climate change, marine ecology, Antarctica, genetics and nutrition[29]. The collaboration further aims to produce a more informed community who visits the exhibition, through permitting them to contribute their own pieces of art. However, this means that only those members of the community with some degree of artistic talent may participate. Furthermore, the subject matter is academically dictated and no community participation can be observed at this 'ideas' stage.

Marine emphasis is central to the Voluntary Marine Conservation Area (VMCA) set up in Helford, Cornwall. Helford VMCA is supported by English Nature (EN) and the World Wildlife Fund for Nature (WWF) and is coordinated by Cornwall County Council. With

[29] www.science-in-salamanca.tas

the aid of an education ranger and selection of volunteer artists, a wide variety of conservation and arts based initiatives have taken place, with central involvement of the local community. Although communicating only a simple science base, interpretation tools such as beach art, driftwood designs, environmental awareness postcards (e.g. pollution warnings) and guided shore walks have been possible.

Backyard Biodiversity Day is a yearly endeavour of the Association of Biodiversity Education. This promotion of biodiversity and its inherent threats, takes place as part of Science Festival, regionally, throughout the United Kingdom. Arousing regional interest in environmental affairs and increasing understanding is attempted via a selection of programmed activities, scheduled via a Biodiversity 'action kit'. From backyards to the wider outdoors, involvement in coordinated activities is left to the disposal of the general public, though a distinct emphasis on children is apparent. Furthermore, exclusively terrestrial in nature, there is no provision for marine-based activities.

'Turning the Tide' is a five-year project, started in 1996, to redefine the strong sense of identity and community spirit founded on the mining heritage of County Durham. With partners including local authorities, government agencies and voluntary organisations, the project promotes the regeneration of a 12-mile stretch of the Durham coast. An integrated approach to management aims to bring together issues of conservation, access and tourism by improving the environment of the coast and helping to enhance peoples' perception of the area. Involved in over 100 projects, with a team of 5 working with a community of 120,000 people, the major challenge is to effect real community consultation and involvement. More specifically, 'Turning the Tide' uses innovative interpretive techniques, particularly the use of 'Art in the Environment'. Facilitating community forums, public exhibitions, training events, school visits and commissions for local artists, contractors and tradesmen, the focus is on improving the area for locals rather than tourists. Also, by getting children involved in designing some of the artwork, the project aims to engender their interest in the local environment, with a view to avoid future problems such as vandalism. Moreover, it is this arts-based approach that has stimulated considerable local interest in the project. The use of art in this way is thought to be a good example of lateral thinking and a non-conventional approach to the interpretation of an area's natural and cultural heritage. To date, art has been used effectively to establish 'links' between different sites along the Durham Coast, establishing a unifying theme along this recreational route[30].

'Seen and Unseen' is an 'artist: scientist: community' collaborative project funded by Helix Arts, taking place in the Northeast of England. Founded in the 1990's, it is primarily a web-based forum, intended to be a springboard for new environmental restoration and conservation initiatives achieved through shared information. With target communities being those devastated by industrial and agricultural pollution, the project explores the way in which experimental artists can contribute to sustainability by raising awareness within a wide target audience[31]. The focus issues of the project are water pollution and ecology. The project has produced a variety of educational resources and is further developing a package of multi-media items, however little direct community participation is observable in this process. Although the commissioned artists claim to 'listen to local people', the project relies fundamentally on the ideas of a community of experts.

3.2.2 Public art initiatives

Usage of sculpture trails is proving popular, notably in recent years, to increase the visual appeal of sites for locals and tourists alike. Two projects, Eden Benchmarks and the River Parrett Trail, both display how visual art, more specifically sculpture, can provide an interactive focus to an area of countryside.

Eden Benchmarks, during the years 1996 to 2000, was a project taking place under the auspices of the East Cumbria Council and the organisation Cumbrian Countryside Project. Other stakeholders included EN, the National Lottery and certain arts councils. Pathway design along the river Eden, community consultation over the placing of commissioned sculptures and improving the aesthetics of the area were the project ethos. In terms of redeemable (scientific) information however, there is little or none.

[30] www.turning-the-tide.org.uk
[31] www.seen-unseen.com

The River Parrett Trail, constructed in 1996, was a similar project, though more focused on a heritage interpretation ethic. Overseen by the Bridgwater Arts Centre and the Bridgwater Docks Commission, a path following a canal was created, to integrate access for the community and to promote green tourism. This canal, disused since the introduction of a nearby railway, was chosen as a subject for wooden sculpture and inscribed poetry. After formation of an art's working group and a series of local workshops, local interest in the area was stimulated. Similar to Eden Benchmarks however, the user groups of both projects are limited in size and again little scientific information is redeemable.

In 1996, the largest artwork commissioned in Britain at the time was designed and produced by the environmental artist, Andy Goldsworthy. A prominent figure in this rapidly growing field, Goldsworthy termed his 'Sheepfolds' Project' as a series of 'useful' sculptures. Commissioned by the National Lottery and Rural Cumbria Council, the project ran for 4 years and produced a number of ephemeral works. Heavily connected with the local farming industry, Goldsworthy's remit was the repair of old sheepfolds and the construction of new walls. Promoting traditional farming practice and involving people locally, through a process of consultation, the project has a great sense of permanence, though no scientific base.

More recently, since 1994 in Southwest Pennsylvania, 'AMD and ART' have been 'artfully transforming environmental liabilities into community assets'[32]. AMD, or acid mine drainage, seeps from a large number of abandoned coal mines within the local area, coating streams and river beds with a bright orange sediment, leaving a permanent reminder of an era of poverty and economic abandonment. Employing an interdisciplinary approach to regeneration of the area, incorporating science, art and history and using innovative design and community engagement, AMD has apparently become a 'public interest subject'. The general public is invited to participate in the design and construction of enjoyable and educational park-like landscapes, based on environmental relics. For example, aerators are converted into fountains, ditches into waterways and settlement cells into ponds and wetlands. In a positive sense, this project has created much new space and habitat for wildlife and restored a community sense of place and ownership. However, the project is

[32] www.amdandart.org

Figure 24. *Sheepfold.* Andy Goldsworthy (1997) (www.smithsonianmag.sci.edu)

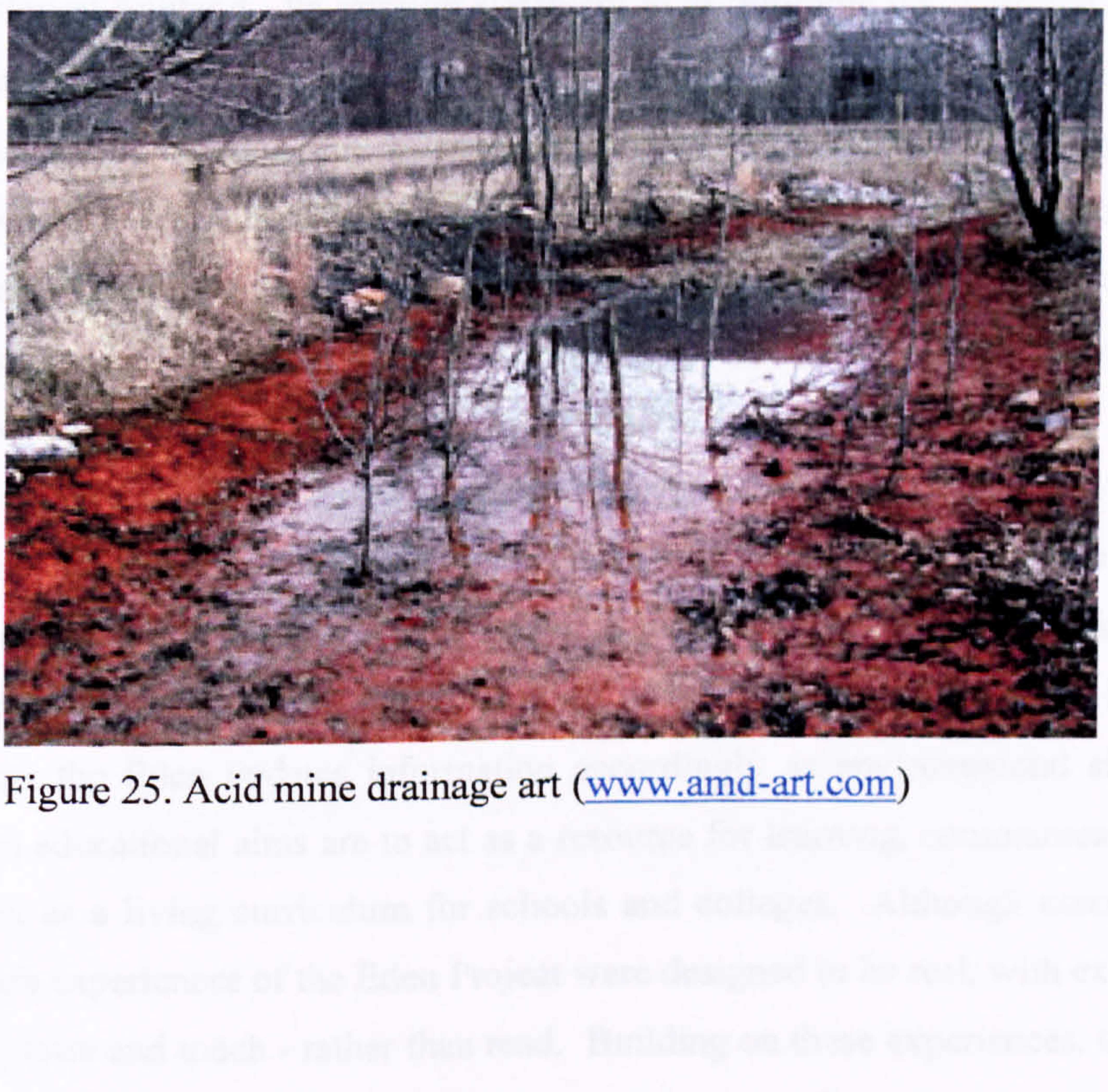

Figure 25. Acid mine drainage art (www.amd-art.com)

more about response to environmental destruction than it is interpretation of science. Furthermore, the creation of public 'art' reflects rather more a process of landscaping and environmental improvement.

3.2.3 Interpretation initiatives

The Eden Project, owned by registered charity the Eden Trust, is an interactive museum, in Cornwall, Southwest England. Its mission statement is to 'promote the understanding and responsible management of the vital relationship between plants, people and resources leading to a sustainable future for all'. The Eden Project promotes itself as 'a symbol of regeneration, bringing life and community where there was none' and 'a cauldron where science, technology and the arts can be cooked into an entertaining and educational experience, inspiring us to look at the world with fresh eyes'. The project works with partners in Development, the Environment, Industry and Science, creating "a new foundation to explore an understanding of the interdependence of people and plants". Furthermore, education and communication are central to the Eden Project. On-site exhibits and programmes are designed for all ages and abilities and will increase in information content with time. Claiming to respond to the need of the public and formal and informal education groups the Eden updates information accordingly as environmental situations change. Its own educational aims are to act as a resource for learning, communication and dialogue and act as a living curriculum for schools and colleges. Although essentially a museum, people's experiences of the Eden Project were designed to be real, with exhibits to see, smell, hear, taste and touch - rather than read. Building on these experiences, the Eden Project works with artists including, sculptors, musicians, performers, painters, mosaic artists, weavers, dancers, stone-carvers and cartoonists[33] to increase interactivity. However, with minor attempt to incorporate the information requirements of the target audiences, only with regard to formal education curricula, the Eden Project remains a museum for a scientifically dictated programme of botany.

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[33] www.edenproject.com

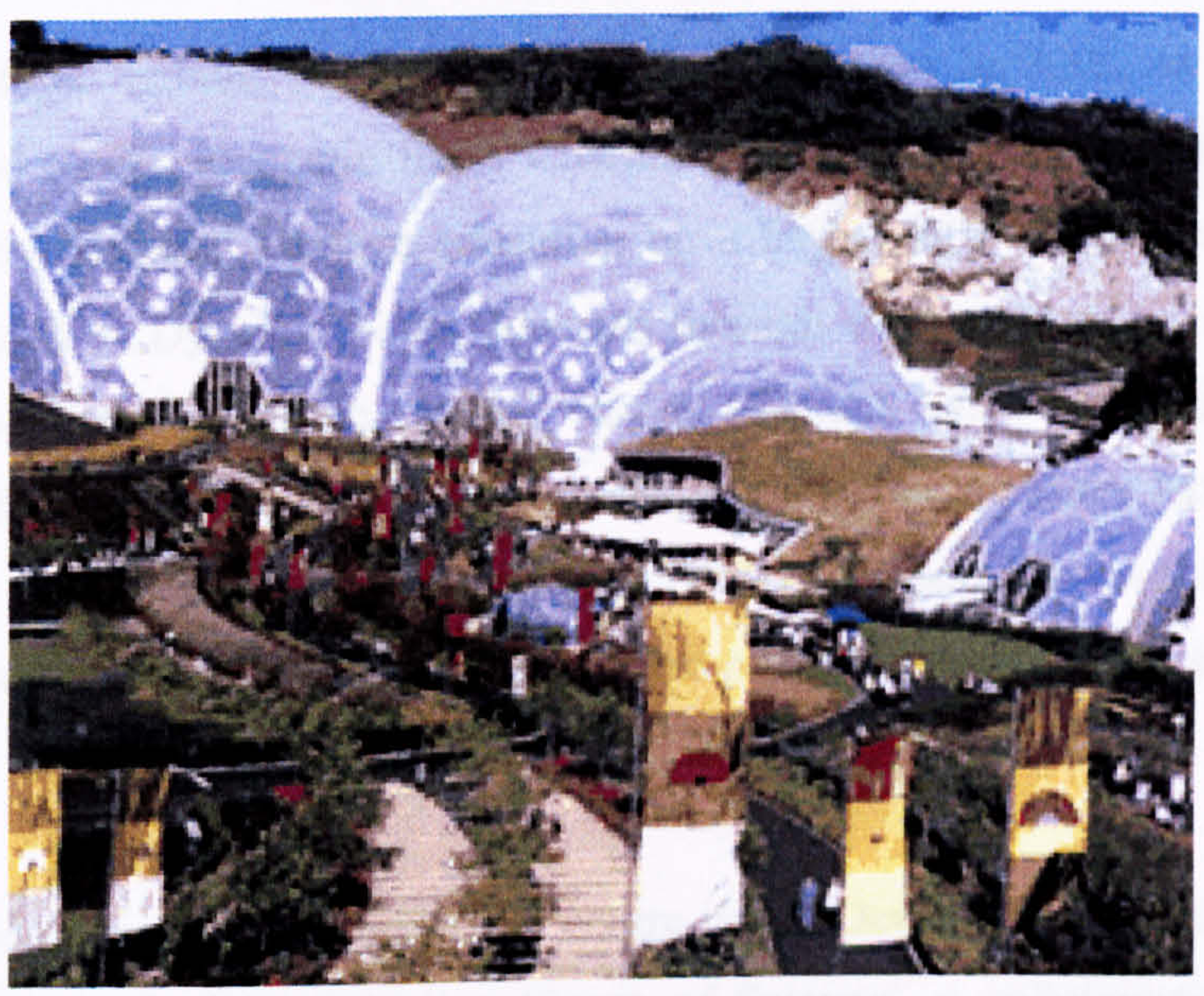

Figure 26. Eden Project biomes (www.edenproject.com)

Online since 1993, is a museum of science, art and human perception, originating in San Francisco, USA. A non-profit organisation 'Exploratorium' is a collage of over 650 interactive exhibits, related to the three disciplines, exploring scientific themes such as astronomy, microscopy and the science of music. Exploratorium represents a definite movement to promote museums as educational centres[34] and visitors to the website can retrieve scientific information through artistic interpretation. However no aspect of participation of the target audience is observed in the process. Furthermore, there is no focus for elements of marine science.

Another 'museum-type' exhibit is Our Dynamic Earth, opened in 2001, in Edinburgh, Scotland. Executed by the Dynamic Earth Charitable Trust, the project is essentially a visitor attraction, for 'holistic' heritage education on a large scale. Concerned with the 'theory of the earth', Our Dynamic Earth, educates through entertainment, in a variety of presentation styles, such as music, video, visual displays and computer imagery. Combining scientific and interpretive design talents, high visitor numbers have resulted. Although reaching a wide audience, notably over 80% of visitors live within a 2-mile radius. Again the content of exhibitions is dictated and participation of the target audiences is negligible.

In 2004, a plant and microbial gene discovery centre in the Department of Biology at the University of York, launched the initiative 'Sense of Science', a collaboration between scientists from the centre and artists from different artistic disciplines. In partnership with Arts Council England, the yearlong project explores how science can contribute to the arts and vice versa, with themes ranging from the use and understanding of science to perceptions about science and scientists. Art works produced by artists in residence, showcased at a variety of arts events around the Yorkshire region, are aimed to make scientific ideas accessible to a wider audience. Three artists, a composer and musician, a photographer and a site-specific artist, work with a variety of media to achieve the centre's central objective to increase public engagement with bioscience[35]. Although the accessibility of science is increased through the regional perspective of the project, little/no

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[34] www.exploratorium.edu
[35] www.artscouncil.org.uk

participation of the target audience in creation of art or scientific subject matter is facilitated. Furthermore, there is no marine significance of the project, with a purely plant microbial focus.

On an international scale, the Atlantic Frontier Environmental Network and the Scottish Fishermen's Federation jointly launched the UK Atlantic Margin Environment Project in the year 2000. Involving the Atlantic frontier countries and resident scientists and fishermen, the project comprised the visual interpretation of sightings and recordings of marine mammal populations. Providing fishermen with simple, visual identification keys for cetaceans and seabirds, the project rationale was wider (stakeholder) involvement of fishers in a programme of marine research. However, with no consultation over the type and format of keys and governing control resting with the scientists involved, the project donated little responsibility to the fishers. With marine biologists stereotypically superior, the real impact of visual material dissolving an information transfer between science and society is immeasurable.

Table 1. Aspects of art for explanation initiatives

	Levels (High, Medium and Low)				
Initiatives	**Marine focus**	**Use of art**	**Audience involvement**	**Science base**	**Faults/ Bias**
Abriachan Forest Trust	Low	Medium	High	Medium	Low
A'Chraobh – the tree	Low	High	High	Medium	Low
AMD and ART	High	Low	High	Medium	Low
Backyard Biodiversity Day	Medium	Low	High	High	High
Dynamic Earth	Low	Medium	Low	High	Medium
Eden Benchmarks Project	Low	High	High	Low	Low
Eden Project	Low	High	Medium	High	Low
Exploratorium	Low	High	Low	High	Medium
Helford VMCA	High	High	High	High	Low
Mountains to the Sea	High	High	Medium	Medium	Medium
River Parrett Trail	Low	High	High	Low	Low
Science in Salamanca	High	High	Medium	High	Medium
Seen and Unseen	Medium	High	Low	Medium	Medium
Sense of Science	Low	High	Low	High	Medium
Sheepfolds Project	Low	High	Medium	Low	Low
Taigh Chearsabhagh	Medium	High	High	Medium	Low
Turning the Tide	High	High	High	Medium	Low
UK Atlantic Margin Environment Project	High	Medium	Low	Medium	High

Table 1 above, highlights the key criteria of the initiatives discussed in this Chapter, and how they relate to each other. The criteria included in Table 1 reflect the objectives of case studies that will from part of this research (see section 3.2). In summary, the majority of the initiatives display a widespread application of art-based interpretation of information. Furthermore, most initiatives display community involvement and or/consultation, in some respect. There is mediocre evidence for the successful presentation of information with a strong science base, with only a handful of initiatives focused on marine environmental affairs. Most initiatives were biased in some way towards a community of scientists rather than a community of stakeholders. This was observed in a top-down process of deciding on suitable subject matter, commonly originating from a community of experts, both scientist and artist.

In summary, the projects most closely approaching the rationale of this research, are the Helford Voluntary Marine Conservation Area (VMCA), Science in Salamanca and 'Turning the Tide'. Most obviously this is owing to their primary focus on marine affairs. These three projects also allow for significant participation of the target audience in the creation of art and/or ideas, with the least amount of bias towards a scientific/artistic community of experts. Those least comparable to the objectives of this study are 'Our Dynamic Earth' and the A'briachan Forest Trust due to a lack of community involvement and lack of marine focus respectively.

3.3 Potential for case studies

This thesis is not designed as a mere philosophical account of investigation into arts-based interpretation, but an assimilation of practical and related case studies. A framework for related case studies now emerges, building on the assembled knowledge, practical and theoretical, and strictly adhering to the unique philosophy of the research. Befitting the nature of the scientific discipline, the component research, despite being heavily arts-based, readily takes the form of a scientific investigation, rather than a purely theoretical account. With clearly defined aims, reproducible methodologies and data sets, case studies will represent individual investigations into the communication of marine science through visual artistic vehicles.

After qualitative analysis of the past initiatives discussed in the proceeding sections, it can be said with conviction that no one example from the literature truly satisfies the objectives of this investigation. In other words, evidence for formulating a visual narrative for marine scientific information that a target audience wants to know, and allowing their open participation in the process, both at the assimilation and dissemination stages has not been found in searching through relevant literature. In particular, those museum-based exhibitions discussed are exemplary of how scientific information is all too commonly presented and accepted into popular culture, without question. To summarise, there is very little evidence among the compiled case studies for:

- involvement of the target audience in the choice of information;
- the provision of information desired or previously unknown; or
- initiatives which depict inclusive target audience participation in arts interpretation of (marine) scientific information.

This research is unique in that it is concerned with the process that precedes scientific interpretation. It will focus on an inclusive participatory approach to marine science representation, commencing at the agenda-setting stage. Integral case studies will be designed to communicate scientific information that people 'want' to know, as opposed to what science dictates one 'should' know, and directly involve them in its assimilation and dissemination. Furthermore, throughout the course of the research, a diverse cross-section of the community will be given the opportunity to participate in the creation of a visual narrative. This will include not only those groups/stakeholders who are most likely to be approachable and willing to participate in science, but those generally unapproachable and unwilling to participate, e.g. members of the Orkney fishing community.

The thesis and the particulars of the case studies relate to engagement of stakeholder/community groups in an agenda-setting discourse for science and their participation in its representation. The role of the researcher and the working groups of scientists involved in case studies will be backseat, as articulators, responding to the needs of the target audiences. The process does not consider the role of managers in the discourse. In suggesting an alternative approach to conventional science representation and communication, management of the process arises as unnecessary. Stakeholders will take the leadership role in the participatory approach, managing the process themselves.

3.4 Conceptual framework

3.4.1 Participation

The research seeks to highlight alternative (visual arts) vehicles for the communication of marine science to particular target audiences. Two case studies will be developed to allow participation of two different groups. The first target audience will be:

- willing to participate in the process of assimilating and disseminating marine scientific information; and
- lacking in pre-existing conflict (skepticism) among stakeholders and between stakeholders and the scientific community.

The second target audience will be:

- less willing to participate in the process of assimilating and disseminating marine scientific information; and have
- pre-existing conflict (skepticism) among stakeholders and between stakeholders and the scientific community.

3.4.2 Communication

Art, in the form of visual narratives, will be used to communicate scientific language of varying degrees of complexity to the target audiences. Two further case studies will be developed to investigate the scale and worth of the visual artistic composition. The first of these studies will:

- compare and contrast a variety of elements of visual art; and
- develop a visual narrative relating to relatively simplistic marine scientific information

The second of these case studies will:

- develop a visual narrative relating to complicated scientific (mathematical) language.

Within the conceptual framework of case studies, developing alternative narratives for marine science, alternatives to the actual science may emerge as the investigation continues.

3.4.3 Goal

The four case studies above, forming individual chapters of the thesis, will collectively attempt to document a unique and mutually beneficial relationship between science communication and visual artistic representation. Furthermore, the discussion will attempt to discover how application of artistic narratives to pieces of science may affect the consensibility of their communication, necessary for a shared understanding.

Chapter 2 discussed several of the key attributes of consensible science, together with the limitations of a lack of consensibility. Of primary importance to this research are: trust in science; mutual agreement among stakeholders; scientific certainty; participation; co-operation; and understanding. Firstly, if provision is made for sets of stakeholders participating in the case studies, to set their own agenda for science representation then real engagement of stakeholders in the process may be possible. Such an inclusive approach may go some way to restoring trust, particularly among stakeholders in situations of conflict with potentiality for eventually contributing to a scientific and societal consensus. With trust and mutual agreement among stakeholders, more faith may be put in the certainty of science – an increased ability to live with the current scientific consensus. In a post-normal approach to science, in the context of the marine environment, moving away from institutionalisation and towards an extended peer community, affected by increasing accessibility, acceptance of scientific unknowns and uncertainties, where they do exist, may be more realistically possible. With this improved consensibility, rational participation in a process of acquiring scientific knowledge, through co-operative arrangement, may be possible. This engagement will theoretically lead to an improved, shared understanding of science among stakeholders. It is visual arts instruments that will attempt to catalyse this conceptual process, providing the opportunity to explore that conventional science representation cannot.

Chapter 4. DEVELOPMENT OF CASE STUDIES

The first section of this chapter outlines the potential target audiences for a selection of case studies seeking to increase the consensibility of marine science through community participation in development of visual arts narratives. The second section of the will describe how case studies were selected and define a potential methodological framework for each. The background to methods, and how they were chosen, will be discussed. More specific methodologies are situated in the respective chapters that follow.

4.1 In search of target audiences

The setting for case studies presented in this thesis was the Orkney Islands, Scotland, during the period 2001-2004. The unique characteristics of the Orkney environment, together with the social and cultural individuality of its communities, within a setting of the Scottish Highlands and Islands, require adequate introduction. Particular consideration, where appropriate, is given to the natural environment, science interpretation, visual arts, community and culture.

4.1.1 Environment of the Highlands and Islands

In a study by McDermott and Noble (1994) concerning environmental interpretation in the Highlands of Scotland, it was noted that this region has some of the most outstanding landscapes, wildlife and cultural heritage in Northwest Europe. With much of the region's economy dependent upon natural resources, through industry and tourism, there has been increasing public awareness of anthropogenic impact on the environment in Scotland. Furthermore, debate on these issues has led to formal recognition by the main public sector agencies that economic growth should be based on sound environmental principles and that new approaches are needed to encourage sustainable use of environmental resources (McDermott and Noble, 1994).

Against this background, McDermott and Noble (1994) conducted a joint study into an integrated approach to enhanced conservation and interpretation of the natural environment. They conjecture that producing an interpretative strategy for Highland areas is essential to explaining the significance of sites to the general public, stating: 'Such strategies, with the blessing of local communities will be effective recognition of their separateness; yet allowing for the expression of an overall Highland identity'. McDermott and Noble (1994) continue that the fundamental goals of such interpretation should include raising awareness of the cultural heritage of the Highlands and creation of opportunities for people to gain a deeper understanding and appreciation of their environment.

4.1.2 Art in the Highlands and Islands

The unique culture of Highland and Island communities is well represented in the works of the representative arts communities. For example in the Western Isles, it has been recently demonstrated by a number of studies that arts have a key role to play in the regeneration of both Gaelic culture and the region's economic standing. Major ventures such as the North Uist arts centre Taigh Chearsabhagh (see section 3.1) amongst others, for example in the Western Isles, have developed the arts infrastructure of the region, relying fundamentally on the voluntary support of local groups and organisations[36]. Such centres share a common rationale that education is fundamental not only to developing future artists, but also to building the confident and concerned public which is essential to a dynamic culture and a sustainable environment.

4.1.3 Orkney

Orkney is an archipelago of approximately 70 islands off the Northeast coast of Scotland (see map Figure 24), on a latitude 59° 41' and 59°24' N and 2°22' and 3°26' W. With a coastline of approximately 570 miles, the Orkney Islands can be subdivided into three main

[36] http://www.w-isles.gov.uk/arts/strategy2

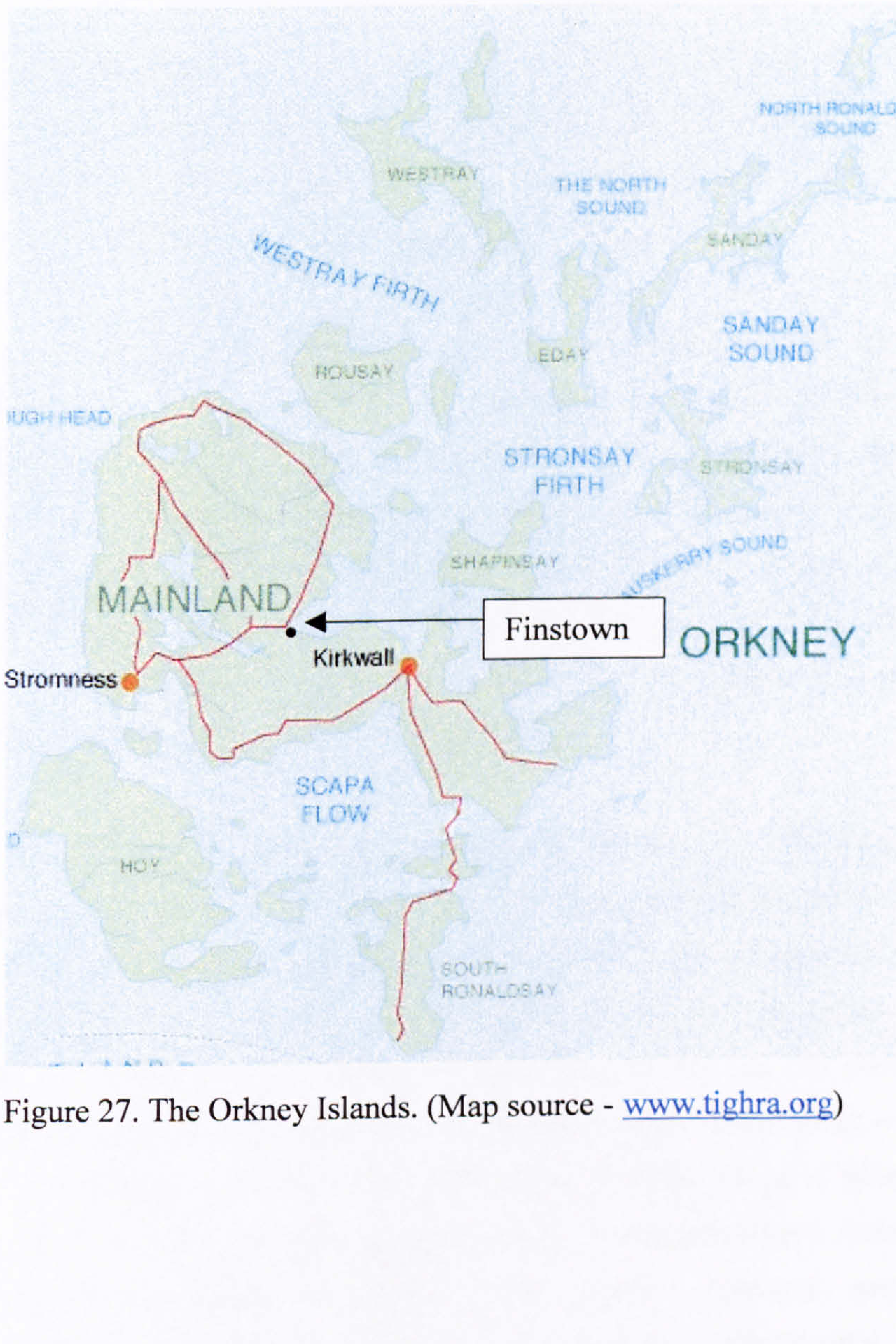


Figure 27. The Orkney Islands. (Map source - www.tighra.org)

regions: the Mainland (East and West); the North Isles, and the South Isles. Less than one third of the islands are inhabited.

The Orkney population stands at 19,245 (2001 census) and has dropped by 1.9% since 1991. This is largely thought to be owing to migration of younger members to the UK mainland for higher education and/or employment. The mean age of the Orkney residents is 40.3 years, with a marked trend towards an ageing population[37].

The Orkney economy has been traditionally based on agriculture and fishing. However in recent years fish farming, tourism and food processing industries have rapidly become significant employers[38] and small-scale craft businesses are also expanding. Recently, a number of businesses servicing the renewable energy sector have emèrged, including the creation of a trade association and locally based consultancy teams, working worldwide on a range of environmental issues. In particular, the establishment of a European Marine Energy Test Centre (EMEC) in Bilia Croo, near Stromness (see Figure 27), provides a strong future base for the sector (Orkney Enterprise, 2003).

The Orcadian community has always had a clear sense of identity. The awareness of identity is reflected in the works of its artists, painters, poets, photographers and novelists and the spirit of its people who try to capture the essence of the environment (Orkney Islands Council (OIC, 2002). With a community that has a long relationship with the marine environment, many people's livelihoods depending on the sea, the environment plays a key role in the daily lives of Orcadians. A suitable example of this sense of identity is the Westray Development Trust, formed in 1998 on the Northern Island of Westray (see Figure 24). The trust was set up to 'develop the economic, social and cultural sustainability of the community by harnessing the quality of the island's resources, people and environment'[39]. The trust works with partners to implement environmental projects, strategies and actions including the set up of new businesses, artist residencies, drop-in centres, craft associations, grants for transport etc.

[37] www.statistics.gov.uk
[38] www.hie.co.uk
[39] www.westray-orkney.co.uk/thetrust

4.1.4 Orkney naturalists

Historically, there have been many individuals who have devotedly studied and recorded the natural environment of Orkney. As put by the famous naturalist, Professor R, J Berry, 'it is impossible to live in a place like Orkney and be unaware of its animals and plants, its moods and seasons'. Besides a large collection of species lists, Floras and Faunas, dating back to the 16^{th} Century, more in-depth study of the Orkney environment by certain key figures has taken place in recent years.

Founded in 1889, the Royal Society for the Protection of Birds (RSPB) is the largest landowner in Orkney, owning and managing more than 8000 hectares of land. For this reason amongst others, the RSPB is responsible for a number of conservation and education initiatives and participatory projects within the county. The first (honorary) RSPB warden in Orkney was Mr. Eddie Balfour in 1937. His devoted study of the hen harrier for over 40 years, gathering and channeling information to authorities and journals, and his passion for conservation is thought to have first put Orkney on the ornithological map (Groundwater, 1974). Balfour was also a founder member of the Orkney Field Club, a forum for naturalists set up to 'promote the study and the conservation of the natural and cultural heritage of the County of Orkney' (Berry, 1985).

Most famous in Orkney for his study of the marine environment, is the poet and scientist Robert Rendall. Rendall displayed a fascination with life on the shores of Orkney and a unique ability to unite the imaginative and the practical (Dickson, 1990). Although his focus was the marine biology of Orkney, Rendall's talents included archaeology, theology and art. His most famous work '*An Orkney Shore*' (1960) was simple testament to the beauty of the Orkney landscape and the people who inhabit it (Berry, 1985). Rendall's other significant work was '*Mollusca Orchadensia*' (1958). Combining his perceptive and descriptive skills, Rendall spent considerable time studying Orkney shell names and their relation to shell games, providing an insight into aspects of unrecorded social history of generations of Orcadian children (Dickson, 1990).

4.1.5 Art in the community

Orkney is arguably one of the richest sources of practicing artists, professional and voluntary, per capita in Scotland. The landscape, weather, history and culture of Orkney commonly inspire artists. Furthermore, working invariably in isolation and tranquility, an Orkney base is attractive for the artistic temperament. Arts organisations strengthen the community of Orkney and provide many opportunities and entertainment. Consequently, approximately 10 percent of the population is involved in an arts organisation or activity of some form, diverse particularly in music and visual arts (OIC, 2002).

The St. Magnus Festival, founded in 1997, is Orkney's annual celebration of the arts. Although it centres more on musical events, the artistic programme includes drama, dance, literature and the visual arts. Education and community projects are often devised in collaboration with visiting orchestras, ensembles and artists[40].

In terms of resources, the Pier Arts Centre in Stromness, Orkney houses a notable collection of 20th British Modern Art. The centre has increasing potential as an educational resource, particularly as it is about to undergo extensive development/expansion. The Orkney community has also benefited in recent years from external funding for state of the art facilities including arts venues, an arts/leisure centre with cinema and a large new public library.

4.1.6 Arts interpretation of science

In terms of forging links between science and art relatively little has been undertaken in Orkney. Festivals which celebrate 'the arts' and 'science' separately are commonplace, though little common ground has yet to emerge. As mentioned previously, the St. Magnus festival is Orkney's major arts festival, but the Orkney Science festival, in its 14th year, is well established and indeed, internationally acclaimed. The festival covers many themes, with an increasingly international scope of interest and aims to 'integrate the world of

[40] www.stmagnusfestival.com

science with the lives of ordinary people'. Other initiatives with relevance to arts interpretation of science are discussed as follows.

OCEAN (Orkney Community Environment Awareness Network) formed in 2004 aims to co-ordinate, promote and provide environmental education across the county. Comprised of representatives from SNH, RSPB, OIC, the Orkney Tourist Board, the Community Biodiversity Project and teachers from local schools, amongst others, the group meets four times a year to co-ordinate events (for an events calendar) and exchange ideas. However, arts-based interpretation of the environment has yet to be included within the scope of the group's work.

'Art Discovery' is an artist led organisation that creates and manages cultural interpretation. A creative and interdisciplinary activity, it aims to bridge many subjects and fields of experience (OIC, 2002). With specific areas of expertise in the interpretation of archaeology and heritage, levels of science content are limited. Indeed, the project requires more development and external funding.

The Orkney department of SNH and the Scottish Arts Council joined forces in 2001 to conduct an environmental interpretation project named 'Sea Adventure'. Working in conjunction with a local youth group, SNH commissioned an artist to oversee a project focusing on art in the marine environment. Using film, animation, computer technology, digitised photography and sampled sound, children were directly involved in creative learning about marine life and shared ideas through artistic means. A widely publicised project, the idea was more to create a commentary on the marine environment than to study it. Although actual marine 'science' was involved the simplistic scientific language used was often inaccurate.

The 'Year of Environmental Inspiration' was the lengthy endeavour of Aquatera, an environmental interpretation consultancy based in Stromness, Orkney. The project was concerned with Magnus, the UK's most northerly oilfield. In order to improve oil recovery rates from the field, the Magnus Enhanced Oil Recovery project involved the laying of over 400 kilometres of pipeline across the North Sea to pump gas to the site. In May 2000, Aquatera commenced a programme of environmental interpretation projects with pipeline operators and local communities affected by it as stakeholders, in order to explain the processes involved. Funded by BP, interpretative exercises included: maps to display the geographical extent of the project; data used illustratively to display operations; and posters to display project milestones and environmental awareness issues. The project culminated in the production of an interactive CD-ROM in 2001 to make the information about the project fully accessible to those people affected by the pipeline. Although the application of this project to the Orkney situation amongst others is limited, pertaining to a very narrow user group, the transparency of scientific and technological information is fundamental to the project's success. With art used more in multi-format computer graphics etc. Aquatera take a more modern approach to aesthetic scientific education.

Orkney can be observed to play host to a diversity of communities for whom the marine environment is important in a social, economic and cultural sense, on many levels. The environment also plays a significant role in inspiring Orkney artists to create art. With arts interpretation of science existing but somewhat in its infancy, the potential for incorporation of Orkney communities in the case studies of this research is immense.

4.2 Research methodology

With Orkney communities set to be target audiences for case studies an overall research methodology can be outlined. Case studies were designed to provide insightful answers to the questions posed by the research (see section 1.3)

4.2.1 Choice of case studies

The overall philosophy for each of the four case studies chosen to comprise the research (see section 3.4) was a bottom-up, participatory approach of science representation. Working with stakeholders, a research agenda would not be imposed upon the groups in question.

Case studies were chosen by the researcher in relation to the following criteria.

- Potential for conflict - among stakeholders and between stakeholders and the scientific community.
- Potential for funding – local (within Orkney) and national.
- Potential for participation – stakeholders supervising/managing the process.
- Potential for use of arts in representation of science – and the scale of use possible.

Choice of first case study

Case study one was required to focus on a community low in potential, pre-existing conflict among stakeholders in the marine environment and between stakeholders and the scientific community. Within an Orkney setting a number of such communities, dependant on the marine environment to some extent, presented themselves. The community of Finstown was identified by the researcher as being a potential candidate community, in the knowledge that the marine environment was unique in terms of its marine communities and physical characteristics (see also section 5.1.1). Initial meetings held within the community would confirm local interest in the project (see also section 5.2.1).

The study was chosen by the researcher to be a 'community arts' style project, based on aspects of the local marine environment chosen by the community from a range of options. The project would be community led and managed, following a programme set by stakeholders. The researcher would respond to and articulate the requirements of the community in terms of the marine science and art representations. Potential funding for the project would be sourced by the researcher, both locally (e.g. the local authority, local environmental agency and enterprise companies) and nationally (e.g. Scottish grant-making authorities and award schemes). Lacking in observable conflict among stakeholders, the potential for participation in the project was high and stakeholders were likely to want to take the lead in how the project developed. Such a set of circumstances would result in the potential for arts interpretation of science representation being diverse.

Choice of second case study

Case study two was required to focus on a community high in potential, pre-existing conflict among stakeholders in the marine environment and between stakeholders and the scientific community. Within an Orkney setting the most obvious choice presented itself to the researcher as the Orkney fishing community. This conclusion was drawn owing to the intensely fraught, often political, rhetoric conducted between the fishing and the scientific communities (see also section 6.2). Locating an advertisement in *The Guardian* calling for 'Science in Society' projects to be funded by the Environmental and Social Research Council (ESRC), to improve science communication to external stakeholders, the researcher saw potential for a project incorporating Orkney (in this case creel) fishermen. (See also section 6.4).

The study was chosen by the researcher to be an arts interpretation project, derived by a discourse between fishers and scientists concerning a range of options. The project would be driven by an agenda set by fishers who may participate. The researcher would respond to and articulate the requirements of the fishing community in terms of the fisheries science and art representations. Potential funding for the project would be in place, if an ESRC grant could be secured. With considerable conflict observed among stakeholders, the potential for participation in the project was low and stakeholders were deemed as unlikely to want to take the lead in how the project developed. Such a set of circumstances would result in the potential for arts interpretation of science being limited.

Choice of third and fourth case study

Case studies three and four arose as a consequence of case study two and the fisheries science and arts representation agenda set by fishers. Case study three was designed to be an investigation of the potential scale of application of elements of artistic composition to the individual research priorities of fishers and how this may improve and/or affect their consensibility (see Chapter 7). Case study four was designed to be an investigation of how arts representation may improve and/or affect the consensibility of more complicated (mathematical) scientific language. More specifically, case study four arose from a request by one particular fisher for more consensible interpretation of fisheries stock assessment models (see Chapter 8).

4.2.2 Social science research methods

The process of social research, like research into the natural sciences, has certain key stages, as follows:

1. Choice of research area.
2. Formulation of research question.
3. Choice of method.
4. Formulation of research design and data collection techniques.
5. Implementation of data collection.
6. Analysis of data.
7. Interpretation of data.
8. Conclusions (Bryman, 2004).

With stages 1 and 2 (above) complete, it becomes necessary to consider the variety of potential approaches this research could take, from a selection within the literature of the social sciences. Alternatives for a research strategy and examples of methods will be discussed in the following sections.

According to Bryman (2004), there are two possible approaches to social science research: deductive and inductive. A deductive approach formulates a theory and uses observations and findings to test the theory. An inductive approach collects observations and findings and from which, formulates a theory. In terms of research strategies, quantitative research is a deductive social research strategy and qualitative research is an inductive strategy. Aspects of quantitative research include: quantification in data collection; emphasis on testing of theories; incorporating normal (natural science) practices; and viewing social reality as an external objective reality. Aspects of qualitative research include: emphasis on words in data collection; emphasis on generation of theories; rejecting normal (natural science) research practices; emphasis on ways individuals interpret their social world; and viewing social reality as a constantly changing/shifting emergent property of individuals creation. Although very different approaches, some writers argue that the two can be combined within an overall research project (Bryman, 2004). Bryman (2004) continues to suggest that if one is interested in the views of members of a certain social group, a qualitative research strategy that is sensitive to how participants interpret their social world is the direction to choose. Furthermore, if one is interested in a topic on which no/virtually no research has previously been done, the quantitative research strategy may be difficult.

Research design depends on a number of factors including: nature of the topic; personal preferences of the researcher; skills and experience; financial and time restrictions; restrictions on access; and ethical issues[41]. Options available for a research methodology and the advantages/disadvantages of each are presented respectively below.

a) Structured interviewing
- Reduces error caused by interviewer variability, can be administered by telephone and computer assisted and results in standardised data that is easy to process.
- Lack of flexibility in question order and content and lack of insight into respondents' subjective meanings.

b) Self-completion questionnaires
- Relatively cheap and easy to administer, absence of interviewer influence and convenient for respondents.
- Cannot probe or comment, difficult to ask many questions (respondent fatigue) and low response rates.

c) Structured observation
- Direct observation of behaviour, overcomes some problems of survey research and a standardised procedure to compare cases.
- Can be difficult to design, problems of ensuring reliability and validity.

d) Secondary data analysis
- Access to high quality data collected by other researchers, opportunity for longitudinal, cross-cultural analysis and relatively cheap.
- Lack of familiarity with data and methods, data sets often large and complicated, no control over data quality and absence of key variables.

e) Ethnography/participant observation

[41] www.oup.com/uk/booksites/content

- Seeing through the eyes of those being studied, finding out what people actually do (and not what they say they do) and a deeper understanding of behaviour.
- Can be unethical, impractical and dangerous and problems of gaining access.

f) Unstructured interviewing

- Questions can be tailored to each interviewee, deeper understanding of participants' values and rich detailed qualitative data.
- Difficult to replicate, difficult to make direct comparisons, interviewer variability and lack of rapport with interviewee.

g) Focus groups

- Insight into the way people make collective sense of phenomena, allows study of group's style of talk and interviewees able to challenge each other.
- Researcher may not have control over proceedings, members either dominant or reticent, difficult to transcribe many opinions and small sample sizes.

h) Conversation/discourse analysis

- Appreciation of the structured nature of the language of interaction, useful for uncovering rhetoric, can make use of existing textual materials.
- Easy to collect too much data, need to learn notation symbols and problems of interpretation.

i) Documentary analysis

- Data already existing, personal diaries and letters may provide insight and mass media outputs can be critically deconstructed.
- Problems with quality and authenticity of documents, questionable representativeness, often biased analysis and lack of transparency.

4.2.3 Selection of methods for case studies

With reference to the above discussion of types of approach to social research and possible strategies, the case studies of this research will adopt an inductive, qualitative approach. Such a strategy befits the relatively unstructured, evolutionary approach to the process of this research. Furthermore, considering a qualitative research strategy is useful for uncovering more rich and detailed information from a smaller sample of cases[41], it can be more suitably applied to Orkney (island) scenarios. With a set of data compiled by case study two and theoretically reflected on, case study three and four refer to a process of further data collection, visual in nature, in order to establish the conditions in which the theories of case study two do and do not hold. This general research strategy can be referred to as iterative (Bryman, 2004), weaving back and forth between the theory of case study two and the subsequent data collected by the case studies three and four.

The methods most relevant to this research, particularly case studies one and two, were chosen to be (self-completion) questionnaires and focus groups (b and g above respectively) and these methods must therefore be discussed in more detail. However, it is important to note here that, in case study one, a questionnaire was actually identified by the community steering group themselves as the preferred method.

Questionnaires are able to provide data concerning factual information, beliefs, attitudes, knowledge and values[41] held by respondents. When surveying community perceptions of the marine environment and related issues, questionnaires can be a highly useful tool. Allowing more flexibility for interpretation, producing data that is easy to code and analyse, they are often used within qualitative research strategies.

To create an understandable sequence of questions they are many factors to consider, such as the type of question (e.g. open or closed), the balance between different types of question, the method of distribution, formatting, the pretest, or pilot questionnaire, the procedure of return and the sorting of data. Such items will be discussed within the more detailed methodologies of Chapters 5 and 6, pertaining to individual case studies.

For case study one and two provision was made for participants in the research to set the agenda for its course. Moreover, in case study one the task of choosing particular methods within the study fell to participants. This decision-making process, and indeed the decision-making process involving fishers during case study two, was facilitated by the used of focus (or steering) groups.

Focus groups can be defined in many different ways but features like organised discussion, collective activity, social events and interaction identify the contribution focus groups make to social research (Gibbs, 1997). Powell et al. (1996) define a focus group as a group of individuals selected and assembled by researchers to discuss and comment on, from personal experience, the topic that is the subject of the research. Particularly suited for obtaining several perspectives about the same topic, the benefits of focus groups include: gaining an insight into people's shared understanding of everyday life; the increased likelihood of revelations via social gathering and interaction; and a multiplicity of views and emotional processes within a group context. They are of particular use when there are power differences between the participants and decision-makers/professionals, when the everyday use of language and culture of particular groups is of interest and when one wants to explore the degree of consensus on a given topic (Morgan and Kreuger, 1993). In other words, focus groups can be useful when investigating situations with value/conflict-laden disputes, of particular significance to case study two of this research. Focus groups can also be empowering for many participants. If a group works well, trust develops and the group may explore the solutions to a particular problem as a unit (Kitzinger, 1995). This has further relevance to case studies one and two, where building trust and confidence in science and scientists, promoting ownership of environments (case study one) and active involvement in science (case study two) is of paramount importance. For further reasoning for the methods used in all case studies see Chapters 5-8.

4.2.4 Involvement of the researcher

The first role of the researcher in all case studies was as a moderator, or group facilitator, of the participants involved (in case study two this was as part of a working group of scientists). This role was critical in terms of providing clear explanations of the purpose for the focus groups, helping people feel at ease and facilitating interaction between group members. During meetings of the focus groups, the researcher's role, as moderator, was to promote debate, challenge participants, and draw out differences and a diverse range of meanings on the topics under discussion. Moving things forward and keeping the discussion focused, the moderator could ensure everyone involved participated evenly but, at the same time, avoiding giving personal opinions towards any particular position. Listening and articulating participants' preferences only, likelihood of trust in the moderator, and open, interactive dialogue would be increased. The second role of the researcher was as the interpreter and communicator of the results established by the case studies and preferences of the participants. Constructing a visual arts narrative to the science involved in each case study, increasing its potential accessibility and consensibility and explaining the process that preceded representation in this way, were the primary tasks of the interpreter.

With community participants taking the lead role in at an early stage of the development of case studies, a widely agreed context could be established. With focus on interpretative methods, visual in order, interest could be generated and the process made more accessible. With ideas assimilated by local people, working in close collaboration with the moderator/interpreter (artist), the communities were responsible for the nature of the constructed visual artworks. Other beneficial reasons for having participants in the decision-making role regarding representational methods included: additional resources; better decision-making; compliance with legislation; democratic credibility; easier fundraising (by the researcher); empowerment; increased ownership of results; satisfying public demand; and sustainability.

Chapter 5. ART IN THE FINSTOWN MARINE ENVIRONMENT

"I hear and I forget, I see and I remember, but I do and I understand".

John Moar, Head Teacher Firth Primary School

The first of the two major case studies (four in total) of the thesis, Art in the Finstown marine environment describes a community-led arts interpretation project. As discussed in the conceptual framework (section 3.4.1) the target audience for the project was outlined as willing to participate in the process of assimilating and disseminating marine scientific information and lacking in pre-existing conflict (skepticism) among of stakeholders and between stakeholders and the scientific community.

5.1 Birth of the project

Review of the available literature (see Chapter 2) has indicated that, art and art-based events are now widely known to stimulate an active interest and promote involvement in marine conservation. However, considering scientists and governmental organisations still universally dictate an agenda, the subject matter of visual marine interpretation is invariably out of the 'hands' of the target audience. Therefore, the crucial next step presents itself as arts projects which, not only increase the accessibility of marine science, but arise from community aspirations for greater knowledge of matters of their own interest. Instead of paying only 'lip service' to community consultation and participation, a process must be developed which puts local people in the leadership role in the quest for adequate knowledge and interpretation of marine environments. Such a need was highlighted in a recent white paper from the Commission of the European Communities entitled 'European Governance'. It suggests proposals for change to achieve this aim include a renewed 'community method', following a less 'top-down' approach and complemented by non-legislative instruments (COM, 2001). Furthermore, community participation in an entire process resulting in the actual creation of art will enable the audience to better realise the benefits of increased knowledge of marine science.

5.1.1 Identifying a community

Orkney offers a plethora of potential target audiences for whom the marine environment plays an integral role in their lives (see Chapter 4). In the search for a community to take part in this case study of art-based marine interpretation, the small village of Finstown was chosen for a number of reasons.

The third largest settlement in Orkney, with a population of approximately 300, the Finstown community is centred around its marine environment. The sheltered Bay of Firth (see Figure 28), the stretch of coastline adjacent to Finstown, has for hundreds of years provided residents, not only with an abundant food source, but a source of recreation and local interest. As well as being an important area for sea trout fishing, the Bay of Firth, possesses the main concentration of Orkney's aquaculture industry, the farming of salmon, mussels and scallops taking place within the Bay. In this way the community has a long and important relationship with its marine environment.

In aesthetic terms the coastline is highly desirable, which lends itself well to interpretation. Moreover, the presence of a number of delicate and rare marine habitats and species determines the area has a high conservation importance. Beds of *Zostera angustifolia,* or narrow-leaved eelgrass, a UK Priority Habitat, is an important attribute of the marine environment. Finstown is the only site for this species in Orkney. This unique marine habitat, being locally rare and supporting diverse communities of marine fauna, makes it extremely important in terms of marine biodiversity. *Z. angustifolia* is located in a small saline lagoon within the Bay of Firth, known locally as the Ouse (see Figure 29). A UK Priority Habitat itself, the Ouse is a sheltered sea inlet, approximately 11 hectares in area and is also a prime example of tidal mudflats. The sheltered muddy sediments of the Ouse are an important feeding ground for seabirds and wading birds. On these grounds the marine environment of Finstown provides a diverse context for interpretation and hence the background to project 'Art in the Finstown Marine Environment' was set.

Figure 28. Bay of Firth

Figure 29. View of the Ouse (www.users.zetnet.co.uk/firth/orkney)

5.2 Methodology

5.2.1 Building trust and confidence

Initial discussions with members of the Finstown community began in March 2002. The aim of these discussions was to observe and record responses to the project concept and to provide a list of community contacts. The project was proposed as 'an investigation into what aspects of the Finstown marine environment interest the community and which they would perhaps like to find out more about'. Suggested item(s) could then provide a framework for interpretation through a programme of visual arts and events.

Discussions were held in particular with the local school (Firth Primary School), the Orkney branch of Scottish Natural Heritage (SNH) and the Orkney Islands Council (OIC). These discussions included the current level of environmental education/interpretation resources available for Orkney communities. At this time, stressed by the local Head Teacher, John Moar, were the need for additional marine educational resources for children, and the desire for the Firth Primary School to achieve the status of an 'ECO School'. He commented. *'One of the most important things we can do, as a society is to nurture in our children a respect for their environment and the world they live in. Here at Firth School, we have a wonderful situation where the children have an excellent opportunity to see the workings of the environment at first hand. Our job as teachers is to build on that, to help the children see the wonder of what is around them and to nurture a sense of responsibility - and also to have a bit of fun whilst they're learning. The key to involving children is to do something active'.*

A meeting was further held in April with the Pier Arts Centre in Stromness, Orkney, to investigate historical linkages between art and science in Orkney. Moreover, this was an attempt to ascertain what art and science initiatives within Orkney, indeed the Highlands and Islands, have taken place and may be of relevance to the project (see section 4.2.4).

5.2.2 The community steering group

With permanent local contacts now in place and a list of interested stakeholders constructed, the project could become entirely community led. Future methods of the project would be derived and decided upon by this group. Any further role for myself in the project would be as co-ordinator of activities and events. Individual representatives from the community and interested stakeholder organisations were invited to take part in the project as a member of a community steering group. Responses to this invitation were good and the steering group was outlined as having the following 11 members. Ideally, every representative would have originated from Finstown (Firth). This was, in practice, impossible owing to time constraints etc. The members listed are those who were able and willing to take part.

Dr Mark Baine	International Centre for Island Technology, Heriot-Watt University
Mrs Effy Everiss	Orkney Field Club
Ms Susan Ferguson*	Environmental Concern Orkney
Mrs Pauline Hunt*	Firth Minister's wife and Youth Group leader
Ms Kathy Hutchison*	Firth Scottish Women's Royal Institute
Mrs Jane Laud*	Environmental Resource Technology
Mr John Moar	Head Teacher, Firth Primary School
Ms Julia Partridge	Orkney Area Officer, SNH
Mr John Ruscoe*	Firth (Finstown) Community Council
Ms Nadine Russell	Orkney Biodiversity Officer
Mrs Christine Skene	OIC, Planning Department

* Finstown residents

The first meeting of the steering group was held in July 2002. There were four items on the discussion agenda, which were as follows:

1. Aspects of the marine environment i.e. those interesting the community and to be considered for interpretation.
2. Target audiences i.e. those people the steering group believed would benefit from participation in the project.

3. Interpretation Techniques i.e. ways of using art to explain/describe the aspects of the marine environment.
4. Interpretation advisory groups i.e. who should oversee aspects of the project as well as take part in the events.

A small presentation was given on each item, describing the possibilities for each item, specific to Finstown. Discussions with the group, within this framework, led to suggestions of personal preferences. For the above items, the following preferences were suggested:

1. Aspects of the marine environment: birds, seaweed, seagrass, sea trout, fishing and angling related aspects.
2. Target audiences: school, youth group, community council
3. Interpretation techniques: guided shore walks, between local woodland and the shoreline and interpretation of aspects of Sea Trout ecology. Most significantly, it a walk around or alongside the Ouse, the local saline lagoon, was the strongest preference.
4. Interpretation advisory groups: the steering group agreed their own willingness to oversee the project

It was suggested by the steering group that items 1-3 (above) should be further discussed within smaller, internal groups of the community. Furthermore, that the ideas and preferences of the steering group, regarding these items, alongside researched local area information, should be the basis for questions posed to these community groups. The groups were chosen by the steering group to be local schoolchildren, the local youth group, the community council and the school board. The most suitable method of surveying, the steering group decided, was a questionnaire survey (see minutes – Appendix 1).

5.2.3 Surveying community opinions on the marine environment

Two questionnaires were prepared, one adapted for schoolchildren and the other for adults (see Appendix 2). Individual meetings were held with all the target groups, except the youth club, who unfortunately had no available space in their timetable, to go through and complete the questionnaire. However, the questionnaire for primary 6 and 7 schoolchildren was explained at length and completed during an afternoon class session. Questionnaires were given and explained at meetings with the community council and the school board. In addition to the target groups, the questionnaire was also circulated among steering group members. Questions were organised into five sections:

1. The marine environment – to ascertain levels of community interest in aspects of the marine environment.
2. Marine interpretation - to ascertain community perceptions concerning the most appealing/effective method of arts based interpretation.
3. Display sites- to gather ideas on suitable sites to display marine based art works in Finstown.
4. Events – to align community preferences on possible interpretation events with those the steering group suggested.
5. Groups of the community – to ascertain which target audience the community believed would most benefit from participation in the project.

From a total of 20 questionnaires returned by post and 17 children's replies, the modal answers to each question were identified. The summarised results, of use to a project proposal are presented in Table 2. Answers, where appropriate, are listed in order of descending popularity. Answers in bold are the modal response.

Table 2. Finstown marine questionnaire results

QUESTIONS POSED		CHILDREN	ADULTS
	Marine Environment		
1	Average frequency of visits to Finstown shoreline	**Once a month**	**Once a year**
2	Most interesting aspect of the marine environment	**Seaweed, shells, drift, sharks, seals, crabs,**	**shells, seaweed, rockpools, fish, birds, littoral organisms**
3	Would like to learn more about the marine environment in Finstown	**Yes (80%)**	**Yes (100%)**
4 i)	Most interesting aspect of the marine environment (of those chosen by steering group) (in order of preference)	**1. Fishing** 2. Ouse 3. Seagrass beds 4. Seaweed 5. Sewage/pollution	**1. Ouse** 2. Seagrass beds 3. Shoreline 4. Fishing 5. Sewage/pollution
ii)	Which of the above aspects did you know least about?	**1. Seagrass beds** 2. Ouse 3. Sewage/pollution 4. Fishing	**1. Seagrass beds** 2. Ouse 3. Sewage/pollution 4. Fishing

		5. Seaweed 6. Shoreline	5. Seaweed 6. Shoreline
iv)	Which of the above would you like to learn more about (in order of preference)?	**1. Seagrass beds** 2. Ouse 3. Shoreline 4. Fishing 5. Seaweed 6. Sewage/pollution	**1. Seagrass beds** 2. Ouse 3. Seaweed 4. Sewage/pollution 5. Shoreline 6. Fishing
6	Is there enough local information available concerning the marine environment?	**No (60%)**	**No (100%)**
Methods of Interpretation			
7.	Which of the following methods of interpretation have you seen before?		
	Leaflets	**Yes (70%)**	**Yes (85%)**
	Sculpture	**Yes (50%)**	**No (57%)**
	Mosaic/collage	**No (70%)**	**No (57%)**
	Display cases	**Yes (80%)**	**Yes (57%)**
	Interpretation boards	**Yes (80%)**	**Yes (100%)**
	Guided walks	**Yes (55%)**	**Yes (85%)**
8	Would you like to be involved in producing something like the above for Finstown?	**Yes (90%)**	**Yes (72%)**
9	Which method would you like to be involved in producing (in order of preference)?	**1. Mosaic/collage** 2. Sculpture 3. Interpretation boards 4. Guided walks 5. Display cases 6. Leaflets	**1. Guided walks** 2. Sculpture 3. Mosaic/collage 4. Interpretation boards 5. Display cases 6. Leaflets
11	Would you like to see something like this displayed in Finstown?	**Yes (95%)**	**Yes (100%)**
Display sites			
12	At which of the following sites (chosen by the steering group) would you like to see something displayed? (in order of preference)	**1. Bridge** 2. Firth School 3. Car park 4. Community centre 5. Old School	**1. Firth School** 2. Bridge 3. Community Centre 4. Car Park 5. Old School
13	Would you go to visit interpretation work displayed at this site?	**Yes (95%)**	**Yes (100%)**
Events			
15 i)	Which idea of an arts event (chosen by the steering group) most appeals to you	**Walk from Binscarth woods to the Bay of Firth**	
iii)	Would you be willing to take part in the above event?	**Yes (80%)**	**Yes (100%)**
16	Would you be willing to get involved as part of a group?	**Yes (90%)**	**Yes (72%)**
Target Audiences			
17	Which of the following groups of the community (of those group outlined by the steering group) do you think will most likely get involved in the project?	**1. Firth School** 2. Community Council 3. Youth Group 4. Families 5. SWRI	**1. Firth School** 2. Youth Group 3. Community Council 4. Families 5. SWRI

It could be inferred from the correlated results for each section that:

i) the Ouse in Finstown was the most interesting aspect of the marine environment, in the community's opinion, owing to the present of seagrass beds;

ii) a guided walk and collage were the preferred methods of interpretation;

iii) the schoolchildren were outlined as the target audience to take part in producing arts based interpretative material;

iv) a walk from local woodland to the Ouse was the preferred type of event; and

v) the school itself and the bridge at the Ouse were possible places to display the work.

5.2.4 Schedules

Based on the questionnaire surveys and discussions with community members, it was apparent that a walk alongside the Ouse was the obvious community choice. Although questionnaire respondents displayed a preference for a walk extending through local woodland, issues of problematic access, and complications with farmland grazing were later realised, preventing this option. A schedule for the project 'Art in the Finstown Marine Environment' could hence be drafted to incorporate a walk within a programme of supporting visual arts-based activities focusing on the Ouse and its environment, with the direct involvement of the Firth Primary School.

The viability of certain project options was discussed with the community and the steering group during January 2003. The individuals approached, the matters discussed and the results of these discussions are outlined in Table 3. Offers of support and assistance in the project made by individuals or groups are included where appropriate.

Table 3. Discussions with the community and outcomes

Individual(s)	Subject of discussion	Outcome
Christine Skene, Planning Department, Orkney Islands Council (OIC)	Ouse site visit, planning and design aspects of a guided shore walk	Site will require an extensive (beach) clean up One side of the Ouse is more suitable for a walk, in terms of aesthetics and access OIC agree to fund a degree of construction and interpretation of a walk
Susan Ferguson, Environmental Concern Orkney (ECO)	If the members of ECO would be willing to take part in an Ouse beach clean up as part of their annual Orkney beach clean 'Bag the Bruck'	Confirmation of involvement in clean up and volunteered labour of ECO members
Sheila Headley, acting Head Teacher, Firth Primary School	Involvement of the schoolchildren in interpretative art and events Possible ways to secure funding for the project	School agree to take part School agree to be funding applicant group if necessary
Local artists from the Finstown area	Possible involvement of local artist in creating some marine based art Past artistic ventures within the local area	Artists agree to lend their support where necessary Informed of a local sculpture trail existing in the village of Rendall
Community Council	Logistics of an 'Ouse Walk'	A walk down one side would be the best possible solution to the problem of multiple land ownership
Local landowners, of the land surrounding the Ouse	Access to land for interpretive project purposes	All approved of project * Permission to go ahead

* Although all landowners were willing for the project to go ahead, one individual Mr. G. C. Gray, specified his concerns with regard to the permanency of any aspect of the project and how current land use by the public alter e.g. increased numbers of dog walkers. However, he was reassured that land use would not alter and agreed on the grounds that schoolchildren were to be involved and that the project would no doubt benefit the community. The landowner appreciated being consulted.

A project proposal was then designed to satisfy all community preferences where possible and was presented to the steering group at the end of January 2003. 'Art in the Finstown Marine Environment' was proposed to comprise the following four stages:

1. A beach clean up of the Ouse.
2. A shore based 'Seaweed Day' for children.
3. Production of interpretation boards and a stone viewing seat, to form part of
4. The design and construction and launch of an 'Ouse Walk'.

Specifics of the four stages and a timetable of the events were outlined as follows.

Stage 1. Beach Clean Up (April 2003):

- Improve Ouse site safety, condition and accessibility.
- Remove large amount of litter and larger items such as barbed wire bundles, wheels and metal objects.
- Rake a proportion of the dense, rotten drift seaweed away from the high tide mark.

Stage 2. Seaweed Day (May 2003)

- To involve two classes of schoolchildren (primary 6 and 7) at a suitable stage in their curriculum most able to benefit from participation in the project.
- Shoreline excursion to collect specimens of seaweed from the Ouse.
- Classroom-based identification of specimens of the major species.
- Pressing of seaweed in a seaweed press.
- Creation of a large collage, or seaweed map of the Ouse, to be displayed at the School.

Stage 3. Production of interpretation boards and a stone viewing seat (June 2003)

- Arrange a visit to the Ouse for local Orkney biodiversity recorders to assimilate all area records.
- Obtain all other descriptions of the local flora and fauna of the marine and terrestrial environment from literature and local experts.
- Design and produce a set of interpretation boards for the Ouse Walk to display important features of the local area.
- Oversee the design and production of a stone viewing seat to be placed at one end of the walk.
- Hold a small competition for schoolchildren who took part in the project to produce a design for an engraving for the stone seat.

Stage 4. Construction and launch of the Ouse Walk (July/August 2003)

- Small bridges and stretches of boardwalk laid down to cope with the unevenness of the shoreline.
- Strimming of very long grass to create a designated path along the high tide mark.
- Erect interpretation boards and seat.
- Advertise an official launch day in Finstown and the local press, as part of the Orkney Science Festival, 2003.
- Invite those involved in the project to attend plus the community of Finstown.

- Provide opportunity to take a guided walk, view displays of schoolchildren's artwork and enjoy some refreshments.

The steering group offered their support for all stages of the project and comments and further ideas were offered. The meeting continued with a summary of proposed costs, for individual aspects of each stage of the project. In a resulting question and answer session it was established that the project could now approach both the local grant-making authorities (SNH, OIC and Orkney Enterprise) and certain external funding bodies.

5.2.5 Funding

Total project costs were approximated at £6690. Although securing local funding for the project was of primary importance, it was clear that the total costs could not be covered without external financial assistance.

Local funding

With representatives on the community steering group, both SNH and OIC volunteered to contribute funding towards total project costs. After careful consideration by OIC, and applications sent to SNH and Orkney Enterprise, OIC and SNH offered to fund certain aspects of the project, and Orkney Enterprise agreed to make up any shortfall.

External funding

After discussing the project with Voluntary Action Orkney, a community support group, funding proposals were sent to the following organisations, whose funding criteria were met: Shell Better Britain Campaign; Awards for All Scotland; and the Royal Incorporation of Architects in Scotland (RIAS) Millennium Awards. RIAS Millennium Awards agreed to fund the project

Secured funding

The result of the applications made, and funding secured is outlined in Table 4 (below), for the relevant stages of the project. N.B. After revisiting the Ouse site with OIC, an extra stretch of boardwalk was deemed necessary for an area of the shore, not previously recognised as unsafe. The extra cost for this boardwalk was quoted as £1,000, updating total project costs to £7690. After advising Orkney Enterprise of this additional cost, they agreed to make up the shortfall.

Table 4. Funding for the project 'Art in the Finstown Marine Environment'

GRANT-MAKING AUTHORITY	RIAS Millennium Awards	SNH	OIC	Orkney Enterprise
PROJECT STAGES	Offer to fund (Yes/No)			
Stage 1 - Beach Clean	Yes	No	No	No
Stage 2 – Seaweed Day	Yes	Yes	No	No
Stage 3 – Boards & seat	Yes	Yes	Yes	No
Stage 4 - Ouse Walk	No	Yes	Yes	Yes
TOTAL GRANT	**£3860**	**£1530**	**£1400**	**£1000**
TOTAL PROJECT COST = £7690				

Why was project funding successful?

All project funders were asked individually, why the project successfully secured financial backing. Responses were received from two of the four organisations and their comments were as follows:

Hazel MacBride, Awards Administrator, RIAS Millennium Awards

"I can say that your application fulfilled both the main criteria important to the Assessment Board regarding individual and community benefit. First, you displayed that there was very strong support for your project both at a local and wider level having already carried out a questionnaire survey of adults and young people as preparation for making your application. Secondly, it was felt that there would be a high level of community benefit through the activities scheduled to take place during the course of the project and in the final outcome of making the marine environment more accessible to everyone by means of the guided walk and visual interpretations.

Finally, the Board felt that you would personally benefit through gaining new knowledge of a local habitat that you would be artistically interpreting and the project would provide you with the experience of organising work suitable for young people. On top of this the board felt that the project represented excellent value for money in regards to the longer term benefits that locals and visitors to the area will gain from this".

Julia Partridge, Orkney Area Officer, SNH

"Granting funding for the Finstown Community Project will enable all sectors of the Finstown community, and visitors to the area, to learn more about the local marine environment. The project will enable people to gain access to a walk, which will be constructed alongside a lagoon and the provision of interpretation will give walkers the opportunity to inform themselves on the ecology of the lagoon.

The project has been developed in consultation with the local community and has been steered by a group consisting of community organisations, Orkney Islands Council and Scottish Natural Heritage. The outcomes of the project therefore reflect the wishes of the local community and enable them to gain knowledge in areas that are of specific interest.

Funding of this project will help SNH in it's remit to facilitate people's enjoyment of the natural heritage, by helping to implement a local project, which will provide enjoyment for the community for many years".

It is speculated that both OIC and Orkney Enterprise, who did not respond at this opportunity, granted funding owing to the local interest and regenerative aspects of a project, which was good value for money. OIC's positioning of a representative on the community steering group would have made funding the project more justifiable.

5.2.6 The construction phase

Management and participation

With funding secured and a timetable of events agreed, the project could proceed. The next sequential step was to enlist the support of those organisations, whose participation was necessary for fulfillment of aspects of each stage of the project. Those people approached (March – June 2003) and who agreed to take part in the part in the events are outlined in Table 5 (below).

Table 5. Local involvement in the project 'Art in the Finstown Marine Environment'

Individual/Organisation	Project stage	Help volunteered
Firth Primary School	Stage 1 – Beach Clean	To conduct their own litter pick up
Alison Skene, Aquatera Environment Consultants	Stage 2- Seaweed Day	To assist in seaweed identification/art interpretation
Christine Skene, OIC	Stage 2- Seaweed Day	To assist in seaweed identification/art interpretation
Effy Everiss, Orkney Field Club	Stage 2- Seaweed Day	To supervise seaweed pressing
Dr Martin Wilkinson, Heriot-Watt University	Stage 2- Seaweed Day	To assist in seaweed identification
The Orcadian Newspaper	Stage 2- Seaweed Day	To supply 'end of roll' newsprint free of charge
Royal Society for the Protection of Birds (RSPB)	Stage 3 –Interpretation Boards and Seat	To provide all local bird information for boards
Orkney Field Club	Stage 3 –Interpretation Boards and Seat	To take part in a biodiversity recording day at the Ouse, published in the Field Club bulletin
Elaine Bullard, Orkney Botanical Recorder	Stage 3 –Interpretation Boards and Seat	To visit the Ouse site and construct a list of all vascular plants
Kevin Shaw, local Stone- dyker	Stage 3 –Interpretation Boards and Seat	To produce a small stone viewing seat from local flagstone
Tracy Laurenson, Monumental Mason, of Finstown	Stage 3 –Interpretation Boards and Seat	To engrave a design on the stone viewing seat
Christine Skene, Orkney Islands Council	Stage 4- Ouse Walk	Agreed to be responsible for and to maintain walk after its launch
Dr Howie Firth, Orkney Science Festival organiser	Stage 4- Ouse Walk	To promote Ouse Walk launch as part of the Science Festival programme of events
Rt Hon Jim Wallace QC, MSP for Orkney	Stage 4- Ouse Walk	Agreed to officially open Ouse Walk
The Orcadian Newspaper	All stages	Publicity of events and Millennium Award

Practical activities

All project events were carried out during the period April – August 2003 inclusively. An overview of the events and the particulars of what took place are detailed below. Where unstated, the project co-ordinator facilitated events and activities.

Stage 1 – The Ouse Beach Clean Up

In order for the site at the Ouse to be made safe, clean and accessible for walkers, clearance of a large amount of rubbish, litter and drift seaweed from the intertidal zone was essential. With labour and machinery provided by the Orkney Islands Council, large items of rubbish such as barbed wire, wheels and other metal objects could be removed from the shoreline and disposed of. In terms of litter clearance, The Firth Primary School organised a beach clean up (see Figure 30). This was combined with a following weekend of litter clearance, taking place as part of ECO's annual 'Bag the Bruck' event, at the Ouse in April.

Further scheduled was a seaweed-raking event, where seaweed was repositioned on the shoreline by simple raking landwards. This resulted in a more even pathway underfoot. With advertising locally in Finstown, and promotion by the School, a sizeable group from the community was able to participate in the seaweed raking (see Figure 31). Approximately 20 people took part including many members of the community steering group. In general the event was a success except for one concern from an employee of SNH. Concerns were raised about habitat alteration of the areas of seaweed, a valuable food source for wading birds and habitat for marine invertebrates. After explanation that the seaweed was simply being repositioned as opposed to being removed, the objection was nullified.

Stage 2 - Seaweed Day

The concept of the seaweed day was first introduced to the Firth Primary School at the end of April 2003. Pupils and teachers showed much enthusiasm for the event and the school was willing to contribute many of the materials required.

Once the site at the Ouse had been made safe, a day's excursion for schoolchildren could be scheduled. During the morning, Primary 6/7 students from the Firth School were taken, along with their class leader and helpers from the community steering group, to the shoreline of the Ouse. With the provision of identification sheets for the major species, adapted for children's' use, identification and collection of seaweed samples was possible. These samples were brought back to the school for identification. Children were able to identify the major zone-forming, brown seaweed, their common names being representative of species morphology (see Figure 32).


Figure 30. Firth School beach clean up


Figure 31. Seaweed raking

Figure 32. Seaweed collection

Pupils were then asked to select their two favourite specimens. During the afternoon, specimens were labelled and pressed in a seaweed press (see Figure 33). The preserved specimens were brought back a week later, once dry, to create: a) a large collage display (a map of the Ouse in terms of its seaweed communities) (see Figure 34), for display at the Ouse Walk launch and b) a book of seaweeds (or herbarium) for the school to keep for future use.

Stage 3 –Production of Interpretation Boards and Viewing Seat

The local Orkney biodiversity recorders made a group visit to the Ouse, to correlate all biodiversity records and get an accurate description of the flora and fauna of the local area. Species and habitat records for the Ouse were also obtained from: The Orkney Biodiversity Records Centre; RSPB; SNH; the Joint Nature Conservation Committee, Marine Nature Conservation Review (MNCR) and the Orkney Community Biodiversity Project. All records for the area were then correlated and the most important marine and terrestrial features were outlined for display.

3 Interpretation boards were designed for the Ouse Walk and produced by *The Orcadian*, the local newspaper and printers. The position and content of each boards was outlined as follows:

i) At the east-end of the Ouse. This board displays a map of the Ouse, pointing out its major features of interest and a guide for the walk along one side This board, considering its convenient and attractive location/vantage-point, is accompanied by the stone viewing seat (see Figure 35).

ii) At the west-end of the Ouse. This opposed board displays a similar map, with guidelines for the walk and interpretation of the local area features, from a different vantage-point.

iii) On the north side of the Ouse, at a central station along the walk. This interpretation board explains, in more detail, the most unique marine habitats and species within the Ouse, namely the seaweed and seagrass communities.

Figure 33. Seaweed pressing

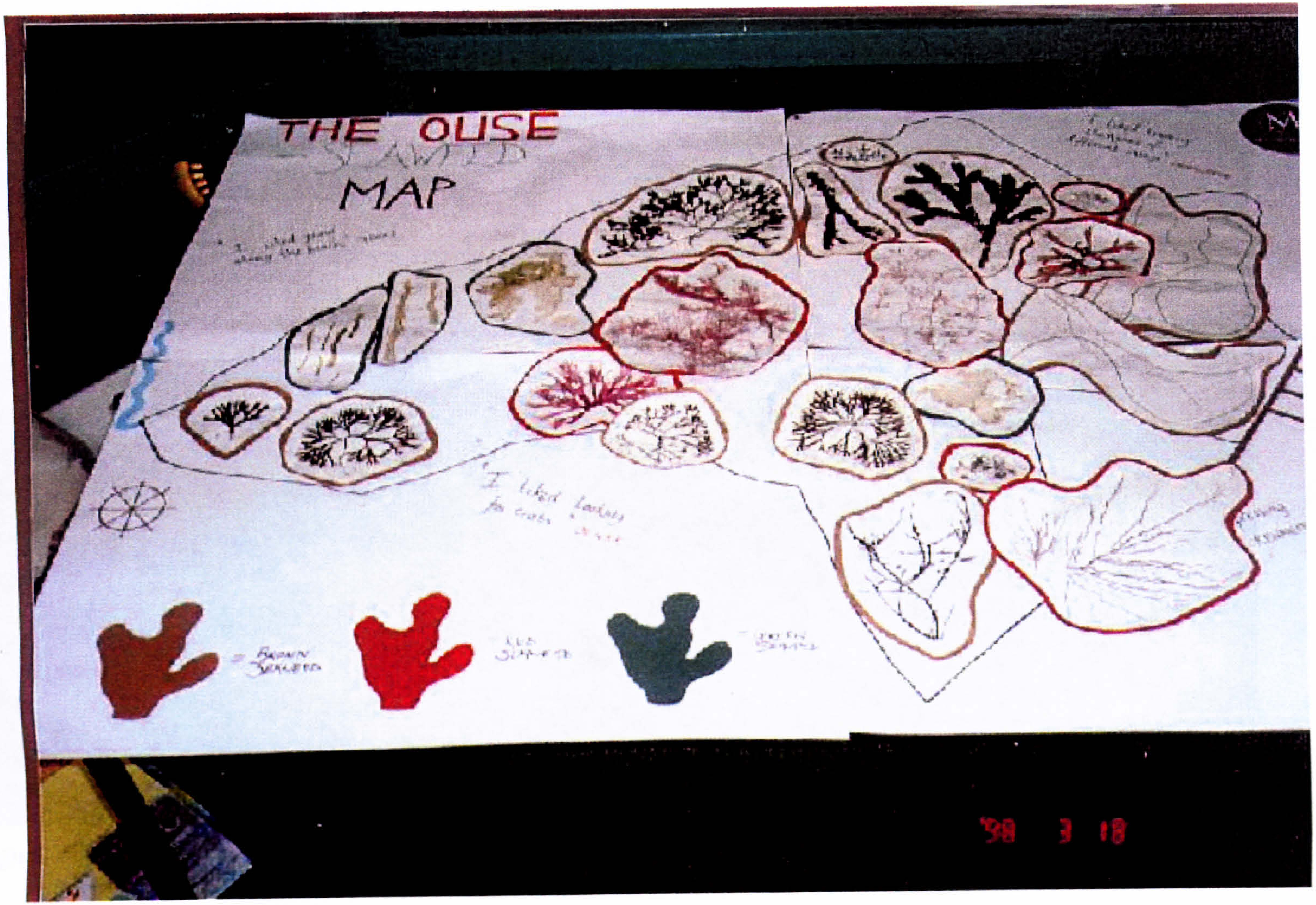


Figure 34. Seaweed map/collage

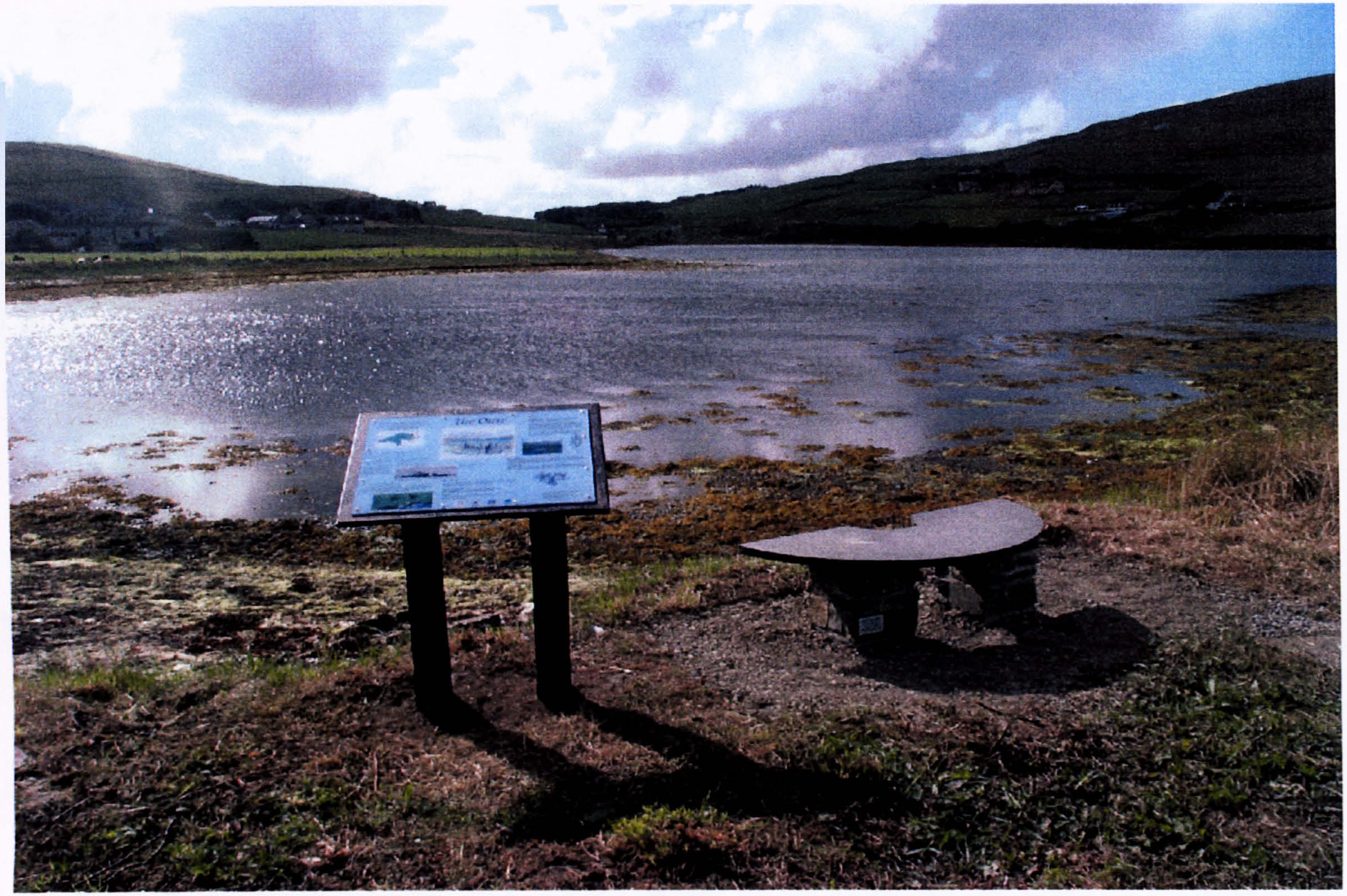


Figure 35. Interpretation board (east side of the Ouse) and stone viewing seat

The schoolchildren, who took part in the Seaweed Day, were then approached to enter a competition to design a logo/motif to be engraved onto a stone viewing seat, designed by a local stone-dyker. Pupils were asked to design a motif, which personally reminded them of the Ouse. A winner was selected whose design most effectively captured the important local features of the lagoon. A monumental mason from Finstown then engraved this design onto the flagstone seat. In this way the seat was very much a product of community design.

Stage 4 – The Ouse Walk

The site was firstly prepared to cope with walkers. Due to problematic areas of dense seaweed, steep banks and water inlets/gullies, small stretches of boardwalk and a few wooden bridges were constructed to create an even pathway around the Ouse. Other materials such as gravel chips or stepping-stones were used, where appropriate to fill in holes. The footpath was constructed in keeping with features of the local environment where possible. Strimming of a narrow footpath took place to level stretches of very long grass.

Once the interpretation boards and seat were erected in designated positions along the pathway, the Ouse Walk launch day was advertised by way of posters in local shops and businesses, and an advert was placed in local newspaper *The Orcadian*. The Orkney MSP and Deputy First Minister for Scotland, the Rt Hon Jim Wallace was asked and agreed to officially open the walk, as part of the Orkney Science Festival proceedings 2003.

5.2.7 The end product - launch

The Ouse Walk was officially launched on Sunday 31st August 2003 (see Figures 36 and 37). Throughout the afternoon, people arrived at the starting point, the Firth School, and walked the Ouse at their leisure. With guides at certain stations of the walk, to point out features of interest and answer questions, people walked the designated pathway alongside the Ouse. At the end point there was stationed a minibus to deliver people back to the school for refreshments, kindly organised and staffed by the Firth Parent Teachers' Association. Over refreshments, walkers were invited to view displays of information

Figure 36. The Finstown community attend the Ouse Walk launch

Figure 37. Walking the Ouse boardwalk

about the project, the children's seaweed collage and other artwork. At the same time they were asked to complete a questionnaire (see Appendix 3) to rate their enjoyment of the event and opinions of the project as a whole.

5.3 Feedback

Approximately 80-100 people attended the Ouse Walk launch. An estimated 30% of these people were residents of Finstown, 63% were living in Orkney and 7% were tourists. Of these people, a total of 30 filled in the launch day questionnaire, 13% of which were children and 87% were adults.

5.3.1 Questionnaire results

Specific questions within the launch day questionnaire were designed to:

a) determine the level of community participation in all aspects of the project;
b) rate the community's enjoyment of the Ouse Walk;
c) determine levels of marine information retrievable from the end product(s);
d) find out if the community were inspired to find out more about their marine environment;
e) determine the community's perceptions of art as a medium to explain scientific information; and
f) to find out if people would use the resource in the future.

A summary of the results of the launch day questionnaire is presented in Table 6. Answers given by the highest percentage of respondents are shown in bold.

Table 6. Launch day questionnaire results

SUBJECT OF QUESTION	PERCENTAGES	
Aware of project prior to launch day?	57% Yes	43% No
Aware of/took part in questionnaire survey?	10% aware	17% took part
Aware of/took part in beach cleanup?	47% aware	13% took part
Aware of/took part in seaweed raking?	33% aware	10% took part
Aware of/took part in seaweed day?	40% aware	13% took part
Aware of the community steering group?	43% Yes	57% No
Involved in steering group?	17% Yes	83% No
Would like to have been involved in steering group?	23% Yes	77% No
Did you read the interpretation boards?	93% Yes	7% No
How much of the marine information was new to you?	3% no new; 67% partly new; 30% all new	
Was the Ouse Walk informative?	100% Yes	0
Does the walk suit the environment at the Ouse?	100% Yes	0
Do you now know more about a) the Ouse? b) the marine environment in general?	77% Yes 60% Yes	7% No 17% No
Did the arts media make marine science easier to understand?	87% Yes	3% No
Should arts be used to explain science to general public?	100% Yes	0
Want to know more about a) the Ouse b) marine science c) science in general	53% Yes 67% Yes 33% Yes	23% No 13% No 33% No
Score out of 10 the influence of art media on the above answer	6/10	
Score out of 10 the quality of: a) boards; b) seat; c) walk; d) end product	9/10; 9/10; 8/10; 8/10	
Project a success?	100% Yes	0
Will use walk in the future?	90% Yes	3% No

The results show that the majority of the community was aware of the project before the final stage, the Ouse Walk. This was either a consequence of advertising, word of mouth, or via their direct consultation during the project. Indeed, the majority of the respondents were aware of the individual project stages taking place. The number participating was considerably less, though expected.

Although many respondents (43%) were aware of the existence of the community steering group, the majority (77%) did not want to take part in such a way. It is conjectured that most community members considered themselves too busy to take part or were more than happy for others to take the leading role. With 17% of respondents involved in the group, this suggests relatively high attendance of steering group members on the launch day.

With 93% of respondents taking time to read the erected interpretation boards and 54% reading 75-100% of interpretation board information, a high interest in local area marine information within the community is suggested. Those who did not read boards (7%) offered that it was due to too many people surrounding them. Several of these respondents mentioned they would almost certainly return after the event to read the boards in their own time. 67% of respondents suggested board information was at least partially new to them and 30% suggested it was entirely new. In this way, new information was made available to the community.

With regard to the walk itself, respondents unanimously decided the walkway suited the natural environment at the Ouse and that it was an informative addition to the local area. This would suggest the walk will gain approval from other members of the community and hopefully, further afield, within Orkney.

A high majority of respondents (77%) felt that, after the launch day experience they now knew more about the marine environment of the Ouse and 60% felt that the marine environment in general was now better understood. This increased knowledge was a direct result of the project and its events. In terms of whether knowledge can inspire further interest, 53%, 67% and 33% of respondents suggested they wanted to find out more about the Ouse, marine science and science in general respectively. The higher percentages, relating to interest in the Ouse and marine science were predictable, owing to their greater significance to members of the community i.e. the Ouse being their local marine environment. With 33% of respondents wanting to find out more about science in general, an equal figure (33%) did not wish to. This decreased interest in general science, is suggested to be due to its perceived lesser relevance to the community, and society in general.

In terms of arts increasing consensibility, it was unanimously decided by the community that the arts were a useful medium in translating scientific information to the general public. 87% of respondents felt the arts-based interpretation tools used within the Ouse walk and throughout the project, had made the marine scientific information easier to understand. In terms of how the use of arts media had influenced respondents opinions on whether or not they wanted to find out more about the Ouse and aspects of marine and general science, respondents offered an average likelihood of 60% (6 out of a score of 10). In other words, the arts media, in making scientific information more accessible, stimulated an interest in marine affairs.

On average, high levels of quality were attributed to all articles produced as part of the project, with average scores of 9/10,9/10 and 8/10, suggested by respondents for the interpretation boards, stone viewing-seat and Ouse Walk respectively. The end 'product' (the culmination of all project stages) was attributed an average quality level of 8/10 and 100% of respondents thought the project had been a success. In terms of future use of the Ouse Walk, 90% of respondents stated they would use the resource.

When asked to sum up the launch day experience in one word, i.e. a personal description of the project and its events, the following words (Table 7) and comments were suggested:

Table 7. One-word descriptions of respondents' launch day experiences

Comments				
Midgey	Interesting	Smelly	Enjoyable	Cold
Involving	Great	Re-inviting	Interesting	Interesting
Excellent	Muddy	Informative	Enlightening	Phenomenal
'Ousey'	Excellent	Enlightening	Educational	Great
Brilliant approach and realisation	Visionary/ accessibility	Would prefer a circular walk	Surprising	Extend walk to Binscarth Woods?

Although a discussion of such individual and personal comments is difficult, the following is conjectured. In ascending order, the smallest number of respondents offered either a comment regarding the execution of the project (8%) or a suggestion for possible future extension to the project (8%). A greater number of comments (12%) were then made referring to the community involvement aspect of the project. General adjectives e.g. excellent, was the next highest majority (20%) as well as a selection of unique descriptive words such as 'muddy' or 'smelly' (20%). However, the greatest majority of respondents chose to use a word or comment regarding the informative nature of the project or the interest it generated. This would suggest that the translation of scientific information was the most positive impact of the project, in the community's opinion.

Orkney MSP, Mr. Jim Wallace made additional comments on the project, at the Ouse Walk launch day event, in his opening speech. These comments were further documented within the Thursday 4th September 2003 edition of *The Orcadian* Newspaper. They were as follows:

"The plan for the Ouse Walk was to look at how marine scientific information can be made available for local communities, which has certainly been achieved. While the end result will be used by local people, who will gain a deeper understanding of their local environment, I am also sure that it will be enjoyed by visitors to Finstown, both from within Orkney and from further afield. On top of that, the project has involved the pupils, teachers and parents at the Firth Primary School in a worthwhile and enjoyable community project, allowing them to benefit from the expertise of the Orkney environmental groups, who gave the project their support. This is a good example of how science can be communicated to the wider audience. This successful project has provided enjoyment and will continue to provide for years to come".

5.4 Post launch day conflicts

One week prior to the official launch of the Ouse Walk, a letter was received from one of the local landowners, stating he had not consented to an interpretation board being erected on his ground. Furthermore, if it was not removed promptly he would do so himself. This very unexpected and unfortunate objection was met with a letter of apology, clearly explaining that insufficient consultation he felt was in no way intentional and a grave disappointment. It was maintained that appropriate, informal, consents were sought prior to site works, on the advice of the Orkney Islands Council, although specific consents to an interpretation board may not have been. This was deemed to be an error of judgement of those members of the steering group in an advisory position.

Telephone conversations were held between the landowner in question and a representative of Orkney Islands Council (OIC) in order to rectify the situation. These, together with the letter of apology resulted in agreement by the landowner that the interpretation board in question could remain in place for the launch day and for the duration of the Orkney Science Festival (one-week). After this period, it was agreed that the board would be removed. The landowner specified he would be willing to be re-contacted in the spring of 2004 to discuss the matter.

This issue prompted concerns within OIC that maintenance of the Ouse site may be objected to by the said landowner, despite no mention on his part. Discussions of this matter between OIC and Scottish Natural Heritage (SNH) led to their concern that the future viability of the Ouse Walk may be affected by the maintenance issue, together with the lack of a third interpretation board. Consequently, the SNH grant for the project was withheld until the matters could be dealt with to a satisfactory level.

This decision prompted an emergency meeting between relevant members of the steering group to discuss a suitable strategy for remediating the problem. Those present included the Project Co-ordinator, the Firth School Head Teacher and representatives from the Firth Community Council, OIC and SNH. Items discussed included a) why consents for site works were informal, b) what discussions had taken place with the landowner and c), who should take the lead in resolving the matter with the landowner. It was explained to the group that informal consents for project site works were sought and that the steering group as advisors, and OIC who carried out the works were fully aware of their nature and extent. Thus, any consent could have been withdrawn by any landowner, at any point. This being understood by the group, reassured those concerned that the situation was unfortunate, and that specific consents on location of an interpretation board should have been more clearly specified as necessary. It was further maintained by the project co-ordinator that the landowner's objections were only to an interpretation board and not to the presence of a walk. In this way, the future viability of the walk remained unaffected. However, SNH remained concerned that without the third interpretation board, the walk was not complete.

It was decided that the most suitable strategy for remediation of the problem, involved the Head Teacher and Community Council representative taking the lead in further discussions with the said landowner, in that these individuals could relate to him on a more personal level. With his agreement for maintenance to take place and possible replacement of the third interpretation board, the grant conditions of SNH would be met satisfactorily.

On approaching the landowner, the Head Teacher discovered that the landowner's concerns were linked to a fear that further infastructure would take place, owing to the existence of an Ouse Walk. Subsequent to this revelation, a letter on behalf of OIC was sent to the landowner, to offer assurance that no further construction works would take place. Unfortunately, during this period, the landowner had consulted a solicitor, whom informed him that the presence of a walkway across the Ouse might affect his claim on the land. In other words, it came to light that the said landowner did not have official land ownership, instead being in the process of making a claim to a section of the Ouse. A further counter measure by OIC was to protest to the landowner and his solicitor that the Ouse has been a public right of way, walked daily by the people of Finstown for over 20 years and who continue to do so. Hence, his land claim could not be affected merely by making the walk more sound underfoot.

Satisfied by the measures taken to rectify matters at the Ouse, the remaining SNH grant was paid in February 2004. The only matter left outstanding is the future of the third interpretation board. Being stored at the Special Projects department of OIC, there remains potential for the remaining board to either be replaced in its original position, assuming the landowner is in agreement, or alternatively, relocated to another suitable location along the Ouse Walk at some point in the future.

This issue, although eventually resolved, brings to light some others. Unfortunately, the landowner in question felt he was not sufficiently aware of exactly what was to be placed on the land in question. This was indeed an error, resulting from insufficient guidance from those concerned, more so considering priorities of the project included wide-scale community consultation and participation. However, this individual had previously reacted positively to the project and more specifically its links with the Firth School.

What occurred highlights that issues of land ownership can often be very complex, with those concerned often extremely defensive of their rights. All other members of the user group of 'Art in the Finstown Marine Environment' remain positive about the project and its outcomes, feeling they have benefited from their own participation. However, it is important to note that conflicts can and do exist within what, at first glance, would appear to be an open-minded, well-receiving user group.

The eventual display of support from a skeleton steering group, in response to the problems that occurred, was a favourable show of their commitment to the project and level of concern for it to come to a successful close. However, this was more likely due to the small-scale, integrated nature of the Firth Community and School, and their strong commitment to environmental affairs.

5.5 Future extension of the project

The success of 'Art in the Finstown Marine Environment' was to some degree a consequence of the environmental conscience already instilled in the pupils of Firth School who participated in the project, ultimately due to the enthusiasm and imagination of the staff and teachers. This was a catalyst for the School's willingness to participate in the project and provided a framework for its translation of environmental knowledge.

Firth School has notably taken part in a number of environmental and conservation projects. Past projects with such a theme have included: a bird hide refurbished in the school grounds; a completed resource pack on sustainable development of Orkney; the launch of a multilingual website showing environmental projects; and the set up of alternative energy equipment at the school - starting with a wind generator and the planting of about 2000 Orkney native trees (1 for every year of the Millennium). On a marine theme, the project 'Trout in the Classroom', involved the donation of trout eggs by SNH, to a group of children from the School. Hatched and reared in the classroom, the juvenile fish were released into a local burn and their survival estimated using electro-fishing techniques. Such a range of projects suitably highlights the continued desire of younger members of the community and their mentors, to be increasingly involved in local marine-based conservation projects. This was central to the success of 'Art in the Finstown Marine Environment'.

As a result of 'Art in the Finstown Marine Environment', future work is now planned for the school grounds. The school hopes that an extension of the Ouse Walk can now be constructed, with children actively involved in its design. It is hoped that the combined pathways could represent a "learning path" with additional information (interpretation) boards. With many of the marine aspects of the environment already explained, the school wishes to further interpret terrestrial features such as trees, flowers, birds and animals. Other proposals for the site at the school include a "chequer-board garden" and tree and shrub planting. In this way, the project has not only inspired a curiosity and interest in the natural environment, but a desire for the school to take a leadership role in environmental interpretation.

Furthermore, in a recent edition of *The Sunday Times*, Firth Primary school was named one of the best in Scotland, on account of its involvement in environmental projects. Comments included: "the school has taken advantage of its unique position on the Bay of Firth, nears woods, lagoon and moorland and has won awards for environmental education". In a resulting column of local newspaper *The Orcadian,* on Thursday 13th November 2003, head teacher John Moar said, "it was gratifying to receive recognition of the work done within the school and with the community". It can be reasonably assumed that the 'Art in the Finstown Marine Environment' contributed to the school receiving this important accolade.

5.6 Conclusions

5.6.1 How did people benefit from their own participation?

The process of this project ensured there was a local need for the project and that local decision making took the lead role. The community was involved in every stage of the process, in outlining features of interest, in creation of marine-based art and through participation in the local events.

Steering group debriefing

In this project, the community steering group took the leadership role, acting on behalf of the Finstown community. The members, who represented the community driving force for the end product, oversaw decisions and procedures. Although the community took an active interest in the project from start to finish, it originating from their ideas, the steering group was the driving force to put ideas into actions.

On closure of the project, steering group members were asked their perceptions on its relevance to the local community and if and how they benefited from their own participation, to whatever degree. Of the replies received, the following comments from members have been extracted:

'A community project is quite an undertaking and to encourage the participating parties to agree and to source adequate funding is an achievement in itself. Raising public awareness of the marine environment is not easy, it is perhaps an aspect of our surroundings that we so often take for granted. The research and documentation of the marine habitats of the Ouse produced in conjunction with the project work carried out with the Firth School have raised the awareness of the Finstown community to their rather special marine habitat, a splendid coastal lagoon with its associated flora and fauna'.

Effy Everiss, Orkney Field Club

'The Ouse Walk is a fantastic asset to Orkney and tourists alike. Local schools will benefit enormously from this project for many years to come and it will serve to encourage youngsters to care, wonder and learn about the very unique and important environment parked right on their doorstep. Environmental Concern Orkney is delighted to have played a part in this project and in conjunction with Firth Primary School and the local community, we shall endeavour during out annual 'Bag the Bruck' campaign to keep the Ouse free from debris and litter'.

Susan Ferguson, Environmental Concern Orkney

Seaweed day questionnaire

The primary target audience for the project was the pupils from the Firth Primary School. With this focus on the younger members of the community, the project ensured they were able to take an active and practical role in the science of their marine environment.

To determine how the target audience benefited from their participation, pupils were asked to complete a simple questionnaire (see Appendix 4), as part of the seaweed day proceedings. Children were asked to evaluate the enjoyment derived from participation in the project. The following, most relevant conclusions were drawn:

i) The majority of children decided, out of the categories of: didn't enjoy, quite enjoyed, enjoyed and really enjoyed, that they enjoyed taking part in the seaweed day.

ii) When asked what aspect of the process they most enjoyed, children most commonly suggested being taken to the shore and collecting seaweed samples.

iii) When asked how much of what they learnt about seaweed they could remember, out of the categories of: nothing, a little bit, most things and everything, children most commonly decided they remembered most of the information.

iv) When asked how much they felt making seaweed art helped them to learn, out of the categories of: didn't help helped a little, helped a lot and really helped, children most commonly suggested it helped them a lot.

Although a very simple analysis of children's perceptions of an event they directly participated in, it is clear that the process had a positive impact on the participants. Firstly, the novelty of the event had a positive effect on children, that is, the opportunity to be involved in a unique project. Experiencing the outdoor environment on their doorsteps added to this novelty. The ability to have taken part in the project will hopefully generate a greater sense of curiosity and future interest in wider environmental issues such as marine conservation and pollution and exhibit a knock-on effect for the wider community.

Questionnaire returns inferred that the process of creating marine art, in which pupils participated, had the potential to make marine information more accessible and could aid in the retention of presented information. However, this deduction requires further investigation and application to a number of alternative scenarios and target audiences to be confirmed in a more conclusive way.

5.6.2 Art for accessibility

The use of arts-based techniques to translate marine scientific information to local communities was the key aim of 'Art in the Finstown Marine Environment'. New, or previously unknown, information was successfully described in a transparent way, via the use of visual arts techniques (interpretation boards, collage etc.), to inspire community interest in a local marine environment. In this way, visual narratives have been confirmed as a vital tool in improving the accessibility of scientific information on a local level. This related not only to the primary target audience (schoolchildren) but also to secondary audiences from the wider local community.

More significantly, art has been shown to stimulate an interest in marine environmental affairs in general terms. This has implications for the wider environmental issues such as long-term sustainable development and conservation of marine habitats and species, in contrast to this project, which concentrated on the description of an isolated local marine situation. The next level for future community arts projects should be tackling this wider environmental situation and the wider audience of associated stakeholders.

5.6.3 Contribution to the knowledge

The high attendance on the launch day exhibits a positive response to this type of community arts project. This positiveness stems not only from the direct benefactors of the project i.e. the people of Finstown, but from Orkney residents and tourists alike. This would suggest widespread ownership of the project. Furthermore, with a lasting impression made by the launch day and the recognition of high quality resources left at the community's disposal, it is hoped these resources will be reused and revisited in the future.

With available information cited as the most valuable outcome of the project, it is clear that a genuine desire for marine scientific information stems from this local community. Using this community as a paradigm, it is suggested that the search for adequate knowledge of environments, made available in a more transparent, potentially artful way, is an important requisite of all communities.

Although the project has shown people as able and willing to find out more about the science of their marine environment, the implications for science in general remain unclear. With an equal split of votes between those people willing to learn more science and those unwilling, science would seem to be perceived with uncertainty in this community. When scientific information is made locally relevant, as in the case of the Ouse, opinions would seem to distinctly alter and interest generated. The key would seem to be, not only to make science more accessible, but to personalise the subject matter, giving it perspective to a particular target audience.

Ultimately, the situation and organisation of Finstown, a community dependent on its marine environment, confers few conflicts among the target audience. Moreover, with a strong willingness to participate in the project and a strong desire for locally relevant knowledge, the community exhibited negligible prejudice against the methods of science the proclamations of scientists. Therefore, the successful application of similar arts interpretation techniques in situations where conflict exists cannot be qualified. The sequential next step is to approach a target audience in such a situation of conflict, in attempt to widen the application of aesthetic educational tools.

5.6.4 'Art in the Finstown Marine Environment' compared with conventional marine interpretation

Figure 38 compares 'Art in the Finstown Marine Environment' with a comparison model of (what is deemed to be) a conventional marine interpretation process. Derived from experience of typical interpretative processes that have occurred in Orkney over the last few years, conducted for example by SNH or local environmental consultancies, it relates to a piece of interpretation located at Aikerness, near the small Orkney village of Evie.

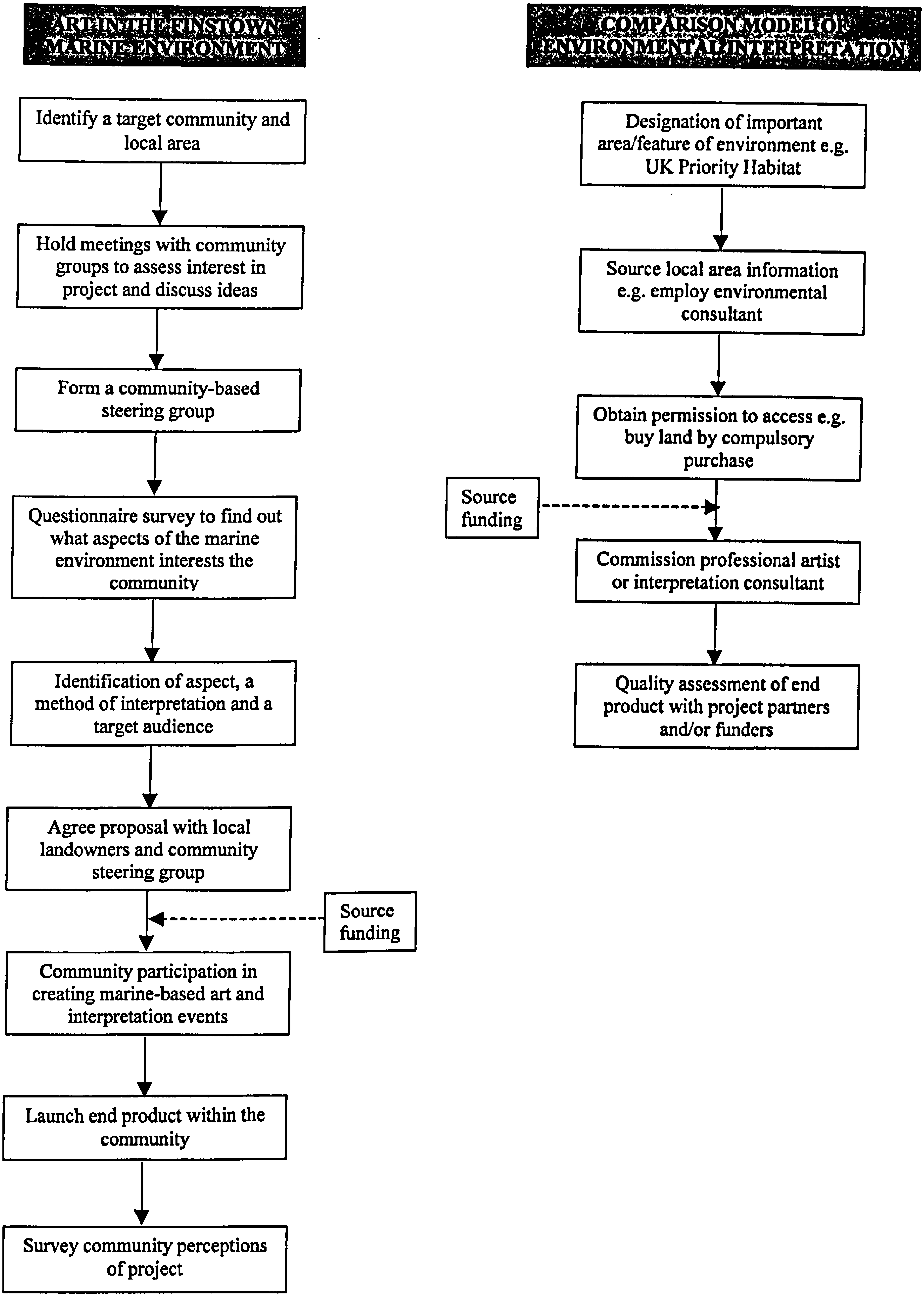


Figure 38. Comparison of environmental interpretation methods

Pertaining to Aeolianite, a natural concrete of shell and sand, the process which preceded erection of an interpretation board included: acquisition of land by compulsory purchase from the landowner; creating a boundary around the habitat and employment of an interpretation consultant. The community at Evie remains generally unaware of its existence or significance owing to a lack of consultation.

It is important to note the following. Whereas 'Art in the Finstown Marine Environment' was initiated and co-ordinated by an individual, the comparison model was co-ordinated by a co-operative of project partners, in the above example - SNH. The two methods, when compared, display very different selections of methods and outcomes. One can observe in the comparison model that:

- the need/opportunity for interpretation comes from an official designation of a locally important area/feature and most probably stems from a legislative process;
- the process is led by an expert team of environmental consultants/environmental agencies;
- it includes a 'top-down' process of sourcing environmental information and decision-making;
- the community remains unaware of the project proposal, location, methods and end product;
- interpretation arts and events are carried out by professionals, the community unable to participate; and
- the project partners and funders determine the quality of the end product.

Whereas, one can observe of 'Art in the Finstown Marine Environment' that:

- the project ideas/concepts come directly from the community, based on aspects of the marine environment they would like to find out more about;
- the process is community-led and community-driven;
- it includes a bottom-up process of generating information concerning the environment, interpretation method, target audience and decision-making;
- the community are fully aware of the project proposal, location, methods and end product;
- the community directly participate in production of interpretation arts and events; and
- the community determines the quality of the end product.

This comparison of features of the two very different processes begs the question, why is interpretation generally carried out in such a conventional sense? In answer, the redeemable factors of the comparison model include the following:

- it conserves time. Involving the community in an interpretative process, moreover working with local communities in general, notoriously takes time and compliance with timetables they determine;
- a conventional approach can be sub-contracted to save time and effort;
- fewer people are involved in overseeing the project and the general decision-making process. Not only is this more economical but more effectively avoids conflict of opinion;
- a guaranteed, standard and quality of interpretative material is ensured;
- a lack of consultation minimises community objections;
- compliance with a legislative process which outlines important habitats/species reflects a positive, admirable, agenda of promoting locally important areas/features; and
- following a tried and tested process means the end product is more likely to be satisfactory ('if it isn't broken don't fix it'!).

5.6.5 Suggested improvements to the method

In terms of what aspect of the project methodology could be improved, the following items are suggested. Such comments may be relevant to similar methodologies of future community arts interpretation of science in alternative scenarios.

Firstly, a bigger sample size of the community, asked for their level of interest in the local marine environment, would perhaps have been useful. In particular, a greater number of questionnaire respondents would have confirmed the most popular choices for the focus and features of marine interpretation events. Indeed, the Finstown Marine Questionnaire could perhaps have been sent to all Finstown residents (~300). However, this idea was rejected, the steering group, in the decision-making role, suggesting the questionnaire be sent to a selection of 'key' community groups (see section 5.2.3). These target audiences were deemed by the group as more likely to take an active, participatory, role in the project.

The sample of respondents to the Finstown Marine Questionnaire was also affected by a number of questionnaires not being returned by post.

Secondly, if a longer time period for completion of the project had been available, it would have feasible for schoolchildren to have participated in creating integral pieces of art, other than the seaweed map (see Figure 34) and stone seat (see Figure 35). Children from Firth School could have contributed to the content and design of the 3 interpretation boards located at the Ouse (see Figure 35) had it not been so urgent that they were completed and erected prior to the Ouse Walk launch day. Indeed, it would have been possible to create more public (marine-based) art e.g. sculpture at the Ouse, with children most heavily involved, had there been a greater time-scale for the project.

Thirdly, had the correct advice concerning the consents, necessary from local landowners at the Ouse, been obtained by the relevant members of the steering group, conflicts with one landowner, would not have been experienced post launch day. This would have avoided the efforts of many steering group representatives in resolving the conflict and would have left and the landowner in question with a more positive perspective of the project and what it achieved. If the process were to be repeated, more advice and support from more experienced professionals would be gathered before plans for construction and interpretation of the walk were finalised.

5.6.6 Links to a further case study

Co-operation of the community targeted by 'Art in the Finstown Marine Environment' was fostered with little complication. The target 'captive' audience was receptive, willing to participate in the project and retrieve the information presented through artistic means. It is suggested this be largely due to mutual agreement and trust among the majority of community members. Therefore, bottom-up, community-led co-operation was easily obtainable.

The challenge now faced by any further investigation is to target a community for marine interpretation, lacking in mutual agreement and trust amongst its members and between itself and the scientific community. Such a case study must attempt to foster co-operation among this more divergent group of environmental stakeholders, who will be potentially less receptive to and less willing to participate in the process. That is, to achieve a rationalised and co-ordinated interpretative tool for the marine environment, inclusion of a commonly unapproachable (by science) societal group should represent a greater challenge to the research.

Chapter 6. PROJECT FISHER

The second of the two major case studies (of four in total) of the thesis, Project Fisher investigated potential agenda setting and participation of a fishing community in a science-art interpretation project. As discussed in the conceptual framework (see section 3.4.1) the target audience was less willing to participate in the process of assimilating and disseminating marine scientific information and exhibited pre-existing conflict (skepticism) among of stakeholders and between stakeholders and the scientific community.

6.1 Introduction

The imposition of scientific advice by 'expert' scientists can never be a more appropriate solution to situations of environmental conflict than engendering co-operation. Within a spectrum of environmental stakeholder groups, the fishing community, for many reasons, represents one of the most challenging groups upon which to base a somewhat controversial study of improving communication of science. We observe two opposed contingents that debate the issue of rational management of fisheries: the fishing community and a community of fisheries scientists. Throughout history, these groups, for the most part, communicate in rhetoric, conducted at arms length.

Fisheries science can be characterised as an output-orientated, expert-driven, normative field of enquiry. Its application to decision-making is top-down and little effort has been directed to offering explanations of the science behind these decisions, most importantly to those whose livelihoods are most affected by them (Side, 2001) – the fishers (the gender-neutral term now preferred, even though almost all people in the fishing industry are still men). For the fishers, any relationship with fisheries science and the decision-making system it underpins could undoubtedly be characterised by alienation and avoidance. In general, one does not observe support for the work of fisheries scientists and managers by fishers, rather hostility.

Currently, one of the most insurmountable barriers to successful, coordinated and strategic fisheries management, throughout the UK and elsewhere, is the distinct lack of confidence fishers have in scientific provision of information and the leadership role science unequivocally takes. Such mistrust and unilateral prejudice against scientific dictatorship entails that a discourse between the two contingents is rarely obtainable.

Investigation and illumination of the underlying value conflicts within a community of fishers and fisheries scientists, provides the context for this case study. In attempt to catalyse rational co-operation of fishers, where mutual trust and agreement on objectives are lacking, visual narratives may represent an effective approach to communicate science and develop understanding.

6.2 History of the relationship between scientists and fishers

On a global scale, fisheries are suffering gross depletion of stocks, adverse impacts on the marine environment, declining profitability and social upheaval. The fundamental question is - why does fisheries management fail? The simplistic answer – too many boats are chasing too few fish (Grieve, 2001).

The Common Fisheries Policy (CFP) manages fish stocks of commercial importance within the UK and Europe. Internal systemic weaknesses and internal challenges have led to extensive plans to reform the CFP. Recent reviews of the CFP declare its weaknesses, or ignorances, as including: stocks outside safe biological limits; overcapacity of the fleet; high quotas leading to overfishing; and exclusion of stakeholders. The challenges it now faces include: enlargement of the European Union; an increased focus on environmental issues and economic development; and a growing interest of civil society in fishing matters. Its policies requiring radical reshaping include that of conservation, decision-making, monitoring and control, and economic and social dimension (Grieve, 2001).

Based on principles established in the 1970s and the Elizabethan ideal of 'open (access) sea' for fishing (Side, 2004), many believe the CFP is antiquated and flawed. It is now widely conjectured that no single fisheries policy can be appropriate for all conditions, all fishing grounds and all fishers. In terms of reforming the CFP, there are now plans to restructure it into a new Europe-wide policy based on regional management of fisheries. Such a policy would see the development of Regional Advisory Councils (RACs), a measure suggested by the recent review of the Common Fisheries Policy (COM, 2003) which divides EU waters into management regions. Stakeholders in the RAC will be more involved the future direction of management of the regional fishery. By way of example, an influential Scottish Parliament committee has praised the work of the North Sea Commission Fisheries Partnership (NSCFP), which brings together scientists and fishers from nine countries surrounding the North Sea. The partnership, a pilot scheme, believes that such arrangements are the only way forward for sustainable management and future viability of the fishery (Ledingham, 2004).

Another alternative to the CFP, more insular in nature, is the idea of exclusivity. A suitable example is observed in Iceland, which has exclusive control and use of fisheries resources surrounding the island to 200 nautical miles (Matthiasson, 2003). Iceland chose not to ratify the CFP and fishes exclusively owing to its heavy economic dependence on fishing (65% GDP). Although referred to by many as a 'model' fishery, the Icelandic stock is thought by some to be struggling of late and due to high levels of discarding, not quite the panacea that fisheries management once thought[42].

Although they may be consulted, fishers and their representatives are not directly involved in fisheries management policy or quota negotiations. Moreover, many fishers believe managers and scientists do not take into account their knowledge and experience. This lack of acknowledgement tends to undermine fisher's support for conservation policy and measures (FRS, 2003). Indeed, the lack of trust and fragmentation within fishers' own organisations and the lack of honesty they perceive in fishing leaders and fishing politics further exacerbate the problem. The lack of adequate representation of fisher's views and interests in the management process, underlines the notoriously hostile relationship between the fishing community and the community of scientists and policy makers.

[42]www.parliament.the-stationery-office.co.uk

6.3 The Orkney Creel Fishery

The archipelago of the Orkney Islands relies heavily on its marine environment in an economic, social and cultural sense. Still one of its major industries, fishing and fisheries management is a notoriously contentious issue in Orkney. Furthermore, development of some form of participatory framework comprising scientists, policy makers and the fishing community is a key topic on the Orkney marine conservation agenda. Within the fishing sector, there is a tendency for skepticism concerning current marine environmental data, for example, stock assessment and population data relating to fisheries, in particular, the creel fishery. The majority of creel fishers in Orkney want the fishery to be managed sensibly, with minimal involvement of fisheries managers.

The Orkney inshore fishery could be thought of as a local 'commons', or communal resource (Side, 2004). However, lack of agreement locally between fisher's organisations and managers, whose advice is underpinned by science, hampers co-operative dialogue on issues of sustainability. The prospect of a regulating order, which might permit local management of the creel industry, offered hope to many fishers. However, its limited development, coupled with recent proposals within a strategic review of inshore fisheries, to establish new management committees, has increased fears of many fishers that the future of the industry is out of the hands of those most heavily dependent on it. Indeed, that science still universally dictates the agenda of an industry disinclined to innovation.

6.4 The Science in Society Programme

The International Centre for Island Technology (ICIT), the Orkney campus of Heriot-Watt University, has for several years been conducting specialist research into the local creel fisheries. In particular, research continues into a process initiated by fishers to establish the regulating order, which would bring the creel fishery under local management. Staff at ICIT, have also been notably involved in broader studies of coastal zone management and resource development, showing the benefits of collaborative forums and systems of environmental value judgement analysis such as the AGORA philosophy (see section

6.6.3). In this way, commitment has been made to investigate a programme of scientific enquiry that emerges from such a participatory approach.

A recent funding initiative of the Environmental and Social Research Council (ESRC), targets projects which have the central philosophy of 'Science in Society'. Challenging the design of traditional scientific programmes into fisheries, a funded collaboration between ICIT and the ESRC, permitted investigation into the renegotiation of scientific enquiry and evaluation of core solutions for a fishery, based on discourse rather than imposed solutions (Side, 2001).

6.5 Fishers and scientists – a forum for discussion

There are increasing calls for more 'bottom-up' generated approaches for community based management of common property resources. Top-down, normative approaches of 'science' and the information they provide, seek still to characterise a 'problem' that fishers, more often than not, don't seem to think exists e.g. depletion of stocks to dangerous levels. This lack of response to the needs of the fishing sector often aggravates conflict among stakeholders and detracts from positive concourse.

While there are now several examples of fisheries scientists working with fishers on research projects, these often amount to little more than the engagement of fishers in sampling, most obviously in tagging experiments (Side, 2001). Some studies, like those undertaken by Fisheries Research Services (FRS), an agency of the Scottish Executive, have taken some first steps to incorporate fisher's knowledge into research programmes. For example, FRS have met with fishing industry representatives to obtain comments and feedback on the preliminary results of stock assessments (FRS, 2004). However, real participation, in a leadership role has yet to be established. If rational co-operation is based on trust, scientists involved in any new initiatives must accept a purely catalytic role, bringing fishers together in a process of informed dialogue.

6.5.1 Examples of a similar philosophy

The review committee of the Common Fisheries Policy has discussed the need for ways to improve the provision of scientific and technical advice for management purposes, especially regarding measures to improve the relationship between scientists and fishermen. It is clear that new and innovative approaches to fisheries development are needed especially in the field of education (Msiska and Hersoug, 1997).

A prominent figure in this recent shift in direction is Pew Fellow Richard Allen. Allen watched lobster fishermen and scientists 'butt heads' over regulations for years. Seeing this battle as counterproductive and unnecessary, Allen proposes that something could be done to make lobster fisheries better for fishers, conserve lobsters and satisfy the scientists (Ely, 2003).

One of Allen's latest strategies for getting a conservation message across involves putting two computer models for the American lobster fishery into the hands of fishermen. One is a bio-economic model called 'SIMLOB' and the other is the official National Fisheries Service model used in evaluating and setting regulations for the lobster industry. Once fishermen understand simulation models, Allen hopes users will be able to model a whole regional fishery, demonstrating outputs such as the number of boats in the fishery, the number of traps per boat and a host of other variables (Ely, 2003).

However, achieving Allen's ideals is limited by disagreements over definitions. For example, the model is based on a definition of overfishing that fishermen do not understand and don't agree with. It is defined as follows: 'The American lobster resource is overfished when it is harvested at a rate that results in egg production from the resource, on an egg-per-recruit basis, that is less than 10 percent of the level produced by the unfished population'. Such a mouthful, Allen suggests, implies, 'the average female should be allowed to live long enough to produce 10 percent of the eggs she would if she lived out her natural life. Using the official definition, a national regulating body declared the American lobster to be overfished in the mid 1990s. However, lobster fishermen, observing their catch rise from 30 to 80 million pounds over the past two decades, remained unconvinced. Such apparent contradication between what the model suggests and what they see for themselves, heightened fishermen's skepticism towards the scientists' definition and the model. Allen, on the contrary, presumed fishermen to be lulled into a false sense of security by this high recruitment (Ely, 2003). Allen cited two problems on this issue. Firstly inaccessibility, in other words, the model remained mysterious to fishermen and secondly, too narrow use of the model. Allen suggested that if fishermen could be persuaded to think in terms of yield, they could improve and achieve scientific recommendations, at the same time improving catch and profits (Ely, 2003).

Essentially, Allen's work attempts to give scientific models a 'friendly face'. In fact, in January 2002, he was able to unveil a fishermen-friendly version of the model, known as 'LobSense', incorporating a familiar-looking computer screen and simple menu options. Demonstrating this version to as many fishers as reasonably possible, Allen believes they are able understand the options and choices better. However, he states that the idea of less fishing producing higher catches and more profits is counterintuitive to most fishermen and even those who are convinced in theory, may balk at the practical measures needed to bring about this reduction in effort (Ely, 2003). Allen accepts that such issues come with a high emotional quotient and that people are not going to alter their beliefs purely because someone has shown the logic of a different perspective. He merely attempts to move the lobster conservation debate out of the realm of mythology and into the realm of science (Ely, 2003).

According to Rolbein (2003), a team of scientists at the University of Maine's Darling Marine Center is carrying out work in a similar vein. Attempting to break down the barriers between scientists and people who fish for a living, they hope to make fisheries management smarter and fairer in the process. Led by Robert Steneck, a University Professor, their work calls into question some of the basic science that drives public policy about lobsters, Maine's most important catch (Rolbein, 2003). According to Steneck, a grassroots framework for forging alliances between scientists and fishermen already exists in Maine, with fishermen starting the rule making at local level. However, he continues, "throughout the industry, suspicion of 'armchair' science, of academics and policy 'wonks' who use statistics and analytical modeling to define fishing policies, has been very deep. Just as deep has been the scientific community's distrust of many fishermen, who are seen as short-term thinkers, willing to wipe out stocks and destroy the future for one good trip or one mortgage payment" (Rolbein, 2003).

It took a potentially big crash in the lobster fishery for Steneck to secure some credibility with the fishing industry. Despite dramatic new fishing regulations being enforced to safeguard the fishery, fishers' reports were quite contrary to fears of a collapse. 'Lots of juveniles' were reported, however, such accounts were dismissed by scientists as 'anecdotal' and 'self-serving'. Steneck decided to take a hands-on approach, getting in the water himself to investigate the real status of the lobster population. Such tactics proved the fishermen to be right, having discovered high numbers of juveniles. The conclusion was that there were many females, offshore in deep water, adding eggs to repopulate inshore. This prediction of big harvests, not dire collapse, saw Maine record one of its largest harvest in recent years (Rolbein, 2003). Only through the common sense, ecological approach of Steneck, and the stance taken to uphold the beliefs of fishermen, did he win their understanding and concentration. Designed essentially to gather scientific information, his work also attempts to create contact and communication, to help those in the fishing sector, stop seeing scientists as 'the professor' and to break down a science stereotype that sees fishermen merely as 'cowboys', interested in only short-term goals (Rolbein, 2003).

A similar research ethic, integrating the knowledge and experience of local fishermen, exists within the series of voluntary and compulsory 'no take zones' (NTZs) which exist around the north and south coast of Cornwall. In 1997, the lobster fishermen of St. Agnes, Cornwall, agreed to set aside 24 hectares of their regular coastal fishing grounds to a voluntary NTZ. Further, in 2003, the designation of the first statutory no take zone, specifically for conservation purposes, took place for Lundy, a small island off the north Cornwall coast. These sites, plus extra research carried out at Lyme Bay, Devon, have acted as a catalyst for a five-year project to monitor the effectiveness of such an approach in improving the health of UK inshore waters. The projects aim to improve the long-term sustainability of a local fishery in rapid decline (Hoskin, 2003).

With the help of local fishermen, research such as experimental lobster 'potting' to compare 'Catch Per Unit Effort' between the NTZ and neighbouring fishing grounds, is proving highly successful. Furthermore, at Lyme Bay, fishermen have voluntarily agreed to self-police a 'no scallop' dredging policy for crucial seabed areas, previously damaged by such dredging activities. Ongoing discussion with fishermen is working towards a management plan that aims to enhance scallop potential of the area and add market value to the product supporting the industry. The projects aim to show that fishermen and conservationists can work together, to produce meaningful changes to fishing practices that will benefit the natural environment (Stanford, 2003).

For the past two years FRS have met with fishing industry representatives and working with Aberdeen University, have interviewed skippers of demersal fishing vessels operating in North East Scotland. The aim of the process was to obtain fishers' views on fisheries management and to investigate their level of knowledge of fish biology and state of the stocks. The interviews were designed to engage fishers in conversation and provide an opportunity for them to talk about their experiences[43].

The NSCFP, piloting a RAC for the North Sea (see also section 6.2), is potentially allowing for fishers to become much more involved in giving advice on management of fisheries. This involvement is more likely to pertain to scientists consulting fishers at an early stage of fisheries stock assessment, bringing these fishers closer to the workings of 'expert' management groups[44].

6.6 Elaboration of a method

The initiatives discussed in the previous section describe the foundations of research that have taken place in recent years, to make fisheries science more inclusive with regard to fishers. However, the majority of the examples relate more centrally to issues of management and stock assessment, with fishers only participating in the discussion at certain, finite stages of investigation. More commonly, it is representatives of fishers' associations and organisations only that represent the wholesale 'fishers' view'.

[43] http://www.marlab.ac.uk
[44] http://www.northsea.org

This new venture, undertaken by ICIT between April 2002 and April 2004, is the first example of a study that seeks an inclusive participatory approach commencing at the agenda setting stage. The central themes included a forum for discussion, determination of research priorities for future investigation by science, the collection of data and the development of a means of communication of the results. All of these procedures were ultimately under the control of the fishers themselves, to ensure positive contributions to discourse. In this way, the process calls for future direct and proactive co-operation among fishers, scientists and decision-making authorities.

6.6.1 Relevance to this research

Considering the revolutionary nature of the venture, promoting new dialogue between scientists and fishers, the opportunity arises to trial alternatives to the way fisheries science is commonly presented/communicated (or not as the case may be) to the target audience – the fishers. Developing a visual narrative for aspects of fisheries science, which emerge from the dialogue, represents the focus for this research. The process seeks to foster fisher's own priorities for future research into the creel fishery. Therefore, presenting evidence of the process and the resulting information back to fishers in a consensible, accessible format represents the essential contribution the visual arts can make to this venture.

Although the following sections of this chapter refer to the general methodologies employed by the ICIT 'Science in Society' project, the key focus for this case study of the thesis, is the communication of (fisheries-based) scientific information, through visual narratives, to a target audience of creel fishers who participate in the dialogue.

6.6.2 Aim and objectives

The aims and objectives of the 'Science in Society' project were as follows:

1. Development of a participatory forum with structural representation from stakeholders with interests in the design and execution of a programme of scientific enquiry into the Orkney creel fishery.

2. Exploration of value expressions, or research priorities, applied as criteria for an alternative programme of research, and the relative importance of these to the fishers and all other stakeholders groups concerned.
3. Use of the AGORA approach (see methods, section 6.6.3), to explore core solutions and solidarity/trade-offs between stakeholder groups with regard to research priorities.
4. Examination of the determination of priorities via discourse within the participatory forum, with regard to future research, participation in this research by stakeholders and communication of the results.

6.6.3 Methods

A working group

ICIT secured funding for the 'Science in Society' project in December 2001. Discussions into the elaboration of a project methodology commenced at ICIT in September 2002. Discussions took place within a working group comprised of two members of ICIT staff (Professor Jonathan Side and Dr Mark Baine), two PhD students (Kate Johnson and Joanna Henley) and Climis Davos, Professor of Environmental Evaluation from the University of California, Los Angeles. An initial meeting of this group was held to discuss possible project directions, development of a fisher's forum, outcomes and timetables. The project was given the title 'Project Fisher' (used from here onwards) and the following project methodology was elaborated by the working group:

- Identification of appropriate stakeholders from both the Orkney creel fishing sector and other stakeholder groups of the Orkney marine environment (i.e. those with an interest in a programme of scientific enquiry into the fishery).
- The establishment of a fully inclusive forum. This forum would set the agenda and provide the principal focus for value discourse. With previous research into the fishery as a starting point for discussion, the focus of discourse would include personal perceptions of the fishery, a shared understanding of obstacles and types of information valued by fishers.

- The development of alternatives, resulting in a 'shopping list' of potential research priorities. Explicit to each of these must be the aims and clear explanation of the question each project seeks to answer, the methods and means of investigation and the ease of assimilation of results.
- The use of AGORA* (Assessment of Group Option with Reasonable Accord) as a means of analysis of priorities. AGORA would be used to determine: a) core solutions for a programme of scientific enquiry; b) coalitional analysis using cluster analysis to group those stakeholders (within the fishing community and other environmental stakeholder groups) with statistically similar value preferences; c) examination of solidarity among members of each stakeholder group for the support of the alternatives and d) trade-offs between stakeholder groups.
- Agreement on preferences for a series of future projects could comprise further scientific investigation into the fishery, requiring the pursuit of further funding for such a participatory programme.
- Consideration of a means of communication of the data set, amongst other fisheries science methods and analyses and the extent to which core solutions depend on shared understandings and knowledge of these. This would therefore involve exploration of how this information can be presented in an accessible way that makes it easily assimilated.

* The AGORA philosophy and methodology, named after the traditional market place of Ancient Greece where both goods and ideas were exchanged, was developed by Professor Climis Davos (1986). AGORA employs methods of questioning and analysis that are intended to be self-normalising, without distorting the values of the respondents. It has been used in the past, both in the US and EU, to illuminate the specific conflicts between stakeholders and the application of science in decision-making contexts.

6.7 <u>Programme of research</u>

6.7.1 The forum - talking to fishers

At the forefront of the Project Fisher rationale proposed by the working group was the inclusion of the entire creel fishing sector, with no creel fisher excluded from participation in the discussion forum. In the hope that a broad interest would be forthcoming from the various fishermen's groups already existing in each major fishing area in Orkney and from merchants who have represented fishing interests, the project was promoted through local media, Radio Orkney and *The Orcadian*, in November 2002. These advertisements invited fishers from throughout the creel-fishing sector to attend an initial meeting to canvas the interest in a future programme of research. At the same time, detailed discussion of an agenda for this meeting took place within the working group. Items for discussion included what items and opinions were most significant to document during the inaugural meeting, what contentious issues might arise and protection/control of the results.

The inaugural meeting

The inaugural meeting with fishers was held at ICIT on 23rd January 2003, with a total of 12 fishers or fishers' representatives in attendance. For additional information regarding attendance and minutes of this meeting see Appendix 5. The meeting defined Project Fisher's objective 'to get across a shared understanding of the problem', outlined to fishers what research into the creel fishery had been carried out previously by ICIT and what needed to be done by the ESRC Science in Society programme. The venture was described to fishers as 'an opportunity for fishermen to determine the priorities of a research programme into the local fishery'. Furthermore it was stressed that the project was NOT an attempt to impose any preconceived ideas whatsoever on what such a research programme should look like. Similarly, that it was not attempt to impose any management system, resurrect any ideas of using a Regulatory Order, or introduce some other scheme of this kind.

The timetable for the project was outlined as follows.

First stage:

- establish a forum of fishers willing to participate in discussions;
- establish a shared understanding of what questions/problems/issues could usefully be further researched;
- establish a "shopping list" of priorities for future research.

Second stage:

- development of a simple questionnaire designed to capture priorities from each respondent, able to reach a much wider group of fishers than those able or willing to attend meetings (every fishermen getting the chance to assign priorities to the shopping list);
- presentation of the results to the forum of fishers for further discussions;
- circulate a similar questionnaire to other parties (non-fishermen) that may have an interest in fisheries research topics (e.g. fisheries scientists, bodies that fund fisheries research etc.) and may seek to influence such research;
- presentation of the results to the forum of fishers for further discussions*.

*It was this second stage of Project Fisher that was most crucial to this case study. Accordingly, development of suitable vehicles to present the preferences of fishers, using artistic instruments, will be the primary focus of the proceeding sections.

The inaugural meeting of Project Fisher was successful, in that it satisfied its objective of producing of an initial 'shopping list' of priorities for future research outlined by fishers (see Appendix 6), many in attendance and taking an active role the discussion. However certain contentious issues were brought forward by participants and included:

- questions of ICIT's motivation for such an approach in Orkney;
- concerns over a lack of control of the research by fishers;
- concerns that findings could be damaging in the 'wrong hands';
- concerns over previous failures of scientists and government to manage the whitefish industry; and
- knowledge of scientists' and managers in the past not listening to fishers

The representatives from the working group, who reiterated that the programme research and its findings were to be placed fully in the fishers' control (see minutes Appendix 5), mediated these comments.

Further meetings with fishers

A second meeting with fishers was held on 6th March 2003. The purpose of this meeting was to add any remaining priorities for research to the shopping list (Appendix 6) that resulted from the inaugural meeting. In addition, it aimed to canvas agreement/disagreement with this list of priorities amongst the fishers. Unfortunately, due to extremely limited attendance, the meeting progressed discussion with the project group no further. It was suggested that issues of timing, location and tidal height on the scheduled day for the meeting were responsible for the poor attendance.

Despite this lack of confidence in the degree of fishers' willingness to participate in Project Fisher, a series of meetings were arranged with creel fishers from the outer Orkney Islands, during the period 13th March – May 2003. The islands of Hoy, North Ronaldsay, Stronsay, Sanday and Westray were canvassed by a representative of the working group to inform them of the details of the previous meetings held at ICIT, on the mainland. Agreement/disagreement with the initial shopping list was delineated and any additional priorities offered were added to the list. Priorities were divided into four groups, under the following research headings: Lobsters and Related Research; Crabs and Other Shellfish; Economic Development and profitability, and Environmental Factors.

6.7.2 Questionnaire surveys

i) Questionnaire for fishers

The next challenge for the working group was to develop a simple questionnaire, to be distributed to as many creel fishermen as possible, and to record how individuals would prioritise the research areas identified at the above meetings. There was an additional need to gauge relevant background opinion on certain issues.

A questionnaire was developed, divided into 3 parts. Part A sought general background information, Part B sought fishers' prioritisation of research areas and Part C sought fishers' views on the conduct of any research that might be undertaken in the future.

Aspects of the questionnaire were further discussed at a third meeting with fishers held on 10th April 2003 and a pilot questionnaire was distributed and amended. The final draft (see Appendix 7) was then sent to all registered creel fishers (those with licensed vessels) in Orkney.

ii) Questionnaire for other stakeholders

Creel fishers that took part in the process recognised that they do not work in isolation, but in a community of other users of the marine environment and public interest groups. They were asked, as part of the questionnaire for fishers, "how much should the interests of the following groups be taken into consideration in defining the research agenda of fisheries science?" Fishermen listed the eighteen organisations listed below as having a possible interest in the research. Each were sent a separate questionnaire (see Appendix 8) that sought to define the nature and extent of the organisation's interest in the research and their views concerning the issues fishers were asked to prioritise. The individual organisations were as follows:

Orkney Islands Council
Orkney Enterprise
Scottish Natural Heritage
Scottish Environmental Protection Agency
Royal Society for the Protection of Birds
Orkney Dive Boat Operators' Association
Environmental Concern Orkney
Orkney Fish Farmers' Association
Orkney Marine Coastal Studies Forum
Orkney Field Club
Orkney Trout Fisherman's Association

Harbours Authority

Orkney Ferries

HM Coastguard

Northlink Ferries

Sea Fish

Scottish Executive, Inshore Fisheries Branch

Marine Laboratory, Aberdeen

Scottish Fisheries Protection Agency

Fishermen's Associations

The stakeholder questionnaire was developed in 3 parts. Part A sought to ascertain a) the relevance of fisheries research to the work of the organisation in question, b) how much the organisation believed fishermen's associations, fisheries scientists and other stakeholder organisations should influence this research and c) the relevance of other organisations such as their own to future research. Part B was designed to determine the level of agreement/disagreement of the organisation with the research priorities outlined by the various clusters/groups of fishers who scored their priorities in a similar way. Finally, Part C sought to compare the organisations level of trust and/or confidence in science and fisheries science, within the categories of i) facts and data, ii) motivation of scientists/fisheries scientists and iii) models and predictions.

6.7.3 Communicating results to fishers (Stage 1)

The first stage of communicating results to fishers involved a series of graphical representations based on, where necessary, statistical (including AGORA) analysis. A set of figures was produced to communicate results of both the fisher and stakeholder questionnaire. Bearing in mind all results were designed to be presented to fishers, where appropriate, graphs and figures were adapted from traditional formats into more accessible (visua) ones. For example, data was presented in pictoral form, using colour, if and where possible.

i) Results of the questionnaire for fishers

A high number of responses were received from over 50% of Orkney creel fishers and the results of a total of 50 useable, compliant (giving answers related to the question) responses could then be correlated. However, such a positive response was largely due to extensive telephone canvassing and personal contact, encouraging fishers to complete the questionnaire. A meeting of the working group was subsequently held to discuss the results and a possible means of their analysis and presentation. Further, during the period 1st-4th September, a visit of Prof. Davos, made possible an extensive experiment into forms of statistical analysis to be carried out on the questionnaire results. Possible analysis options included tree diagrams, box and whisker plots and cluster analysis. Discussions of the working group arrived at conclusions on a) those sections of the questionnaire, which required crucial analysis and b) the forms of analysis to produce.

Graphic representation and analysis of the questionnaire for fishers was carried out as follows.

Part A:

- Map to show fishers returning questionnaires and Orkney registered fishing vessels by port/region;

Part B:

- Cluster analysis to show separate and group respondents who scored their priorities for future research in a similar way, under each of the four research headings;

Part C:

- Line graphs to show respondent levels of trust and confidence in a) science in general and b) fisheries science, within the categories i) facts and data, ii) motivation of scientists/fisheries scientists and iii) models and predictions;
- Tree diagram to show those respondent answers to the questions "Do you want research into the local fishery to be undertaken in the future?' and 'If so, are you willing to participate in this research?"
- Bar chart to show respondents views on the relevance to the research of other users of/stakeholders in the marine environment.

ii) Results of the questionnaire for stakeholders

Stakeholder questionnaires were sent in late September 2003 and 12 compliant were received in total, again, largely a consequence of extensive canvassing. The results from the stakeholder questionnaire were designed to form a useful comparison with the views assimilated by the fisher questionnaire. For this reason, certain similar forms of graphical representation and analysis were performed on the stakeholder data as follows:

Part A:

- Bar charts to show a) the relevance of fisheries research to the work of the organisation in question, b) how much the organisation believed fishermen's associations, fisheries scientists and other stakeholder organisations should influence this research and c) the relevance of other organisations such as their own to future research.

Part B:

Due to a small sample size of respondents and difficulties stakeholders encountered in understanding figures presented in the questionnaire, no cluster analysis was performed on Part B of the questionnaire. Qualitative results only were produced.

Part C:

- Line graphs to show respondents level trust and confidence a) science in general and b) fisheries science, within the categories i) facts and data, ii) motivation of scientists and fisheries scientists and iii) models and predictions.

6.7.4 Results

i) Questionnaire for fishers

Part A

Out of a total of 160 dispatched questionnaires, 55 were returned. The origination of a total of 50 fishermen returning useable questionnaires and Orkney registered fishing vessels by port/region is displayed in Figure 39. The majority of responses were received from fishers located in the regions of Kirkwall (and South) and Stromness (and area), in other words, the

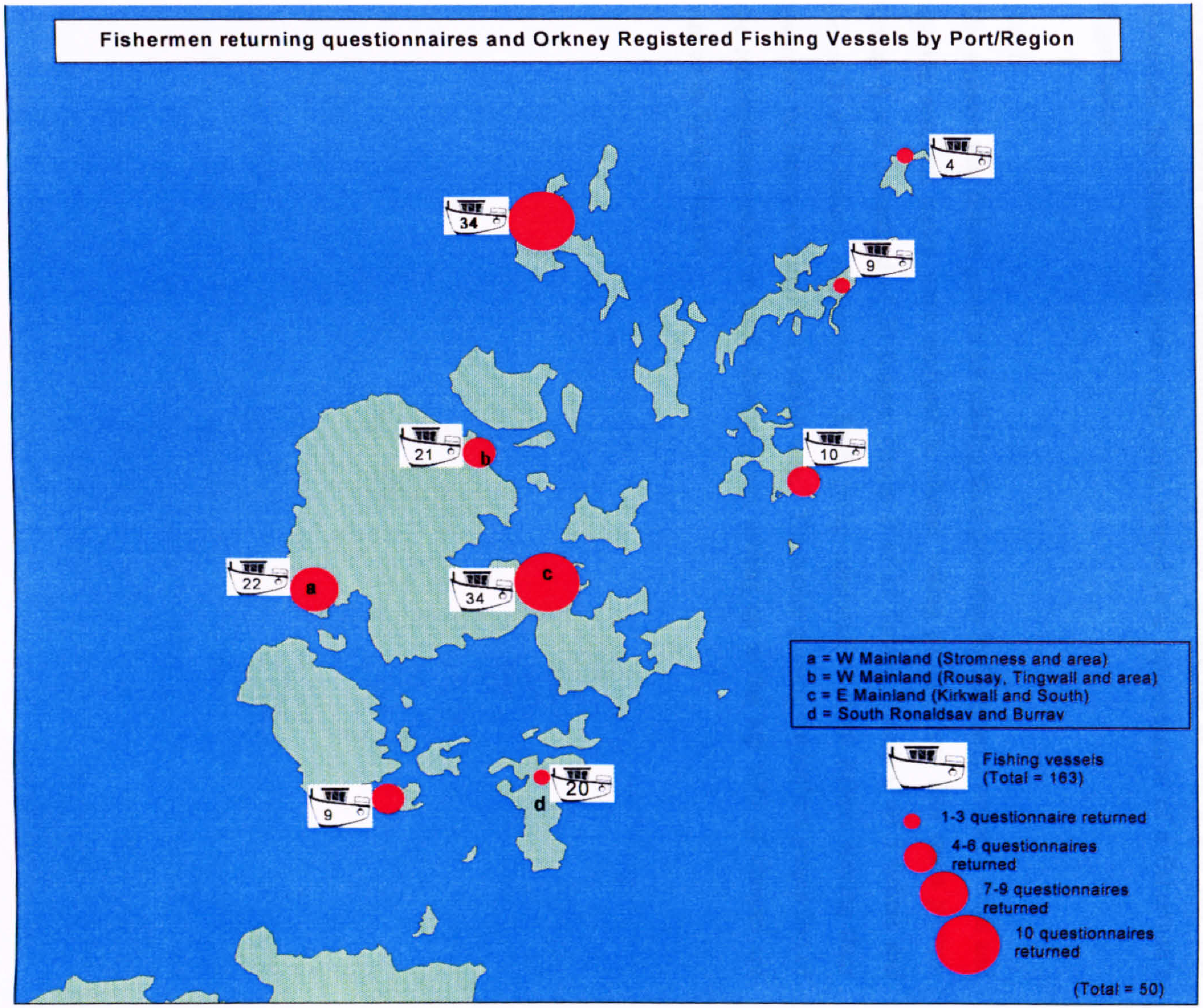


Figure 39. Map of Orkney creel fishers by port/region

two main population centres in Orkney. A high number of responses were also received from the outer island of Westray. Orkney registered fishing vessels were observed to be mainly concentrated in these regions as well as the Southern island of South Ronaldsay. 37 of the 50 fishers returning questionnaires described themselves as active and full-time fishermen, the others being either part time, retired or a representative of a fisherman's organisation.

Part B

The answers that fishers gave in identifying their priorities to the general research areas and specific research topics were analysed to cluster voting patterns into four main groups. Group A was comprised of 20 fishers, Group B of 21 fishers, Group C of 5 fishers and Group D of 4 fishers, respectively. Each group consisted of those fishers scoring their priorities for future research in a similar way. The topics gaining the highest proportion of the consolidated voting in each cluster group, adding up to the top 50% of choices are ranked in Table 8 below.

Table 8. Table of figures – fisher research priorities

Class	Research Topic	R	%	R	%	R	%	R	%
Lobster (Econ)	Conservation / replenishment schemes including V-notching compensation schemes.	2	7.2	2 =	6.7	1	27.2	2	14.5
Lobster	Reproductive cycles in Orkney.	4	6.1	9	3.8	4	6.0	-	-
Lobster	V-notching – independent collation of data.	5	5.6	7	5.0	3	8.0	-	-
Lobster	An examination of fisheries models and their flaws.	7	4.0	-	-	-	-	-	-
Crab	Brown crab distribution, movements and migration. Seasonal and spatial variations in population.	1	7.3	6	5.1	2	8.7	-	-
Crab	Velvet swimming crab growth patterns.	3	6.6	2 =	6.7	-	-	-	-
Crab	Brown crab male only fishery feasibility.	6	4.8	-	-	-	-	-	-
Econ	Better handling of shellfish to reduce mortality from sea en route to final markets.	8	3.9	1	6.8	-	-	-	-
Econ	Maximising market price for catch.	9	3.7	2 =	6.7	-	-	1	29.3
Econ	Examine management of fisheries with the objective to reduce bureaucracy.	-	-	-	-	-	-	3	14.0
Env	Investigating seal populations in Orkney and solutions to impacts on fisheries (culling?).	-	-	5	5.8	-	-	-	-
Env	Effects of salmon farming on the local creel fishery.	-	-	8	4.8	-	-	-	-
Preference Cluster >>>>>>		A		B		C		D	

Where:
R = Rank preferred within each cluster.
% = Preference score relating to this topic within this cluster.
Econ = Economic Development and Profitability
Env = Environmental Factors

The following conclusions can be drawn from the table of figures above. More priority was given to the research category 'Lobsters and Related Research' than the three other categories 'Crabs and Other Shellfish', 'Economic Development and Profitability' and 'Environmental Factors'. The most preferred topic in the preferred category was V-notching and compensation schemes, being outlined as a priority for all 4 clusters, in the top 25% of scores for cluster A, B and C.

The research categories with the next highest level of priority were jointly 'Crabs and Other Shellfish', and 'Economic Development and Profitability'. The most popular choices of topic under this heading being 'Velvet Swimming Crab Fishery' (a priority for clusters A and B and 'Maximising Market Price for Catch' (for clusters B and D) respectively, in the top 25% of scores for each group.

'Environmental Factors' was of least priority to the 4 clusters. Only cluster B outlined the specific topics 'Seal Culling' and 'Effects of Salmon Farming' as a priority, in the top 50% of scores for this cluster.

Much agreement on priorities can be observed between clusters A and B, who exhibited a very similar scoring pattern. Similar choices to A and B were also made by cluster C, however, distinctly fewer choices of topic were made. However, cluster D showed the most disparity in its scoring pattern and little agreement with any other cluster. D was the only cluster to favour the research category 'Economic Development and Profitability'.

Part C

The level of trust/confidence fishers specified they had in science in general, fisheries science and the differences between these views are displayed in Figures 40-42.

Figures 40 and 41 show fishers' views of both science in general and fisheries science are concentrated around a neutral perspective. However, there are more negatively skewed views relating to fisheries science compared with science in general. Moreover, Figure 42 shows a more negative regard for scientific models and predictions, as opposed to facts and data and the motivation of scientists.

Figure 43 represents a pictorial logic tree to exhibit fishers' answers to the questions 'Do you want research into the local fishery to be undertaken in the future?' and 'If so, are you willing to participate in this research?' Of 52 fisher questionnaires useable for this comparison, 47 agreed they wanted future research to go ahead and of these, 41 were willing to participate. Of the 5 who said they did not want research to go ahead, 1 respondent was still willing to participate in the event it did.

Figure 44 displays other users of the Orkney marine environment and their relevance to the fishery, in the opinion of the fishers. Of most relevance to research into the local fishery

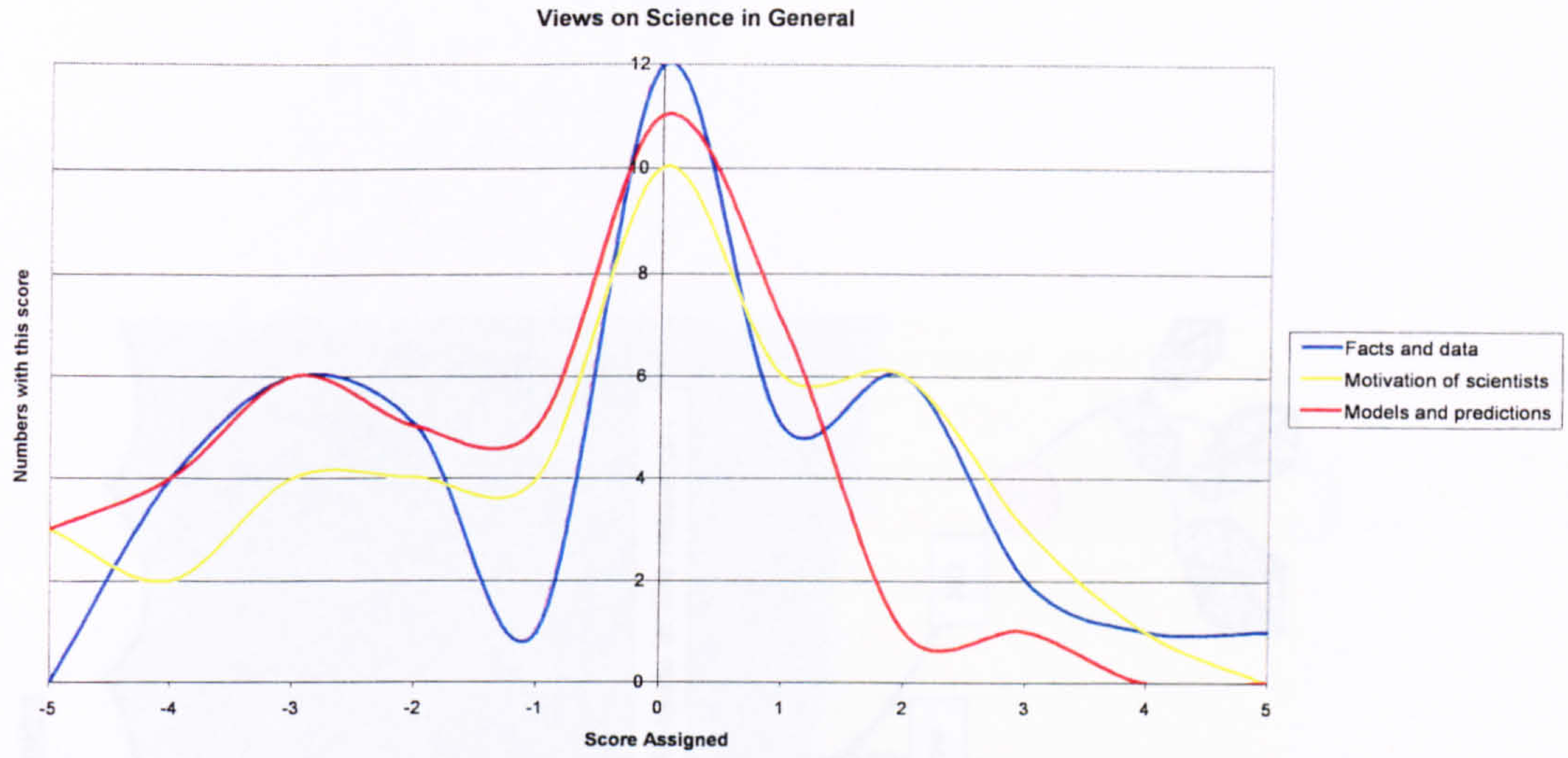


Figure 40. Fisher's views on science

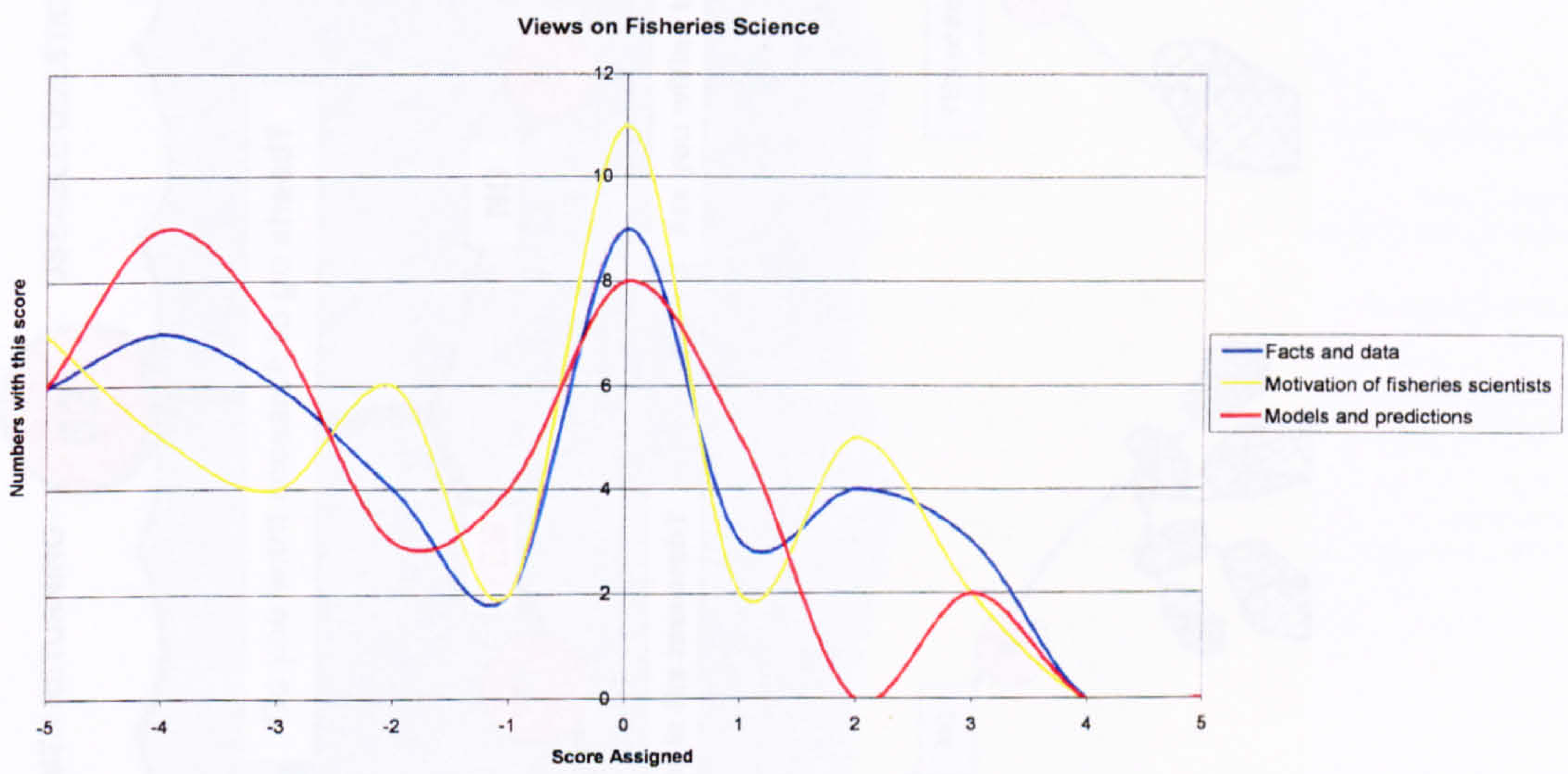


Figure 41. Fisher's views on fisheries science

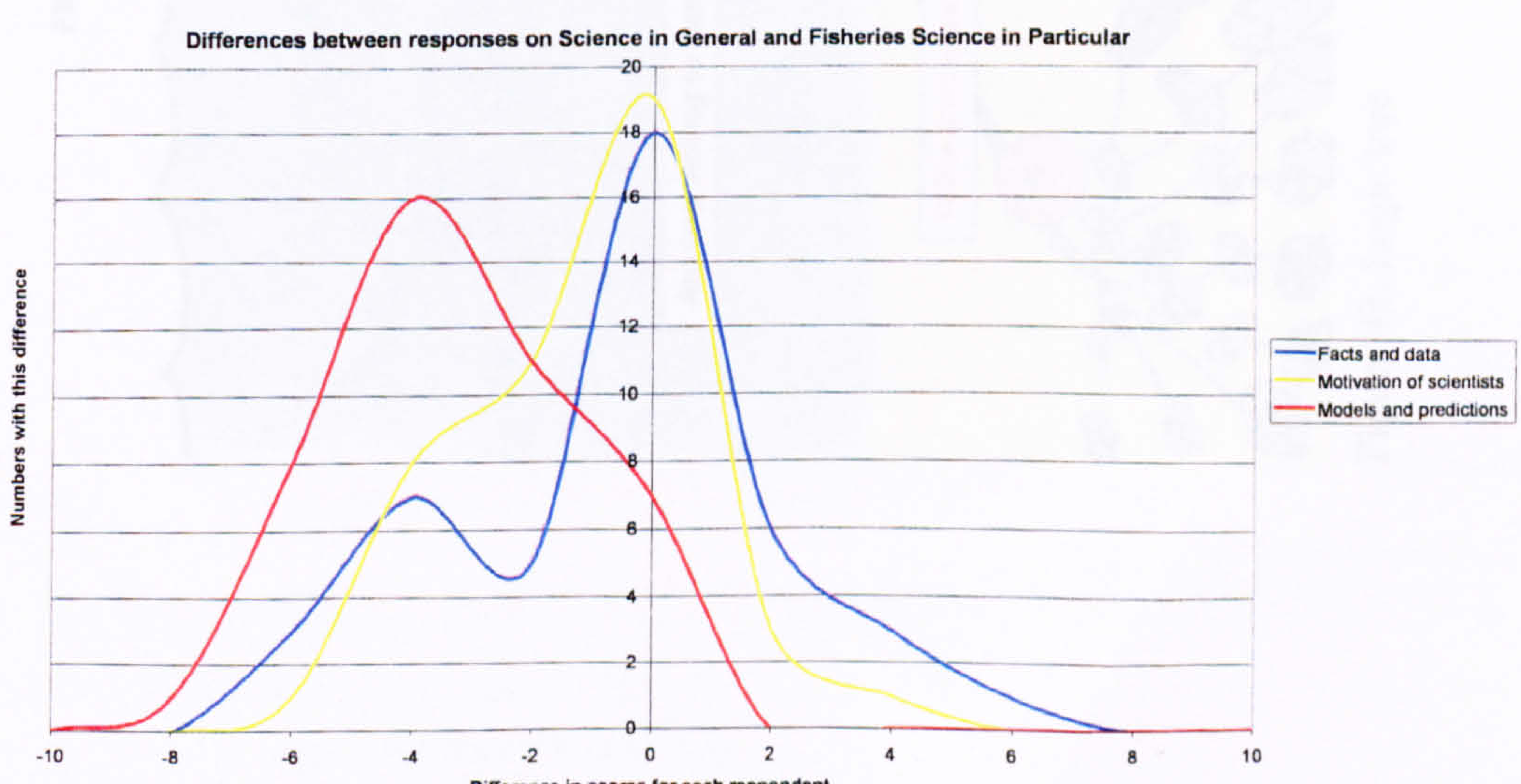


Figure 42. Differences between fisher's views on science and fisheries science

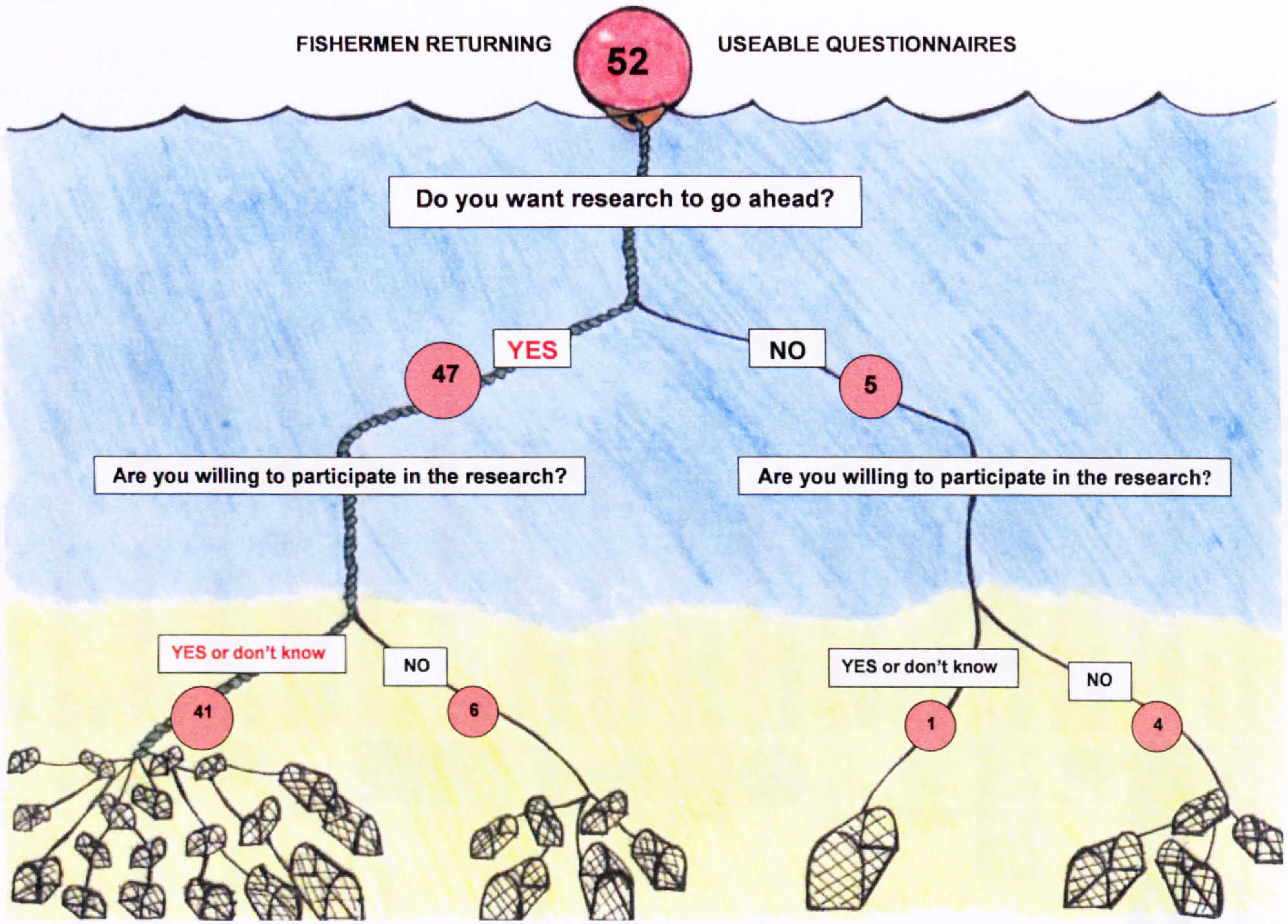


Figure 43. Logic tree

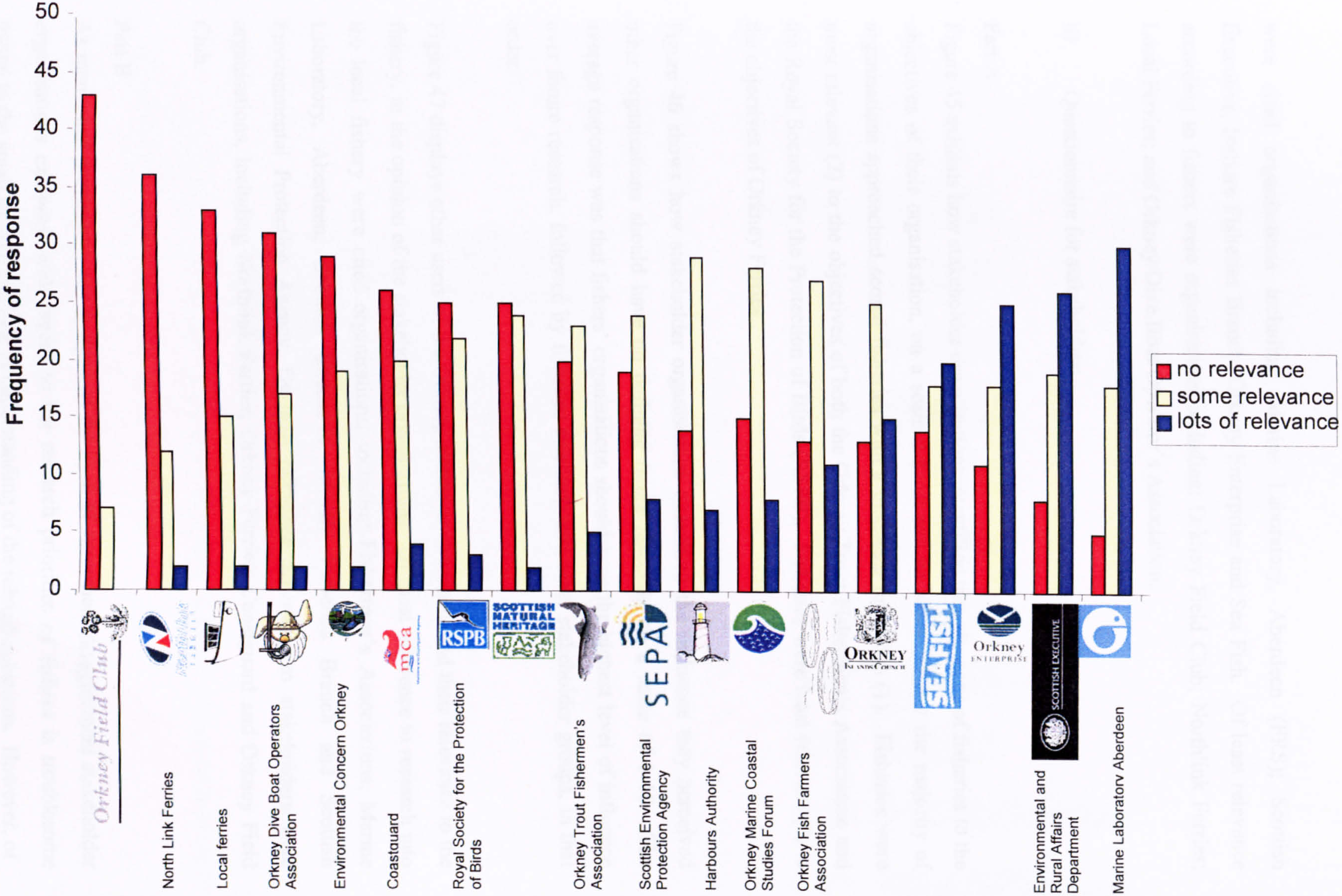


Figure 44. Relevance of other stakeholders to future research – the fishers' view

were cited organisations including: Marine Laboratory, Aberdeen (FRS); Scottish Executive, Inshore Fisheries Branch; Orkney Enterprise and Sea Fish. Of least relevance according to fishers were organisations including: Orkney Field Club; Northlink Ferries; Local Ferries; and Orkney Dive Boat Operator's Association.

ii) Questionnaire for stakeholders

Part A

Figure 45 exhibits how stakeholder organisations quantified the relevance of fisheries to the objectives of their organisation, on a scale 0-2. It can be observed that the majority of organisations approached scored fisheries with a moderate relevance (1). Fisheries were most relevant (2) to the objectives of both the Orkney Trout Fishermen's Association and the Royal Society for the Protection of Birds (RSPB). Fisheries were least relevant (0) to the objectives of Orkney Ferries.

Figure 46 shows how stakeholder organisations quantified the influence they perceived other organisations should have on defining future research, on a scale of 1-10. The average response was that fishers' organisations should have the highest level of influence over future research, followed by fisheries scientists and other stakeholder groups, in that order.

Figure 47 displays other users of the Orkney marine environment and their relevance to the fishery, in the opinion of the stakeholder organisations. Of most relevance to research into the local fishery were cited organisations, including Fishermen's Associations; Marine Laboratory, Aberdeen; Scottish Executive, Inshore Fisheries Branch and Scottish Environmental Protection Agency. Of least relevance according to stakeholders were organisations, including Northlink Ferries; Orkney Ferries; Coastguard and Orkney Field Club.

Part B

As mentioned previously, any analysis of the level of agreement/disagreement stakeholder organisations exhibited with regard to the research priorities of fishers is troublesome owing to the small sample and lack of understanding of the related questions. However, of

Figure 45. Relevance of fisheries research to stakeholder organisations

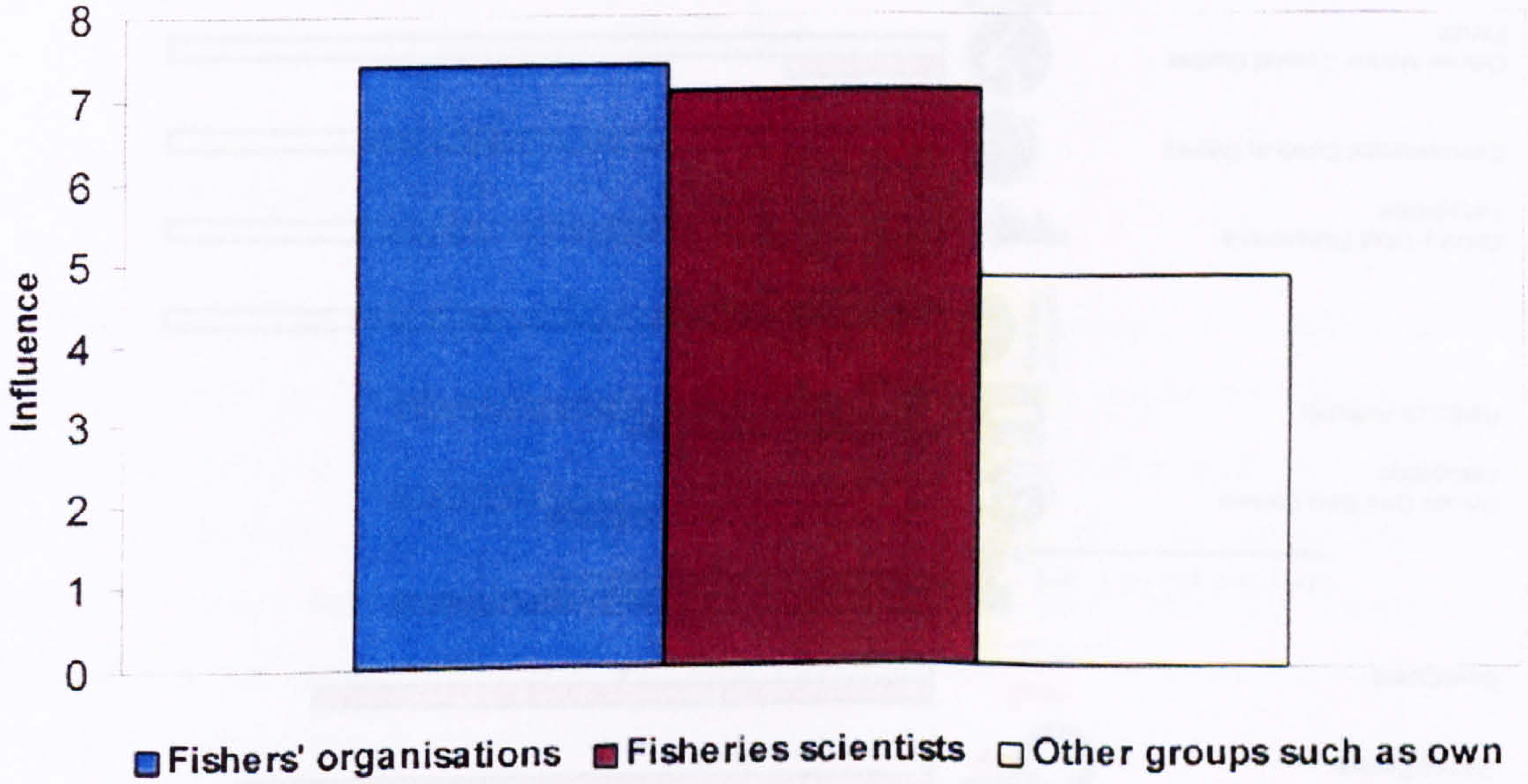


Figure 46. Stakeholder views on research influences

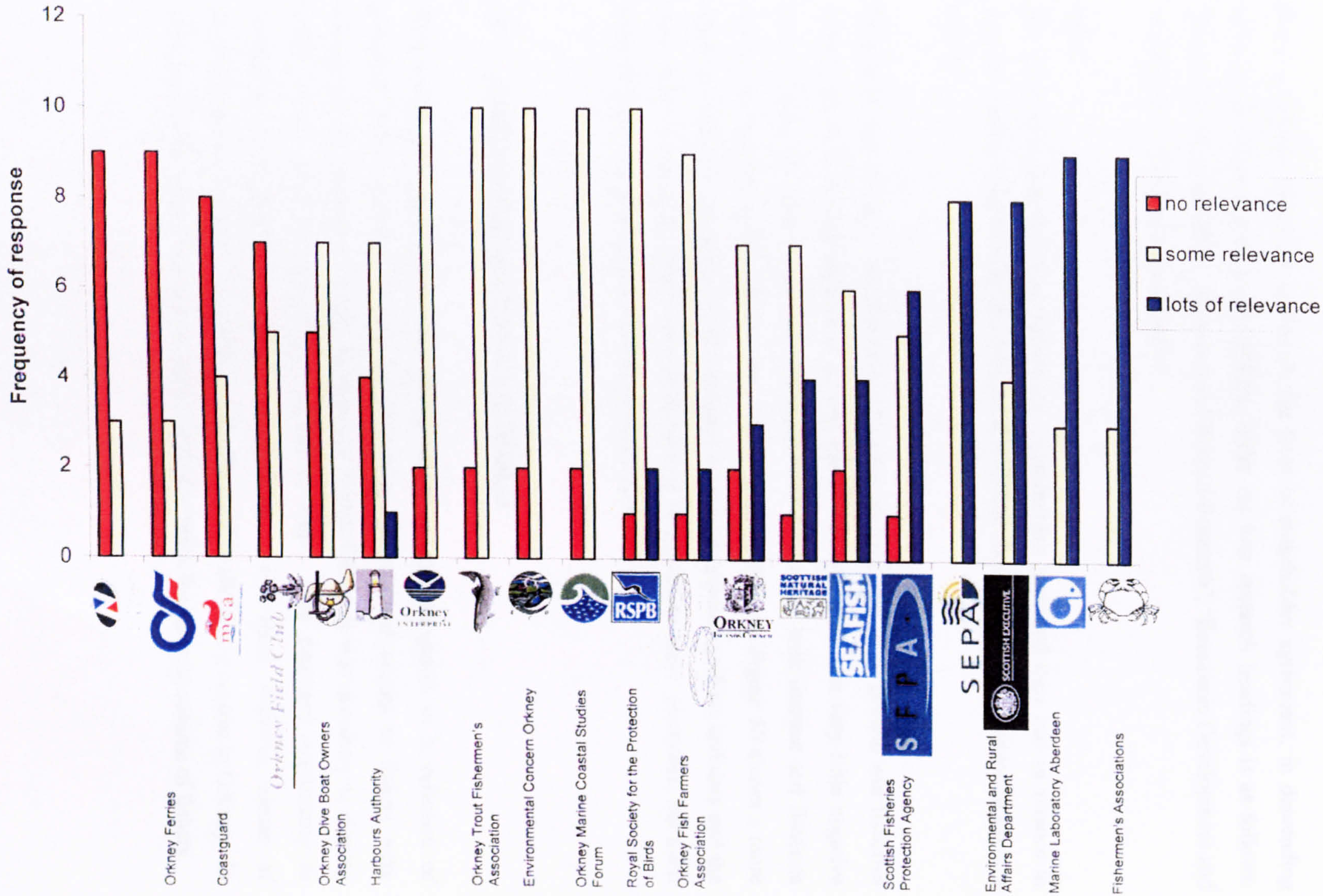


Figure 47. Relevance of other stakeholders to future research – the stakeholders' view

those compliant responses to Part B, the level of stakeholder agreement, in descending order, with research priorities of fishers, under the four research headings is as follows: 'Crabs and Other Shellfish', 'Lobsters and Related Research', 'Economic Development and Profitability', 'Environmental Factors'.

Part C

The level of trust/confidence stakeholder organisations specified they had in science in general, fisheries science and the differences between these views are displayed in Figures 48-50.

Figures 48 and 49 show that stakeholders views on both science in general and fisheries science are both heavily skewed to a more positive perspective, with very little negative views displayed. The patterns of voting are very similar for both science and fisheries science, in contrast to the fishers' view. In terms of differences, Figure 50 shows a more negative regard for scientific models and predictions, as opposed to facts and data and the motivation of scientists, which were both viewed in a positive way. However, the main concentration of responses is around a neutral perspective.

6.8 Communicating results to fishers (Stage 2)

With assimilated results from the questionnaire surveys presented in a selection of graphical forms, possible options for presenting all compiled results to fishers were considered. To comply with the objectives of Project Fisher, it was necessary to display results in the most transparent and accessible way. This provided opportunity to incorporate more aspects of artistic composition. The most effective means of interpretation was chosen to be a poster to be displayed in all fishing centres in Orkney. In this way a visual narrative of results would be able to reach the greatest volume of fishers.

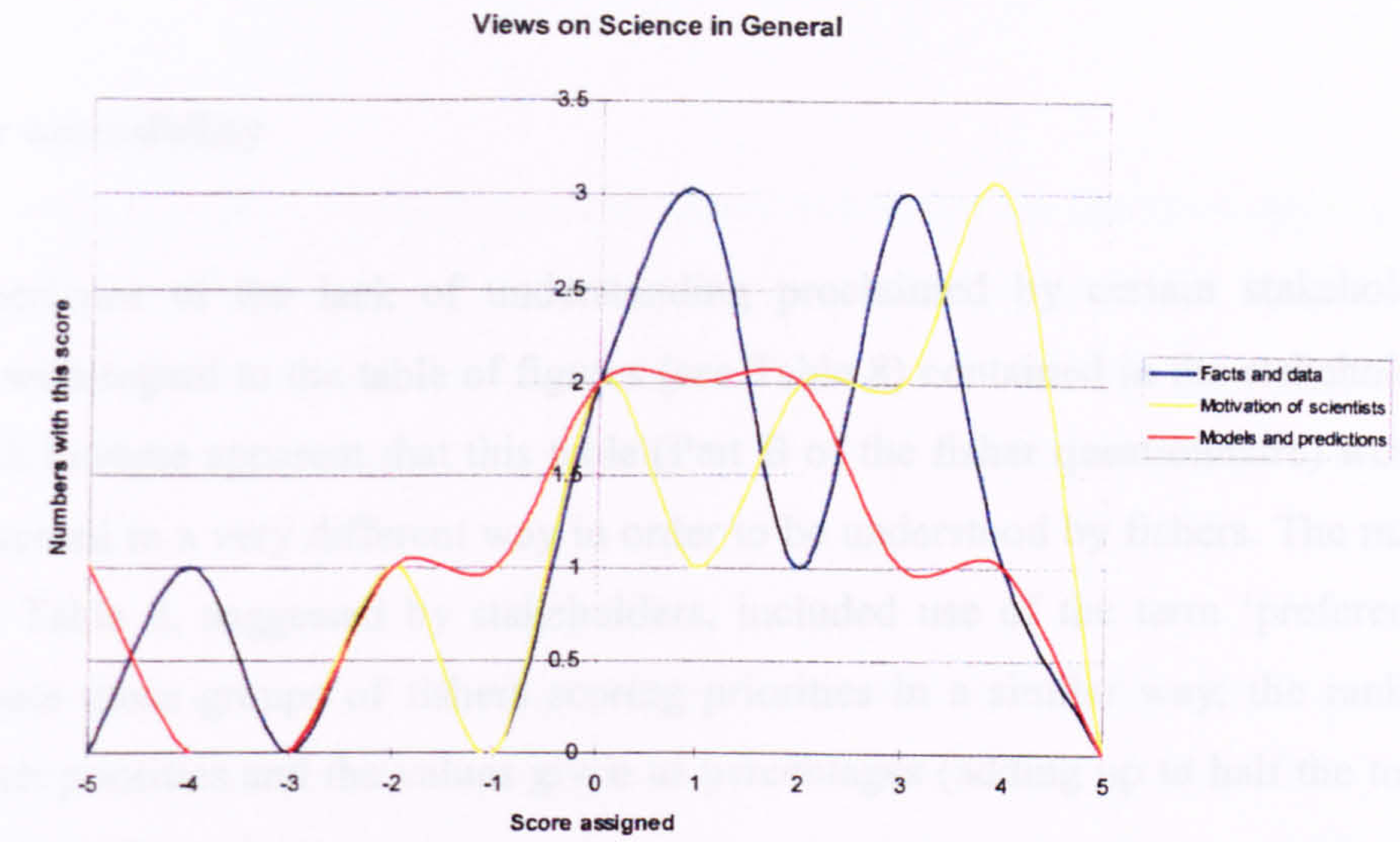


Figure 48. Stakeholders' views on science

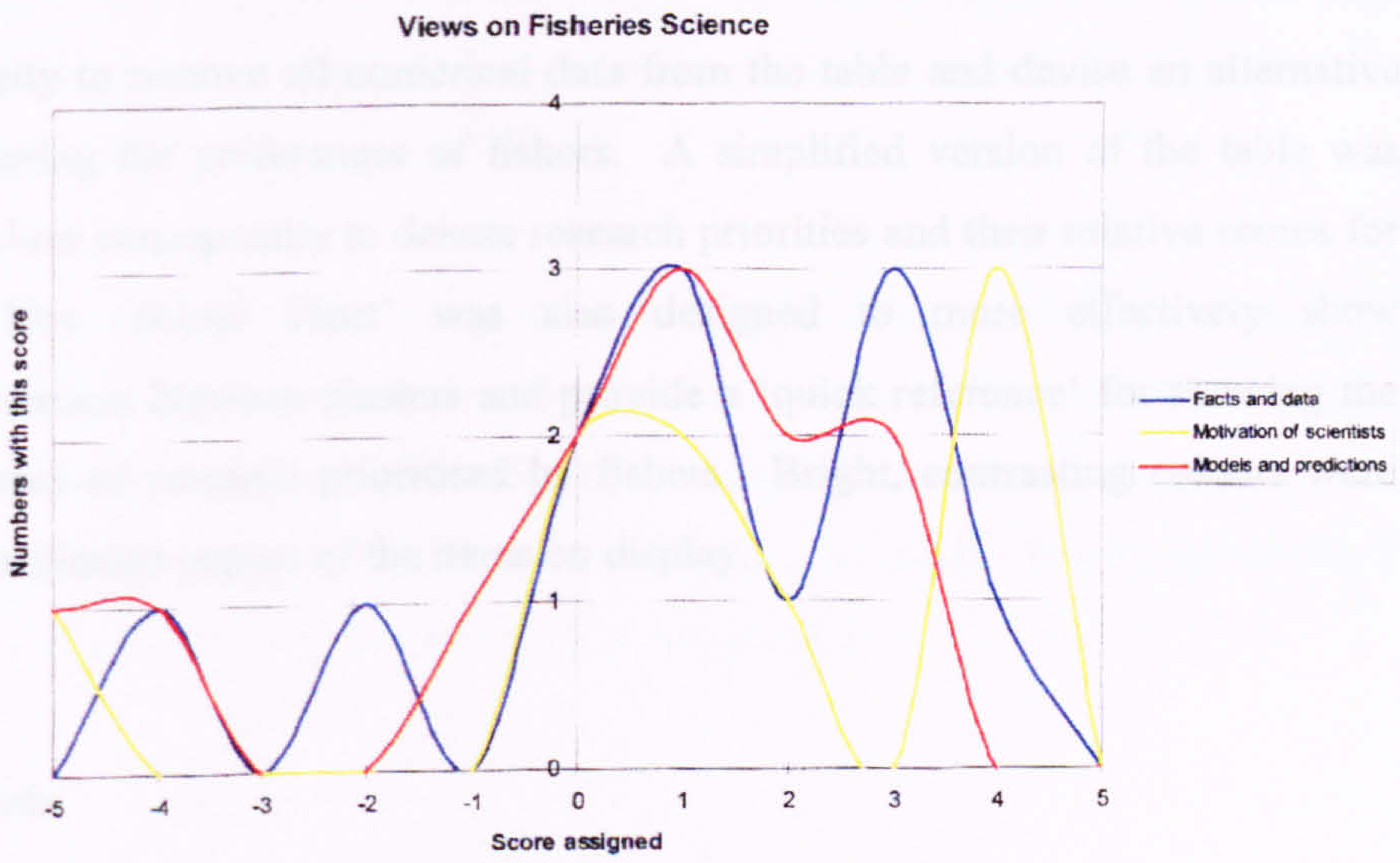


Figure 49. Stakeholders' views on fisheries science

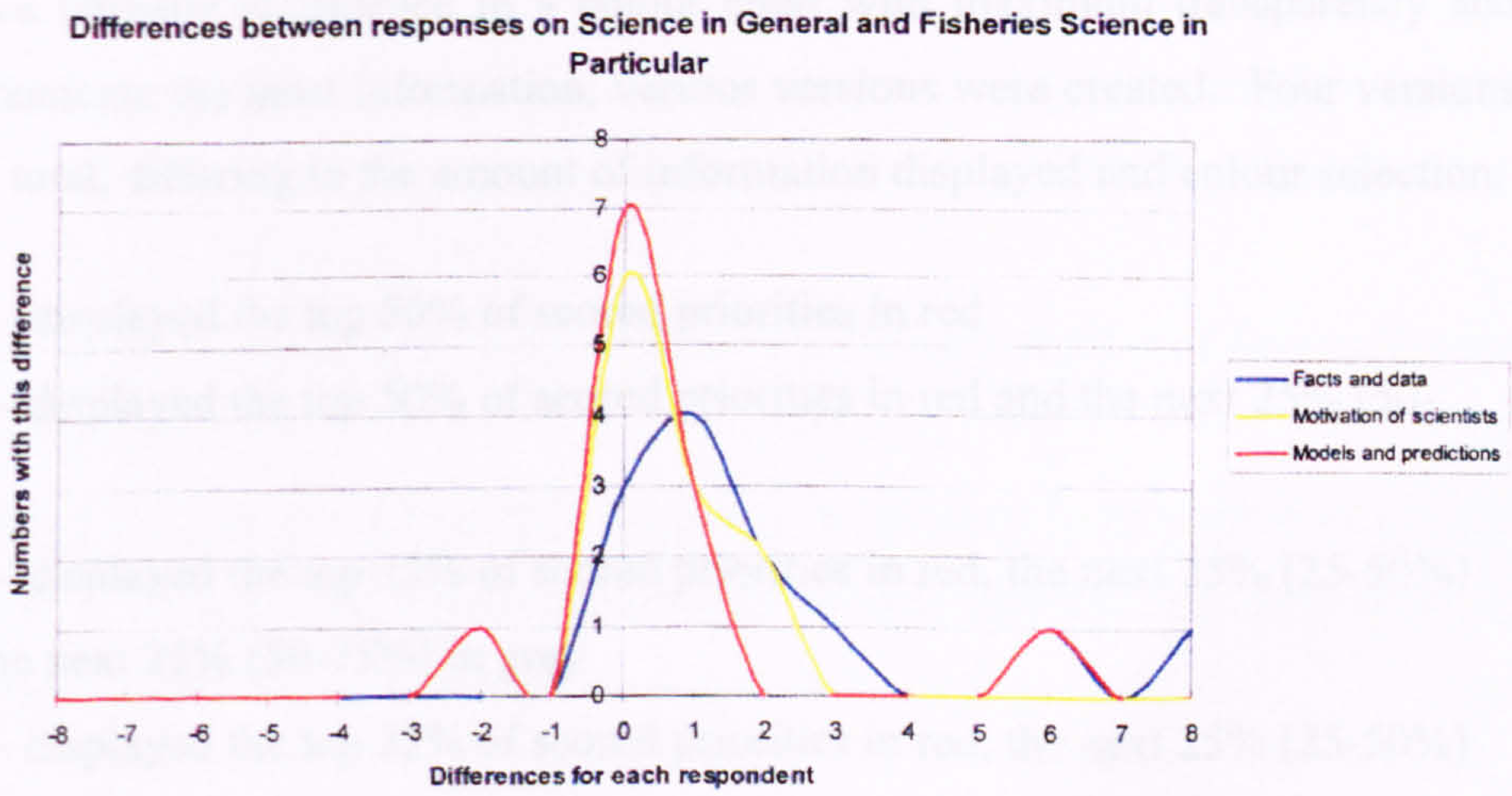


Figure 50. Differences between stakeholders' views on science and fisheries science

6.8.1 Art for accessibility

Based on experience of the lack of understanding proclaimed by certain stakeholder organisations, with regard to the table of figures (see Table 8) contained in the stakeholder questionnaire, it became apparent that this table (Part B of the fisher questionnaire) would need to be presented in a very different way in order to be understood by fishers. The main problems with Table 8, suggested by stakeholders, included use of the term 'preference cluster' to denote those groups of fishers scoring priorities in a similar way; the ranked order of research priorities and the values given as percentages (adding up to half the total score for each cluster/group).

It became a priority to remove all numerical data from the table and devise an alternative method of comparing the preferences of fishers. A simplified version of the table was devised, using colour conceptually to denote research priorities and their relative scores for each group. This 'colour chart' was also designed to more effectively show agreement/disagreement between clusters and provide a 'quick reference' for showing the most favoured areas of research prioritised by fishers. Bright, contrasting colours were used to achieve maximum impact of the items on display.

6.8.2 Fisher trials

In order to have ultimate confidence in a colour chart with maximum transparency and ability to communicate the most information, various versions were created. Four versions were created in total, differing in the amount of information displayed and colour selection.

Colour chart 1 – displayed the top 50% of scored priorities in red
Colour chart 2 – displayed the top 50% of scored priorities in red and the next 25% (50-75%) in yellow
Colour chart 3 – displayed the top 25% of scored priorities in red, the next 25% (25-50%) in yellow and the next 25% (50-75%) in grey
Colour chart 4 – displayed the top 25% of scored priorities in red, the next 25% (25-50%) in yellow

In order to assess the relative worth of the four charts and decide on the most appropriate version to form part of the poster, a group of fishers were asked to give their opinions on which was the most effective chart. In October 2003, a group of fishers in Westray, one of the outer Orkney Isles, were visited in an attempt to come to a conclusion as to the most suitable chart.

Of the fishers who gave opinions on the four charts, three out of four preferred colour chart 4. The reasons given included that it presented less information and was therefore more understandable, two colours as opposed to three was more pleasing on the eye and it was easier to see the agreement between clusters/groups. All fishers agreed the colour chart was a more effective means of interpretation of the questionnaire results than the table of figures (Table 8).

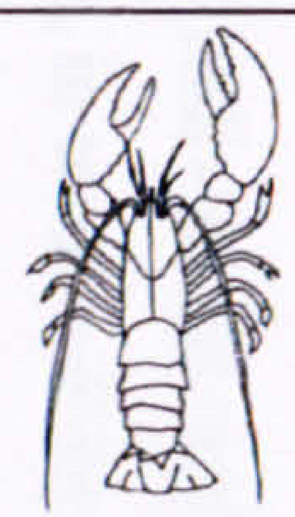
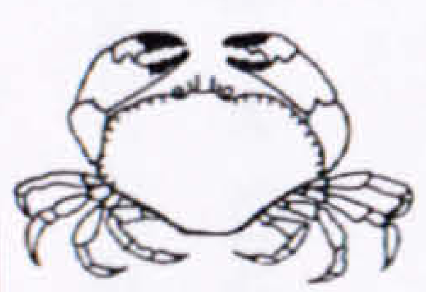
Fishers did raise the issue that figures included in the colour chart would help quantify the information on display. However, as it was a priority to avoid use of any numerical values, in a movement away from the classical descriptive tools of science, this suggestion was rejected. The final colour chart (4) (Table 9), for use in the poster displaying results is presented below. Colour charts 1-3 can be found in Appendix 9.

6.8.3 Poster design

In parallel to the design of colour charts, preparation of a poster displaying results began in October 2003. Aside from the colour chart chosen by fishermen (Table 9), the component diagrammatic features of the poster were:

- Map to show fishermen returning questionnaires and Orkney registered fishing vessels by port/region (Figure 39).
- Line graphs to show respondents level of trust and confidence in a) science in general and b) fisheries science, within the categories of i) facts and data, ii) motivation of scientists/fisheries scientists and iii) models and predictions (Figure 40-42).

Table 9. Research priority colour chart

Research topic		Group 1	Group 2	Group 3	Group 4
	V notching and compensation schemes	RED	RED	RED	YELLOW
	Lobster reproduction	RED	YELLOW	YELLOW	
	Data V notching programmes	YELLOW	YELLOW	YELLOW	
	Flaws in stock assessment models	YELLOW			
	Ways of ageing lobsters				
	Evaluate other research				
	Velvet swimming crab	RED	RED		
	Movement/migration spawning and juveniles	RED	YELLOW	YELLOW	
	Male only fishery and sustainability	YELLOW			
	Buckies				
	Evaluate other research				
	Queen scallops				
	Cockle recruitment				
£	Maximising market price for catch	YELLOW	RED		RED
	Better handling to reduce mortalities	YELLOW	RED		
	Prevention of increased bureacracy				YELLOW
	Factory processing of buckies				
	Mussel farming				
	New business ventures				
	Evaluate other research				
	Effects of salmon farming on creel fishery		YELLOW		
	Seal culling		YELLOW		
	Scallop research on shellfish toxin closures				
	Dinoflagellates in ballast water				
	Effects of climate change etc.				
	Sea temperature changes in Orkney				
	Effects of seismic charges on fish eggs				
	Sand eel fishery				
	Natural events and bumper catches				
	Evaluate other research				
TOTAL NUMBER OF FISHERMEN IN GROUP		20	21	5	4

RED — Research topics in the top 25% of scores for each group

RED plus YELLOW — Research topics in the top 50% of scores for each group

- Tree diagram to show those respondents answers to the questions 'Do you want research into the local fishery to be undertaken in the future?' and 'If so, are you willing to participate in this research' (Figure 43). Bar chart to show fishers' views on the relevance to the fishery of other users of/stakeholders in the marine environment to research into the fishery (Figure 44).

After design and layout of the poster were finalised and appropriate text written, a local design company produced the poster. The final poster (see Appendix 10) was sent to all major fishing centres in Orkney and representatives from fishermen's associations. Comments regarding the design and layout of the poster received from individual fishers were generally positive and it remains displayed in the major fishing centres in Orkney as planned.

6.8.4 Final meeting with fishers

The poster, together with all assimilated results from Project Fisher was presented to fishers at a meeting in Kirkwall, on 25th November 2003. Despite invitations being sent to all registered creel fishing vessels in Orkney and particular consideration given to the time and location of the meeting, there was a disappointingly limited attendance of only 3 fishers.

After discussion of the results a discussion ensued regarding the possible options available to fishers, armed with the results of the project. It was suggested to fishers that the results of Project Fisher could go towards a research programme, fishers could independently gather potential funding for. However, it was expressed that one tragedy of the project was the lack of a potential vehicle/organisational structure for fishers, such as that which exists for stakeholder organisations, such as those involved in Project Fisher, to enable a 'united view'. Moreover, it was maintained that there was a distinct need for fishers to build a capacity to represent themselves (see minutes, Appendix 11).

The 3 individuals attending the final meeting voiced certain negative responses to the project, in terms of the neutrality of its methods, and a lack of confidence in the integrity of results. However, later comments from a representative of Orkney Fishermen's Society, suggested a possible future for the results to be used in some form/programme of research to be undertaken by the Society.

6.9 Conclusions

6.9.1 General conclusions

Initial conversations with certain members of the creel fishing sector, gave rise to suggestions that many fishers would be unwilling to establish any form of discussion group with the scientific community. However, nearly all Orkney creel fishermen contributed to Project fisher in some way. Indeed, the high volume of responses to the questionnaire for fishers suggests quite the opposite, despite the extensive canvassing required. With 47 of 52 fishers keen to see research go ahead and 42 of these fishers willing to participate in some way, the support for a future research programme is evident among the fishing community. Despite fragmentation of the fishing community, it is nonetheless possible, though difficult, to achieve a widespread participation in response to a proposal. In reinforcement, the Secretary of the Orkney Fisheries Association offered in a recent issue of *The Orcadian* 'nearly all research is done at the national level, at arms length from Aberdeen or elsewhere. Whereas, this research (Project Fisher) at a local level gives far greater opportunity for fishermen to assess accurately what is going on locally and get closer to the truth'.

Other positive outcomes of Project Fisher relate to the unexpectedly high amount of agreement between fishermen over priorities for future research topics. All four statistically defined clusters of fishers agreeing on 'V-notching and compensation schemes' as a major research priority and other commonalities under the research headings 'Lobsters and Related Research', 'Crabs and Other Shellfish' and 'Economic Development and Profitability'. In this way, consensus among the fishing sector was well observed, in stark contrast to the history of conflicts among fishers during attempts to impose changes in the management regime of the fishery.

Although fisheries science was viewed in a rather more negative fashion by the majority of questionnaire respondents, the more positive views of science, with particular regard to scientific fact and data, was a pleasing outcome of the exercise. Both fishers and other stakeholders' negative views related to scientific models and predictions. This may provide emphasis for future investigation of the failings of the predictive powers of science, for example, fisheries (stock assessment) models.

Problems with the presentation of data and a consequent lack of understanding observed primarily from the stakeholder questionnaire respondents makes obvious the need for a more transparent method of displaying information. Certain patterns observed in the scoring of priorities by fishers lead to possible questions as to the accuracy of choices. It was apparent that fishers were more inclined to select priorities at the top of the list under each of the four research headings. In other words, priorities located nearer the top of the list under each of the headings: 'Lobsters and Related Research', 'Crabs and Other Shellfish', 'Economic Development and Profitability' and 'Environmental Factors' were more likely to be selected by fishers owing to their position. A possible conclusion which follows on from this observation is that fishers, scoring priorities out of a total of 100 points under each research heading, were more likely to attribute points to topics placed higher in the list and consequently, ran out of points further down the list. Alternatively, it could be concluded that the working group listed topics in an order which fishers had articulated to them at the first meetings. Unfortunately, these theories can be no further elaborated.

Although fishers appreciated that results of Project Fisher had been presented/communicated to them in a more transparent way, offering comments and feedback where appropriate, skepticism of the process of scientific analysis and lack of faith in the neutrality of the results of the exercise, was still observed among fishers. Such lack of trust will ultimately limit co-operation and participation of fisher in future programmes of this nature, unless trust can be restored through some medium.

Probably the most fundamental difficulties experienced by the working group, in organisational terms, were in association with getting fishers to attend meetings. Poor attendance at the initial meetings was not improved upon as the project developed, despite extensive canvassing to persuade fishers to attend through advertising, personalised invitations, convenient locations and refreshments on offer. Initial problems could perhaps have been owing to meetings arranged at prime fishing times, however improving the timing of meetings had little/no effect on levels of attendance. With only 3 fishers attending the final meeting of Project Fisher, this almost represents its most fundamental research finding. That is, the lack of representation, presenting a united voice for the fishing community, combined with limited free time to attend meetings, and a deep-seated skepticism of the scientific community, restricts fishers' taking the leadership role in future research into the creel fishery.

Although possible to get fisher participation – it is very difficult. If the lack of capacity of the fishing sector is ignored, hostility will inevitably result when attempting to radically reshape the management of a fishery. However, is it really the responsibility of scientists and/or managers to resolve the fishers' problem of a lack of capacity?

Although a strong preference was observed for fishers to take the driving seat in any future research programme, coming from the working group, fishers and stakeholders alike, meaning progress is limited, however much agreement exists among the fishing sector on future priorities for research. Skepticism of scientists and scientific information presents a barrier to the insight and understanding essential to rational participation in any research programme.

6.9.2 Comparisons of Project Fisher with the conventional decision-making process

The following flow diagram (Figure 51) outlines the differences between Project Fisher and a model of the conventional decision-making process involved in Scottish inshore fisheries management. Originating from and determined by government policy, such processes involve a lengthy list of key players including a council of fisheries ministers, advisory groups, government environmental agencies, fisheries scientists (in the form of research services/marine laboratories etc.), regulators, in this case the European Commission thirdly, and lastly the fishers. In contrast, Project Fisher represents a more 'idealist' model of a decision-making process, where fishers are the key players.

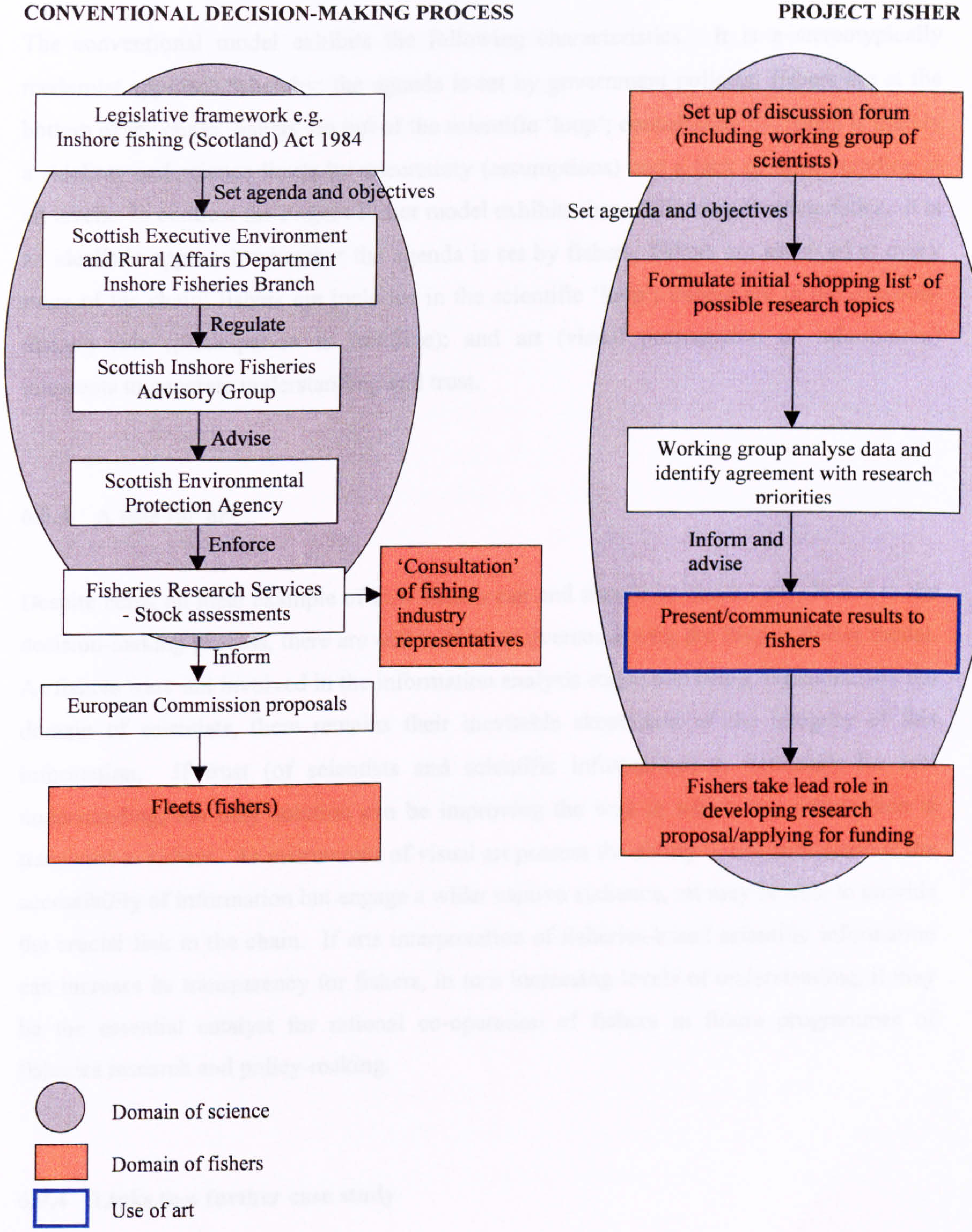


Figure 51. Project Fisher and the conventional decision-making process within Scottish Inshore fisheries

The conventional model exhibits the following characteristics. It is a stereotypically modernist approach whereby: the agenda is set by government policies; fishers are at the bottom of the chain; fishers are out of the scientific 'loop'; consultation of fishers is merely a sideline; and science limits by uncertainty (assumptions) and a lack of understanding at all levels. In contrast the Project Fisher model exhibits these following characteristics. It is an idealistic approach whereby: the agenda is set by fishers; fishers are involved at every stage of the chain; fishers are included in the scientific 'loop'; fishers are in the decision-making role (participation is frontline); and art (visual presentation of information) intercepts to generate understanding and trust.

6.9.3 A role for art

Despite being an ideal example of how fishers can and should be inextricably linked to the decision-making process, there are still hurdles to overcome with the Project Fisher model. As fishers were not involved in the information analysis stage, this being fundamentally the domain of scientists, there remains their inevitable skepticism of the integrity of this information. If trust (of scientists and scientific information) is necessary for real understanding, the only solution can be improving the way in which this information is translated to fishers. As instruments of visual art possess the ability to not only increase the accessibility of information but engage a wider captive audience, art may be able to provide the crucial link in the chain. If arts interpretation of fisheries-based scientific information can increase its transparency for fishers, in turn increasing levels of understanding, it may be the essential catalyst for rational co-operation of fishers in future programmes of fisheries research and policy-making.

6.9.4 Links to a further case study

It is accepted that the extent to which fishers were involved in generating visual interpretations of the results of Project Fisher was ultimately limited. The level of use of principles of artistic composition was somewhat limited in this case study. However, in the following two chapters, visual art provides a new context for the information and feedback that resulted from Project Fisher. These chapters attempt to provide a superior narrative for a variety of (fisheries-based) scientific information in terms of its accessibility and application and continue a search for a participatory approach to representation of science.

Chapter 7. RADICAL IDEAS: ELEMENTS OF ARTISTIC COMPOSITION

7.1 Introduction

The lessons of Project Fisher suggest that there may be a role for art in improving accessibility of and understanding in science, building trust and engaging a community, in this case – fishers. Furthermore, with clear evidence in the literature that science must radically rethink its methods of communicating information, to improve its consensibility within a wide public domain, this chapter takes a more radical approach. Following on directly from Chapter 6 and the first steps made by Project Fisher to communicate information to fishers in a visual way, this chapter widens the audience to contain a greater cross-section of environmental stakeholders. With the results of Project Fisher as subject matter, this study draws reference back to key elements of the artistic composition e.g. colour, form and shape etc. The following experiments represent an attempt to break some of the existing boundaries of traditional science presentation.

7.1.1 Tools of science communication still proliferate

The development of a colour chart (Table 9) to display results of Project Fisher (Chapter 6) represents an initial attempt to introduce elements of art in interpretation of scientific facts and data i.e. colour and contrast. Furthermore, it introduced the use of icons to represent the four research headings: 'Lobsters and Related Research', 'Crabs and Other Shellfish', 'Economic Development and Profitability' and 'Environmental Factors'. However, this colour chart still uses a basic tabulated format, in other words, a traditional tool for the explanation of science. The sequential step is therefore, to find new formats or 'canvases' to act as a framework for communication for scientific data and its communication.

7.2 The challenge

On receipt of responses to the questionnaire for stakeholders, forming part of Project Fisher (see section 6.7.2), several comments were received from certain individuals who found the Table of figures (Table 8), relating to the scored priorities of fishermen for future research into the fishery, extremely difficult to interpret. Reasons given for this lack of understanding included an awkward layout of tabulated figures and an inability to follow accompanying text. Such comments provided the rationale for a set of experiments to find a more transparent way to present this data, accessible to a wider audience, outside the Project Fisher working group. Ultimately, if members of environmental organisations, in certain cases with scientific backgrounds, could not interpret the information being presented, little hope remained for such information being further translatable to fishers and other interest groups.

Generally speaking, the classic visual tools used to represent science are maps, tables of figures, graphs and models. The challenge of this study was to bypass such traditional methods and communicate information using component methods of representation used extensively by art and artists. There exists a diverse list including perspective, colour, contrast, shape, form, dimension, abstraction and design. These elements of the artistic composition, with potential to be included in this study, were discussed in section 2.11.2. This discussion and the experiments that follow aims to:

a) gather information regarding potential methods for the re-representation of the table of figures (Table 8);
b) outline the advantageous and disadvantageous attributes of each method; and
c) gather feedback regarding the value of artistic representation of scientific information.

7.3 Project Fisher stakeholder experiments

As stated, the colour chart developed during Project Fisher represented a first attempt at utilising basic elements of the artistic composition to increase the clarity and accessibility of a table of figures (Table 8). The use of two contrasting colours, to draw the viewer's attention to the most significant information (where red = the top 25% of scored research priorities; yellow = the next 25% of scored research priorities and red plus yellow = the top 50% of priorities), was a substantial improvement on the original method of presentation of this data as suggested by fishers.

From here evolved the concept for a series of similar experiments concerned with the application of alternate aspects of artistic composition, each with their own unique way of interpreting information. Collectively, they represent a process, through which it was intended to establish the most transparent and accessible means of visually displaying the data – the results of Fisher. Chronologically speaking, proceeding experiments build on the lessons learnt from the preceding, and progressively incorporate a greater use of artistic elements. The key elements of visual notation, central to the following experiments are presented in Table 10.

A total of three experiments were designed, produced, tested and compared (alongside the colour chart) during the period December 2003–February 2004. The experiments chosen to represent the tabulated information were as follows:

a) The use of icons (free-hand drawings) to represent research priorities.
b) The use of a coloured 'Venn Diagram' to display agreement/overlap between groups.
c) The use of a 3-dimensional installation.

Table 10. Elements of artistic composition used

Element of art /Experiment	Colour	Contrast	Form	Shape	Symmetry	3-dimensions	Invitation to explore
Colour chart	Yes	Yes	Yes				
Circles with icons	Yes	Yes	Yes	Yes			
Venn diagram	Yes	Yes	Yes	Yes	Yes		
Installation	Yes	Yes	Yes	Yes	Yes	Yes	Yes

7.4.1 Iconic representation

The first movement away from more scientific representation of data was to extract the information from the table and discard this format. Instead, circles (1-4) were used to represent the four groups of fishermen outlined in the table, with the relative size of these circles indicative of how many fishers were in each group. Taking influence from the icons in the colour chart (Table 9), further icons were developed to represent individual research priorities in the top 50% of scored choices i.e. only those marked with red and yellow in the colour chart. These icons are collectively shown in the key, Table 11.

The icons corresponding to the research priorities of each group of fishermen, were inserted into the circle denoting that group. To indicate relative importance of each priority, within the circle/for that group, each icon was enclosed in a further circle. Larger circles were used to represent research priorities in the top 25% of choices for that group (i.e. indicated by red in the colour chart) and smaller circles were used to represent research priorities in the next 25% of choices for that group (i.e. indicated by yellow in the colour chart). Furthermore, the colour of the circles enclosing the priorities was used to indicate which of the four research headings that specific priority fell under. The colours used and the corresponding meaning were as follows:

Red	- Lobsters and Related Research
Blue	- Crabs and Other Shellfish
Yellow	- Economic Development and Profitability
Green	- Environmental Factors

The final layout of the experiment 'circles with icons' is presented in Figure 52. This format was designed to more suitably show the specific preferences of each of the four groups of fishers and under which of the four research headings they fell under. Furthermore, relative size of these groups (circles) is more visually apparent i.e. groups 1 and 2 (20 and 21 fishers respectively) being much larger than groups 3 and 4 (5 and 4 fishers respectively). However, a downfall of this type of arrangement is that the level of agreement/disagreement between groups is not as easy to visually determine. Furthermore, the arrangement must be viewed alongside the key to icons (Table 11) i.e. requires additional interpretation. Therefore, the sequential next step is to find a visual format, which can more readily exhibit the level of agreement/disagreement, or overlap between groups.

Table 11. Key to icons

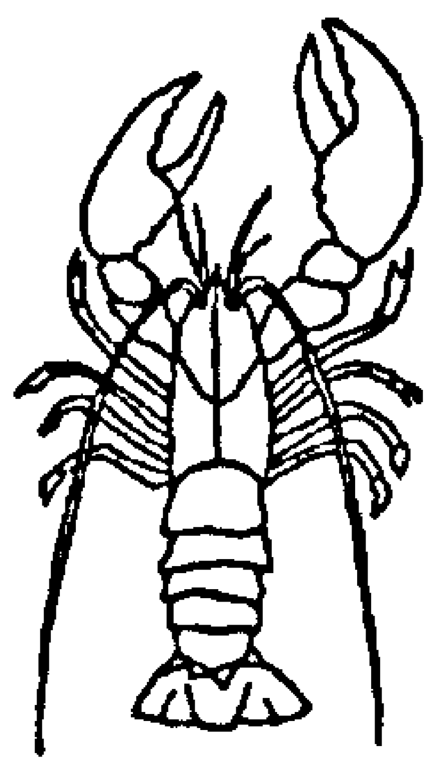
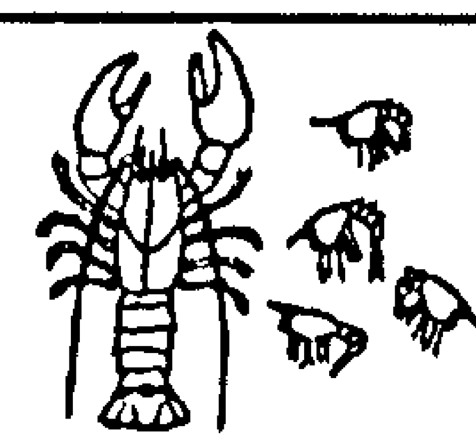
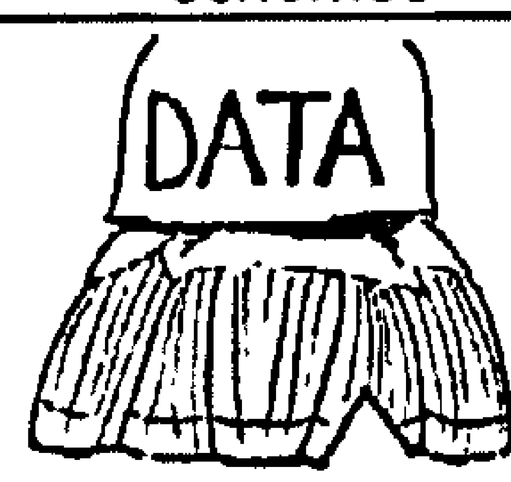
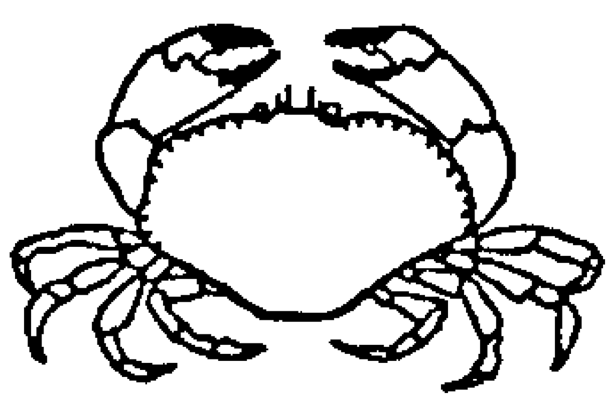
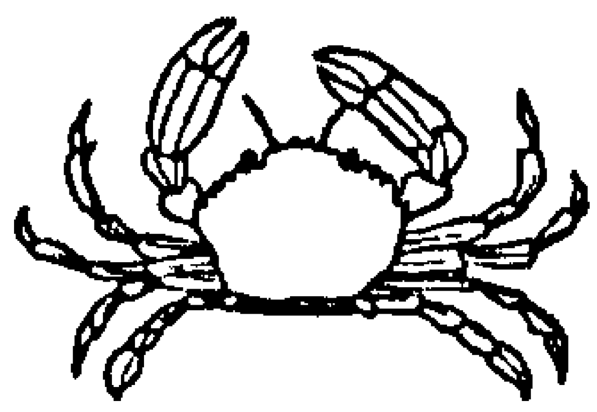
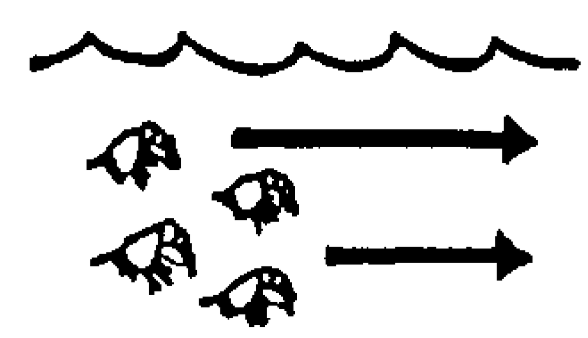
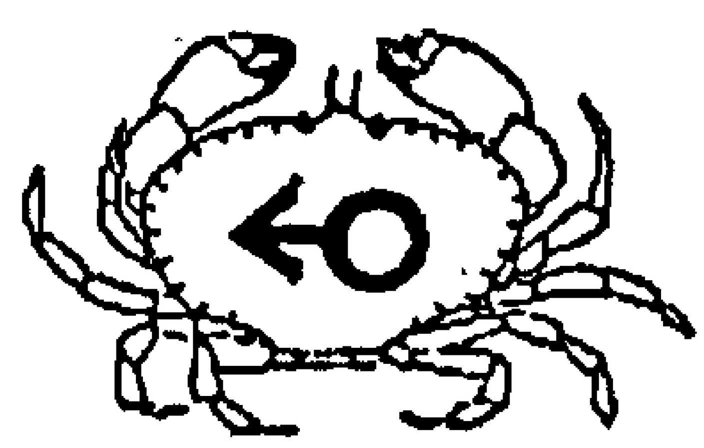
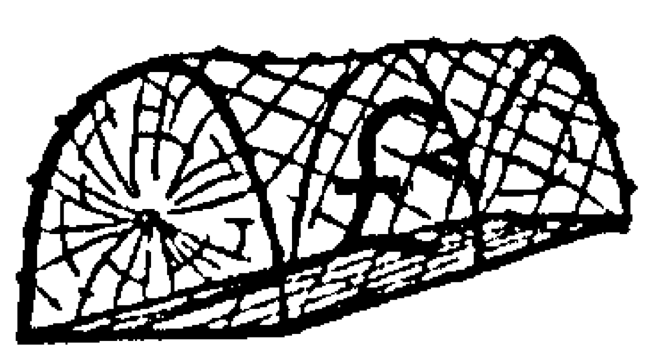
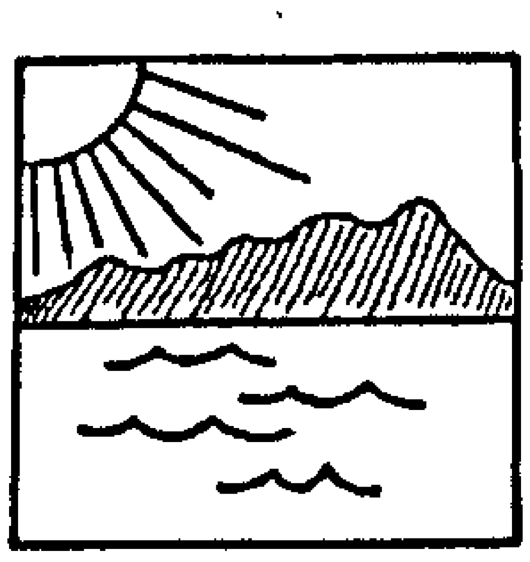
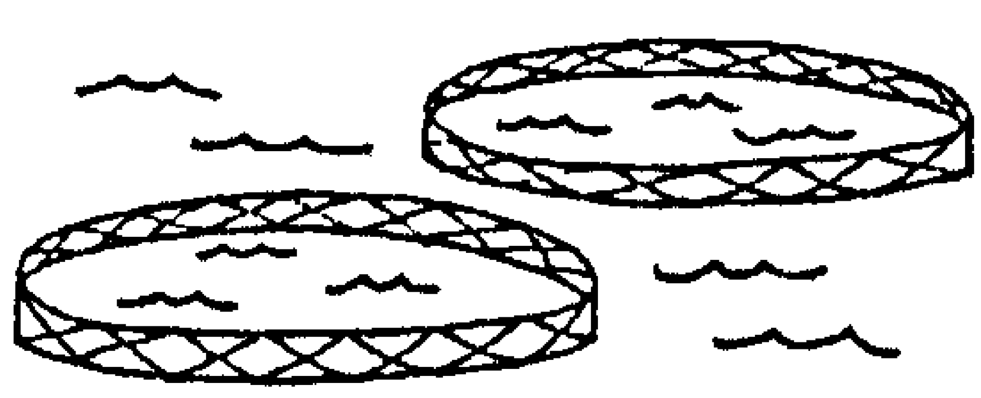
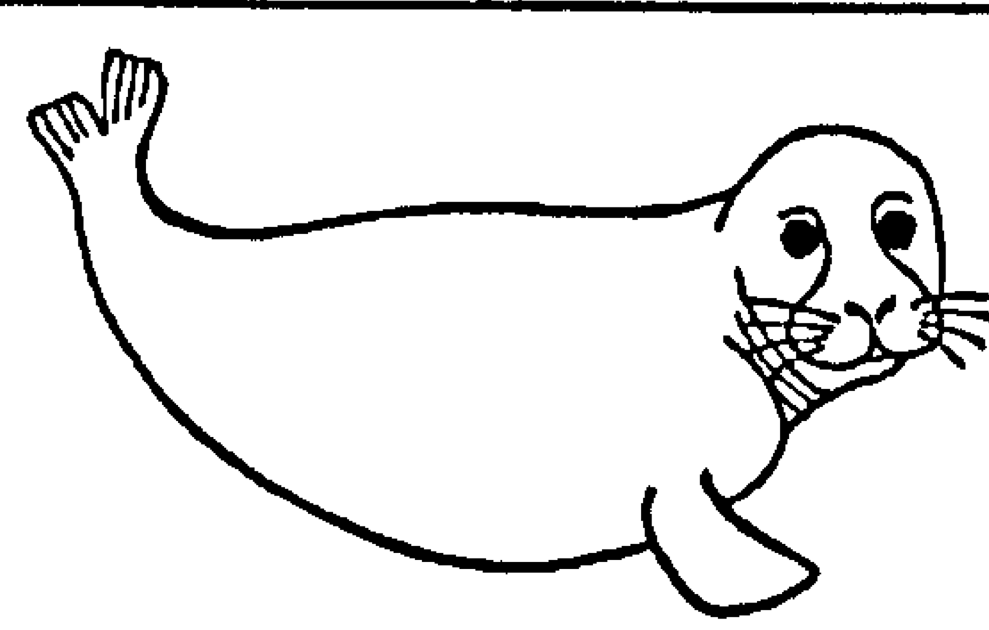
Research area	Specific priorities	
 Lobsters	 V notching and compensation schemes	 Lobster reproduction
	 Data on v notching programmes	 Flaws in stock assessment models
 Crabs and other shellfish	 Velvet swimming crab	 Brown crab migration and movement of juveniles
	 Male only fishery and sustainability	
 Economic issues	 Maximising market prices for catch	 Better handling to reduce mortalities
	 Prevention of increased bureaucracy	
 Environmental issues	 Effects of salmon farming on creel fishery	 Seal culling

Figure 52. Circles with icons

7.4.2 Four element Venn Diagrams

Venn Diagrams are usually made up of two or more overlapping circles, however other shapes such as squares are often used in a similar way. Most commonly used in mathematics to show relationships between sets, Venn Diagrams are also used in language and arts instruction. Frequently, this is due to their usefulness for examining similarities and differences. Venn Diagrams use many of the fundamental first principles of art e.g. contrast, shape, form and symmetry.

In creating a Venn Diagram, icons previously replicated a number of times in the circles (see key to icons Table 11), could be reduced in number to only one replicate in each element. This would mean a simplified format, more easily assimilated by the eye. Two versions of a Venn Diagram were chosen, to compare and contrast their display potential, one comprised of the more traditional circles and the other squares.

In the most basic Venn Diagram (2 overlapping circles), each intersection consists of one connected region. With four groups of fishers to represent diagrammatically, it was necessary to construct Venn's consisting of a number of intersecting regions, suitable to display all common research choices amongst the four groups of fishers. In addition, it was necessary to slightly 'skew' these Venn's in order to indicate the relative sizes of the four groups (see Venn Diagram layouts Figure 53). Owing to these limiting factors, and to the choice of shapes (circles and squares) all possible combinations of sets (intersections of groups of fishers) were not practically possible (see Figure 53). That is, the certain combinations of groups are not possible due to the opposing positions of Venn elements A and C, B and D, respectively.

In the circular instance, there are no intersecting regions of the makeup AC or BD. In the square instance, there are no combinations of the makeup AD or BC. In this way the layout is not mathematically perfect, however the diagram serves the purpose of showing the overlap between the sets of fishers, necessary to be compared.

In order for the Venn Diagrams to have maximum visual impact and show the most contrast between sets, each set was represented by a different colour. However, with 4 sets

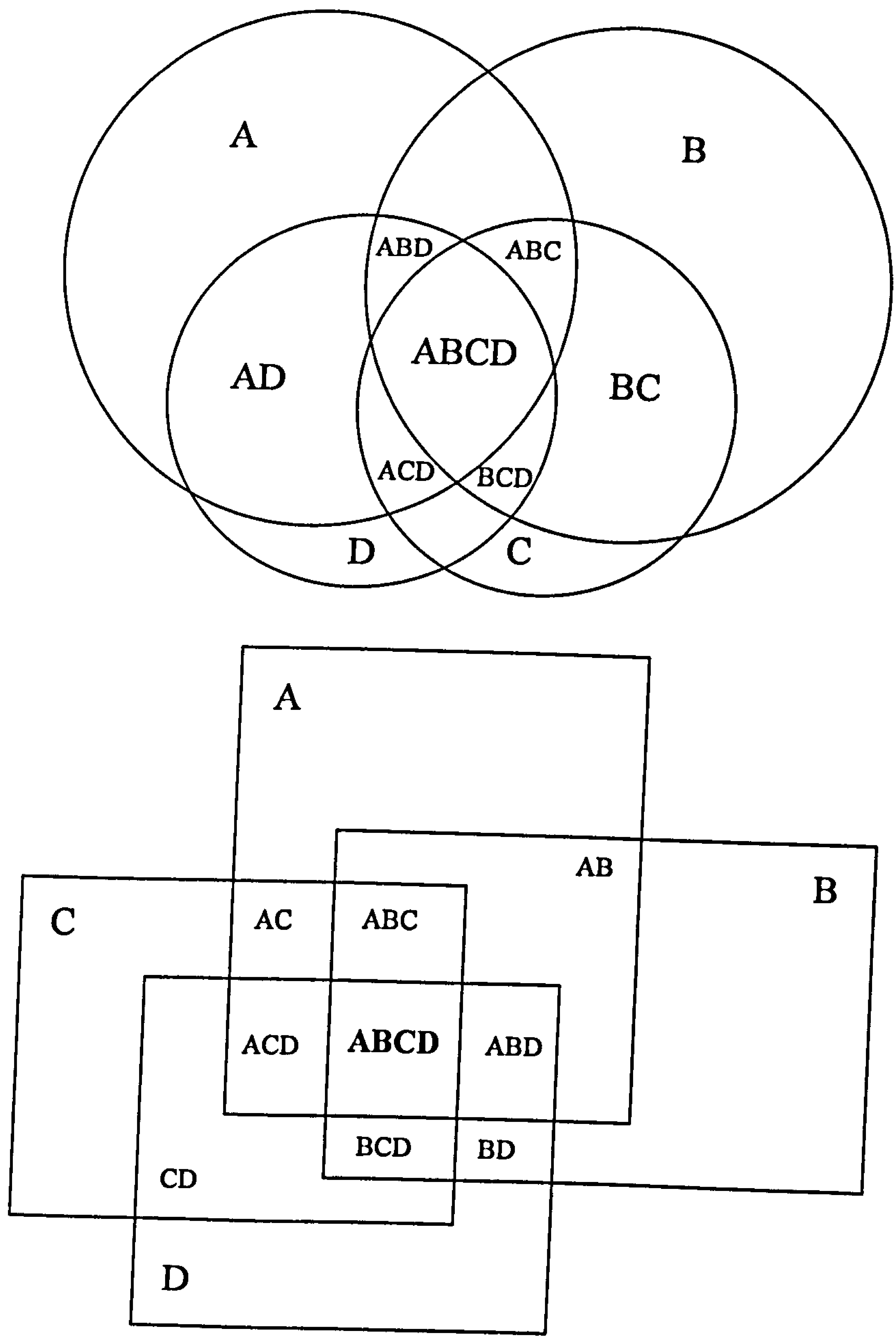


Figure 53. Four element Venn Diagram layouts

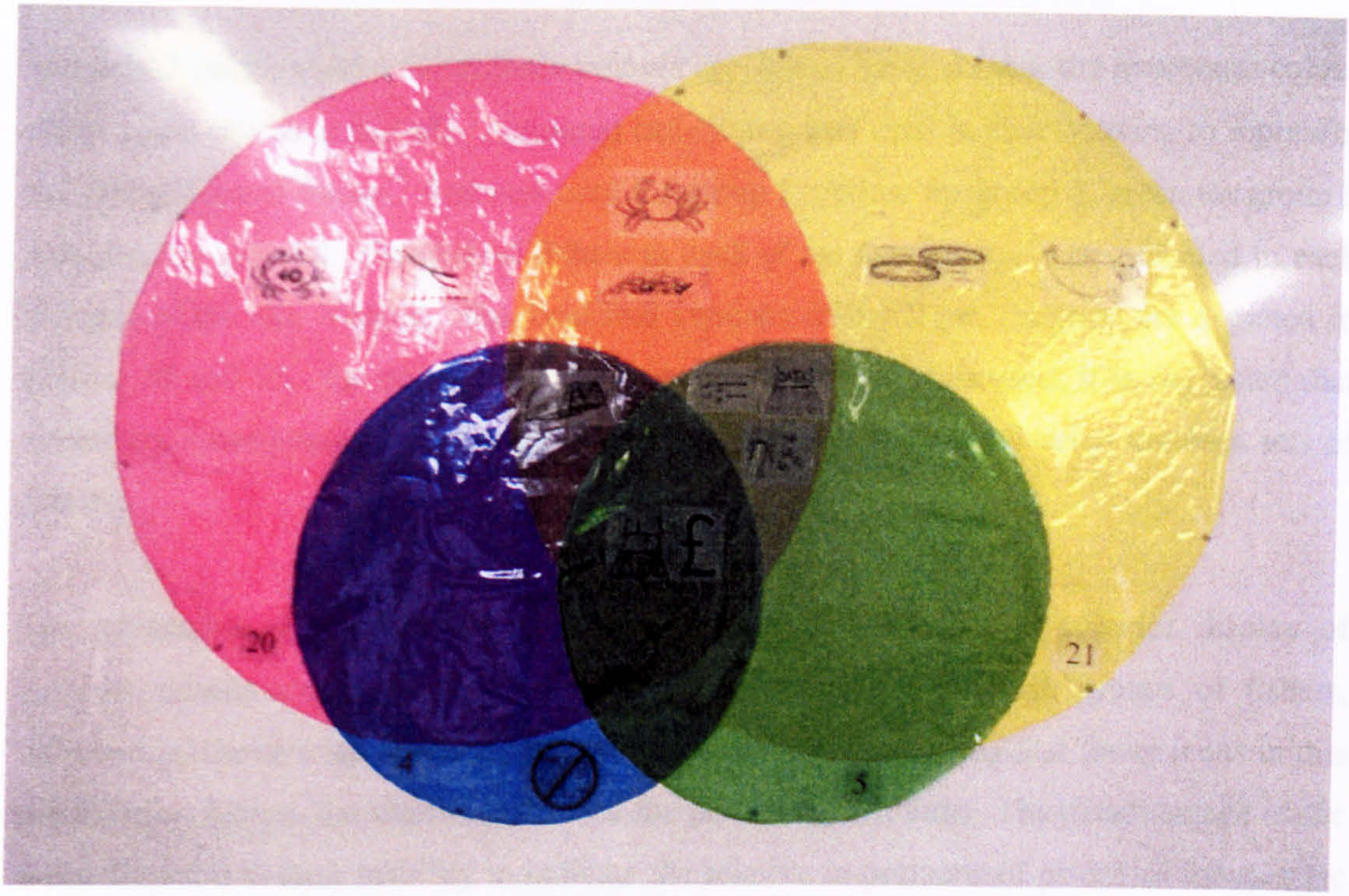


Figure 54. Circular Venn Diagram

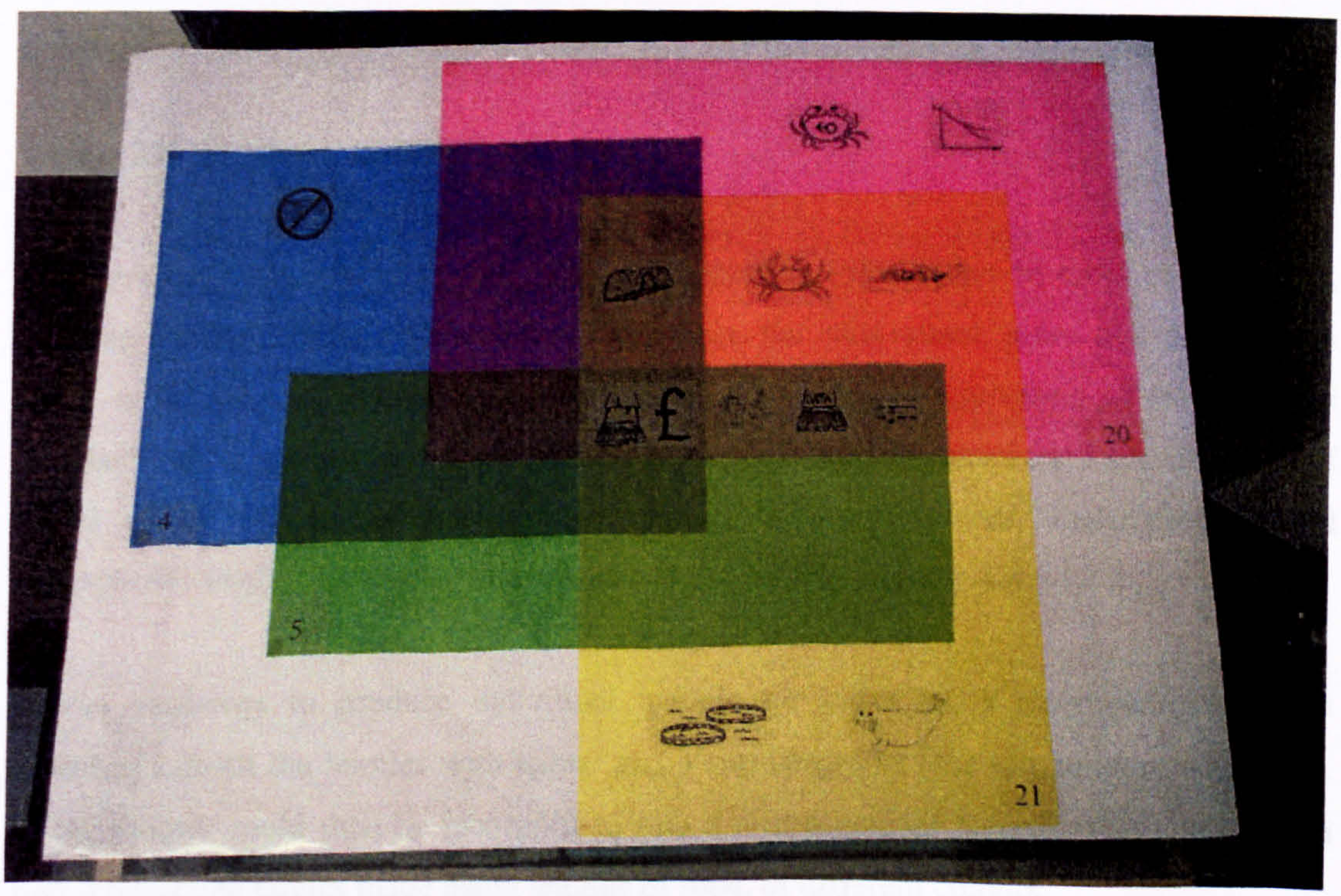


Figure 55. Square Venn Diagram

and only 3 primary colours i.e. those colours capable of being mixed, the maximum colour effect could not be achieved. Coloured cellophane was used in four colours, to represent the four groups of fishers. Red was used for group 1, yellow for group 2, green for group 3 and blue for group 4. Number of fishers in each of the four groups was indicated in each element of the two Venn's. The final two versions of the Venn Diagram are depicted in Figures 54 and 55. On comparison of the two geometric shapes used, it is suggested that circles are more pleasing on the eye and more readily display the overlap between sets of fishers.

The advantage of this method of presentation of the data is the superior display of agreement/disagreement on research priorities between the different groups of fishers, indicated by the overlap between sets. In addition, bright colouring and fewer icons in this presentation format, are improvements on the preceding methods. The disadvantage of the Venn diagrams is their inability to indicate the relative importance of priorities for specific groups as well as between groups, owing to size restrictions.

7.4.3 3-dimensional installation

The previous experiments function well at presenting information in more unique ways, building on basic artistic principles. From here, the subsequent, more radical approach arose as building a diagram in 3-dimensions. A direct interpretation of the previous circular Venn Diagram, such presentation of the data would represent the most novel use of visual art to translate scientific information. A 3-dimensional 'installation' would conceptually enable the viewer to walk around the display and interact with it.

It was necessary to produce individual models for those icons representing research priorities in both the 'circles with icons' and Venn Diagrams (see key to icons Table 11). These models could then be incorporated into a 3-dimensional Venn-style diagram, with four intersecting circles made using lengths of rope, of different colours.

3-dimensional models for icons were developed. Owing to financial and time constraints, coupled with limited access to materials, interpretations of the research priorities were, in some cases, different from their iconic forms. The individual models for priorities under the four headings were designed as follows:

Lobsters and Related Research:

- V-notching and compensation schemes – cardboard model '£' sign and v-notched tail.
- Data from v-notching programmes – pile of scientific reports and tallied number chart with cardboard model of v-notched tail.
- Lobster reproduction – preserved lobster accompanied by 'male' and 'female' symbols and papier-mâché juveniles.
- Flaws in stock assessment models – pile of textbooks on fisheries stock assessment and cardboard 'hazard' symbol.

Crabs and Other Shellfish:

- Velvet Swimming Crab – stuffed toy Velvet Crab made from green velvet.
- Brown Crab movement and migration of juveniles – papier-mâché juvenile crabs on a map of Orkney with directional arrows.
- Male only fishery and sustainability – preserved Brown Crab accompanied by 'male' symbol.

Economic Development and Profitability:

- Maximising market price for catch – lobster creel accompanied by cardboard '£' sign.
- Better handling to reduce mortalities – workman's gloves holding small plastic model lobster and crab.
- Prevention of increased bureaucracy – black bowler hat and umbrella accompanied by cardboard 'warning' sign.

Environmental Factors

- Effects of salmon farming on creel fishery – replica fish pellets (salmon feed), accompanied by model nutrient bottles and picture of a salmon. Cardboard '?' signs surrounding to suggest uncertainties.
- Seal culling - stuffed toy seal accompanied by a makeshift 'club'.

Ropes in four colours obtainable were laid out in large intersecting circles on an open floor space. The relative size of these circles was used to indicate the number of fishers in each of the four groups, akin to the circular Venn Diagram. The various colours and groups of fishers indicated were as follows, numbered accordingly:

Orange/red – Group 1 (20 fishers)
White – Group 2 (21 fishers)
Green – Group 3 (5 fishers)
Blue – Group 4 (4 fishers)

Paper chains of stick men were placed inside each circle to further indicate the number of fishers in each group. Models of the research priorities, above, were placed in position, according to the Venn Diagram layout. The final exhibit is depicted in Figures 56 and 57.

Akin to the 2-dimensional Venn Diagrams, this method of presentation has the advantage of clearly showing the level of agreement/disagreement between set of fishers. However, it also has the inability to exhibit the relative importance of specific research priorities for each group. The most advantageous features of this method, is undoubtedly its aesthetic appeal, novelty value, interactive aspect and sheer size that collectively, it is suggested, provoke interest and engage the viewer for longer.

7.5 Feedback

In order to compare and contrast the relative worth of the above experiments, an exhibition was held in early February 2004, where the finished pieces were displayed alongside one another. To clarify these pieces were: the initial table of figures (Table 8); the colour chart (Table 9); the circles with icons (Figure 52); the 2 Venn Diagrams (Figures 54 and 55); and the 3-dimensional installation (Figures 56 and 57). Stakeholders in the project, fishers and representatives of the other stakeholder groups, particularly those encountering problems with the questionnaire (see section 6.7.2), were invited to view the exhibits. In addition, members of the public, the local secondary school and other postgraduate students from ICIT were invited to view, the exhibitions being advertised on local radio.

Figure 56. Discussing the 3-dimensional installation

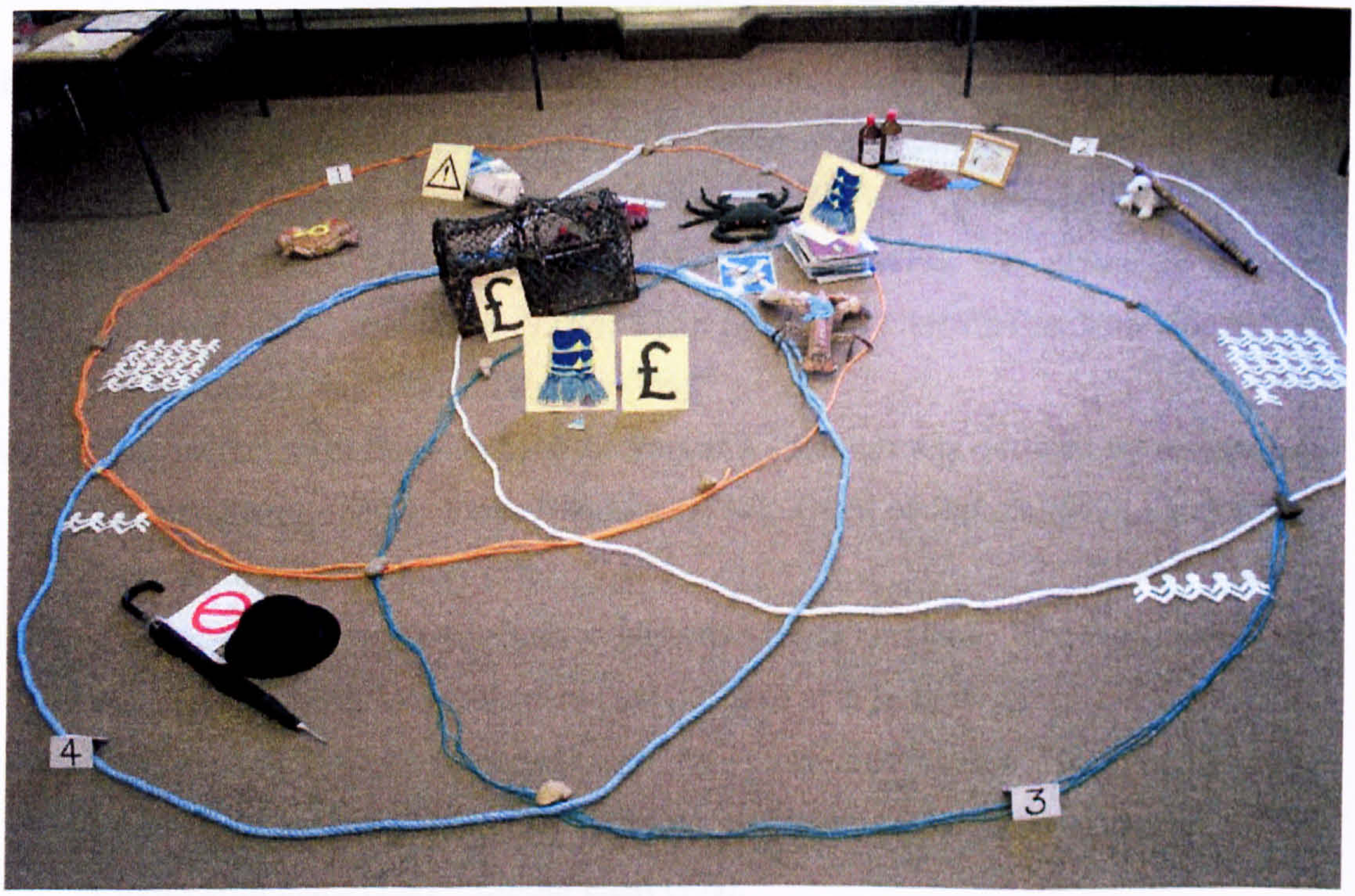


Figure 57. 3-dimensional installation

A brief explanation of the theoretical progression through the various experiments was given to visitors, using the displays as visual aids. This was followed by a brief questionnaire for visitors (see Appendix 12). This questionnaire was used to assess which method: a) was most preferable in aesthetic terms, b) communicated the most information and c) was most transparent and accessible. Further questions, amongst others, were used to qualify and quantify how the use of arts-based media had influenced their preferences.

7.4.3 Questionnaire results

A total of 30 responses to the questionnaire were received. Of those compliant responses (answering questions correctly), the following quantitative results were assimilated.

i) 100% of respondents stated that 'Yes' it was easy to follow the thought progression through the various arts-based methods of interpretation.

ii) The order of descending transparency and accessibility of the methods of interpretation used was deemed by respondents to be: Venn Diagram; Installation; Circles with icons; Colour chart; Table of figures. 43% of respondents cited the Venn diagram as the most transparent and accessible method of presentation.

iii) 53% of respondents cited their chosen (most transparent) method of presentation as being their preferred display, with 47% choosing an alternative method. Of the 53%, the preferred displays were: Installation (80%); Colour chart (50%); Venn Diagram (38%); Table of figures (25%). Of the 47%, the alternative displays preferred were: Installation (72%); Venn Diagram (7%); Circles with icons (7%); Colour chart (7%); Table of figures (7%).

iv) The method most likely to hold the viewer's attention was outlined by respondents as: Installation (68%); Venn Diagram (14%); Table of figures (9%); Circles with icons (5%) = Colour chart (5%).

v) The method most aesthetically attractive, was outlined by respondents as: Installation (79%); Venn Diagram (16%); Table of figures (5%).

vi) The method which communicated the most information, was outlined by respondents as: Installation (39%); Table of figures (25%); Venn Diagram (21%); Circles with icons (7%) = Colour chart (7%).

vii) 93% of respondents agreed being able to walk around the 3-dimensional installation was an advantage of the exhibition experience, 7% disagreed.

viii) 93% of respondents claimed there was no aspect of the exhibition that they did not understand. 7% specified there was one or more aspect that they did not understand, most commonly the model representation of the v-notched Lobster tail.

ix) 73% of respondents had not seen any of the information on display before. Of the 27% who had, 100% claimed they had a better understanding of the information after viewing the displays.

x) The average extent to which the use of arts media had influenced respondents' answers to questions was determined to be 4 out of a possible 5.

7.5.2 Qualitative results

The following table (Table 12) summarises the above results of the questionnaire in simple qualitative form.

Table 12. Qualitative (installation viewing) questionnaire results

Attribute of method	Most common choice
Most transparent and accessible	Venn Diagram
Preferred display	3-dimensional installation
Most likely to hold the viewer's attention	3-dimensional installation
Most aesthetically attractive	3-dimensional installation
Communicates the most information	3-dimensional installation

Reasons for preference of one the five forms of arts-based interpretation over the others, given as part of the questionnaire, are listed below.

3-dimensional installation:

- Open view of subject
- Proportions clearer
- Involving and entertaining
- Good for a young audience
- Easy to visualise consensus between sets
- Better impact

- Easier to understand
- Interactive
- More interesting
- Simplest representation of information
- Well set out and easy to follow

Venn diagram:

- Most easy to interpret by the eye
- Familiarity with technique
- Easier to understand

Colour Chart:

- Most easy to comprehend

Table of figures

- Complete accuracy
- Contains actual data

Reflected in the volume of comments concerning the installation, is its obvious favour in terms of overall preference. Despite this fact, the Venn Diagram was chosen as the most transparent and accessible means of presentation. The majority of positive comments regarding the installation relate to the interactive nature of the display and its consequent 'fun' and 'entertaining' aspects. Many comments also pertain to it being the simplest means of presentation. Similar comments regarding simplicity were also made regarding the Venn Diagrams and Colour Chart. With regard to the Table of figures, the presentation of 'actual data' was seen as its most advantageous attribute. No comments, and hence preferences were made concerning the Circles with Icons.

Additional comments were made, relating to a question, which asked 'why walking around the installation was potentially an advantage?' Comments included the following:

- Gives a more lasting impression
- Brings topics to life
- More interesting than displaying information on paper
- More saturating

Aside from the opinions and comments captured within the questionnaire responses, many more general comments were made throughout the duration of the exhibition. Elements of this discourse and more specific comments from viewers are explored below.

It became obvious that the majority of viewers preferred the 2-dimensional Venn Diagram in terms of its accessibility. The most common reason given for this preference was the ease at which it was possible to see the agreement (overlap) between clusters. It was suggested that although the 3-dimensional installation was a direct interpretation of the Venn Diagram, it in some respect made the issues more confusing. Possible reasons for this deduction were suggested as: the lack of contrasting colours as a background for the four sets (circles), the relative size/scale of models and greater difficulty in determining where circles (sets) overlap, marked by thin rope boundaries. However, it was suggested that the ease of retrieving information from the Venn Diagram was a direct consequence of having already seen/walked around the installation, it representing the visual centrepiece. (N.B. Vice versa, was the 3-dimensional installation favoured by certain viewers only because they had experienced the Venn Diagram?).

It was the opinion of several viewers that the table of figures represented the most accurate method of presentation of the data. This was conjectured owing to the fact that the table contained the most information, in numeric form, relating to the relative importance of priorities for each group of fishers. However, with the majority of such deductions being made by those with a scientific/academic background, this could be deemed perhaps the rather more 'educated view'.

The last in a series of visual experiments into the potential of art to convey scientific messages, it was somewhat assumed that the 3-dimensional installation would provoke the most positive response and be the most accessible means of communication. Feedback from viewers suggests that the installation the most preferred display and communicating the most information. However, it was the Venn Diagram that was thought to be the most accessible method of presentation. It is conjectured that these methods combined, provoked the greatest aesthetic response in viewers, the installation in terms of its multiple dimension and the Venn Diagram in terms of visual contrast.

It was suggested that the main advantage of the installation was that it engaged viewers' attention and hence provoked a more in depth discussion. Furthermore, it was suggested that the installation was potentially accessible to an extremely wide audience, with a spectrum of ages and backgrounds being capable to understand the concept and inherent messages communicated. Such comments suggest a potentially high worth of such a 3-dimensional exhibit as an educational tool, or an interactive exhibit, which could be used, for example, at events such as local 'Science Festivals' or 'Environment Days'. It is the invitation to explore, permitted in this case, by the 3-dimensional display that visual arts can provide and science cannot. Science must allow for such features if it is truly serious about engaging society in the scientific discourse.

Despite a generally positive response to the installation and this use of arts-based media, questions concerning its wholesale application within the field of scientific communication were raised. The use of models, in this case to display research priorities may perhaps detract from its original message, i.e. agreement among fishers. Concerns over how items of information were made to be more 'fun' in an interactive way may effect a loss of scientific credibility. In addition, with models of unavoidably varying size and scale, it was suggested that greater size might imply a greater importance of certain priorities than others, when the actual relationship might be quite the contrary.

Certain viewers suggested that an understanding of the inherent messages captured by the 3d installation was only possible after explanation of process that preceded it. In other words, standing alone, such a model would not be as transparent or easy to follow. It was suggested those with no previous experience of the items on display or issues raised, may be baffled by the viewing experience. In contrast, those with a deep understanding of the issues, primarily fishers, may feel patronised by the arts-based interpretation used.

Comments were made regarding the amount of information displayed comparatively by the various methods of interpretation. It was suggested that at each stage of the process (evolution of a more radical method), information had been lost as a consequence of simplifying the presentation. Furthermore, making the information more 'fun' to comprehend may have detracted from the actual data on display.

7.6 Suggested improvements to the method

The 3-dimensional installation remains the quintessential radical approach discussed in this chapter. During the process of questionnaire, feedback and discussion, a number of potential alterations/improvements to the installation arise as ways in which to increase its potential application to other interpretation situations. An example would be the provision of more supporting information e.g. handouts. This would mean explanation of the process that took place prior to arrival at this presentational 'end point' would not be necessary. Indeed, the various pieces of interpretation could then stand alone as individual displays.

It was further suggested that raising the relative height of the models comprising the installation could be used to indicate the relative importance of priorities. In addition, decreasing the size of the exhibit to make it more portable, or creating a museum 'case' type format, were suggested as ways to increase its potential application to other interpretation scenarios.

7.7 Conclusions

It was a primary aim of this series of experiments to make scientific information consensible to a wide audience of environmental stakeholders. However in light of the evidence, it is conjectured that the success of this type of arts interpretation fundamentally depends on the nature, not size, of the target audience. For example, the installation, compared with other methods, was found to be interpretable by the widest audience. However, the objectives of the display became blurred for some members of this audience, maintaining the need for an accompanying dialogue (further interpretation). Therefore, application to a more specific user group would have increased its relevance and tangibility. For example, if fishers, scientists or schoolchildren alone were the designated target audience, exhibits could be tailored accordingly. This would further reduce the risk of patronization or confusion where it could possibly be felt and promote engagement and improve understanding of more relevant subject matter.

Contrast arose as the most successful arts-based technique for increasing accessibility of the subject matter. The Venn Diagram, with its ease of assimilation by the eye, owing to vivid primary colours against a white background, led to the greatest visual effect. In contrast, the most advantageous feature of the 3-dimensional installation was found to be its size. By creating an exhibit which could be explored to fully appreciate its content, the amount of time viewers were likely to spend in contemplation of the visual material increased, thereby increasing the amount of retrievable information. In this way the installation effected a greater 'contemplation period' and subsequently greater information saturation of the science in view. In addition, the added fun/entertaining aspect to the display, exaggerated the information saturation of the viewer and made it more appealing, particularly to younger members of the audience.

In general, it was found that the greater extent, to which elements of art was applied to the information on display, the greater its accessibility. More information was communicated to the target audience as a direct consequence of the increased contemplation period, facilitated by more visual art. Both the Venn Diagram and the installation held the attention of the viewer more readily than the other methods of presentation used. Both methods evoked the greatest aesthetic response in the viewer. All methods evoked an emotional response. Any further categories of response evoked in the viewer, it is suggested, would require a greater conceptual understanding of both the science and the art on display i.e. the viewer being either a scientist or artist.

Scientific tools, in this case the Table of figures and to some extent, the Colour Chart, were unanimously unfavoured by the target audience. N.B. Although the Venn Diagram is used regularly by science, it is essentially a visual tool. The Table, it was found, could not hold the viewers' attention as easily, or for as long as methods of interpretation incorporating art. This said, the Table of figures was viewed as having the highest level of (scientific) accuracy i.e. it presented actual numerical values and displayed the most 'useful' information.

A certain level of (scientific) accuracy was ultimately sacrificed by removing any values from the artistic representations of the Table. This was accentuated by focusing more on an aesthetic form and function of the display. However, it was not a priority of the investigation to display the greatest volume of information. The priority instead, was increased accessibility and consensibility of science for a particular target audience, through a process of arts based interpretation. More scientific methods of presentation of data are more likely, it is suggested, not only to baffle anyone outside the scientific community, but remain unable to grab their attention and be sooner dismissed.

It is proposed that the representational approaches used may still be too radical for the majority of scientists and academics to contemplate. Indeed, focus on the visual characteristics of scientific information, providing invitation to explore and creating an element of entertainment, may not be taken seriously by science. This is perhaps particularly true of fisheries science, often too institutionalised to look objectively at innovation. This will ultimately limit possible application of the method elsewhere.

Future application of the method ultimately requires its perfection through continued experimentation. As the need for accompanying dialogue for the visual information remains, the displays unable to act as 'standalones', alterations may be necessary. However, it is suggested that such methods are applied to other scenarios where there is a) a marked demand for new presentational vehicles and/or b) a need to increase the accessibility of scientific information for a particular target audience. Art may play the crucial role in catalysing a process, which generates improved scientific understanding.

In summary, it is conjectured that the ability of arts-based representation to increase understanding of science for the non-scientist, is an infinitely valuable contribution to the knowledge, arising from this set of experiments. However radical, the intrinsic value of increasing the contemplation period of science, for those to whom contemplation is non-essential, cannot be overlooked.

7.8 Links to a further case study

Although this series of experiments has established that representation through art can increase the consensibility and accessibility of scientific information that representation through science cannot, they still pertain to relatively uncomplicated scientific information i.e. the research priorities of fishers. There remains the challenge to focus on more highly scientific subject matter, that is, more complicated information with regard to the scientific language it uses. This should be made relevant to a similar target audience, where science is viewed with skepticism. Only then will it be discovered if there are indeed limits to what art can represent and can effect in the realms of consensibility of science.

As with the Project Fisher study, this set of experiments has not yet derived a rational, participatory approach whereby outsider stakeholders in science, namely fishers, can actually become involved in the representational process. Wherein the case of the 'Art in the Finstown Marine Environment' study, the target audience was actually involved in the creation of arts interpretations of science, fishers have yet to co-operate in such a process. Lack of trust and an uncertainty of science predominate. Can participatory arts-based representation only operate in circumstances of mutual agreement and lack of conflict?

Chapter 8. FISHERIES STOCK ASSESSMENT MODELS: ENHANCING CONSENSIBILITY

'Fisheries stock assessment models are, at best, a guess and are completely destroyed by observation. They are in fact, totally unscientific.'

Robert Smith, Orkney creel fisher

8.1 Introduction

There exists a need to determine limits to what aspects of science art can and cannot represent. The previous chapters have established that:

- art and participation in creating art can increase the accessibility and consensibility of certain types scientific information;
- increasing the level of artistic compositional elements has a positive effect observational consensibility of scientific information;
- certainty of science and trust are key to participation of outsider stakeholders in the process of arts representation; and
- participation of fishers is limited by their lack of organisational capacity.

Using the above as a framework for investigation, this chapter will seek to determine whether artistic representation of more complicated scientific language, in the form of a mathematical narrative, can be represented in an artistic way and indeed, made more accessible. Using fishers as a target audience once more, the scientific subject matter in this instance will be fisheries stock assessment models. Such subject matter was chosen due to its contentious relevance to a target audience of fishers and the fact that scientific models and predictions were previously outlined by fishers and other stakeholders as the aspect of science held in the most negative regard (see section 6.7.4). Not only will such investigation relate to the limits of artistic representation, but to its fundamental role in the search for an alternative, participatory process that can increase scientific understanding and co-operation.

8.2 Quantitative fisheries stock assessment and associated problems

Fisheries stock assessment can be defined as 'the interpretation of commercial catch statistics to estimate potential yields'. In the political arena for example, where key fishery regulatory decisions and catch limits are made, debate often focuses on these simple summary statistics and simplistic, common-sense, models of fish stocks (Hilborn and Walters, 1992).

8.2.1 Stock assessment models and assumptions

A major task of the fisheries biologist is to estimate population parameters. These include stock abundance, growth, recruitment and mortality. Fish stock assessments are also complicated by the biology and behaviour of the fish themselves. The system of a fishery is dynamic and values are known to fluctuate widely, even in the absence of fishing (King, 1995). Nevertheless, these estimations are invariably determined by the application of mathematical models.

In simple terms, analytical models track each 'year class' or 'cohort' of fishes in a stock, through its life history, by the application of equations. Models of systems, have 2 critical features: i) the assumptions necessary for their derivation and ii) the imposition of (stock) equilibrium states. By example, all stock assessment models:

- treat a single stock in isolation from all others and the ecosystem;
- have no spatial dimension;
- treat the fishery as a single system of inputs (recruitment and fishing effort) and outputs (yields); and
- disregard any selective evolutionary changes (Side, 2004).

These combined with often inadequate sampling, data acquisition and data handling techniques contribute to a process, with many (scientifically accepted) shortcomings. For this reason, stock assessment models are often referred to as scientific 'black boxes'.

Stock assessment is a means to force clear and explicit recognition of what model is being used as the basis for choice. However, scientific and management decisions are necessarily based on some predictive model, whether this model is explicitly stated or not. Such circumstances have a number of associated problematic implications for the fishing industry, most notably: widespread distrust of models; distrust of available statistical data; and a lack of expertise in assessment techniques. To exaggerate the problem, in certain political instances; the tendency to accept scientific advice uncritically has been surpassed by the common use of deliberate misinformation as a tactic to confuse debate and delay action (see also section 2.10.4). Indeed, forced through political pressure, fishing authorities often grasp at estimates provided by advisors to satisfy industry interests. In other words, if scientists do not provide answers, someone else will (Hilborn and Walters, 1992).

Furthermore, among the fisheries scientists themselves, conflicts exist between those operating in stock assessment and marine conservation paradigms. The latter can provide an unusual challenge to the former in favouring certain management decisions. An example would be the favouring of no take zones, a management option that conventional stock assessment models are unable to describe (Side, 2001).

8.2.2 The communication problem

More recently, stock assessment can be done on a simple spreadsheet and consequently translated in many forms e.g. via email or Compact Disc. However, such technological advance in scientific communication of models has not advanced communication to the audience of fishers.

Fishermen invariably believe their opinions and perceptions are not respected by fisheries managers and are generally not consulted regarding decision-making. It is rare for stock assessment working groups to have any interaction with fishers at all. Work is published annually and written 'in code' to those with no formal background in fisheries science.

Fisheries scientists commonly accept information is often distinctly lacking, even though fishermen possess a great deal of knowledge and experience, both in terms of what they land for market (*landings*) and what they don't (*discards*). However, the only way scientists can make sensible estimates is by using mathematical and statistical models. Indeed, most fisheries working groups, most often from regional marine laboratories, commonly protest about a lack of resources and have little/no capacity for new science. However, such groups still provide the internationally agreed scientific 'advice'.

The nature of the problem will always mean that the estimates are uncertain to a greater or lesser degree, with the most recent years being the most uncertain. But uncertainty is not a problem in itself, so long as it is acknowledged when fisheries managers come to make their decisions.[45] This does not always occur, particularly in the minds of fishers.

'What can be gained from another expensive laboratory of 'scientists' dreaming up nonsense?' A comment made by an Orkney creel fisher in The Orcadian, Thursday 24th June 2004 highlights the lack of trust fishers have in stock assessment. It is suggested that one of the fundamental barriers to trust in fisheries stock assessment models is their lack of consensibility. Uncertainty in the 'science' of the models, a result of ineffective communication of their nature, derivation and indeed limitations, ultimately creates conflict between scientists and fishers. With few fishers prepared to blindly accept and follow rules and regulations they do not believe or understand, what is the point of a rule if it is non-consensible?

8.3 Rationale

The uncertainty associated with these analytical models needs to be rationalised for fishers, and put into context for fisheries stock assessment as a whole. If fishers could acknowledge the limits of scientific models, this valuable, but uncertain science could become a much more powerful tool. Furthermore, building confidence in scientific

[45] http://www.marlab.ac.uk

modelling, is the essential first step to increasing their accessibility for fishers. With increased confidence, the framework for explanation and interpretation is considerably widened.

In the discussions that took place during the discussion forum developed as part of Project Fisher (see Chapter 6), the need for some explanation and manipulation of stock assessment models was voiced by certain participating, creel fishers. Moreover, some vehicle for the practical manipulation of the models by fishers themselves was requested. This request was taken on board by members of the working group and projected as a case study to run alongside Project Fisher, in order to get feedback the participating creel fishers in question.

The objective of this study was to produce some form of interpretation of fisheries, in this case, lobster stock assessment models, building in the visual criterion. Individual aims of the investigation were as follows:

- to construct a narrative, both written and visual, to increase the consensibility of lobster stock assessment models;
- to visually represent the central concepts of a process of lobster stock assessment, explaining key terms and mathematical derivation of formulae;
- to clearly accept and specify where limitations occur within these parameters; and
- to develop a participatory vehicle for fishers to manipulate stock assessment models.

8.4 Attempting a narrative

Without conceptual grasp of the mathematics behind stock assessment models, understanding of the nature and purpose of the model is impossible. Indeed, understanding of the reasoning behind the theoretical factors of the model cannot be attained without explanation of the mathematical underpinning. It is well established that graphs and tables, graphic and descriptive in nature, are useful and familiar tools to conceptualize data, requiring relatively little existing knowledge. However, models and functions are essentially mathematical and require mathematical understanding.

A key output of this investigation was to produce a narrative, in some form, for Orkney fishers, describing in detail the science behind fisheries stock assessment. As for Project Fisher, the context would be the Orkney Creel Fishery. Certain formats were considered for this visual narrative: comic strip; leaflet; booklet etc. The former two options were rejected for fear of patronising fishers and having limited space respectively. A booklet was chosen, intended to use simplistic and where possible, unscientific language, supported by simple, explanatory figures/visual aids.

The central theme for the narrative was chosen to be Length Cohort Analysis (LCA) as a means of stock estimation. Following a length (surrogate for age) cohort through a fishery, LCA is one of the most common models used by fisheries scientists to analyse the structure of stocks.

Development of a narrative of LCA was ultimately an experimental process. Indeed, it was uncertain at the initial stages of design, whether such a narrative would, or could, be produced in a consensible way. Intended for creel fishers, it was of paramount importance that it be uncontrived and transparent. In this way, derivations of the models and their critical assumptions would be clearly explained. Other key features of the document were outlined as:

- stepwise, mathematical derivation of all formulae;
- visual interpretations of explanatory graphs to display key trends; and
- simple spreadsheets, possible for manipulation by fishers

8.4.1 Life and death in the sea

The document was given the title 'Life and Death in the Sea'. Once the contents of the document (narrative) were finalised, text could be written and supporting visual material produced. Professor Jonathan Side of ICIT wrote the text of the document and the author produced visual material. Where necessary, explanation of the models were based on sampling data from Fisheries Research Services (FRS) Marine Laboratory, Aberdeen, gathered in Orkney during the period 1983-1999. Although other species are mentioned in examples, the majority of data relates to inshore species of brown crab (*Cancer Paguras*). Lobsters and other shellfish are used diagrammatically where appropriate to provide association for creel fishers. The document was completed in July 2004. 'Life and Death in the Sea' is presented in Annex I of the thesis.

8.4.2 Initial feedback

During Project Fisher and prior to the completion of 'Life and Death in the Sea', one creel fisher, Mr. Robert Smith, of South Ronaldsay, Orkney, was provided with an Excel spreadsheet for LCA, designed and produced by Prof. Side (see CD, Annex I). The nature of this spreadsheet permits the viewer to manipulate values of contributing factors. For example, altering the value of Natural Mortality (M), it is possible to observe consequent effects on the theoretical stock assessment (average numbers). Provided with the spreadsheet at that time, Mr. Smith stated he understood the nature of the model and appreciated its sensitivity to fluctuations in the value of M. He concluded such alterations led to a very different value of population numbers and, considering the value of M is largely theoretical, was not convinced of the predictive powers of the model.

8.5 Theoretical 'brick wall'

On contemplation of 'Life and Death in the Sea', it is suggested little has been gained from the exercise of producing a visual narrative, for scientist and fisher alike. For the following reasons, the true value of the narrative is seemingly small:

- The sheer volume is off-putting. Intended originally as a supplement, perhaps a leaflet (a few pages of key text and figures), what resulted is too lengthy and time consuming a read for the average fisher. And yet, all of the content is entirely necessary for complete scientific understanding of the derivation of the model.
- The level of mathematical understanding necessary to make models of length cohort analysis truly transparent is unrealistically high.
- It is perhaps fair to assume the majority of fishers won't understand it.

8.5.1 Limitations of the science

The models and their functions used within the narrative, involved a series of unknowns and assumptions. Assumptions, it can be observed, interplay at most stages within the process of fisheries stock assessment i.e.

i) compilation of fisheries data (and assumptions);
ii) analyses of historical data;
iii) estimates (assumptions) of growth and mortality parameters;
iv) predictions (including assumptions) of yield for a range of exploitation levels (assumed); and
v) derivation of optimum fishing level and maximum sustainable yield.

The following questions arise. Why attempt to explain, in a more accessible way, to an audience of non-scientists, something that is, by its nature, inaccessible to those outside the scientific community? Will consensibility ever really be achieved via lengthy explanation and supporting visual interpretations? It is suggested the answer to the latter will be 'yes' only if the observer is willing to accept the unknowns. But the unknowns are all too crucial. Ultimately, it appears a visual narrative cannot be made based on a mathematical narrative and precision retained. Further limitations of the science (with relation to the narrative) will be discussed in section 8.6.2.

8.5.2 Limitations of art

In terms of representation, the investigation of a narrative for LCA really reached a brick wall in as far as art cannot make accessible all aspects of science. The lack of explanation of the assumptions made by the science and the fact that representation still requires a narrative confer a boundary to representation. Although the graphics employed by the narrative (see Annex I) go some way towards making mathematical functions more 'user-friendly', such visual aids are bound within the framework restrictions of graphs and bar charts. We have, in fact come full circle, where enhancing consensibility of science through art is limited by the non-consensibility of science.

8.5.3 Need for alternatives

In light of the evidence, it is conjectured that any attempt to explain, in reality justify, the nature of stock assessment models is only explaining, or justifying, the actions of scientists. One can only be providing insight into what scientists do i.e. make 'guesstimates' and devise theoretical models. In any case, the components of such models are heavily reliant on computer-based derivation and programming that are inherently non-consensible or 'alien' to the average fisher.

Not only does this undermine the case for arts interpretation of stock assessment models, but it undermines the case for the models themselves. These scientific 'systems' of predictions are seldom seem to correspond to what is seen by fishers, within their own fishery. The need for alternatives arises.

With an unsatisfactory level of resources, in terms of data acquisition, available to working groups of fisheries scientists, the concept for a fisher-driven process presents itself. As it stands, the fishing industry and its management committees are relatively indisposed to innovation, with little sense of being driven by those most affected - the fishers. Moreover, the actions of fishers' organisations are invariably reactive not proactive, with few initiatives of their own. The objectives of these organisations and the science which informs them, must be reset.

8.6 In search of alternatives

The exercise of attempting a narrative of fisheries stock assessment models provided knowledge and experience with regard to the limits of science (its models and predictions) and art (its representative powers). It established that where science is uncertain, art couldn't enhance consensibility. Indeed, that artistic interpretations of mathematical graphs and functions (see Annex I) have little value where such uncertainty exists. By their very nature, an understanding of science is necessary to construct them.

The opportunity arose for trial of a more advanced, participatory, method of arts interpretation of aspects of the narrative, that would not require mathematical understanding to be consensible. Such an investigation would ask the following questions.

i) Could a method of representation be established that fishers themselves could construct and from this, draw their own conclusions regarding the status of stocks? and

ii) Could this method avoid use of any scientific 'black boxes' i.e. models and predictions based on assumptions and impositions?

8.6.1 Experiments with size/frequency distributions

The focus of experiments was chosen to be size/frequency distributions. The catch data used was the FRS data used in Annex I, relating to *C. paguras* populations in Orkney. Simple analysis of catches, as an alternative to LCA, presented as size/frequency distributions, were proposed to represent a method by which fishers themselves could investigate the structure of stocks and provide insight regarding their stability.

Thermal imaging

Within Annex I, certain figures, were represented as 'thermal images'. These images were used to represent size/frequency distributions of *C. paguras* catches, male and female, by month and year, across the time period 1983-1999. By using vivid, contrasting colours, 2-dimensional graphs were converted into seemingly 3-dimensional 'relief' images (see Annex I). Though assumedly easier to interpret than line graphs of the same data, such models, it is suggested, could not be constructed by the average fisher.

'Bead and stick' models

The sequential next step arose as actually building these 'relief' images in 3-dimensions. A direct interpretation of the thermal images, 3-dimensional relief models were proposed to represent a presentational format fishers could construct themselves. In this way, fishers could participate in the creation of arts-based interpretation of fisheries data, something that has been unattainable thus far in the research.

It was crucial to find a 3-dimensional format suitable to present the data, with the key element being the models reduction to individual symmetrical units or 'building blocks'. The three dimensions of the model were 1) time (year) – horizontal axis, 2) size (carapace width in mm) – perpendicular axis and 3) frequency - vertical axis. Colours of the rainbow (red, orange, yellow, green, blue, indigo, violet) were chosen to highlight frequency of varying degree i.e. the higher the frequency the more colour would be used from the spectrum.

Choice of symmetrical units, available in rainbow colours, from which to build the models were limited. One possibility was single-stud Lego® bricks, mounted on a base plate. However, limited availability of these single bricks prevented this option. The chosen, most favourable, alternative was chosen to be wooden beads, threaded on wooden skewers, mounted on a wooden board. This model would resemble an 'abacus-like' structure, in multiple layers. All colours of the rainbow were available in wooden beads, apart from violet, which was substituted by brown. Each colour (in the reverse order (brown, indigo, blue, green, yellow, orange, red) was chosen to represent an interval of frequency, ascending in units of five or thereabouts. In other words, 0-5=brown, 6-10=indigo, 11-15=blue etc.

The model was constructed in three replicates, to represent different size/frequency distributions as follows:

- Replicate 1 – *C. paguras* females by year (1983-1999)
- Replicate 2 – *C. paguras* males by year (1983-1999)
- Replicate 3 – *C.paguras* females averaged by month (Jan-Dec)

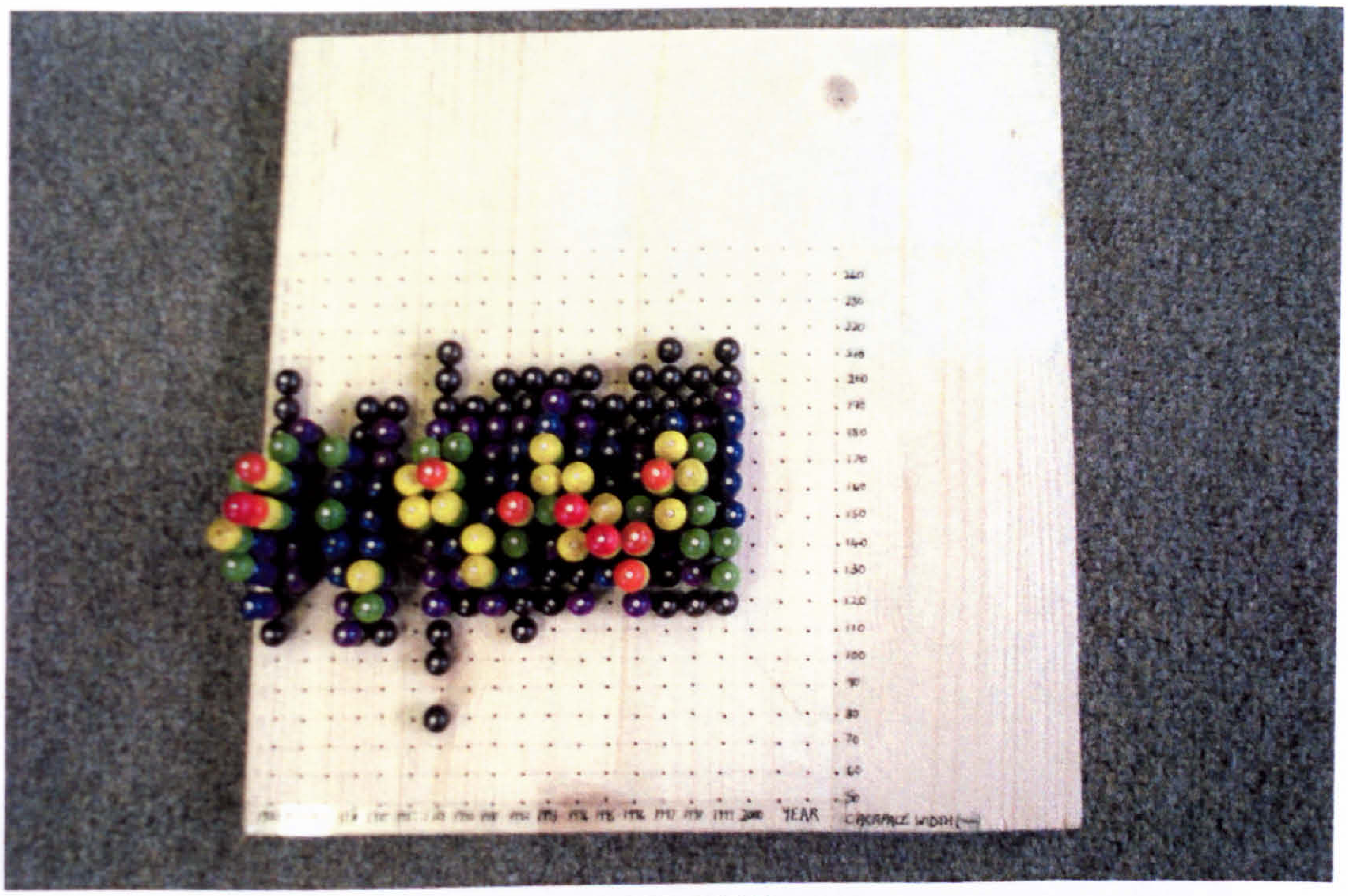


Figure 58. *C. paguras* females by year (1983-1999)

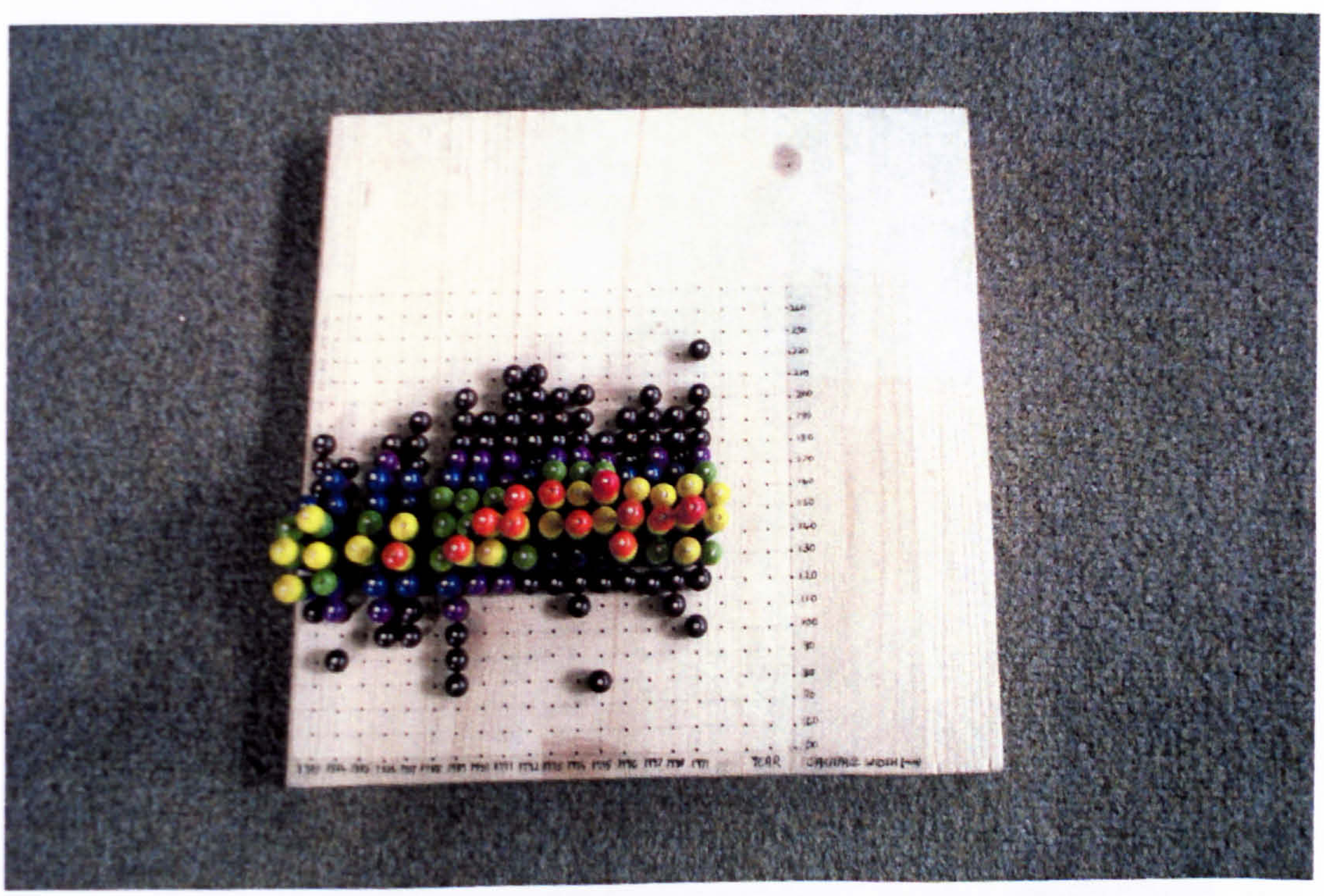


Figure 59. *C. paguras* males by year (1983-1999)

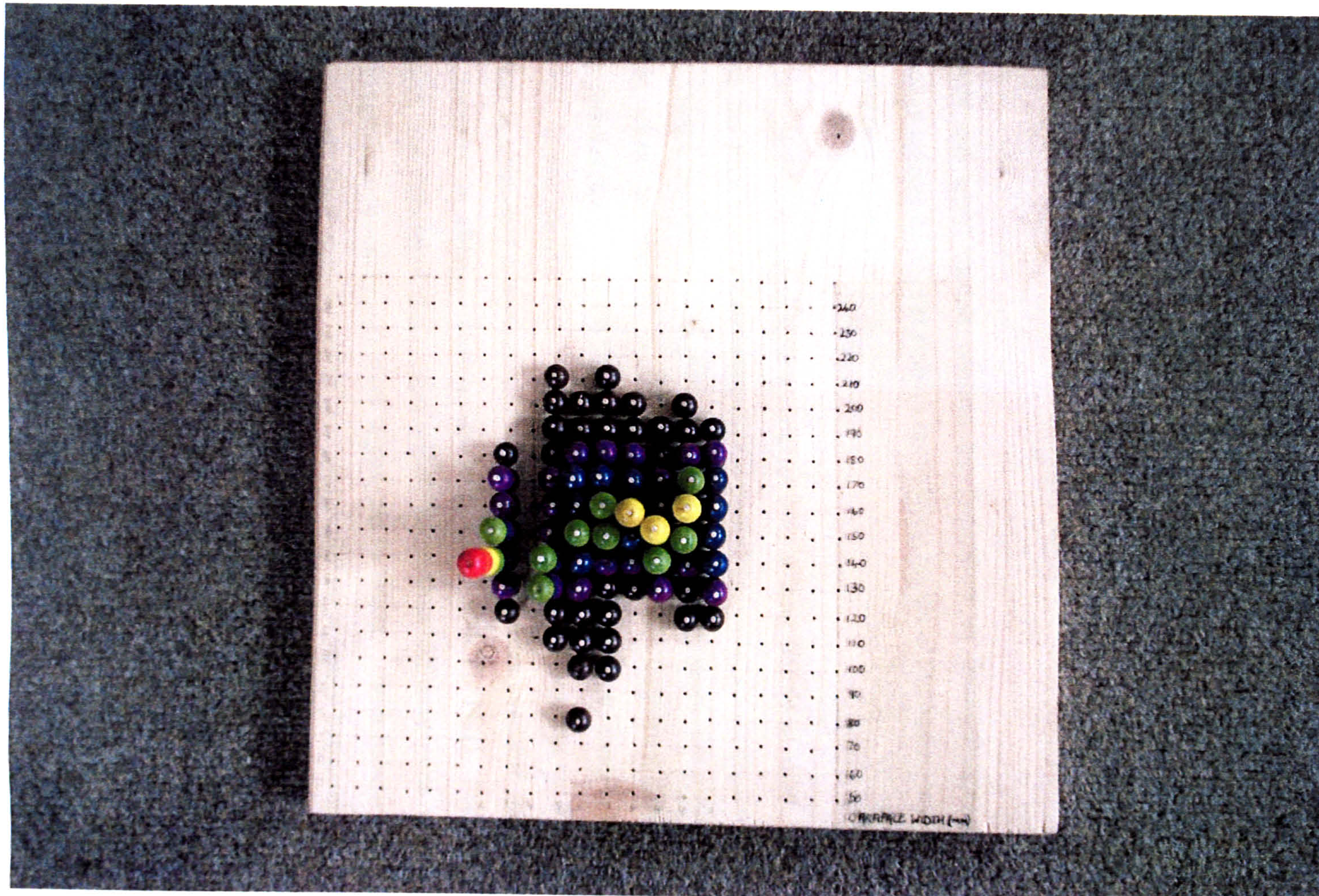


Figure 60. *C. paguras* females by month

Three replicates were produced firstly, to highlight the inadequate features of the data. Secondly, comparison of the three models would reinforce the representational advantages of such a format. Thirdly, viewing replicates in synchrony would provide a more detailed picture for fishers of the status of *C. paguras* stocks in Orkney and their potential stability. The replicates (1-3 above) can be viewed in Figures 58-60 respectively.

8.6.2 What the 'bead and stick' models show us

The 'bead and stick' models confirm the limitations of fisheries science (modeling) discussed in section 8.5.1. Yet perhaps the weakest aspect of the models was the data used as example (see Annex I).

For LCA, the model presupposes a data set over a long period of time. So for these purposes, the FRS Marine Laboratory data is sufficient (collected during the period 1983-1999). Indeed, for the monthly plots, averaged over the 16 years, the data is irrefutable. However, when presented by month, for example the size/frequency distribution of *C. paguras* females (see Figure 60) the data is hugely influenced by the month of year samples were taken. In this way, the data is valid over a long period of time, but not for one specific year. This is ultimately a consequence of a lack of resources available for FRS to take regular samples in Orkney. Furthermore, the work of ICIT Ph.D. student, Jeannine Hazlehurst, has elaborated that sample means taken from different ports within Orkney even during the same month may show significant variation. With fisheries management predictions and catch changes in Orkney, often made on a yearly basis, this is a startling observation. Further flaws are observed in the acquisition catch data. With an impossible ratio of male: female *C.paguras* individuals (see Table g) Annex I), such data cannot be a true representative of the stock. These flaws in the acquisition of data, combined with the imposed 'unknowns' within the models, highlight the uncertainty of a science and the challenge faced by any process of arts interpretation.

8.6.2 Some feedback

The 'bead and stick' stock models and their worth as visual narratives were discussed at a meeting held at ICIT on 2nd January 2004. Present at the meeting were Alistair Carmichael, the Orkney and Shetland MP, Orkney creel fisher Robert Smith, and members of ICIT staff and PhD students. Individuals were asked to give their opinions of the models and comment on their accessibility. It was suggested at the meeting, that fishers could recreate these models with relative ease, requiring their own catch data to be inserted into a simple spreadsheet only.

In general, those consulted perceived the models as:

- more accessible than their 2-dimensional counterparts (see thermal imaging, Annex I);
- readily able to provide a clear trend of stability of *C. paguras* stocks over time i.e. no evidence of overfishing (no shift to smaller length frequencies);
- able to display the data's high dependence on month samples were taken;
- visual displays which could be added to over time;
- a method which could be replicated by fishers themselves, more easily than a process of analytical modeling; and
- more aesthetically attractive than 2-dimensional graphs and figures.

8.7 <u>The alternative</u>

8.7.1 A process

With a method established of how fishers could more readily and simplistically display assimilated data regarding a stock over time, there evolves the potential for fishers to develop their own process of sampling which would facilitate the method. Indeed, considering the shortcomings in marine laboratory data acquisition and handling outlined by the narrative (Annex I), existing methods such as LCA, undertaken by fisheries working groups, need radical rethinking in terms of their objectives and the reasoning behind them.

What arises, as a more valuable exercise, is a programme of fisher-led sampling and analysis. Considering the lack of resources available to fisheries scientists to take regular samples, both temporally and spatially, the obvious alternative would be for fishers to collect their own samples and assimilate the gathered evidence. With unlimited access to data, it could be collected via a simple logging system. Art-based representation of data could interplay by visually interpreting the data for fishers and other stakeholders, in a method such as the relief models (above).

The proposed alternative process has a number of advantages:

- the data would be irrefutable (if provided accurately);
- unrestricted access to data would permit 'real' annual assessments of stocks;
- fishers would have 'ownership' of the data;
- it would promote mutual agreement among fishers and greater trust in science;
- the data could be used by fishers as a bargaining/debating tool in discussions of regulation and management;
- it would involve no assumptions or unknowns;
- it would require few resources e.g. samples taken on board ship or organised through the merchant fishers; and
- it could be used to investigate lobster stocks which are thought to be in decline in Orkney.

8.7.2 Re-identification of roles

Such a 'bottom-up' programme of research into the fishery would benefit the fisher in a number of ways. Firstly, only a few people would need to volunteer their efforts for such an approach to be successful. Secondly, it would require minimal structure that: takes advice (only) from scientists, uses (minimal) bureaucracy as a tool and allows fishers to dictate their own requirements of science. Indeed, at the meeting 02/07/04 (see section 8.6.3), the concept was proposed to Robert Smith, a characteristically skeptical (with regard to science) representative of Orkney Creel fishers. After discussion of the practicalities, Mr. Smith offered his opinions. In dispute of the process, he firstly voiced concerns that the process of analysis of collected data would be time-consuming. Secondly, he suggested such a process would require better marketing and media support in order to be respected. However, in support of such a method, Mr. Smith suggested that if fishers can collect data, in a way it will be recognised, it would be a good idea worth pursuing.

A fisher-driven process of investigation into the fishery would require re-identification of the role fisheries scientists play in programmes of stock assessment and resulting management. Currently there exists a predisposal of scientists to stray from science to policy-making, setting and imposing rules. Furthermore, where, for example, the oil industry sets its own agenda for scientific research whereas in the fishing industry, scientists set the agenda. This predicament must change if a fisher-led process of research is to be facilitated.

The new role for scientists must be one of listening and articulating, advising fishers, perhaps on a regional basis, instead of deriving and imposing rules to follow. Scientists must merely catalyse this process, which brings stakeholders together into co-operative dialogue, and promotes the emergence of alternatives (Side, 2004). Ultimately, if we need information – we need scientists. Science will always provide information. There will always be 'experts' and 'specialists'. The new challenge is how scientists articulate and present this information to the target audience. Ultimately, the actual science can only benefit from such reshaping.

8.7.3 Problems may still exist

It is understood that any programme of fisher-led sampling must come from fishers in the first instance and once established, seek to be inclusive of all fishers (Side, 2004). However, whether this is, in fact logistically possible is uncertain in the current fishing climate. The process requires a capacity that few fishers and fishers' organisations have at the present time. Such circumstances are further exaggerated by rivalry and suspicion among fishers and fragmentation of (and between) national organisations of fishers. With a necessity for the process to be built on trust and mutual agreement amongst fishers, making real progress with such a 'bottom-up' initiative is severely limited. Furthermore, when asked at the meeting 02/07/04 (see section 8.6.3), whether or not governments could assist in building fisher's organisational capacity, Alistair Carmichael MP suggested he would be skeptical.

Well-organised, strong fishers' organisations are necessary to co-ordinate the alternative, participatory approach. Currently there are no such organisations in Orkney. For example, the Orkney Fisheries Association has fewer than ten members, and as some fishers would suggest, has no mandate to speak on behalf of Orkney fishermen on mass. Although Project Fisher (see Chapter 6) established, that gathering the opinions of fishers and highlighting consensus are possible, it also highlighted the difficulties in such a process. Ultimately, the developments of alternative approaches cannot occur until the problem of lack of organisation amongst fishers is resolved.

8.8 Conclusions

This final case study of the thesis has fostered a number of interesting outputs, practical and philosophical. Development of the narrative 'Life and death in the Sea' established that enhancing consensibility through words and pictures, of science, complicated in terms of its language that requires a scientific background of the reader/viewer is fruitless. Indeed, such endeavour may have the opposite intended effect i.e. it will reinforce the uncertainty of science. Trust and subsequent participation in science will not result where there are assumptions and unknowns.

Previous chapters established that science needs an alternative to numbers to engage, provoke insight and communicate that insight to others. Visual arts representation may be that alternative. In this study, 3-dimensional models were found to be a vehicle through which the target audience can participate in such representation. Real understanding of science and the pursuit of reliable scientific information requires inclusivity. Focusing on the process through which this information is assimilated, challenging the current process through which science is carried out (and by whom) and redefining the role of science and scientists may achieve this ultimate goal.

To put this in context, if the fishing community, in this case – Orkney creel fishers, leave it to government and the science which informs it, to make decisions, reform is the ultimate outcome e.g. regulating orders. Only fishers, with adequate capacity, mutual agreement and participation, can change the course of the scientific process, which precedes the imposition of rules.

Chapter 9. DISCUSSION

This chapter seeks to: compare and contrast lessons learnt from the case studies; determine their contributions to our understanding; derive meaningful conclusions regarding the relationship between marine science communication and the visual arts; and make suggestions regarding an alternative participatory approach to representation of science.

9.1 Summary of case studies

9.1.1 Key contributions

Table 13 (below) highlights the key features of each of the case studies, comprising this research: Art in the Finstown Marine Environment (Chapter 5 - referred to as AFME), Project Fisher (Chapter 6), Radical Ideas (Chapter 7) and Fisheries Stock Assessment Models: Enhancing Consensibility (Chapter 8 and Annex I).

Table 13. Summary of key features of the case studies (Chapters 5-8)

Case study / **Features**	**AFME**	**Project Fisher**	**Radical Ideas**	**Enhancing stock assessment models**	**The Ideal***
Divergent stakeholders	No	Yes	Yes	Yes	Yes
Conflict among stakeholders	No	Yes	Yes	Yes	No
Certainty of science	Yes	Yes	Yes	No	Yes
Complicated science	No	No	No	Yes	Yes
Trust/stakeholder agreement	Yes	No	No	No	Yes
Willingness to participate	Yes	Yes	Yes	Yes	Yes
Participation in art	Yes	No	No	No	Yes
Art increases understanding	Yes	Yes	Yes	No	Yes

* Alternative participatory approach as discussed in the following sections

Shaded areas of the table highlight the desirable features of an idealistic participatory approach to visual arts representation of marine science. The conceptual model of the ideal participatory approach can be viewed in Figure 61. Although all case studies of this investigation reflect the ideal approach, in that they complete the feedback loop, the way in which they satisfy the criteria of the conceptual approach varies significantly.

With reference to Table 13 and Figure 61, the key elements of the respective case studies were as follows. AFME referred to a situation of little/no conflict among the target audience, in relation to science and scientists. This enabled the community to set their own agenda (for arts representation of science) and find agreement among stakeholders. This established trust, allowed for belief in/certainty of the science presented. The community directly participated in the creation of items of arts interpretation, which led to a shared understanding of locally relevant marine science.

Project Fisher referred to a situation of intense conflict between the scientific community and a divergent stakeholder group. Although the target audience set the agenda for visual interpretation, disagreement and a lack of trust among stakeholders was observed. Belief in/certainty of science was observed purely by way of the volume of response to the questionnaire. Although fishers did not actively participate in the arts-making process, they did suggest a willingness to participate in the project. Furthermore, creation of arts interpretation of the fisheries science could not have taken place without the input of fishers. Increased understanding was achieved with regard to a number of shared research priorities amongst fishers. However, skepticism of scientists, noted in their lack of attendance and comments at meetings and lack of organisation remained the underlying barriers to participation of fishers.

The chapter, Radical Ideas, was a further investigation of the accessibility of ideas elaborated by Project Fisher. The study established that increasing the extent to which elements of artistic composition are applied to scientific information could increase shared understanding of science among the target audience. Although direct participation in creation of arts interpretation was again not facilitated, the concept for arts interpretation was determined by fishers.

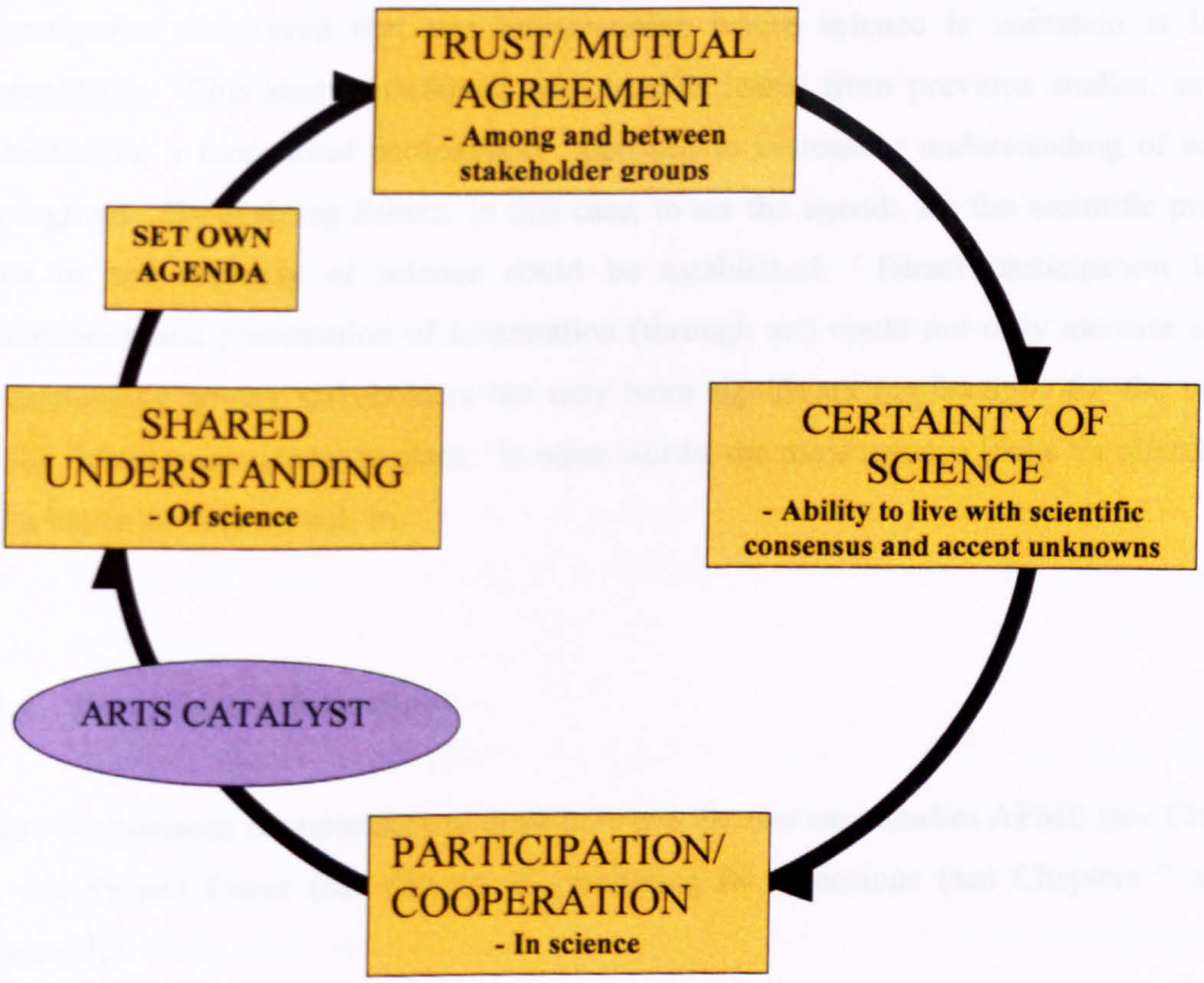


Figure 61. A conceptual model of the participatory approach to visual arts representation of marine science

Chapter 8, in attempting to enhance the consensibility of fisheries stock assessment models, regarded arts-based interpretation of more complicated scientific language. Such investigation discovered that arts interpretation where science is uncertain is largely unprofitable. This study, combined with lessons learnt from previous studies, saw the potential for a more ideal participatory approach to increasing understanding of science through art. By enabling fishers, in this case, to set the agenda for the scientific process, trust in and certainty of science could be established. Direct participation in the assimilation and presentation of information (through art) could not only increase shared understanding among stakeholders but may have significant implications for the way in which fisheries science takes place. In other words, the more science looks for alternatives – the better the science will be.

9.1.2 Parallels and distinctions

Some comparisons are necessary to draw between the two case studies AFME (see Chapter 5), and Project Fisher (see Chapter 6), including its extensions (see Chapters 7 and 8 {Annex I}).

For both case studies, it was concluded that use of the visual arts was an effective interpretation tool for aspects of marine science. To qualify, artistic display methods applied to scientific information, in both cases, led to its increased transparency for the stakeholder group in question. However, in the case of AFME, it was possible to show more clearly the effects of integrating arts into a programme of marine interpretation because full participation of the target audience in the creation of art was virtually guaranteed, owing to a lack of conflict and the existence of mutual agreement and community organisational capacity. In the case of Project Fisher, fishers were found to be willing to participate in a programme of research. However participation in the creation of art was logistically difficult to achieve, owing to a lack of trust, lack of mutual agreement and lack of organisational capacity.

The AFME methodology represents a more simplistic and hence easier test of stakeholder perceptions of marine affairs. With a defined end 'product' i.e. the Ouse Walk, a previously desired resource, for wholesale community ownership, stakeholders were more likely to participate in a compliant manner. In the case of Project Fisher, there was more potential for fishers to be disillusioned with the process, the end product being undefined, it being their decision whether or not to pursue with future research.

It must be noted at this stage of comparison that the scientific, marine issues for interpretation were very different in the case of AFME compared with Project Fisher. In AFME the background for interpretation was a unique local marine environment, a tidal lagoon, to which the stakeholder group had assigned environmental value. The project was ultimately therefore one of local ownership. Contrastingly, in the case of Project Fisher, the framework for interpretation was a contentious political arena, fisheries science, under managerial crisis, which was likely to provoke a confrontational approach in the stakeholder group.

More positive views about science, in particular scientific facts and data, and an unequivocal desire to find out more about science in general was more strongly felt among fishers. The stakeholders participating in AFME displayed a more ambiguous view of and desire to find out more about science. This has implications for future development of a participatory interpretation approach involving fishers as the target audience. However, fishers' perceptions of fisheries science, in particular, were highlighted as much more negative. This was most likely a predisposed skepticism of fisheries scientists and managers and their imposition of unfavourable rules.

Fishers, like those participating in Project Fisher, commonly deemed unapproachable by the scientific community, displayed widespread agreement on research priorities where more disagreement was expected. The most conflicting comments however, received from either of the case studies were as a consequence of the Ouse Walk, the end product of AFME. Issues of land ownership were more contentious than predicted and brought with them conflict-laden disputes between a certain member of the Finstown community and the local authority. The stigmatically uneasy relationship between scientists and fishermen did not lead to conflict-laden dispute, but more so enthusiastic debate. This observation of the origins of conflict highlights the unpredictable nature of environmental projects, especially where externalities are involved.

The primary case studies contrast how the potential for marine interpretation is greater in small-scale local community scenarios as opposed to diverse stakeholder groups. In other words, the extent of measurable application of a visual narrative to scientific information was far greater in AFME (target audience organised and represented) compared with Project Fisher (target audience unorganised and underrepresented). The underlying question remains, how can a small rural community have better organisational capacity than the large-scale Orkney Fishing community? Indeed, if working groups of fisheries scientists, such as the ICES (International Convention on the Exploration of the Sea), can be in mutual agreement and organised in order to present one 'united view', why can't the fishing sector? Lacking the organisation to pursue the results of Project Fisher, it is concluded that target groups with organisational capacity can be the only audiences for successful visual representation of science.

9.2 Providing answers to research questions

Drawing on the evidence of the compiled case studies, the following answers are suggested to the original research questions.

9.2.1 Can artistic methods of presentation increase the accessibility and societal relevance of marine scientific information?

Arts-based techniques used during AFME promoted insight and understanding, which engaged further interest in marine science. This desire to find out more about marine affairs was a direct consequence of providing visual inspiration and restating the importance of a local marine environment. However, this poses the question of whether or not interest was a consequence of local, intrinsic, environmental ownership and ownership of the end 'product' i.e. the Ouse Walk or the arts interpretation.

Largely the target audience of AFME reacted positively to the project, enabling conclusion that the visual arts have positive effect on transparency of science. However, participants presented an ambiguous view concerning whether or not they wanted to know more about science. This has unknown implications for improving societal relevance of marine science on a large scale. It remains relatively easy to interpret pieces of science for the layman, but responding to existing interest seems a necessary component of scientific arts interpretation.

Radical approaches, based on the information derived by Project Fisher, to increase the accessibility of science, by the presence of the 'visual criterion' were found to depend on the nature of the target audience. Furthermore, such approaches proved to some extent require further written or spoken narrative as explanation of the information on display/nature of the display.

Visual colour contrast arose as one valuable and viable method for improving the accessibility and consensibility of science. However, the collected evidence highlights the worth of 3-dimensional models as interpretive tools. The Ouse Walk (Chapter 5), the 3-dimensional installation (Chapter 7) and the 'bead and stick' models, (Chapter 8), are all suitable examples of 'models' which provide the invitation to (visually and physically) explore.

9.2.2 Can the target audience directly participate in the creation of visual arts representation and if so, will participation increase the knowledge transfer of marine scientific information?

Working within an engaged local community, as in the case of AFME, art was found to increase the accessibility of marine scientific information for the target audience, a direct consequence of their participation in the assimilation and dissemination of information. In this case, participation was key to the success of the art-making process.

When taking a more radical approach to arts representation of science (Chapter 7), participation was more positively engaged by providing a fun, entertaining and involving element. This was found to increase the information saturation of viewers (in particular relation to a 3-dimensional exhibit), intermediately due to a greater 'contemplation period' of the display. After all, Lukacs (2002) suggested that participation, with all of its inaccuracies, depends on listening (or looking) which in turn, requires attention and concentration. Art has that essential ability to hold the viewer's attention that conventional science presentation does not.

Chapter 8 derived new potential for direct participation of the target audience in a programme of collecting and representing scientific data. 3-dimensional models, which by their nature, could feasibly be constructed by fishers themselves, proceeding a process of simple data collection, are a valuable example of how visual arts could lend themselves to science representation and increasing shared understanding.

9.2.3 Do visual arts presentation methods provoke greater interest in science compared with traditional methods of science communication?

Fishers who gave their opinions regarding the colour chart (Table 9) stated that a greater amount of more useful information could be derived from it, compared with a basic numeric table of percentages and ranked scores. Therefore, application of a very simple visual criterion, contrasting colours, markedly improved the transparency of information.

It is suggested that the contemplation period facilitated visually would have been smaller had traditional scientific communication vehicles (tables, graphs etc.) been used during the investigation. Scientific vehicles, most commonly number-based such as the Table of figures (Table 8) are more readily dismissed than systems of visual notation. It was once proclaimed that numbers represented the 'language of science'. Lukacs (2002) suggests this is a cliché in that they are not the language of human beings. Moreover, he proposes numbers are the re-negotiation of truth, with some reference, one may assume, to scientific data analysis and statistical functions.

More radical, in particular 3-dimensional, methods of presentation of fisheries science were found to provoke greater interest in scientific subject matter, owing to how readily they engaged the viewer's attention. The Ouse Walk, the end product of AFME, in essence a 3-dimensional model, led to greater attention span in the viewer and greater visual impact.

Universally, scientific tools do not have such an effect and were universally unfavoured during the investigation. The preference choice of the target audience was almost exclusively, the more radical approach, provoking aesthetic and emotional (value) responses.

It is suggested that the application of a visual narrative to matters of science could be construed as renegotiation of the truth. In other words, as the scientist is often deemed by the public, as characteristically dishonest and self-orientated, the artist may be viewed with similar disregard. For example, drawing one's attention visually, to the 'key points' could be deemed manipulative. After all, the artist is unlikely to highlight the relevant points in black, when more vibrant 'happy' colours are available. Often the more visually intricate and/or impressive the display, the more suggestive it becomes and the harder it is for the viewer to distinguish fact from interpretation. Giving a, perhaps, biased, over-personalised perspective of the information on display, the danger is that lack of faith in science may be replaced by an extended lack of faith in art. However, drawing the viewer's attention to important aspects of science is unlikely to be harmful, so long as the artist has no alternative agenda.

It is suggested that often a certain degree of scientific accuracy must be sacrificed when using a visual notation system. It is suggested that an improved understanding of scientific information and related methods was of a higher order for the purposes of this study, than was (scientific) accuracy. Increased use and development of visual narratives of scientific material will hopefully refine their level of accuracy, and potential application to a variety of scientific scenarios.

9.2.4 Can visual arts representation aid the inclusion of a stakeholder group, notoriously unwilling to participate in the scientific discourse?

Positive concourse was achieved among an essentially 'outsider' group of stakeholders in the case of Project Fisher. Where previously thought to provoke conflicts among participants, the forum for discussion highlighted a significant degree of agreement between stakeholders, on research priorities. The experience of Project Fisher elaborated that a group of stakeholders, stereotypically isolated from both science and society, were willing to participate in the process. However, can it be known whether this interest and willingness to participate was due to the promise of more transparent interpretation of science? Was it instead due to the contentious, political nature of the subject matter, the promise of the most prominent leadership role for fishers or fear of not knowing what others may do? Furthermore, despite a willingness to participate, suggested by the questionnaire respondents, the reality was much different. Limited attendance at meetings (despite distinct effort to provide a participatory forum, inclusive of all fishers) and a lack of organisational capacity remains the barrier to active participation of fishers.

9.2.5 Can visual arts representation enhance the consensibility of complicated aspects of marine (fisheries) science for the divergent stakeholder group?

Project Fisher and the more radical ideas that followed, were the first exploratory steps in improving understanding of basic conceptual fisheries science among a community of fishers. Chapter 8 however, established limits to how far art can rationally interpret marine science. In an attempt to produce a written and visual substitute for a mathematical narrative (the process of stock assessment modeling), enhancing consensibility was found to be of little benefit to the viewer without pre-existing mathematical understanding. The mathematics was used as a language but found not to translate. Furthermore, the exercise was limited by pre-existing uncertainty of the science (assumptions and unknowns).

9.2.6 Could the visual arts catalyse an alternative participatory approach to marine science communication?

Participation in the interpretation process was established with little difficulty in the case of AFME, where no conflict existed between the target audience and the scientific doctrine. Project Fisher and its extensions contrast that participation in arts-based representation of science is logistically difficult where trust in science is lacking.

Chapter 8, in rejecting any attempts to narrate a contrived area of fisheries science, highlighted opportunities for an alternative approach. By way of a fisher-led process of sampling of status of stocks, building confidence in scientific fact and data, trust and mutual agreement may be established. This may facilitate fishers' participation in interpretation of less onerous data, the creation of models or other visual media being potential communicative vehicles. With focus on a 'process', instigated from the bottom up, incorporating arts representation methods (e.g. visual contrast, 3 dimensions), fishers may be able to take a leadership role in decision-making and management of a fishery.

9.2.7 What are the implications for future directions of marine science communication and application to alternative interpretative scenarios?

Central to increasing the communication between scientists and society is prior effort to safeguard confidence stakeholders may have in the proclamations of science. Elaborated by participants in Project Fisher, were positive views on science in general, particularly with regard to scientific facts and data. Although less confidence was displayed regarding the scientific models and predictions and the motivation of scientists, this positive delineation on behalf of fishers was somewhat surprising. Furthermore, such positive regard for scientific fact in the minds of the fishing community, stereotypically perceived to take the 'anti-science' stance, one can observe potential support for future projects, which seek the participatory approach. However the relatively small sample size of fishers and their limited attendance at meetings means this statement is made with hesitation. It is suggested that organisational incapacity would limit development of further discourse between scientists and fishers. With significantly less faith in fisheries science exhibited by respondents, the discipline uniquely relevant to fishers, the need for radical reshaping of the vehicles used for communication between scientists and fishers is confirmed.

The idea that art can reach a wider target audience is of overwhelming significance to science interpreters everywhere. It has been well established in the history of science's relationship with the image that the application of a visual, or aesthetic criterion to even the most complicated piece of science can improve its accessibility for the layman to a significant degree. The key development here is that increasing the extent to which visual media are applied to scientific information can, to a certain extent, have a positive inclusive effect on audiences of greater size. However, this effect may have an upper limit at the point where the audience can be at the mercy of the artist in that they may renegotiate validity of information with a personal presentational agenda.

9.3 Application of participatory visual arts representation to alternative scenarios, based on experiences in Orkney

The results of this investigation raise the question of whether or not community organisational structure and/or a 'sense' of community is absolutely necessary for vehicles of visual art to increase the accessibility and consensibility of science. Considering the information commons can only grow if so too does the number of people able to use it, community organisational structure is a necessary feature of the target audience.

In the case of AFME, there was a good community organisational structure, governed centrally by the Firth Community Council. Working primarily with a local primary school, further organisation through a network of teachers, parents and governors existed. This structural framework was met with a well-placed sense of community, marked in particular by their 'ownership' of the marine environment being interpreted. In the case of Project Fisher, some organisational structure was noted among fishers' representatives e.g. the Orkney Fishermen's Association and the Orkney Creel Fishermen's Association. However, with few members, little or no organisational framework for a united 'fishers voice' was observed. Although those fishers who participated in the discussion forum spoke in defence of the fishing 'community', their views concerning management and scientific advice in general, were more 'anti-establishment' in nature. In other words, Orkney fishers tended to display a rather insular view regarding the sector, with the scientific community viewed as an externality.

It has been established that art increased the accessibility of science for both the Orkney community scenarios (AFME and Project Fisher), despite the pronounced differences in the level of community organisation and sentiment. However, in specific areas of conflict, relating to more complicated and contentious scientific information (Chapter 8), an alternative process of generating the science is necessary prior to arts-based interpretation. It is suggested that the more simplistic approach to arts interpretation, used in the first two case studies, would work well within a programme of CBRM (see section 2.10.4). However where there are elevated situations of conflict, highly scientific information and/or no need for increased knowledge, the value of such process is unclear.

On reflection, the sense of community observed in certain target audiences, is more predictable in Orkney than it would be in other regions. The isolated nature of the islands on a small-scale, confers that the conceptual spread of innovative arts interpretation (ideas, processes and techniques) is relatively unchallenged, the audience being narrow. As isolated interpretation events have a limited scale of implication, this research has limited relevance to larger-scale interpretive endeavour, where it is suggested, much more publicity and broadcasting would be necessary. Indeed, as few interpretive programmes which forge links between the art and science disciplines have taken place previously in Orkney, unlike on the mainland, projects may not be deemed so original elsewhere.

The emphasis of this investigation was the marine environment and related science. Marine environmental interpretation represents a rapidly developing field, as does its terrestrial counterpart. This is largely a consequence of how well received related projects generally are within the communities involved. It could be said that marine and terrestrial environmental interpretation represents somewhat of a 'fashion of the times', being extremely socially acceptable. However, would a visual arts project, seeking to increase the accessibility of science, be as well received and generate interest if concerned with a less socially/politically attractive subject matter? Would such a project be successful if interpreting issues of genetically modified foods or human embryonic screening for example? It is unlikely that such an unconventional theme, of current public concern, would be incorporated in a successful arts interpretation strategy.

Project Fisher was a first attempt to get fishers to take the helm in a programme of scientific research, with science merely catalysing the process. Indeed, investigation of the accessibility of stock assessment models elaborated that fisher-driven processes, focussing on the process through which information is assimilated, are the only real future of participatory projects incorporating fisheries science and the arts. However, application of the philosophy on a larger scale is, perhaps, rather ambitious. The conflict-laden value disputes and lack of mutual agreement within the Orkney fishing sector, a barrier to rational participation, are ultimately magnified on a regional, national and international scale. With specific reference to Orkney, fishers' support for further research will only be attainable if trust and certainty in science can be guaranteed through an alternative participatory process of generating the science.

9.4 Meaningful outputs and contributions to the knowledge

Art has the ability to increase the contemplation period of scientific fact and data. This new level of attentiveness has considerable value for the growth of the (science) information commons and knowledge exchange between the scientific community and a community of non-scientists. Art has been shown as able to widen the size of the target audience of socially relevant science, provoking engagement and scientific insight. There has been carved the most unique niche for art to truly give meaning and depth to science in a broad social context.

Visual narratives have a positive effect on the observational consensibility of articles of science. Elements of artistic composition such as contrast, colour and symmetrical shape positively affect pattern recognition and vary categories of viewer response. The evidence suggests visual notation has the ability to rise above ordinary factual information on a cognitive level, knowledge being acquired through a more innovative, intuitive and thought-provoking process.

There are no guarantees that the viewers' conceptual grasp and understanding of marine science is actually elevated by artistic representation. What has been documented is that a better understanding can be attained with arts interpretation than if the information had been explained through orthodox scientific methods. The ability of the visual narrative to engage the viewer's attention in the first instance and provoke thought, likely to draw the viewer back in the second instance, has bounteous implication for provoking widescale interest in and understanding of science. This holds value not only to the field of environmental education. It gives new meaning to the way in which society views the world and retrieves information from it.

Evidence of the worth of visual arts notation for elements of science re-stresses the need for science to rethink its visual presentation methods. With no discernable value in blind acceptance of science, science must attempt to communicate to a greater extent in ways open to assessment, such as participatory arts interpretation. The 'openness' of visual art, teamed with its ability to inspire active inquiry, may go some way to redeem some public trust in science. Not only will the public understanding of science be taken to higher ground but the science that results will be better science.

On a more philosophical note, the antiquated view that science and art are antithetical to one another no longer holds true. With both held to some extent, in a negative public regard, yet both claiming to be somewhat associated with truth, one cannot distinguish them as directly opposed. Science and art must be viewed with far more equivalence. Science (explanation) and art (representation) both operate in a similar away. Both are, in fact, representation of the world we see around us. Aesthetic and abstract, theoretical and concrete, both are methods of representing knowledge and a universal experience of will lead to understanding. Where most academics of science might hide from such a radical, unconventional approach to representation of science, others must revolt against convention.

To narrate and document science needs to rethink its visual presentation and rediscover new meaning from art. In this chronological full circle, art and science must reinvent themselves simultaneously, drawing mutual influence and gaining mutual public accord. Scientific effort in a more human orientated, artistic vein, using such methods as incorporating art for inquiry, can be the only solution to the lack of public consensibility of science.

9.5 Conclusion: Visual art and the participatory approach

The participatory approach arts interpretation of science must be promoted by science communicators on a global scale, who must continue to search for alternative communication tools with an arts-based core. Real trust and active participation in science is perhaps unrealistic on a complete scale, but art can make scientific information relevant to a specific, cross-cultural, cross-class, target audience. Indeed, representation of science in individual cases will give tangible meaning to science.

Science is ultimately more consensible and acceptable if it is easier to understand. Arts-based representation can increase accessibility, but it requires scientific certainty, or ability to live within the current scientific consensus, accepting unknowns. Indeed the process of building trust can only work if we can define what we mean by science. Science must:

- listen to the needs of society in terms of valuable information to communicate;
- heed the lessons within art and the insight it can provide for the widest target audience;
- promote alternatives to numbers; and
- radically reshape its public face and respond to a social responsibility.

In the search for alternatives, treading with caution will have no benefit to science where there are uncertainties, or unacceptable unknowns. Only giant, confident steps will lead to participatory public (stakeholder) science of true worth and meaning. A participatory approach to visual arts representation will lead to mutual agreement and increased certainty of science for stakeholder groups, notoriously skeptical of science. Ultimately, the pursuit of real knowledge requires inclusivity. Such an approach, through cooperative dialogue may remediate conflict. However, the participatory process cannot be externally (top-down) imposed and must be built on trust.

This approach is fundamentally post normal (see section 2.10.2). In extending dialogue to all those who have a stake in science, in this case marine science, science must evolve with the changing needs of the community and quickly – not wait for the occasion that demands restructuring.

Science and scientists will be inherently involved in any participatory process but their role needs redefining. Observably, there is little point to academic specialism and sub-specialism, allowing unprecedented depth of knowledge in defined areas. With no broad brush to write, science must be relevant to specific stakeholder sets. Stakeholder-led science is the alternative where scientists respond to the information agenda of stakeholders. However, de-centralising science is valueless if, as in the case of the fishing sector, no capacity exists for the target audience to take the leadership role.

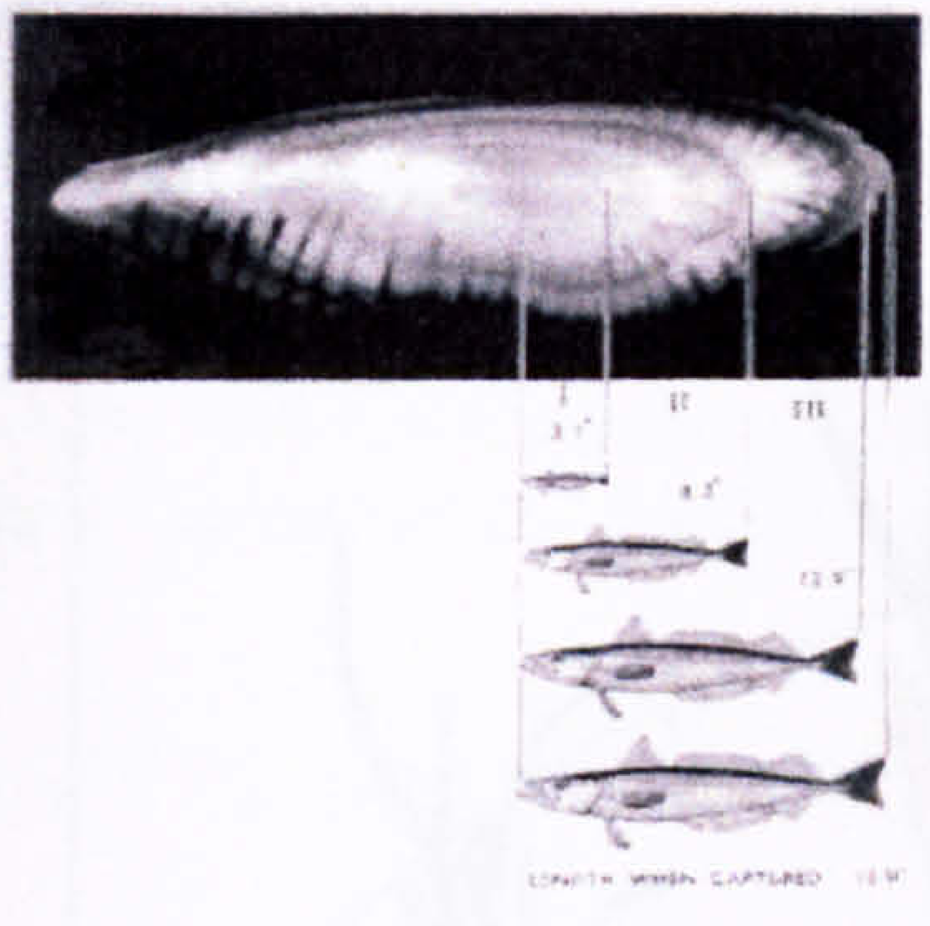
Taking science 'out of its box', the challenge is not only to evolve the participatory process to increase scientific understanding, but more artful language in which we narrate this process and present results. Participation in science via participation in art will lead to greater insight and understanding. The role for art is as a catalyst of the participatory approach.

Annex I. LIFE AND DEATH IN THE SEA

I.I Life and death in the sea

I.I.I Growth and how fishes with fins tell you their age but shellfish don't

Many fishes are able to tell us their age. Usually the otolith, a bone in the "ear" is used and the growth rings on this (rather like the growth rings in a tree trunk when cut in cross section) can be used to count the number of years since the fish was born. With some other fishes it is possible to use their scales instead. Although with some molluscan shellfish it is possible to use a similar technique on their shells with crustacean shellfish such as crabs and lobsters there is no convenient means of telling how old they are. But as a general rule all organisms get larger as they grow older and thus it is possible to use some measure of their size (or weight) as an alternative to their age. With many organisms this increase in size is continuous, with crabs and lobsters it is not. Having a hard outer shell that cannot expand means that there is no alternative but to shed it periodically. This is called moulting and the growth of crabs and lobsters is not continuous but incremental, that is to say it occurs in steps, each step corresponding to the period between moults.



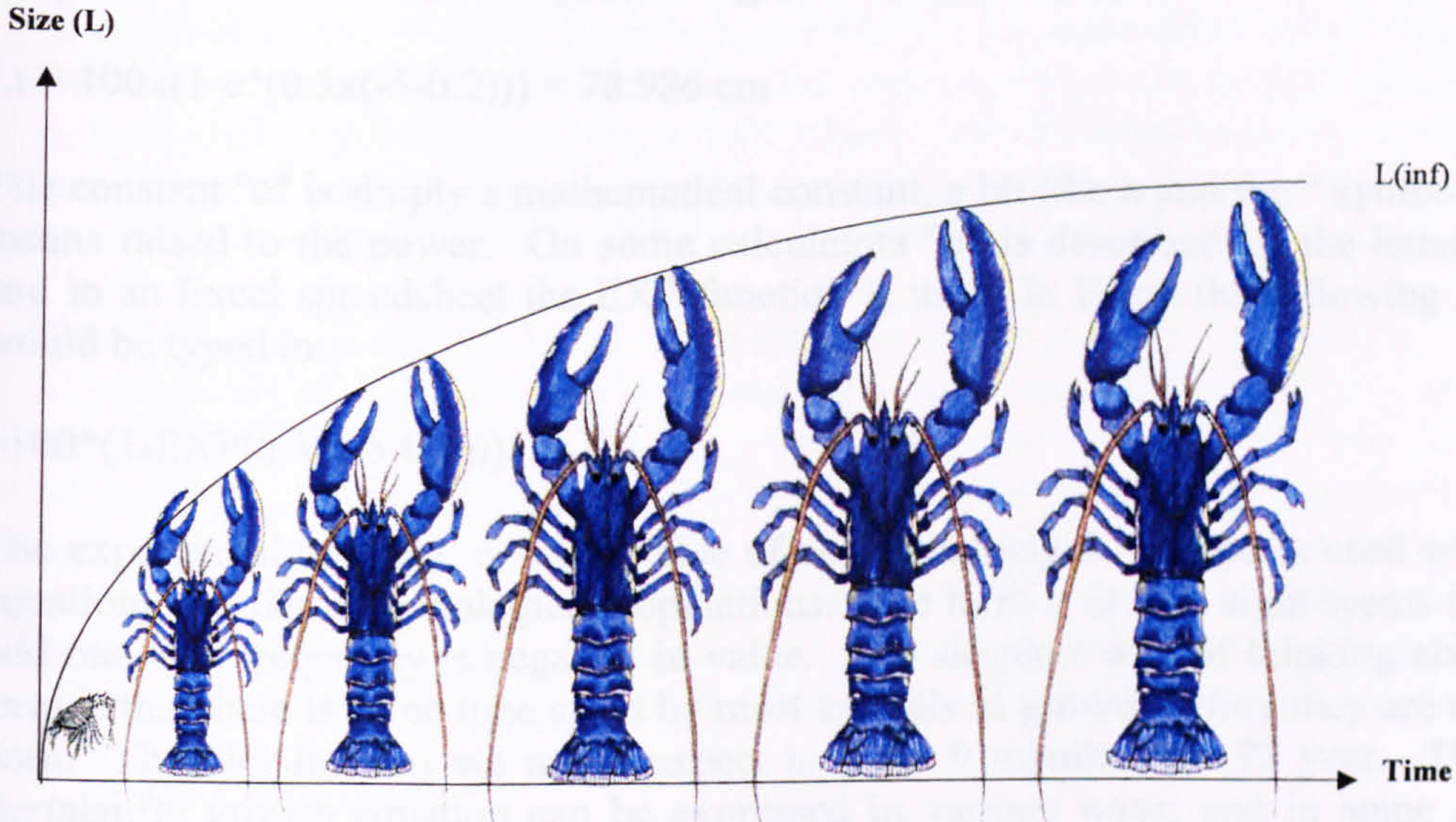
However as we can only really study growth in crabs and lobsters by looking at their size we need to understand how the size of an organism changes during its lifetime, and the extent to which this may be different for males and females of the species, before we consider the additional feature of these incremental steps in growth.

Figure a) The Otolith

I.I.II Von Bertalanffy Growth Curves

Figure b) Ludwig Von Bertalanffy

Von Bertalanffy was the first scientist to really attempt an understanding of the growth of animals. He observed that there were two things that most determined the growth of any animal. The first was an upper limit on its size, which we call L_{inf} (pronounced "El Inf"), and usually written as L_∞, the second was the rate at which the animal grew to this maximum size. Fisheries scientists usually use K to denote this growth rate constant. In the graphs below you can see how during the lifetime of an animal it at first grows rapidly, but then growth slows down, and growth nearly ceases altogether as it approaches it maximum size L_∞. L_∞ is not the record for the largest of the species ever found; rather it is the average maximum size we would expect animals of this species to reach. K and L_∞ are best demonstrated by comparing two very different species that have similar maximum sizes. In the graph below the prawns grow much faster than the lobster, the value of K in the first case is much higher and it gets to its maximum size much sooner, but the value of L_∞ is much lower and it does not grow as large as the lobster.



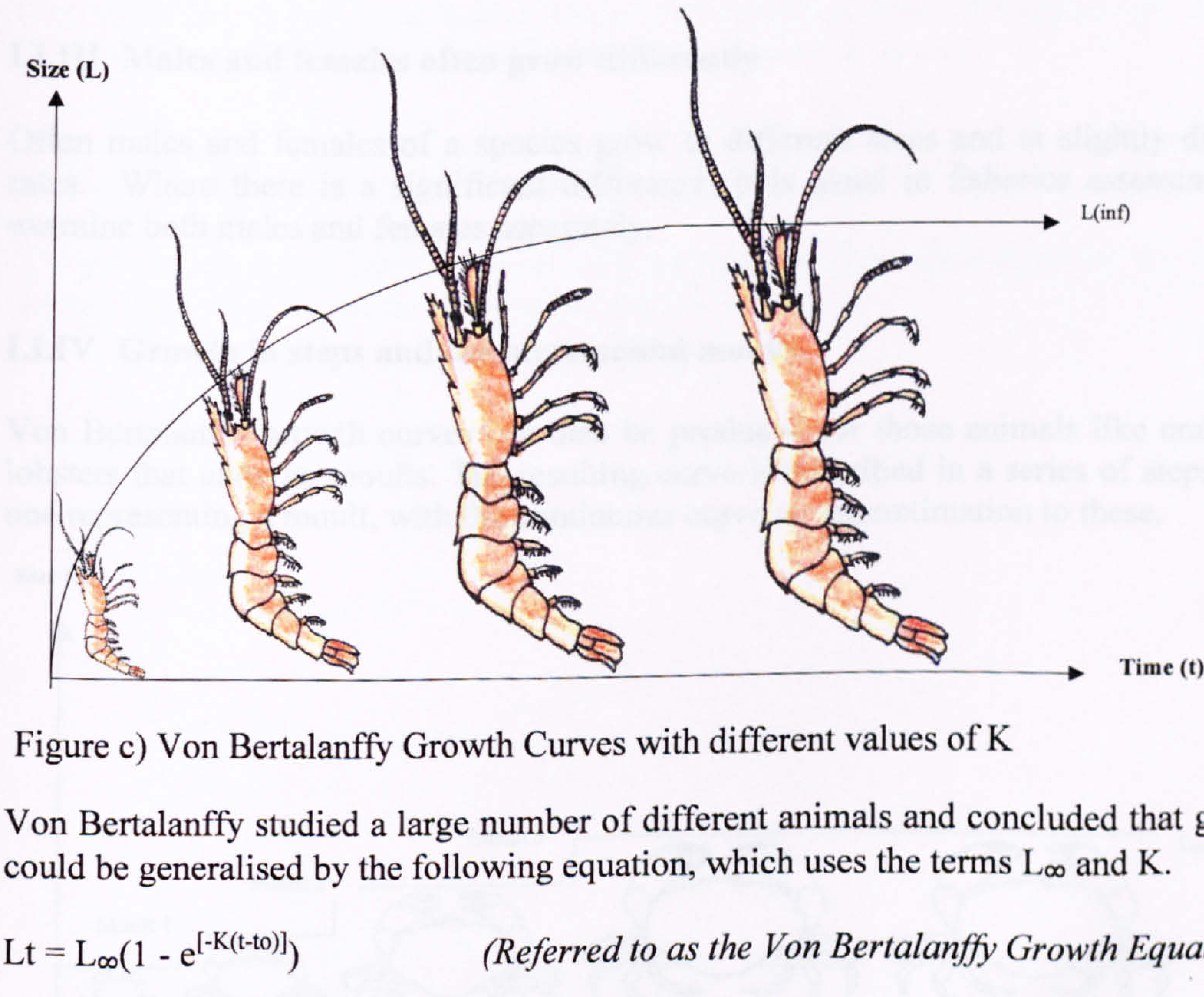


Figure c) Von Bertalanffy Growth Curves with different values of K

Von Bertalanffy studied a large number of different animals and concluded that growth could be generalised by the following equation, which uses the terms L_∞ and K.

$Lt = L_\infty(1 - e^{[-K(t-to)]})$ *(Referred to as the Von Bertalanffy Growth Equation)*

Here:

Lt is the length of the animal at time t

L_∞ is the maximum length of the animal as described in the text above

K is the growth rate constant

T is the time or age at which this length or Lt occurs

T_0 is the starting time, or time at which the length of the animal is zero

The equation is really much simpler than it looks and enables us to estimate the length of an animal from the constants "K", "L_∞", and "t_0", at any time "t" in its life. Thus if I have a species of crab where I know that L_∞ is 100cm, and that K is 0.3, and that t_0 is -0.2 year I can calculate Lt at 5 years using a calculator as follows:

Lt = 100x(1-e^(0.3x(-5-0.2))) = 78.986 cm

The constant "e" is simply a mathematical constant, a bit like π and the ^ symbol simply means raised to the power. On some calculators "e" is described by the letters "exp" and in an Excel spreadsheet the EXP function is used. In Excel the following formula would be typed in

=100*(1-EXP(0.3*(-5-0.2)))

The exponential constant, e, has a value of approximately 2.718 and is used widely in equations that describe biological populations. The term t_0 at first sight seems to be an odd one, and frequently is negative in value. The simplest way of thinking about this term is that there is some time spent by most animals in growth before they are actually born. Thus for humans we might expect t_0 to be 9 months or 0.75 year. The Von Bertalanffy growth equation can be expressed in various ways, and in some simpler forms t_0 is ignored.

I.I.III Males and females often grow differently

Often males and females of a species grow to different sizes and at slightly different rates. Where there is a significant difference, it is usual in fisheries assessments to examine both males and females separately.

I.I.IV Growth in steps and the incremental moults.

Von Bertalanffy growth curves can also be produced for those animals like crabs and lobsters that undergo moults. The resulting curve is described in a series of steps, each one representing a moult, with the continuous curve an approximation to these.

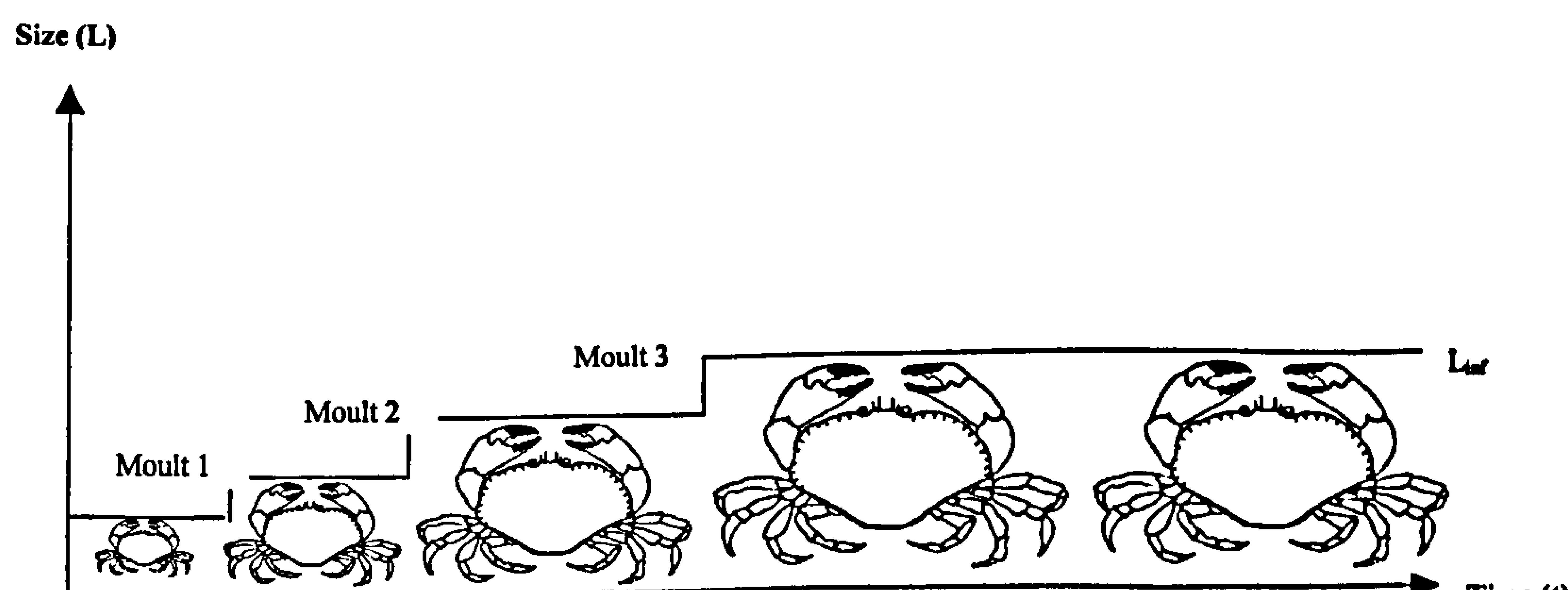


Figure d) Stepwise Growth Curve

I.I.V Death in the Sea

An individual grows and dies. A population would also die out if it did not reproduce. Reproduction is also a form of growth, growth in the population rather than for the individual. Many scientists have studied the patterns of growth in populations just as Von Bertalanffy studied the growth of individuals. But fisheries scientists often apply a simpler approach, which takes as a starting point the number of young fishes recruiting to a stock and reduces these as time passes to allow for the deaths that occur.

Different species of animals follow very different approaches to reproduction. Cod for example put all of their energy into producing a very large number of eggs and hence offspring. The butterfish or gunnel has chosen instead to put its energy into nurture. It produces only a few eggs and offspring but looks after them, protecting them in their early and most vulnerable stages. For nearly all animals death is much more likely when you are young. For us this seems odd as we think of death as being more likely with increasing age, but even for humans in areas of the world with poor health care provision infant mortality is high and death much more likely in the first few months of life than in later years.

Suppose at their birth we have 1,000,000 larval stages of a crab and we track their numbers throughout their lifetimes. Many of these will die young, fewer will die in later years but all will have died at some future point in time. Biologists use, what we call, an exponential decay to describe the rates of death in the sea.

I.I.VI The idea of natural mortality

If a population is not fished there is only natural mortality represented by the term M, the rate of natural mortality of the population or stock.

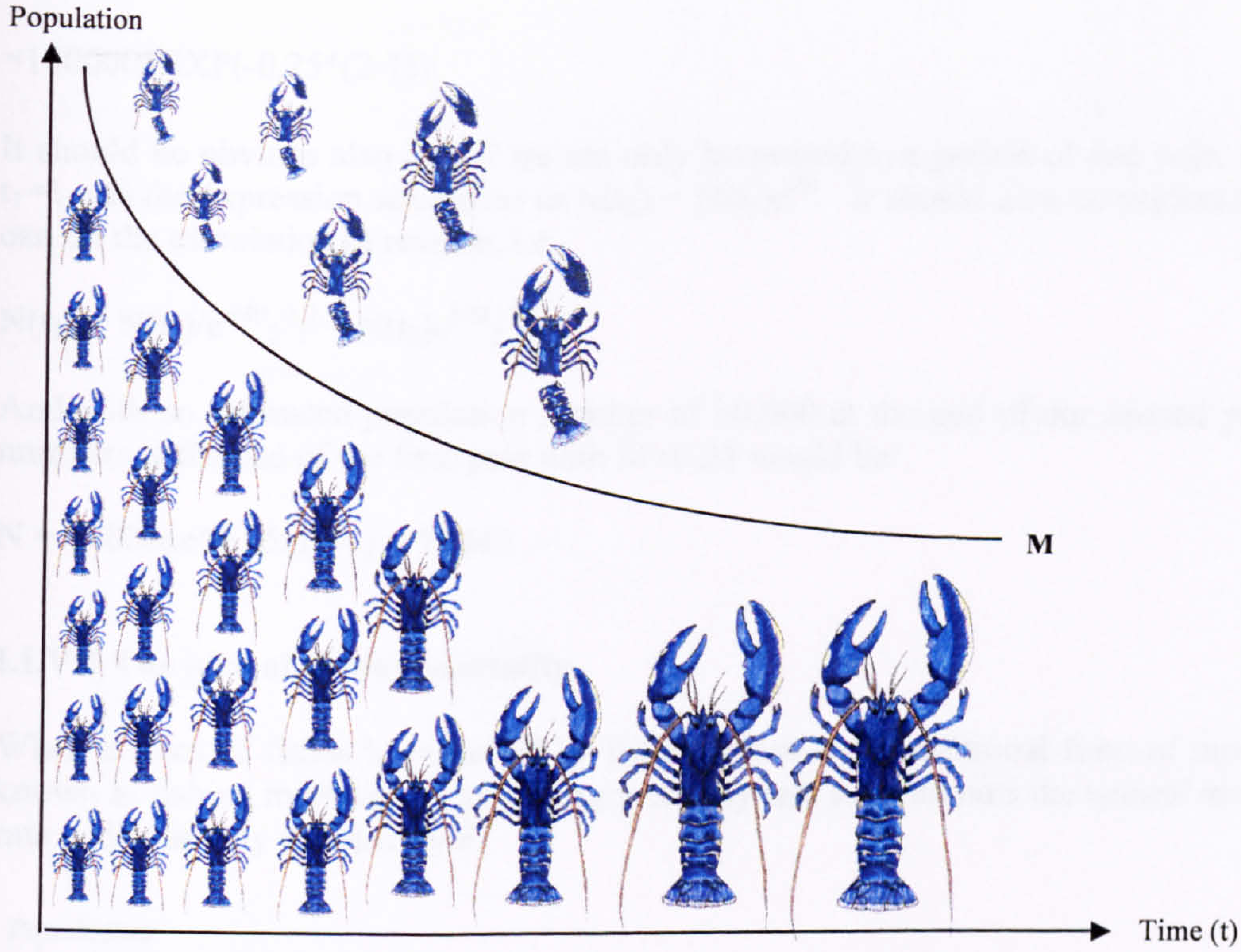


Figure e) Decline in population from natural Mortality

This graph attempts to show two features of growth. Firstly each individual in a population will get larger during its lifetime. Secondly the number of individuals of that age will get smaller during the lifetime of this generation. M describes the rate of decline in population numbers, the larger its value the steeper the decline the smaller its value the lower the rate of decline in population numbers. It is usual to consider M constant for the lifespan of the stock in its exploited phase. In many cases, however, M will vary with age, the natural mortality rate being much higher among larval and juvenile phases than for the adult population and the assumption of a constant M is only usually applied to the adult stock. The relationship is an exponential one, using the term "e" and is very simple:

$N(t_2) = N(t_1)e^{-M(t_2-t_1)}$

(Referred to as the Natural Mortality Exponential Decline Equation)

Here:

$N(t_2)$ is the number in the population at time t_2 (usually time in years)
$N(t_1)$ is the number in the population at time t_1 (usually time in years)
M is the natural mortality rate (usually expressed as a rate per year)

Thus if we know the number in our age group in the stock at the start of its first year and the natural mortality rate (M) we can estimate the number likely to be present at the end of any subsequent year. Suppose the number in the stock is 100,000 at the start of the first year and the M=0.25 then the number at the end of the second year would be estimated to be:

N = 100000xe^(-0.25x(2-1)) = 77880

Or in a form suitable for an Excel spreadsheet:

=100000*EXP(-0.25*(2-1))

It should be obvious also that if we are only interested in a period of one year, then t_2-t_1=1 and the expression simplifies to $N(t_2) = N(t_1)e^{-M}$. It should also be evident that we can do the calculation in reverse, i.e.

$$N(t_1) = N(t_2)/e^{-M(t_2-t_1)} = N(t_2)e^{M(t_2-t_1)}$$

And with an estimated population number of 60,000 at the end of our second year the numbers at the end of the first year with M=0.25 would be:

N = 60000xe^0.25x(2-1) = 77042

I.I.VII The idea of fishing mortality

When a stock of fishes is exploited by fishing there is an additional form of mortality, known as fishing mortality. The fishing mortality rate supplements the natural mortality rate and is usually denoted by F.

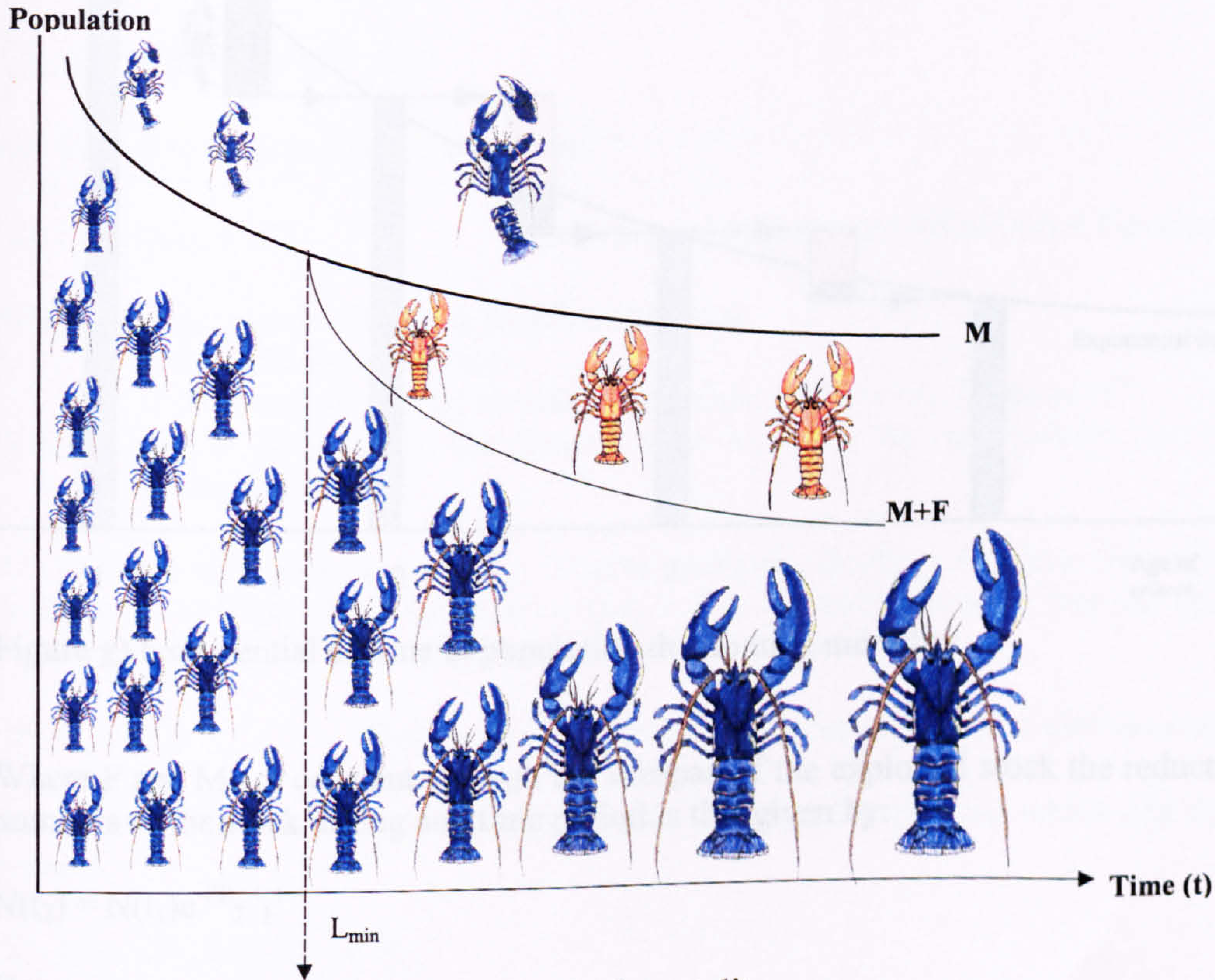


Figure f) Decline in population due to total mortality

In this graph the additional effect of a constant fishing mortality is superimposed on the graph showing natural mortality. The numbers decline more rapidly owing to the additional mortality brought about by fishing, but this only has an effect after the animals have reached the minimum landing size, L_{min}.

I.I.VIII Total mortality

It is usual to use the term Z to describe the total mortality rate. This is the natural mortality rate plus the fishing mortality rate, hence we have

$Z = F + M$

where:

Z Is the total mortality rate
F Is the fishing mortality rate
M Is the natural mortality rate

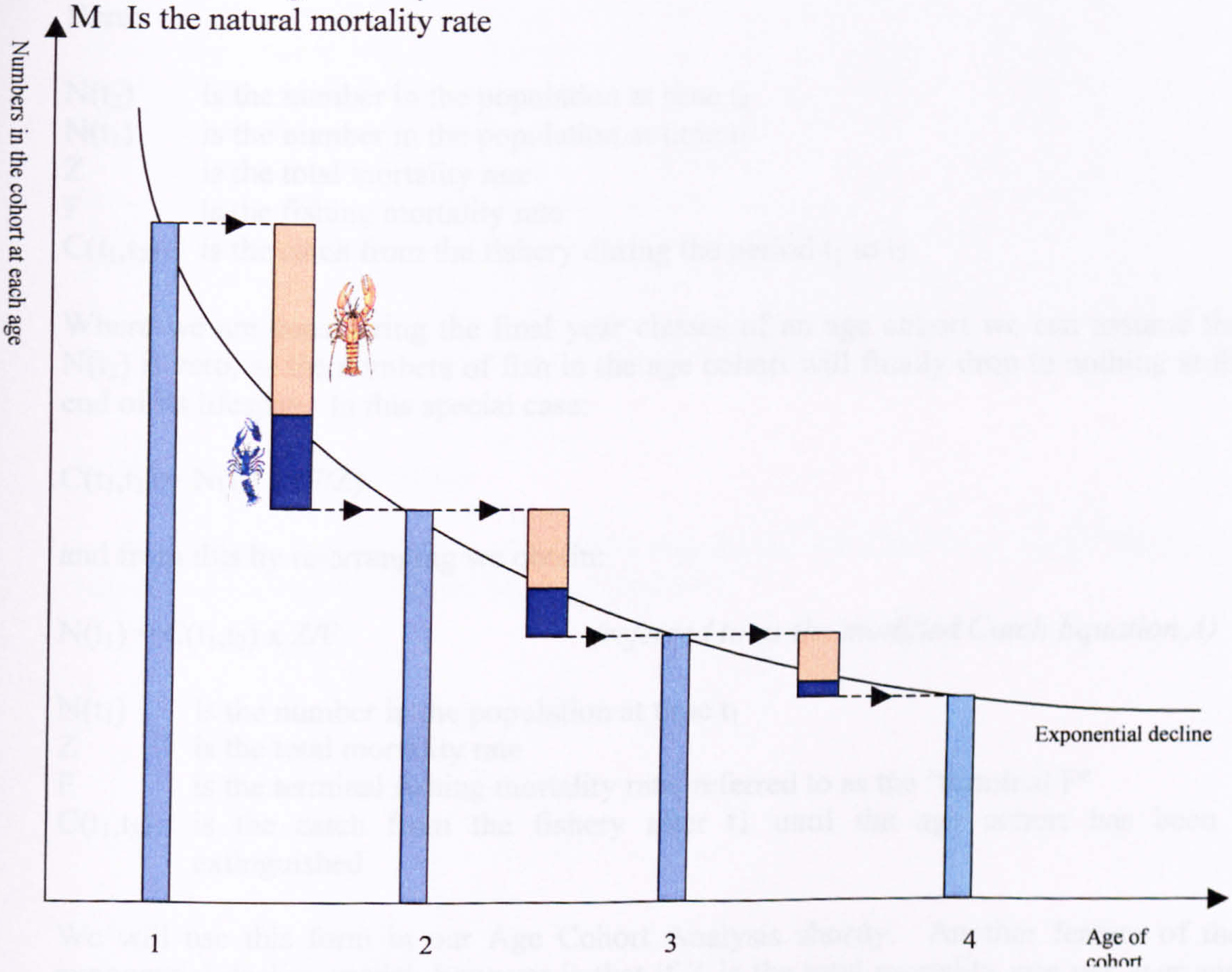


Figure g) Exponential decline in population due to total mortality

Where F and M are constant through the lifespan of the exploited stock the reduction in numbers of the stock during any time period is this given by:

$N(t_2) = N(t_1)e^{-Z(t_2 - t_1)}$

Here:

$N(t_2)$	is the number in the population at time t_2 (usually time in years)
$N(t_1)$	is the number in the population at time t_1 (usually time in years)
Z=F+M	is the total mortality rate, or fishing mortality rate plus the natural mortality rate (usually expressed as a rate per year)

I.I.IX The Catch Equation

We use the relationship $Z = F + M$ in various ways in stock assessment models but one of the most frequent is in the Catch Equation. Suppose we have $N(t_1)$ and $N(t_2)$ representing the numbers of fish in a stock at the start and end of a time period going from t_1 to t_2. Some of these will be caught in the fishery and others will die of natural causes, thus the catch during this period can be expressed as:

$C(t_1,t_2) = (F/Z) \times (N(t_1) - N(t_2))$ *(Referred to as the basic Catch Equation)*

Here:

$N(t_2)$ is the number in the population at time t_2
$N(t_1)$ is the number in the population at time t_1
Z is the total mortality rate
F is the fishing mortality rate
$C(t_1,t_2)$ is the catch from the fishery during the period t_1 to t_2

Where we are considering the final year classes of an age cohort we can assume that $N(t_2)$ is zero, as the numbers of fish in the age cohort will finally drop to nothing at the end of its lifespan. In this special case:

$C(t_1,t_2) = N(t_1) \times (F/Z)$

and from this by re-arranging we obtain:

$N(t_1) = C(t_1,t_2) \times Z/F$ *(referred to as the modified Catch Equation A)*

$N(t_1)$ is the number in the population at time t_1
Z is the total mortality rate
F is the terminal fishing mortality rate, referred to as the "terminal F"
$C(t_1,t_2)$ is the catch from the fishery after t1 until the age cohort has been extinguished

We will use this form in our Age Cohort Analysis shortly. Another feature of the exponential decline model, however is that if Z is the total mortality rate per year and the time period of interest is one year then:

$N(t_2) = N(t_1)e^{-Z}$ *(referred to as the total mortality exponential decline model)*

We can use this to substitute for $N(t_2)$ in our basic catch equation, which can then be restated:

$C(t_1,t_2) = (F/Z)N(t_1)(1 - e^{-Z})$

Again a more useful form of this can be obtained by re-arranging the terms to give:

$Nt_1 = C(t_1,t_2)/\{(1-e^{-Z})(F/Z)\}$ *(referred to as the modified Catch Equation B)*

Finally before leaving the catch equation it is useful to include an account of one derivation from it which is used later in the length cohort analysis example. This enables the calculation of the mean number of fishes, which survive during the period from t_1 to t_2:

Mean $N(t_1,t_2) = \{N(t1)-N(t2)\}/Z$ *(referred to as the mean number of survivors equation)*

I.I.X Following Cohorts of the same age

From the explanations given so far it will be apparent that we can take a group of fishes all born in the same year and follow their progress through the lifespan of the stock. Such a group, having the same year of birth, is referred to as an Age Cohort. As it grows each year it will pass through a number of year classes. We can use the Von Bertalanffy Growth Equation to describe the average length of the fishes in this age cohort as it progresses through each year class, and the Exponential Decline model to make an estimate of the total numbers remaining in the age cohort during each year class. This is the principle behind age cohort analysis. There is a similar procedure, which enables this calculation to be carried out precisely, known as Virtual Population Analysis (VPA). Unfortunately the solution can only be found by iteration and Age Cohort Analysis is frequently used instead as it provides a much simpler calculation that results in a good approximation to the results of VPA.

I.I.XI Age Cohort Analysis

In Age Cohort Analysis the exponential decline in numbers of a single age cohort during one year is represented by a step function.

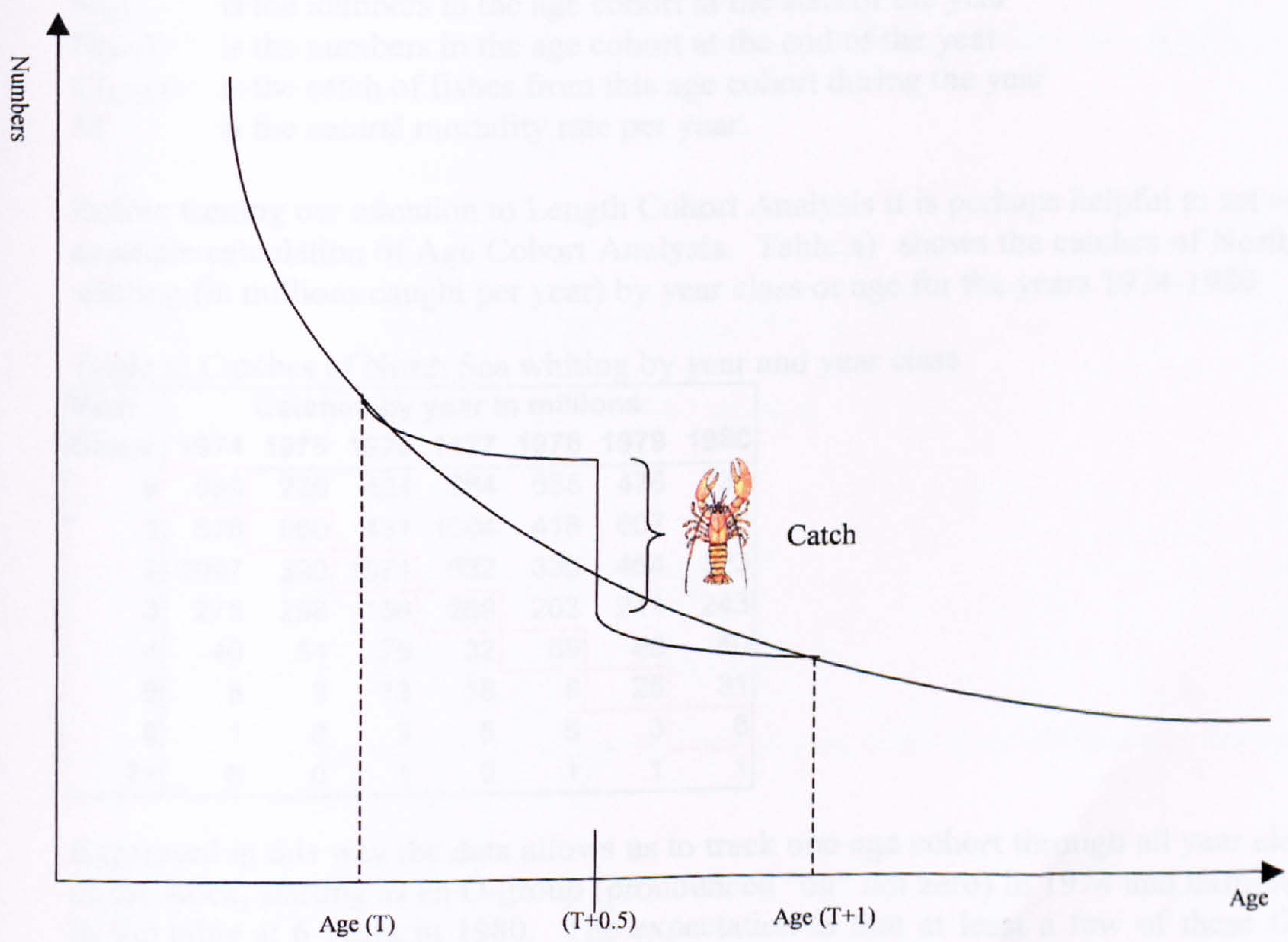


Figure h) Age cohort step function

If we follow the steps on the diagram it is relatively easy to explain the logic behind the method. Point A represents the numbers in that age cohort at the start of the year (say 1st January). The decline in numbers to Point B (halfway through the year or 1st July) is a decline due only to natural mortality. At Point B the entire catch taken during the year, C(t,t+1), is deducted to reduce the numbers in the age cohort to that corresponding to Point C. Thereafter the decline in number from Point C to Point D is that resulting from natural mortality only.

Now as we have seen we can use the exponential decline model to work backwards as well as forwards, and by working backwards from Point D:

Let $N_{(t+1)}$ be the numbers in the age cohort at Point D, thus the numbers in the sea at Point C will be given by:

$$N_{(\text{Point C})} = N_{(t+1)}e^{M/2}$$

And adding the catch to this can derive the numbers at Point B

$$N_{(\text{Point B})} = N_{(t+1)}e^{M/2} + C(t,t+1)$$

And finally the numbers at Point A will be given by

$N_{(\text{Point A})} = N_{(t)} = \{N_{(t+1)}e^{M/2} + C(t,t+1)\}e^{M/2}$ *(referred to as the Age Cohort Equation)*

Here as a reminder of our notation:

$N_{(t)}$ is the numbers in the age cohort at the start of the year
$N_{(t+1)}$ is the numbers in the age cohort at the end of the year
$C_{(t,t+1)}$ is the catch of fishes from this age cohort during the year
M is the natural mortality rate per year.

Before turning our attention to Length Cohort Analysis it is perhaps helpful to set out an example calculation of Age Cohort Analysis. Table a) shows the catches of North Sea whiting (in millions caught per year) by year class or age for the years 1974-1980.

Table a) Catches of North Sea whiting by year and year class

Year Class	Catches by year in millions						
	1974	1975	1976	1977	1978	1979	1980
0	599	239	424	664	685	478	330
1	678	860	431	1004	418	607	288
2	1097	390	1071	532	335	464	323
3	275	298	159	269	203	211	243
4	40	54	75	32	69	86	80
5	6	9	13	18	8	25	31
6	1	8	3	5	5	3	8
7+	6	0	1	0	1	1	1

Expressed in this way the data allows us to track one age cohort through all year classes of the stock, starting as an O-group (pronounced "oh" not zero) in 1974 and terminating in the table at 6 years in 1980. The expectation is that at least a few of these fishes would of course survive to 7 or more years of age in 1981 and beyond.

To start our age cohort calculation we need to have a clear notation and of course an estimate of our natural mortality rate, M. For North Sea whiting M is estimated at 0.2 per year. We shall employ the following notation:

N(Year,Year Class) to refer to the numbers in the sea of that age cohort in that year class in that year.

C(Year,Year Class,Year Class+1) to describe the numbers caught in that year of fishes between the age of the year class, and the year class + 1.

Thus as examples if we refer to C(1974,0,1) we are referring to a catch of 599 million whiting, being the 1974 catch of fishes between the age of 0 and 1, and similarly to refer to the catch of 1071 million in 1974 between the ages of 2 and 3 we would use C(1976,2,3).

In our first calculation we will follow the 1974 (O group) age cohort as it progresses through subsequent year classes during its lifespan. The first step is to use the 1980 catches to calculate the numbers at the start of that year. The simplest approach is to use our *modified catch equation B:*

$Nt_1 = C(t_1,t_2)/\{(1-e^{-Z})(F/Z)\}$

So that in our notation:

$N(1990,6) = C(1980,6,7)/\{(1-e^{-Z})(F/Z)\}$

$N(1990,6) = 8/\{(1-e^{-0.7})(0.5/0.7)\} = 22.2$ million

Thereafter we can simply use the age cohort equation to calculate the numbers in all preceding years:

$N_{(t)} = \{N_{(t+1)}e^{M/2} + C(t,t+1)\}e^{M/2}$

So that in our notation:

$N(1979,5) = \{N(1980,6)e^{M/2} + C(1979,5,6)\}e^{M/2}$

$N(1979,5) = \{22.2 \times e^{0.1} + 25\} \times e^{0.1} = 54.7$ million

and

$N(1978,4) = \{N(1979,5)e^{M/2} + C(1978,4,5)\}e^{M/2}$

$N(1978,4) = \{54.7 \times e^{0.1} + 69\} \times e^{0.1} = 143.1$ million

and so on, until the number of fishes in each of year classes which this age cohort has passed through have been estimated.

N(1980,6) = 22.2 million
N(1979,5) = 54.7 million
N(1978,4) = 143.1 million
N(1977,3) = 472.1 million

$N(1976,2) = 1760.3$ million
$N(1975,1) = 3100.4$ million
$N(1974,0) = 4448.9$ million

Having calculated the numbers in the sea at the beginning of each year for that age cohort it is now possible to estimate the fishing mortality each year class experiences as the age cohort progresses through its lifespan. Our total mortality exponential decline equation was as follows:
$N(t_2) = N(t_1)e^{-Z}$

The laws of logarithms mean therefore that:

$\ln\{N(t_1)/N(t_2)\} = Z$

Where ln is used to denote the natural logarithm or $\log_e$. As F = Z - M, we can calculate F during each year class of the age cohort as follows:

F(Year,YearClass,YearClass+1)=ln{N(Year,Year Class)/N(Year+1,YearClass+1)}-M

Hence $F(1979,5,6) = \ln\{N(1979,5)/N(1980,6)\} - M$

$F(1979,5,6) = \ln\{54.7/22.2\} - 0.2 = 0.7$ per year

And thus the fishing mortality rate can be calculated on our age cohort during each year of its lifespan:

F(1980,6) = 0.5 (remember this was our 'guesstimate' of the terminal F)
F(1979,5) = 0.70
F(1978,4) = 0.76
F(1977,3) = 0.99
F(1976,2) = 1.12
F(1975,1) = 0.37
F(1974,0) = 0.16

Of course these calculations are much more easily performed on a spreadsheet and this example calculation is included on the disk (Appendix 13) as an Excel Spreadsheet. Using this it is possible very quickly to examine the effects of choosing a different terminal F value or the effects of a different value for natural mortality M.

Importantly there is another way of approaching this. In the calculation above we have used age cohort analysis to track one age cohort throughout its entire lifespan in the stock. The same approach, however, can be applied to an averaged time series of data so that it is applied to an averaged year class rather than to a specific age cohort. When it is used in this way it is customary to refer to the averaged year class as a pseudo-cohort and the term pseudo-cohort analysis is sometimes used. Thus if we calculate the average catches in millions for the years 1974-1980 combined for our data on North Sea whiting we can apply pseudo-cohort analysis to these.

Table b) Data from Table a but with the 1974-1980 average catches for each year class

Year Class	Catches by year in millions							1974-80
	1974	1975	1976	1977	1978	1979	1980	Average
0	599	239	424	664	685	478	330	488.4
1	678	860	431	1004	418	607	288	612.3
2	1097	390	1071	532	335	464	323	601.7
3	275	298	159	269	203	211	243	236.9
4	40	54	75	32	69	86	80	62.3
5	6	9	13	18	8	25	31	15.7
6	1	8	3	5	5	3	8	4.7
7+	6	0	1	0	1	1	1	1.4

This example is worked directly in the spreadsheet and the results displayed in Table 3. The only difference in the means of calculation is that as we are using 7+ fishes as the terminal year classes the numbers of fishes entering this year class is calculated using the *modified catch equation A:*

$N(t_1) = C(t_1,t_2) \times Z/F$

and thus

$N(7) = C(7+) \times Z/F = 1.4 \times 0.7/0.5 = 1.96$ million

In other respects the table is calculated as before.

Table c) Pseudo-cohort analysis using 1974-1980 average catches of N Sea whiting

Year Class	1974-80 Average	Estimated Numbers	Estimated Annual Fishing Mortality
0	488.4	3061.1	0.19
1	612.3	2064.3	0.40
2	601.7	1136.1	0.88
3	236.9	385.7	1.14
4	62.3	101.5	1.13
5	15.7	26.7	1.05
6	4.7	7.7	1.14
7+	1.4	2.0	0.5

This provides a history of an average cohort rather than the historical trail of an actual age cohort as it progresses through its lifespan. As we shall see this is exactly the approach used in Length Cohort Analysis, with a few additional adjustments.

I.II Length Cohort Analysis

In Age Cohort Analysis the exponential decline in numbers of a single age cohort during one year was represented by a step function. Length Cohort Analysis (LCA) follows a similar approach with a length cohort being those animals within a given length range. The difference is that we do not know the time period taken to grow a given length, say from L_1 to L_2.

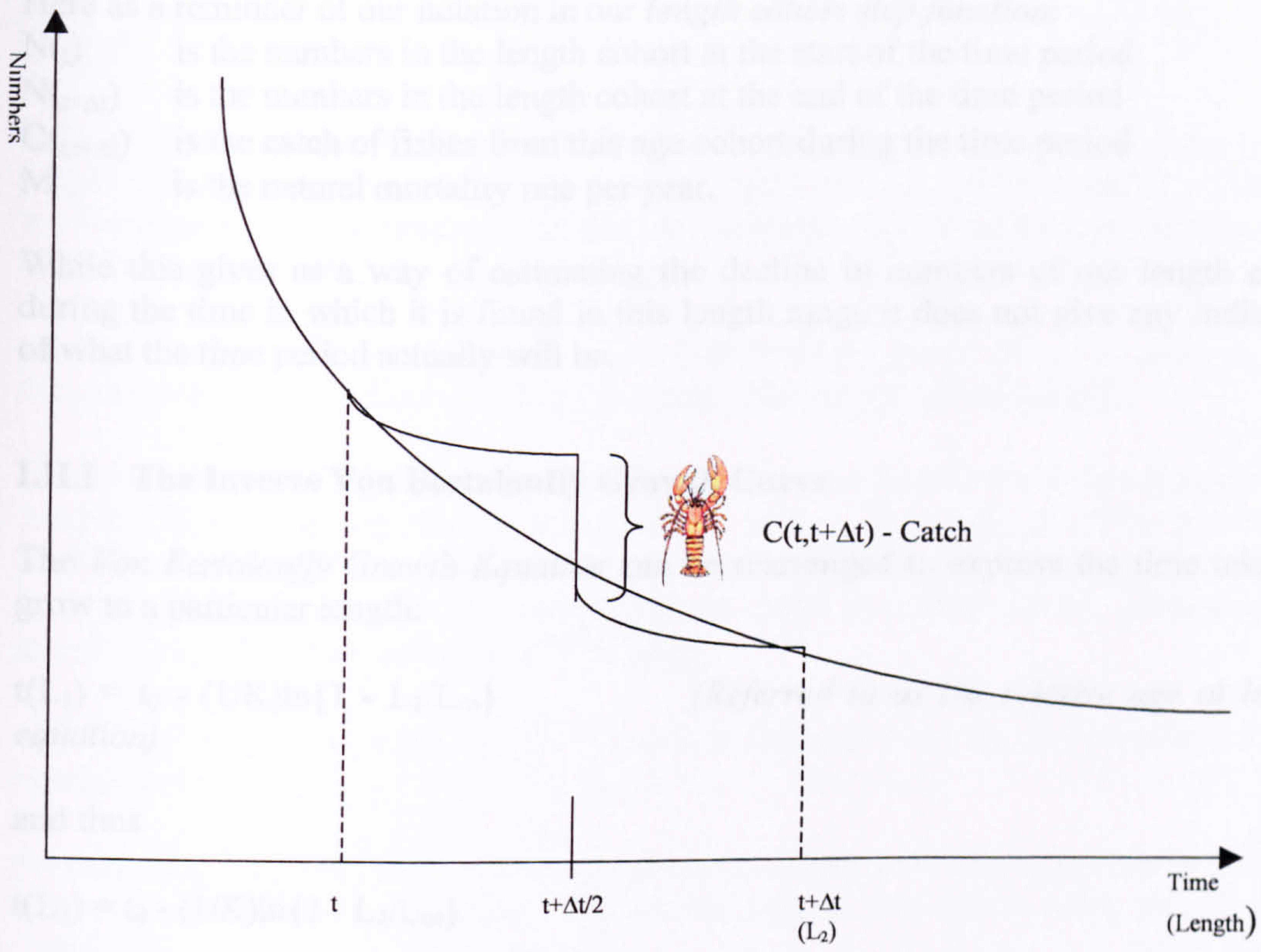


Figure i) Length cohort step function

But again if we follow the steps on the diagram it is relatively easy to explain the logic behind the method. Point A represents the numbers in our length cohort at the start of an arbitrary time period, Δt (pronounced "delta t"). We can think of Δt as being t_2-t_1 in our exponential decline equations. The decline in numbers to Point B (halfway through the time period Δt) is a decline due only to natural mortality. At Point B the entire catch taken during the period Δt, $C(t,t+\Delta t)$, is deducted to reduce the numbers in the age cohort to that corresponding to Point C. Thereafter the decline in numbers from Point C to Point D is that resulting from natural mortality only.

Now as we have seen we can use the exponential decline model to work backwards as well as forwards, and by working backwards from Point D:

Let $N_{(t+\Delta t)}$ be the numbers in the length cohort at Point D, thus the numbers in the sea at Point C will be given by:

$$N_{(\text{Point C})} = N_{(t+\Delta t)}e^{M\Delta t/2}$$

And adding the catch to this can derive the numbers at Point B

$$N_{(\text{Point B})} = N_{(t+\Delta t)}e^{M\Delta t/2} + C_{(t,t+\Delta t)}$$

And finally the numbers at Point A will be given by

$$N_{(\text{Point A})} = N_{(t)} = \{N_{(t+\Delta t)}e^{M\Delta t/2} + C_{(t,t+\Delta t)}\}e^{M\Delta t/2}$$

Here as a reminder of our notation in our *length cohort step function*:

$N(_t)$ is the numbers in the length cohort at the start of the time period
$N(_{t+\Delta t})$ is the numbers in the length cohort at the end of the time period
$C(_{t,t+\Delta t})$ is the catch of fishes from this age cohort during the time period
M is the natural mortality rate per year.

While this gives us a way of estimating the decline in numbers of our length cohort during the time in which it is found in this length range it does not give any indication of what the time period actually will be.

I.II.I The Inverse Von Bertalanffy Growth Curve

The *Von Bertalanffy Growth Equation* can be rearranged to express the time taken to grow to a particular length:

$t(L_1) = t_0 - (1/K)\ln\{1 - L_1/L_\infty\}$ *(Referred to as the relative age at length equation)*

and thus

$$t(L_2) = t_0 - (1/K)\ln\{1 - L_2/L_\infty\}$$

From these we can derive:

$$\Delta t = t(L_2) - t(L_1) = (1/K)\ln\{(L_\infty - L_1)/(L_\infty - L_2)\}$$

(the time in this length cohort equation)

where

L_1 Is the length of the animal at the start of our time period, Δt
L_2 Is the length of the animal after our time period Δt
L_∞ Is the maximum length of the animal as described in the text on Von Bertalanffy
T_0 growth
K Is the starting time, or time at which the length of the animal is zero
Is the growth rate constant as described in the text on Von Bertalanffy growth

Thus we have a means of deriving the time spent in any particular length cohort, which can be used to provide an expression for $e^{M\Delta t/2}$ in our length cohort step function. Firstly:

$$M\Delta t/2 = (M/2K)\ln\{(L_\infty - L_1)/(L_\infty - L_2)\}$$

$$= \ln\{(L_\infty - L_1)/(L_\infty - L_2)\}^{(M/2K)}$$

but as we require an expression for $e^{M\Delta t/2}$ the rules of logarithms mean that this simplifies further:

$$e^{M\Delta t/2} = \{(L_\infty - L_1)/(L_\infty - L_2)\}^{(M/2K)}$$

and this can be substituted directly into our length cohort step function:-

$$N(_t) = \{N(_{t+\Delta t})e^{M\Delta t/2} + C(_{t,t+\Delta t})\}e^{M\Delta t/2}$$

with $e^{M\Delta t/2} = \{(L_\infty - L_1)/(L_\infty - L_2)\}^{(M/2K)}$

We can now work backward from the largest length cohort calculating numbers in each length cohort in the same manner that we employed with age cohort analysis. This time we use notation, which refers specifically to the length cohort rather than the time spent in each length cohort:-

$N(L)$ to refer to the numbers in the length cohort (between L and ΔL, or L_1 and L_2)
$C(L)$ to refer to the numbers caught of this particular length cohort (catch)

The data used is that of the catches over several years raised to the length frequency of samples taken from the catches during these years. Thus this provides an average picture not only of the average annual catch but also its length frequency distribution. In practice the calculation is usually done in steps as shown in the accompanying spreadsheet. Firstly we calculate $e^{M\Delta t/2}$, using

$e^{M\Delta t/2} = \{(L_\infty - L_1)/(L_\infty - L_2)\}^{(M/2K)}$, this is referred to as X_L for simplicity in the spreadsheet.

for each length cohort. Then as with age cohort analysis, only this time starting with the largest length cohort we calculate $N(L)$ for the start of this cohort using the *Modified Catch Equation A*:

$$N(L) = C(L) \times Z/F$$

As before we have to make an estimate of the terminal Z/F for this largest cohort size category. Thereafter we can calculate for the successively smaller length cohorts using our *length cohort step function*:

$$N(L) = \{N(L+\Delta L)e^{M\Delta t/2} + C(L+\Delta L)\}e^{M\Delta t/2}$$

This provides an estimate of the numbers of animals reaching or attaining this length during the course of a year (remember we are using annual average catch data over several years). It is not of course the same as a snapshot of the average number of animals in this length cohort at any given time; the animals may not spend exactly one year in that cohort (as obviously they will with age cohort analysis). Further adjustments are required to obtain an estimate of the average numbers in each length cohort at any given time.

The simplest means of achieving this is firstly to estimate $Z\Delta t$ from the ratios of numbers attaining successive length cohorts:

As $N(L) = N(L+\Delta L)e^{Z\Delta t}$

$e^{Z\Delta t} = N(L+\Delta L)/N(L)$ also referred to as the survival rate or St in the spreadsheet

Hence:

$$Z\Delta t = \ln\{N(L+\Delta L)/N(L)\}$$

Next we can calculate F/Z as being the ratio of the number caught to the total number dying:

$F/Z = C(L)/(N(L+\Delta L) - N(L))$

And from these we can calculate the fishing mortality rate for each length cohort:

$F\Delta t = (F/Z)Z\Delta t$

Now if we have an estimate of the natural mortality rate M for the stock we can estimate the total mortality rate as follows

$Z = M/(1\text{-}F/Z)$, as $M + F = Z$
and from this F (the average annual mortality rate on that length cohort) simply by

$F = Z - M$

Finally the average numbers in the sea for each length cohort is calculated by using the form of the catch equation referred to earlier as the mean number of survivors equation:

$\text{Mean } N(L,L+\Delta L) = \{N(L) - N(L+\Delta L)\}/Z$

Table d) shows the example calculation using excel spreadsheet of length cohort analysis provided on the accompanying disk (Appendix 13).

The first few rows of the table set out the constants used in the calculation. The first and second columns are the lower and upper length limits set for each length cohort. The third column (X_L) calculates $e^{M\Delta t/2}$, using

$e^{M\Delta t/2} = \{(L_\infty - L_1)/(L_\infty - L_2)\}^{(M/2K)}$

The fourth column contains the catch data for the fishery. In European waters it is rare to record the numbers caught more often weight is used. Nor would we ever expect the length of every individual in the catch to be measured which the data presented in this way might imply. In practice the data is compiled from market samples of catches over several years and the average catch during these years is used. As the length to weight relationship is usually one of the first to be established for a stock by scientists it is simply a matter of scaling the average annual catch by weight to the sample data length cohorts.

The fifth column provides the calculation of the numbers attaining each length cohort during each year (on average), using a guessed terminal F/Z value for the largest length category and the equation already described:

$N(L) = C(L) \times Z/F$

Thereafter working backwards for each successive length cohort the length cohort step function:

$N(L) = \{N(L+\Delta L)e^{M\Delta t/2} + C(L+\Delta L)\}e^{M\Delta t/2}$

is used to determine the numbers of animals in the sea attaining that size during an average year. The sixth column calculates the survival rate for each length cohort using:

$$St = e^{Z\Delta t} = N_{(L+\Delta L)}/N_{(L)}$$

and in the seventh column the natural logarithm of this value is taken to derive ZΔt. Column eight calculates F/Z from:

$$F/Z = C_{(L)}/(N_{(L+\Delta L)} - N_{(L)})$$

and column nine FΔt, from

$$F\Delta t = (F/Z)Z\Delta t$$

The tenth column provides the annual mortality rate for the length cohorts from:

$$Z = M/(1-F/Z)$$

and finally the last column provides an estimate of the average annual numbers in the sea in each length cohort using:

$$N_{(L)} = \{N_{(L+\Delta L)}e^{M\Delta t/2} + C_{(L+\Delta L)}\}e^{M\Delta t/2}$$

Table d) Numerical example of Length Cohort Analysis

Linf =	80	
M/K =	1	
F/Z =	0.5	For largest length group
M =	0.2	
K =	0.2	

Length (L1) interval	Length (L2) Interval	X_L	Numbers caught (C_L) (millions)	Numbers in class (C_L) (millions)	St {$St = e^{-Zt}$}	Z delta t	F/Z	F delta t	Z	Average numbers in the sea (millions)
20	25	1.044	0.10	50.48	0.915	0.089	0.023	0.00207	0.205	21.01
25	30	1.049	0.47	46.18	0.899	0.106	0.101	0.010726	0.223	20.88
30	35	1.054	3.88	41.53	0.811	0.209	0.495	0.103519	0.396	19.77
35	40	1.061	5.54	33.70	0.734	0.309	0.618	0.191129	0.523	17.14
40	45	1.069	5.37	24.73	0.672	0.398	0.662	0.263144	0.591	13.72
45	50	1.080	4.62	16.62	0.600	0.511	0.695	0.355108	0.655	10.16
50	55	1.095	3.03	9.97	0.556	0.587	0.684	0.401984	0.634	6.99
55	60	1.118	1.68	5.54	0.529	0.637	0.644	0.410102	0.561	4.65
60	65	1.155	1.02	2.93	0.448	0.802	0.631	0.50637	0.543	2.98
65	70	1.225	0.46	1.31	0.381	0.966	0.566	0.546172	0.460	1.77
70	>70		0.25	0.5						
TOTALS			26.42							119.07

I.III Reflections

As an analytical exercise length cohort analysis is not particularly informative - it provides some estimate of the average annual stock numbers given certain constants can be estimated and holds true for the stock over a number of years. And it assumes constant average recruitment during this period, hence using several years data is always very advisable. But it provides the foundations for further "long run" predictions.

Tables e) and f) represent a worksheet on the enclosed disk (Appendix 13) which shows how the calculation can be further developed to see what the effect of a 40% increase in fishing effort and a 20mm increase in mesh size (or minimum landing size) would be on the average annual stock abundance and on catches. The data used are those in Table d) and the constants can be altered to show the effect on catches of different increases in fishing effort. It is set up for a 40% increase in fishing effort, which when combined with an increase in minimum landing size predicts a slight decrease in the resulting catch. But by changing the fishing effort factor from 1.4 (40% increase) to 1.3 (30% increase) the model predicts a resulting increase in catch when this increase in effort is combined with an increase in minimum landing size.

Importantly these models tell us nothing about the short-term changes in the fishery; they offer only long term predictions based on several years' historic data, and are often very sensitive to the actual values of M, M/K, terminal F/Z and L_∞. The reliability of estimates of these constants remains uncertain, and in the case of M, the natural mortality rate, it is rare to see any attempt to evaluate this independently for different stocks of shellfish in Scotland for example.

During the writing of this account an alternative approach has commended itself to the author. It fulfils a number of important criteria:

- it is easy to understand
- it requires little fluency with mathematics
- it could be administered by fishers themselves
- it rapidly provides information regarding short term changes (if any)
- it explicitly allows for natural variations in annual recruitment

Suppose we plot the size frequency distribution of the catch for a year:

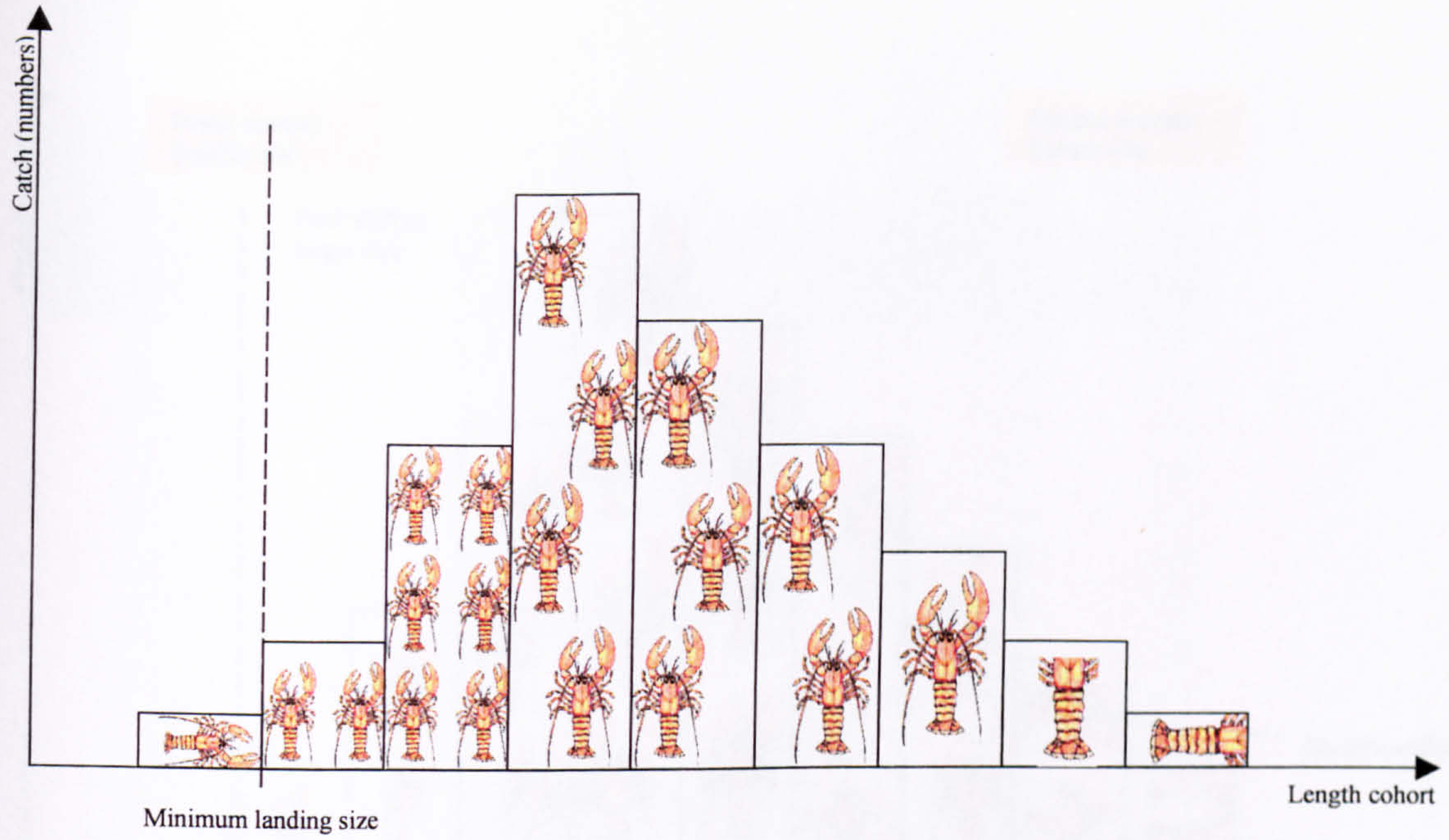


Figure j) Catch curve

If the following year we observe a skewing of this distribution towards the minimum landing size (the peak may move to the left, and the mean length of the total catch may have reduced, possibly accompanied by an increase in the slope of declining numbers in the larger size categories) then it suggests that there has been a change in the length structure of the stock. In this case this might be due to lower recruitment or higher fishing mortality. If however we observe the converse it may be explained by a reduction in fishing mortality or to higher recruitment. Importantly these changes either for the better or for the worse can be followed seasonally and from one year to the next, in a way that length cohort analysis is simply unable to do.

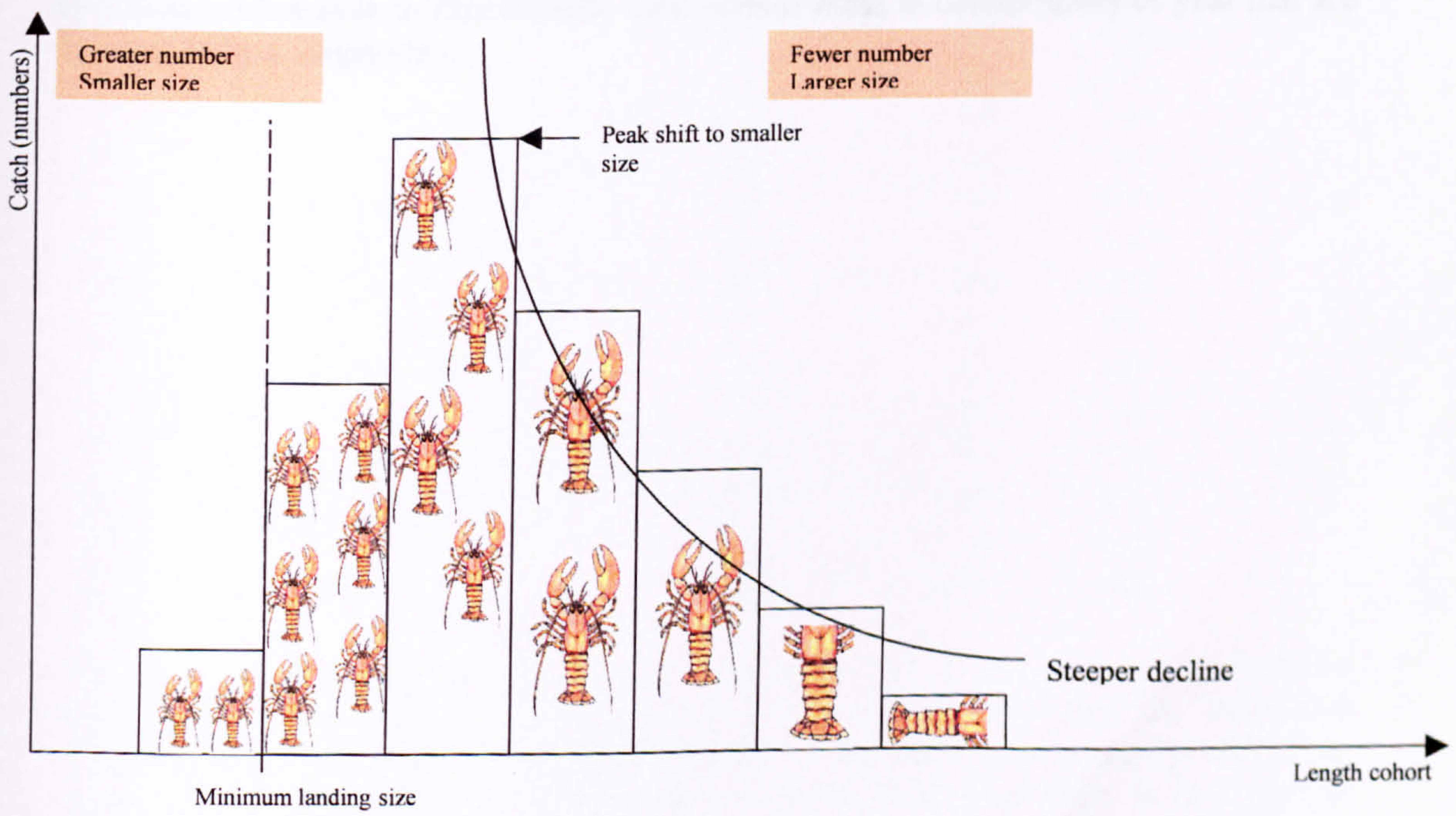


Figure k) Catch curve - change for the worse

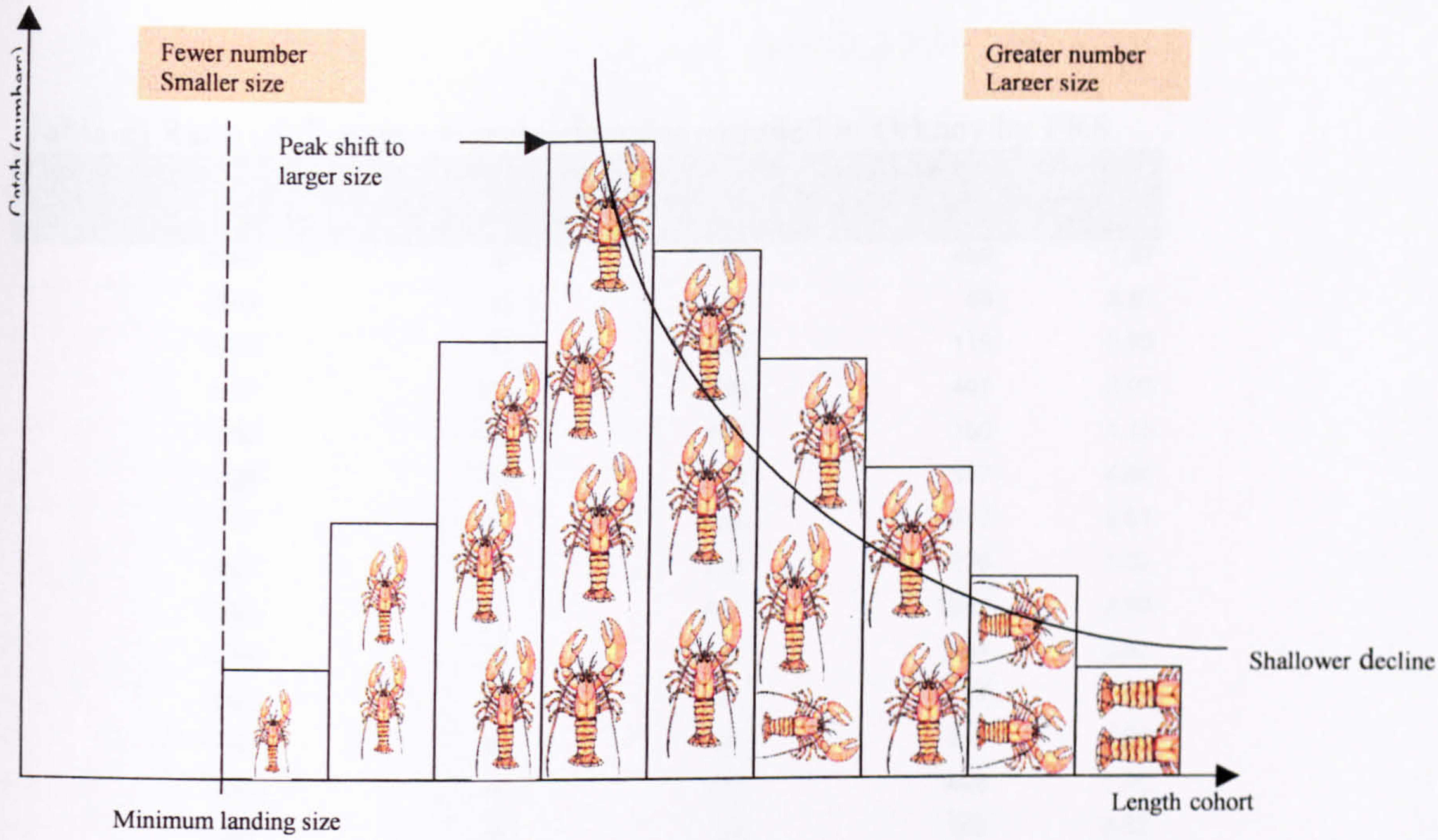


Figure l) Catch curve - change for the better

In an attempt to explore this further FRS Marine Laboratory data on market samples of partan (*Cancer paguras*) catches in Orkney has been used. For reasons given at the start of this paper data for males and females were examined separately.

Table g) shows the numbers of male and female animals sampled during each sampling visit to Orkney by the FRS Marine Laboratory Aberdeen, and the corresponding ratio of males to females. Fishers would express little surprise at the large variation in this ratio, as it is not uncommon to find catches from certain areas at certain times of year that are dominated by a single sex.

Table g) Ratio of *C. paguras* males:females sampled in Orkney by FRS

Year	Month of Sample	Number of Females in Sample	Number of Males in Sample	Ratio M:F (Male; Female)
1996	3	346	439	1.27
1999	4	15	58	3.87
1986	5	128	119	0.93
1987	5	139	407	2.93
1989	5	131	150	1.15
1990	5	66	317	4.80
1991	5	236	617	2.61
1995	5	204	270	1.32
1996	5	541	1567	2.90
1999	5	1167	961	0.82
1983	6	73	97	1.33
1989	6	103	242	2.35
1992	6	232	408	1.76
1993	6	84	749	8.92
1997	6	165	184	1.12
1998	6	379	1083	2.86
1989	7	184	695	3.78
1994	7	737	141	0.19
1997	7	1015	287	0.28
1990	8	651	237	0.36
1991	8	204	281	1.38
1993	8	288	260	0.90
1998	8	333	12	0.04
1984	9	25	166	6.64
1992	9	169	495	2.93
1993	9	85	184	2.16
1998	9	112	910	8.13
1986	10	24	64	2.67
1987	10	13	248	19.08
1994	10	61	511	8.38
1996	10	191	100	0.52
1997	10	727	681	0.94
1999	10	95	321	3.38
1983	11	21	252	12.00
1994	11	30	17	0.57
1996	11	61	168	2.75
1998	12	95	18	0.19
Total		**9130**	**13716**	**1.50**

While the overall ratio from several years data collected in this way may reflect the actual ratio in the catch during this period, it seems less likely that the individual monthly samples are sufficiently large to do this. When the data are aggregated for the entire period (1993-1999) and represented by months, there does seem to be a pattern which suggests that females dominate in the catches in July and August and males at other times of year (ignoring December owing to the small sample size).

Table h) Aggregated *C. paguras* samples over the period 1993-1999

Month	F	M	Ratio M:F
3	346	439	1.27
4	15	58	3.87
5	2612	4408	1.69
6	1036	2763	2.67
7	1936	1123	0.58
8	1476	790	0.54
9	391	1755	4.49
10	1111	1925	1.73
11	112	437	3.90
12	95	18	0.19
Total	9130	13716	1.50

This is shown graphically below:

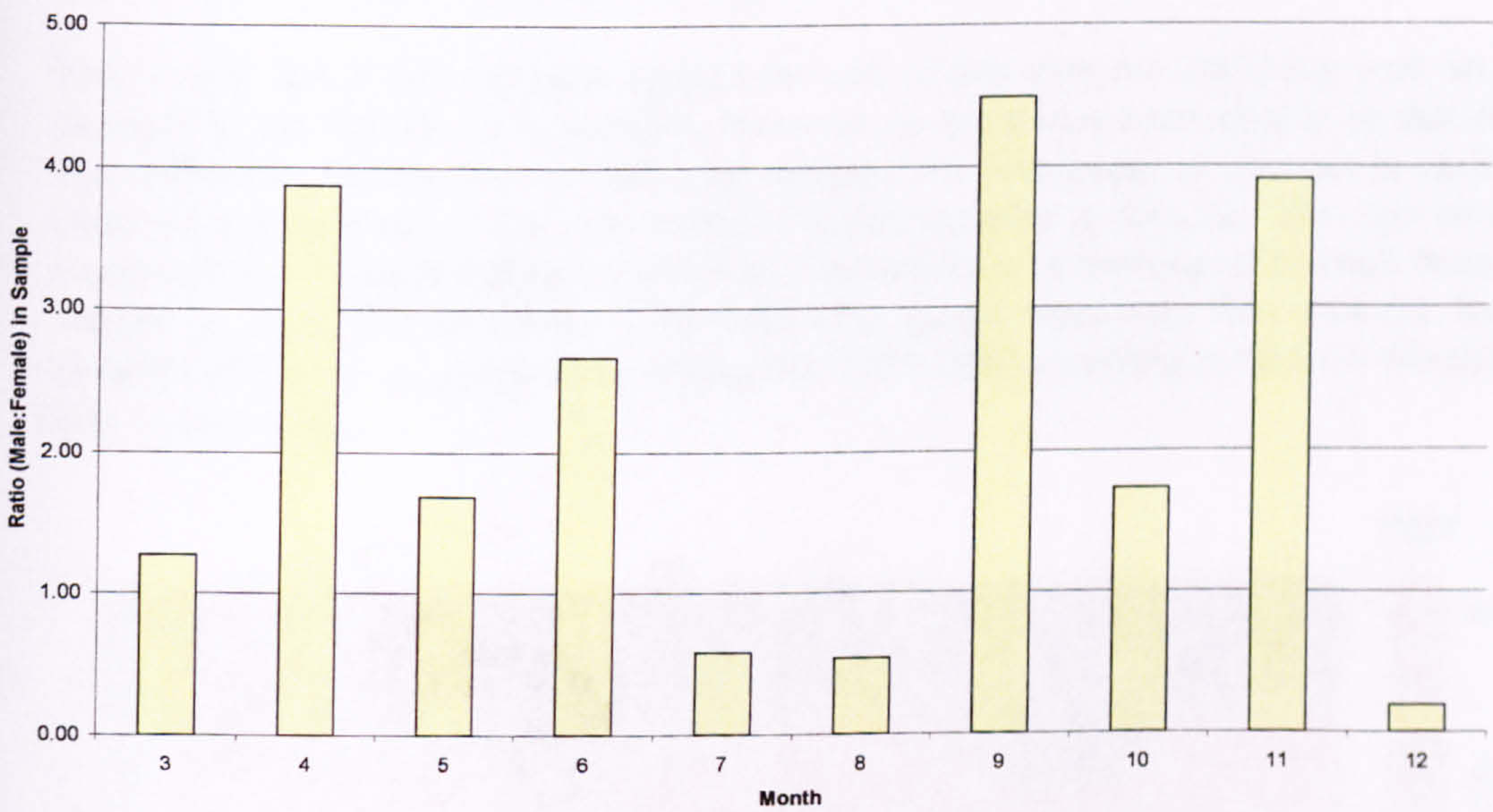


Figure m) Monthly variation in M:F ratios in FRS market data for Orkney

Thus the annual sample data is really not sufficient to make reliable observations on the ratios of males to females in the catches, the small numbers of samples in any year resulting in a large variability in ratio of male to female animals in the samples year on year.

Table i) Ratio of *C. paguras* males:females sampled during the period 1983-1999

Year	F	M	Ratio M:F
1983	94	349	3.71
1984	25	166	6.64
1986	152	183	1.20
1987	152	655	4.31
1989	418	1087	2.60
1990	717	554	0.77
1991	440	898	2.04
1992	401	903	2.25
1993	457	1193	2.61
1994	828	669	0.81
1995	204	270	1.32
1996	1139	2274	2.00
1997	1907	1152	0.60
1998	919	2023	2.20
1999	1277	1340	1.05
Total	**9130**	**13716**	**1.50**

This is one factor that militates against the use of this data for exploring year on year changes in the fishery. It is possible, however, to normalise each sample so that rather than reflecting the numbers in each size category the percentage of animals in each size class (as a percentage of the total animals in that sample) is derived. This can be done separately for males and females and thus represents the proportion of animals from any sample in each size category. The following graph represents this data for female samples of *Cancer paguras* taken during the 1983-1999 sampling period for which FRS data is available.

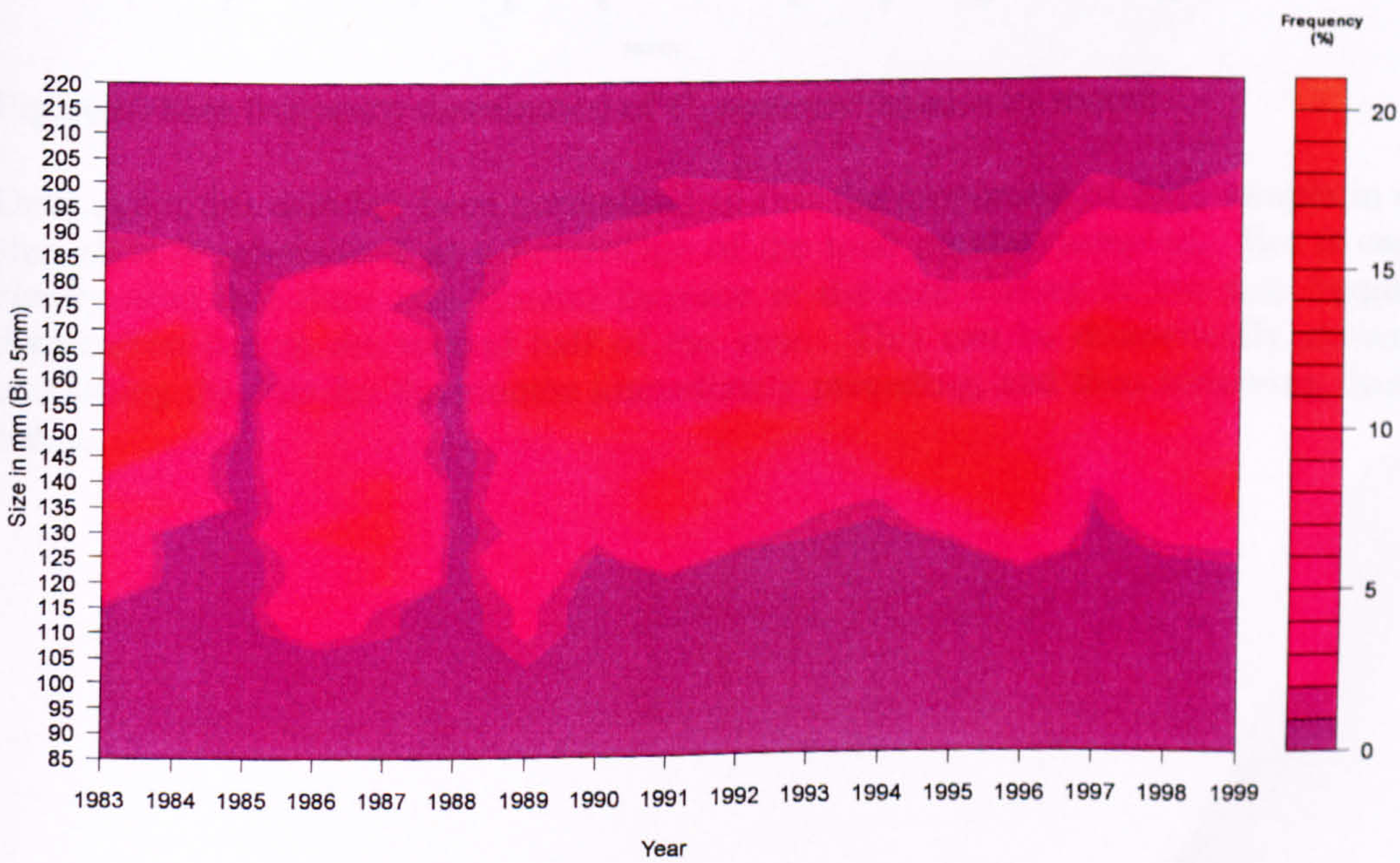


Figure n) Size frequency distribution of *C. paguras* females by year

At first sight this data seems to suggest, for example, that during the years 1994 to 1996 a significant decrease in the size of female crabs landed has taken place. As this graph may be difficult to interpret a model representation of this data has been constructed (see photos). As one would expect an increase in fishing mortality to correspond with a skewing of the size frequency distribution to lower size classes this representation of the data provides a simple way of investigating such trends in a fishery. The difficulty here with the FRS data is that there is a much simpler explanation of this apparent change during 1994 to 1996, which again highlights the restrictions of the use of this data in this way.

If the size frequency distribution for each months data combined is plotted in the same manner there appears to be a seasonal change in the size frequency of the samples of female crabs.

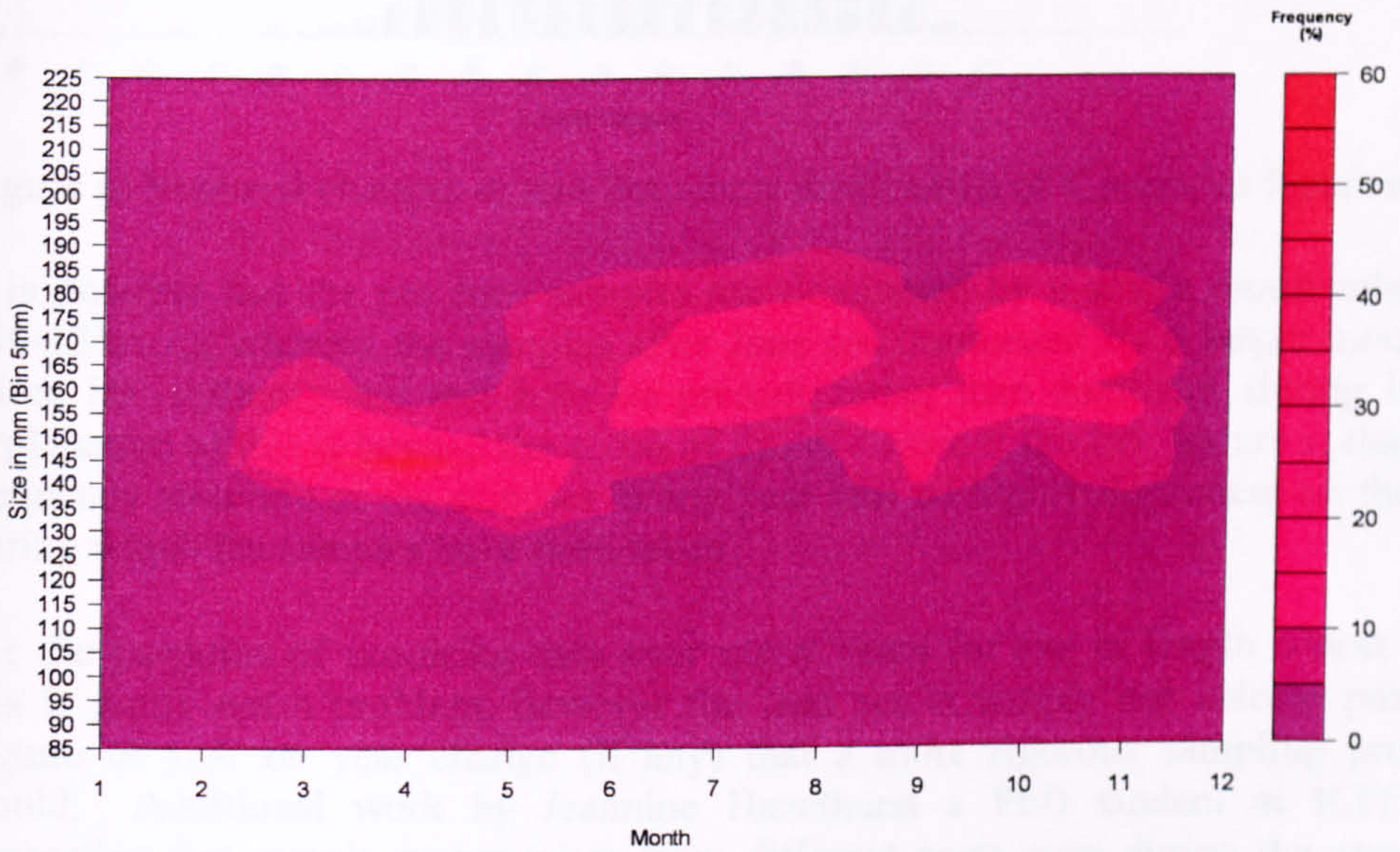


Figure o) Size frequency distribution of *C. paguras* females by month

Once again this data has been normalised so that the proportion of each sample in each size class is represented as a percentage of the total number sampled. But it can be clearly seen that there is a general increase in the size classes of the size frequency distribution during the second half of the year. This can be dramatically shown by combining the data for the months immediately preceding, and then following, June as below:

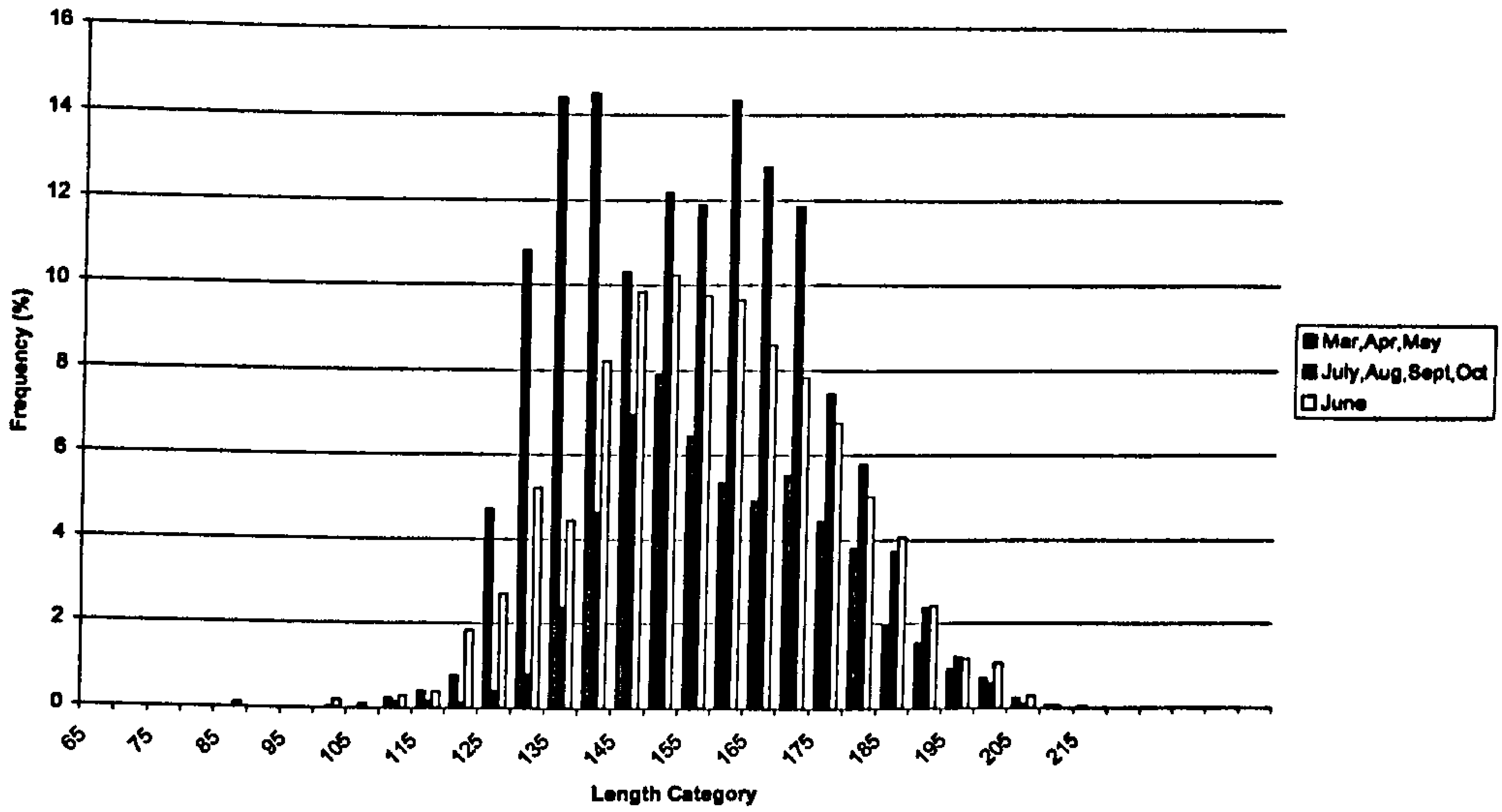


Figure p) Seasonal changes in size frequency distribution of *C.paguras* females

It is possible that the pre June samples are dominated by a single moult cohort (circa 130-135mm), whereas the samples after June are dominated by a larger moult cohort (circa 160-165mm), and that both are present, rather than dominant, during June. An explanation of this is beyond the scope of this discussion; the key feature is that the size frequency structure of the samples in any year will be highly dependent on the months during which the samples have been taken.

For the purposes of acquiring data over many years for use in length cohort analyses this is really not a problem, however the data set is simply not able to provide the picture of year on year change (if any) that a more rigorous sampling programme would. Additional work by Jeannine Hazelhurst a PhD student at ICIT is also suggesting that sample means taken from different ports even during the same month may show significant variation, which is another restriction on the use of FRS data for this purpose. Indeed from the above discussion it is clear that to use this data to infer annual changes in the structure of the catches would be very unwise indeed. In the male partan market samples for example where such seasonal variation is less apparent there is no evidence of any significant changes in the structure of the catch samples just a small variability during the period, which could suggest despite significant variations in catches during this period a fairly stable fishery. But this data is simply not sufficient to do more than suggest no evidence of changes for the worse.

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Appendix 1. Minutes steering group meeting (28/01/03)

ATTENDANCE	INITIALS	PRESENT/ABSENT
Joanna Henley	JH	Present
Mark Baine	MB	Present
Sheila Headley	SH	Present
John Ruscoe	JR	Present
Julia Partridge	JP	Present
Susan Ferguson	SF	Present
Kathy Hutchinson	KH	Absent
Pauline Hunt	PH	Absent
Jane Laud	JL	Present
Christine Skene	CS	Present
Effy Everiss	EE	Absent
Nadine Russell (new member)	NR	Present

JH - Welcomed all members, including new member Nadine Russell, the Local biodiversity Officer and made apologies for absentee, Effy Everiss from the Orkney Field Club.

Question and answer session

JP – Asked was there still the possibility of extending an 'Ouse Walk' through the Binscarth Woods.

JH – Answered that, owing to land use issues such as grazing of cattle, access and land ownership, the consequent difficulties encountered would be outwith the capabilities of the project.

CS – Reiterated this point

SH – Commented that the project appeared to be extremely good value for money

JP – Asked whether or not children would be involved in producing some aspect of the interpretation boards.

JH – Mentioned that a competition for a design for the stone seat could be superimposed on the interpretation boards or, photos of the children taking part in the project could be put on the boards.

NR – Mentioned that it would be good to consider issues of outsider/disabled access for grant applications (likely to receive a greater grant and more readily) and incorporating something for such groups into project design. Further asked whether the use of Braille had been considered for the interpretation boards.

JH – Answered that disabled access would be possible maybe at the start of the walk and that Braille had so far not been considered. However, would make issues of disabled access a definite addition to grant applications to be made.

CS – Added that the first area of the walk i.e. the first interpretation board would be possible for disabled access

JH – Added that the 'Mill end' of the walk could also be modified for access due to a level area of hardcore, at one end of the proposed walk.

CS – Asked SF whether or not the seaweed raking aspect of the 'Beach Clean Up' stage of the project could become an annual event for Environmental Concern Orkney (ECO). Added that the Orkney Islands Council (OIC) would not be able to schedule this every year.

SF – Answered that she would consider this issue and mentioned that in the near future, there may be a community compost heap in operation.

SF – Asked whether a bird hide could become part of the project proposal

JH – Answered that there was already one at the school and that it would be a good idea, though unsure of the likelihood of it coming about

CS – Said should not be put into grant applications at this stage because it would make the anticipated cost outwith the funding capabilities of those grant-making authorities JH will be applying to.

NR – Mentioned it may be an aspect of the project the RSPB could take on

JH – Said that the RSPB, in particular Eric Meek, will be contacted in the near future as the project fits well into their proposals for community participation projects. Added that, someone from the RSPB will be taking part in the local biodiversity recorder day out in the third stage of the project.

JP – Mentioned that Scottish Natural Heritage (SNH) might fund such a hide and would in any case, send JH a grant application form.

JP – Asked what the response rate was to the questionnaire survey

JH – Answered that a good number of questionnaires were completed by children and that there were definitely fewer returns from adults. Added that despite this, a good idea of the community's aspirations was retrievable from those returned.

SH – Asked whether or not the timetable of the project was flexible. Added that the school would be on holiday from the 2nd July until late August. Added it would be more difficult to arrange a get-together of schoolchildren in the holidays than in term time. Therefore mentioned it would be better to schedule launch of Ouse walk in late Aug/early September.

MB – Added that it could be linked in with the Orkney Science Festival at the beginning of September as this would lead to better promotion of the event and a greater attendance form locals as well as visitors. Added that Howie Firth, organizer would want JH to give a talk about the event during Science Festival.

JH – Answered that this would be wise to consider and that perhaps early September would be more suitable.

JH – Asked SH whether or not the Firth School had its own minibus to lend to the project

SH – Answered no, but suggested Evie community bus or the bus from the Stromness Academy.

JR – Asked JH if she would consider the following local artists who as able to contribute to the project: Francis Garrioch (jeweler) and Tracy Lawrenson (stone letterer)

JH – Said she would endeavour to contact them.

MB - Mentioned that Dr Martin Wilkinson from Heriot-Watt University, an expert in seaweed taxonomy should be asked to contribute to the seaweed identification day.

JH – Answered that she would find out if he will be in Orkney at that time and if not, will ask him to make an extra visit in order to participate.

SH – Asked SF whether or not the seaweed raking could occur on the same day as 'Bag the Bruck' in April.

SF- Answered that the schoolchildren do usually take part the Friday before the weekend event and saw no reason why this could not occur again.

SH – Said the children would really want to take part and this would be more successful on a school day.

JR – Asked whether issues of road safety had been considered for the 'Ouse Walk'*, commenting that the bridge at the Ouse does in fact, impair vision of the walks start point for drivers. Added, would this be a problem.

JH – Answered that his matter would be carefully considered.

CS – Added that herself and JH had, not initially considered this issue and that of crossing the road, when surveying the site.

NR – Added, surely this would only require a signpost or a mirror

JH – Agreed

MB – Observed there to be a general since of approval of the project

All – Agreed

JR – Asked whether OIC would be willing to maintain the walk in the future

CS – Answered yes.

JL – Asked if JH would contact the various steering group members to let them know what aspect(s) of the project they could help with.

JH - Answered yes

NR – Asked what uses there might b e for seaweed collected from the shore, could this be used in some way. Said it would be something to consider as a long—term aspect of the project.

JH – Said it would be considered.

JR – Later comments

** Safety issue at bridge would not be a problem as when driving, noticed that the bridge itself does not obscure view of start of 'Ouse walk'.*

'Things to consider. Local artist Max Scratchmann used to live just up the old road from the Ouse (he now lives in Quoyloo). He's really an illustrator, but does all sorts of multimedia type art - collages etc., and has had work on the front of The Big Issue and I've seen some of his work in the BA Highlife magazine. He's got a web site (in fact he's currently advertising in the Orcadian as a web site designer).

The school also has a web site which, I'm sure you could exploit.

Peter Maxwell-Davis wrote a piece or two for the opening of the new Firth school, may be worth having a word with him - could maybe give a musical interpretation of your project- and, there're plenty of good musicians in the parish (plus Owen Tierney's Attic Records studio).

Colin Pirie is the guy who plays the fiddle on the Radio Orkney signature tune - his place overlooks the Ouse, or maybe someone could get Ivan Drever to write a song.

There's also the craft group. They did a tapestry depicting parish life for the millennium - maybe they would be inspired to contribute'.

Appendix 2. Finstown Marine Questionnaire (x2)

FINSTOWN MARINE QUESTIONNAIRE

NAME:
OCCUPATION:

1. THE MARINE ENVIRONMENT

1. Approximately how often do you visit the shore in Finstown?
(Once a year; once a month; once a week; everyday)

2. In general, what aspect of the marine environment in Finstown do you find most interesting?

3. Would you like to learn more about the Finstown marine environment?
(Yes/No)

4. The following are some of the important aspects of the marine environment at Finstown (Bay of Firth):
a) The Ouse (lagoon at the bottom of Binscarth woods)
b) Seagrass beds (underwater marine plants)
c) Seaweed
d) Shoreline
e) Sewage accumulation/pollution
f) Fishing e.g. for sea trout

i) Which of the above (a-f) (if any), do you find most interesting?
ii) If you answered 4i), why does it interest you?
iii) Which of the above (a-f), do you know least about?
iv) Which of the above (a-f) (if any), would you most like to receive more information about?

5. Is there any other aspect of the Bay of Firth marine environment that you are particularly interested in?
(Yes/No)(If Yes, please specify)

MARINE INTERPRETATION

6. Do you think there is enough marine information available locally?
(Yes/No)

7. The marine environment can be interpreted in many ways, in particular through art. Please fill in the table below to show:
a) which of the following methods you have seen used before
b) how you would rank them in order of how useful they are

Method of interpretation	Seen before (Yes/No)	Most/least useful (rank 1-6)
Leaflets		
Sculpture		
Mosaic/collage		
Display cases		
Interpretation boards		
Guided shore walks		

8. Would you like to be involved in producing a piece of marine interpretation for Finstown, like the examples above?
(Yes/No)

9. If Yes, which of the methods above would you most like to be involved in producing?

10. Are there any other ways you would like to see marine information displayed in Finstown?
(Yes/No)(If Yes, please specify)

11. Would you like to see these pieces of marine interpretation displayed somewhere in Finstown?
(Yes/No)

DISPLAY SITES

12. The following sites are possible places to display a piece of marine artwork in Finstown. Please rank them (1-5)in order of preference:
Old School
Firth School
Bridge at the School
Car park on main road
Community Centre

13. Would you visit a piece of marine interpretation displayed at one of these sites?
(Yes/No)

14. Is there anywhere else in Finstown that you would like to see a piece of marine artwork displayed?
(Yes/No)(If Yes, please specify)

EVENTS

15. The following examples are ore detailed ways in which one could describe the importance of the Finstown marine environment, where the local community could really get involved:

a) A walk around the Ouse, with interpretation boards to show the important marine habitats and species
b) A guided shore trail from Binscarth, past the Ouse, to the bridge at Finstown, with interpretation boards, describing how habitats and species change along the way
c) A day explaining the life cycle of a fish (e.g. sea trout) and where it can be found in the Bay of Firth

i) Which of the above (if any) most appeals to you and why?
ii) Would you be willing to take part/visit the arts/event you mentioned? (Yes/No)

GROUPS OF THE COMMUNITY

16. Would you be willing, as part of a group, to take part in producing arts/events like this for Finstown?
(Yes/No)

17. In your opinion, which of the following groups of people (a-e) can you foresee becoming involved (please tick)
Firth School
Youth Club
SWRI
Community Council
Families

18. Are there any other groups of the community you think may be interested in taking part in the project?
(Yes/No)(If Yes, please specify)

THANK YOU FOR YOU HELP

FINSTOWN MARINE QUESTIONNAIRE

THE MARINE ENVIRONMENT

1. How often do you visit the shore in Finstown?
   Everyday ☐ Once a week ☐ Once a month ☐ Once a year ☐
   Never ☐

2. In general, what aspect of the marine environment do you find most interesting?

3. Would you like to learn more about the Finstown marine environment?
   Yes ☐ No ☐

4. The following are some of the important aspects of the marine environment at Finstown (Bay of Firth):
   a) The Ouse (lagoon at the bottom of Binscarth woods)
   b) Seagrass beds (marine plants)
   c) Seaweed
   d) Shoreline
   e) Sewage accumulation/pollution
   f) Fishing e.g. for sea trout

   i) Which of the above (a-f), if any, do you find the most interesting?

   ii) If you answered 3i), why does it interest you?

   iii) Which of the above (a-f), do you know least about/did not know about?

   iv) Which of the above (a-f), if any, would you most like to find out more about?

5. Is there anything else in the Bay of Firth marine environment that you are particularly interested in? (If yes, what is it?)
   Yes ☐ No ☐

MARINE INTERPRETATION

6. Do you think there is enough marine information available about Finstown?
   Yes ☐ No ☐

7. The marine environment can be described/explained in many ways. One of the ways is art. Please fill in the table below to show:

   a) Which of the following methods you have seen used before
   b) How you would rank them in the order of how useful they are? (look at pictures to help you)

Method of Interpretation	Seen before(Y) Not seen (N)	Most-least useful (rank 1-6)
Leaflets		
Sculpture		
Mosaic/collage		
Display cases		
Interpretation boards		
Guided walks, shore trails		

8. Would you like to be involved in producing a piece of marine art for Finstown, like the examples above?
   Yes ☐ No ☐

9. If Yes, which of the method(s), mentioned in Question 6 above, would you most like to be involved in producing?

10. Are there any other ways you would like to see marine information displayed in Finstown? (If Yes, what is it?).
   Yes ☐ No ☐

11. Would you like to see these pieces of marine art displayed somewhere in Finstown?
   Yes ☐ No ☐

DISPLAY SITES

12. The following sites are possible places to display a piece of marine artwork in Finstown. Please rank them in order of which you prefer

Site	Best-Worst rank (1-3)
Old School	
Firth School	
Community Centre	

11. Would you go to visit a piece of marine art displayed at one of these sites?
   Yes ☐ No ☐

12. Is there anywhere else in Finstown, that you would like to see marine art work displayed? (If Yes, where is it?)
Yes ☐ No ☐

EVENTS

13. The following examples, are more detailed ways in which one could describe the importance of the Finstown marine environment, where the local community could really get involved:

a. A walk around the 'Ouse', pointing out the important marine habitats and species
b. A guided shore trail from the Binscarth woods, past the 'Ouse', to the bridge at Finstown, describing how the marine habitats and species change along the way
c. A day explaining the life cycle of a fish, the Sea Trout, and where it can be found in the Bay of Firth

i) Which of the above (a-c), if any, most appeals to you and why?

ii) Would you be willing to take part in/go the event you mentioned above?
Yes ☐ No ☐

GROUPS OF THE COMMUNITY

14. Would you be willing, as part of a group from the school, to take part in producing arts events like this for Finstown?
Yes ☐ No ☐

15. In your opinion, which of the following groups of people (a – e), would most like to get involved (please tick):

a) Firth School ☐
b) Community Council ☐
c) SWRI (Women's group) ☐
d) Youth Club ☐
e) Families ☐

THANKYOU FOR YOUR HELP!

Appendix 3.

LAUNCH DAY QUESTIONNAIRE

Name:

Age group: Under 13 13-18 19-35 36-50 Over 50

1. Are you:

i) A resident of Finstown;
ii) An Orkney resident; or
iii) A tourist

AWARENESS

2. Were you aware of the existence of the project 'Art in the Finstown Marine Environment' prior to this event?
   Yes No

3. Which of these events were you aware of/took part in? (Please tick)

Event	Aware of	Took part in
Questionnaire survey		
Beach Clean Up		
Seaweed raking		
Seaweed Day and/or collage making		

4. Were you aware members of the community oversaw the development of the project through the formation of a steering group?
   Yes No

5. Were you involved in any way?
   Yes No

6. If no, would you have liked to have been involved?
   Yes No

USEFULNESS

7. Did you read the information on the interpretation boards?
   Yes No

8. If so, how much?
   Less than 25% 25-50% 50-75% 75%+ 100%

9. How much of the information you read was new to you?
   None Part All

10. Did you find the walk informative?
    Yes No

11. Do you think the walk complements the local environment of the Ouse?
Yes No

ACCESSIBILITY

12. After attending this launch day, do you feel you know more about the marine environment:
i) of the Ouse? Yes No
ii) in general? Yes No

13. Did the arts and interpretation make scientific information on the marine environment easier to understand?
Yes No

14. From your experience today, do you believe that the arts can provide a useful media for getting across scientific information to the general public?
Yes No

15. Does your experience today make you want to learn more about:
i) The Ouse? Yes No
ii) Marine science? Yes No
iii) Science in general? Yes No

16. On a scale of 0-10, how influential do you feel the arts media was in guiding your answer to the previous question?

QUALITY

17. On a scale of 0-10, please state your opinion on the quality of the following:

Project component	Rank (0-10)
Interpretation boards	
Viewing seat	
Walk	
End 'product'	

OVERALL IMPRESSION

18. In your opinion is the project a success?
Yes No

19. Will you use this walk in the future?
Yes No

Finally, if you were to sum up your experience today in one word, what word would that be.......?

Appendix 4.

SEAWEED DAY QUESTIONNAIRE

Name:

1. How much did you enjoy taking part in the Seaweed Day? (please tick box)

Not at all ☐ Quite enjoyed it ☐ Enjoyed it ☐ Really enjoyed it ☐

2. What part of the day did you most enjoy?

3. Do you feel you know more about the following?:

a) Your local area i.e. The Ouse	Yes	☐	No	☐
b) Seaweed	Yes	☐	No	☐
c) Marine science	Yes	☐	No	☐

4. Did making pressed pictures help you to learn more about seaweeds?

Didn't help ☐ Helped a little ☐ Helped a lot ☐ Really helped me ☐

5. How much can you remember of what you learnt about seaweed in the Ouse?

Nothing ☐ A little bit ☐ Most things ☐ Everything ☐

6. Do you think the seaweed pictures will make an attractive collage display?

Yes ☐ No ☐

7. Will you come and see the display at the launch of a walk around the Ouse in September?

Yes ☐ No ☐

8. Are you interested in finding out more about the marine features of your local area, after taking part in the Seaweed Day?

Yes ☐ No ☐

Appendix 5. Minutes of inaugural Project Fisher meeting

ICIT
Old Academy
Stromness
Orkney KW16 3AW

Telephone: 01856 850605
E-mail: M.S.P.Baine@hw.ac.uk

Attendance

A Coghill (OFA) [AC]	J Henley (ICIT PhD researcher)
J Sinclair (Fisher) [JSi]	R Smith (Fisher/OCFA) [RS]
J Clouston (Fisher)	I James (Fisher)
E Sinclair (Fisher) [ES]	S Crichton (OFS) [SC]
J Reid (Fisher) [JR]	D Geddes [DG]
A Jackson (Fisher) [AJ]	T Noble (Independent Chair) [TN]
M Foulis (Fisher)	J Side (ICIT) [JS]
J Drever (Fisher)	M Baine (ICIT) [MB]

1 TN opened the meeting at 7.05pm and thanked everyone for attending. The attendees introduced themselves to the group. JS provided an overview of the ESRC research project (FISHER). This is summarised in the attached document.

2 ES queried why this research project was needed and JR further asked if it was only being undertaken in Orkney. TN replied that the aim of the research is to provide fishermen with the opportunity to direct future research initiatives. JS further stated that it is only being undertaken in Orkney and is a radical approach to fisheries science. JS also stated that it is a reasonable suggestion that no research should be undertaken.

3 RS noted that there are areas for potential research in Orkney. These include collation of data on v-notching programmes, research into ways of ageing lobsters, examining fisheries models and identifying their flaws.

4 RS asked what the motivation was for this approach in Orkney. JS replied that experience from other ICIT projects in the Galapagos (Ecuador) and San Andres (Colombia) had shown that scientists imposing solutions actually generated conflict. As part of these projects ICIT listened more carefully to the views of fishermen and formulated the idea of researching a way that information can be of value to fishermen and prioritising such information.

5 RS noted that an increase in bureaucracy was a major problem facing the fishing industry. TN noted that the remit of the research also extends beyond science related to management. It can also relate to e.g. productivity. JS reaffirmed that the fishing industry has little control on what research can be completed. This is an opportunity to turn those tables.

6 AC agreed, stating that fishermen need to backed by science. AC suggested possible research initiatives could include migration routes of brown crab, handling

of catch in the summertime to reduce mortalities, distribution of queenie beds and more scallop fisheries research as this industry was dying in Orkney. DG agreed stating that scientists have effectively convinced everyone that scallops are all toxic and that this was overkill given it has never occurred.

7 RS inquired if ICIT was linked to the Orkney Water Test Centre (OWTC). JS replied that historically ICIT was but not any more. RS asked if ballast water could be tested for the presence of dinoflagellates. JS replied that ICIT could find out what water checks are undertaken, and if these can be obtained and provided to the group.

8 DG stated that research could examine how to maximise prices for what there is on the ground in Orkney.

9 RS asked if he could be supplied with a copy of the model used for lobster stock assessments. JS replied that he would supply this to RS. RS noted that the whitefish model has not been challenged and that this was mistakenly interpreted by scientists as a justification that it was right. AC further noted that it is difficult to have the model explained in simple terms. It is, however, challenged as far as could be possible by the whitefish industry.

10 AC noted that ministers and officials normally hide behind what scientists say and that it is difficult to find anyone who is neutral. It would be beneficial to have someone put forward the views of fishermen.

11 SC noted that as a processor he didn't want to influence the meeting too much but that research could examine the distribution of juvenile and spawning brown crabs. SC stated that research should expand beyond velvet crabs and lobster. SC floated other ideas to examine the possibility of a male only brown crab fishery in areas and to look into the sustainability of the brown crab fishery.

12 RS further noted the value of researching spatial and seasonal variations in the occurrence of brown crab, including migratory patterns.

13 JSi noted the need for research into the effects of salmon farming on local creel fisheries, particularly shellfish larvae. Other suggestions included the need for seal culls, DG noting that seal conservationists have no real idea of the extent of the population of seals in Orkney waters.

14 RS asked how this research project would proceed after the initial gathering of research information needed. JS replied that once a shopping list of research areas had been finalised, the wider community of Orkney fishermen will be asked to prioritise these. This will then be explored in more detail. The option then exists for the fishermen and other groups to pursue a programme of research based around these priorities, a research programme which the fishermen will have control over, perhaps through a committee.

15 AJ suggested that it may be beneficial to identify the whole inshore fishing industry as a single business and then address what that business needs in the way of

research. AJ noted, for example, the similar problems associated with transport. RS speculated that perhaps the industry would not want a single entity composed of many different departments, a lot of which do not talk to each other.

16 SC suggested that research could examine and evaluate the research undertaken by other bodies such as the Sea Fish Industry Authority (SFIA). It could establish what future research is planned and what is specific to Orkney. JS noted that this would be possible.

17 AC stated that the group could go away and think of other ideas to include on the list of possible research. JS agreed, noting that any fisherman is able to add ideas to the list and that this can be done either through the meetings or by contacting MB or himself via telephone or e-mail *(note the contact details at the start of these minutes)*.

18 Other research possibilities that were suggested included buckie research and the need for a factory; and transport. DG noted that the Irish government pay for all their shellfish transport. The problem with factories for buckie processing was noted to be economic viability, with only 3 existing in the UK.

19 TN stated that there would be at least 2 and perhaps a 3rd meeting of this type within which research could be explored. The minutes of the meeting would be circulated to everyone at the meeting and to outer isles representatives. Those present were also asked to circulate the minutes to other interested fishermen and members of their organisations such as the OFA and OCFA. AC and RS agreed to do this with respect to their organisations. TN noted that the next meeting would be scheduled for the end of February/beginning of March and asked that those present talk to other fishermen to gauge their interest in attending the meetings. Any fisherman is welcome to attend the meetings.

20 Other possible research areas raised included the effects of climate change and other natural phenomenon on fisheries stocks, changes in sea temperature over the past few decades, and possible correlations between bumper catches and the occurrence of natural phenomenon. The effects of seismic charges on fish eggs was also raised.

21 AC noted the absence of representatives from the outer isles. The possibility of videoconferencing was discussed as was the need for overnight stays for fishermen.

22 JS noted that when it was time to circulate the first questionnaire to a wider body of fishermen in Orkney, there was scope to include questions that would provide information of interest to the group.

23 Discussion then ensued on the use of results from any research projects. JS observed that the research could be controlled by fishermen. It was noted by fishermen in general, however, that such information could be damaging in the hands of the wrong people. RS suggested the possibility of vetoing results, which they deemed to be obviously wrong. AC noted that it was normally the funding body who called the tune with respect to results. How much control will fishermen actually have? AC also noted, however, that there is a lot of research that would not

be viewed as contentious. JS agreed noting that contentious research need not be prioritised highly by fishermen.

24 It was asked if fishermen had the power to stop the research. JS replied that they did. TN asked the group for their opinions on continuing the research. RS and DG both noted that at the moment they were possibly okay with the project (although RS added that this was against his better judgement). AC added that if the science promotes and protects the industry, then yes, but if not, then no. DG stated that hitherto scientists have not listened to fishermen. RS asked why ICIT should be any different. In reply, JS noted that they were all around the table together and that this was a good start. It was agreed that a safeguard would be built into the research, notably the questionnaire, to ask the fishermen as a wider community if they wished to pursue this research.

25 TN thanked everyone for attending and closed the meeting at 8.45pm.

Appendix 6. Shopping list of possible research

- Independent collation of data on v-notching programmes
- Research into ways of ageing lobsters
- Examination of fisheries models and identifying their flaws (in particular, lobster stock assessment)
- Prevention of increased bureaucracy
- Brown crab movements/migration routes
- Brown crab spatial and seasonal variations in population
- Distribution of juvenile and spawning brown crabs
- The possibility of a male only brown crab fishery in areas
- Sustainability of the brown crab fishery
- Handling of shellfish in the summer to reduce mortalities
- Distribution of Queen scallop beds
- Scallop fisheries research linked to shellfish toxin closures
- Ballast water sampling for dinoflagellates
- Maximising market prices for catch
- Effects of salmon farming on local creel fisheries, particularly shellfish larvae
- Seal culling
- Evaluation of research undertaken by other bodies such as the SFIA
- Research into the buckie fishery
- Factory processing of buckies
- The effects of climate change and other natural phenomena on fisheries stocks
- Sea temperature change in Orkney waters
- Correlations between the occurrence of natural events and bumper shellfish catches
- Effects of seismic charges on fish eggs

Interesting quotes on the relationship between fishermen and scientists

"After the recent disasters with the whitefish fleet – thanks but no thanks could well be the answer now (to working with fisheries scientists)" [RS]
"The problems for the whitefish fleet and the scallop fisheries come from science. Everything to date has resulted in damage to the fishing industry" [DG]
"This is comparable to someone giving you the sack and then coming back to you looking for a job" [RS]
" Research could get into the wrong hands and put people out of business – this has happened before"[DG]
"Do we want to get in bed with scientists – as they have destroyed the whitefish industry" [RS]

Appendix 7.

Project FISHER
Questionnaire

Background

The International Centre for Island Technology (ICIT), Heriot-Watt University, based in Stromness, seeks to define a programme of fisheries science investigation with the direct involvement and collaboration of local fishermen. The Economic and Social Research Council (ESRC) awarded funds for this effort in 2002 through its Science in Society research initiative. Basically, fishermen are asked to take the driving seat in identifying future research that they feel would be: (a) most useful to the development of the Orkney creel fisheries; (b) fostering the greatest possible co-operation among local fishing interests; and (c) most helpful to solidifying the bargaining position of local fishermen in local, national, and international debates on issues affecting their interest.

To this end, local fishermen, including fishermen in the outer isles, were invited to participate in meetings at which they were able to identify those general research areas that they would like to see addressed as part of a future programme of fisheries research in Orkney.

The Questionnaire

The aim of this questionnaire, which has been distributed to as many creel fishermen as possible, is to record how you, as an individual fisherman, would prioritise the research areas identified at the above meetings. There are also some questions, which seek to gauge relevant background information and your opinion on certain issues. The results of this exercise will then be presented to fishermen later in the summer, at an advertised meeting, to which all fishermen will be invited to attend.

ICIT wishes to emphasise that:

1) **the information provided from this questionnaire is to be used solely for the purposes of investigating a programme of fisheries research;**
2) **this work is not in any way related to regulating orders, or any other form of imposed management system, and**
3) **your answers will be kept strictly confidential.**

The questionnaire is divided into 3 parts: PART A, which seeks general background information; PART B, which seeks your prioritisation of research areas; and PART C, which seeks your views on the conduct of any research that might be undertaken in the future.

ICIT would be grateful if you could complete the enclosed questionnaire and return it in the prepaid envelope provided. The questionnaire should take no longer than 20 minutes to complete. Your participation is greatly appreciated.

Thank You

PART A: BACKGROUND INFORMATION

Please mark your choice(s) with an X, and write answers where required.

1 Are you a member of any fisheries organisation in Orkney?

- [ ] Yes, please specify: .....
- [ ] No

2 Do you own the vessel from which you fish? Are you engaged in fishing? Are you an official representative of local fishing interests

- [ ] Yes, I own the vessel
- [ ] No, I do not own the vessel
- [ ] I am an active fisherman
- [ ] I am an official representative of local fishing interests

3 How long have you fished, or been involved in fishing, in Orkney waters?

- [ ] Months -10 years
- [ ] 11-20 years
- [ ] 21-30 years
- [ ] >30 years

4 Where are you based? (e.g. Kirkwall, Stromness, Tingwall, Westray, etc.)

5 What best describes your fishing activity (e.g. creel, clam, whitefish ,etc.)

6 What best describes the importance of fishing to your livelihood?

- [ ] Fishing is my main occupation
- [ ] Fishing is not my main occupation

PART B : RESEARCH PRIORITISATION

7 Below are general research areas identified from discussions with local creel fishermen. Subsequent questions will examine each general research area in more detail, and the specific topics suggested which are listed on the following pages. You are advised to make yourself familiar with the specific topics of each general research area, before completing the table below.

We want you to score each of the general research areas in the table below **so that your total score adds up to 100.** This provides us with a means of judging your priorities.

***Use zero (0) in this table ONLY IF you give no research priority to the Specific Research Topics associated with a particular General Research Area.**

	GENERAL RESEARCH AREA	DEFINITION	SCORE (Total =100) *Please see note above about using zero.
A	Lobsters and Related Research	Research on lobster to learn more about their biology and ecology	
B	Crabs, Other Shellfish and Related Research	Research on crabs and other species to learn more about their biology and ecology	
C	Economic Development and Profitability	Development of the local fisheries economy	
D	Environmental Factors	The influence of the marine environment and its users on local fisheries	
	TOTAL		100

Now we will seek your responses on the ideas suggested by fishermen within each of these general research areas. **Remember there are no wrong answers – please tell us your score for each specific research topic so that the total score is 100 for each general research area (A ; B ; C ; D).**

General Research Area 'A'
Specific Research Topics : Lobsters and Related Research

A Independent collation of data on v-notching programmes
There is a need for an independent organisation to collect information on v-notching in Orkney to assess the degree to which this practice is undertaken and its likely impact.

B V-notching and compensation schemes
The need for more information on the effectiveness of such measures as hatcheries, ranching and v-notching, to support funding and a compensation scheme in the case of v-notching.

C Research into ways of ageing lobsters
There is no straightforward way of ageing lobsters. The identification of a means to do so would greatly aid fishermen in understanding the ecology and dynamics of the fishery.

D Lobster reproduction
Research into understanding more clearly the reproductive cycle of lobsters in Orkney waters, including times of the year when they are berried.

E Examination of fisheries models and identifying their flaws (in particular, lobster stock assessment)
There is a need to examine and dissect scientific models used in modern day fisheries management, to highlight those factors, such as assumptions, that affect the outcomes of modelling but which may not necessarily hold true for a given fishery.

F Evaluation of research undertaken by other bodies such as the SFIA
An examination of current and future research to be undertaken by organisations such as the Sea Fish Industry Authority, Marine Laboratory and Academia in the fisheries field. Are there any ongoing research initiatives that would be of relevance to Orkney?

8 **General Research Area 'A'.** Below are specific research topics identified from discussions with local creel fishermen that fall in the category of **LOBSTERS AND RELATED RESEARCH.** Exact definitions of the research areas are provided on the opposite page.

Please show your preferences by scoring each one so that the total is 100.

	SPECIFIC RESEARCH TOPIC [See opposite page for additional definition]	SCORE (Total=100)
A	Independent collation of data on v-notching programmes	
B	V-notching and compensation schemes	
C	Research into ways of ageing lobster	
D	Lobster reproduction	
E	Examination of fisheries models and identifying their flaws (in particular lobster stock assessment)	
F	Evaluation of research undertaken by other bodies such as the Sea Fish Industry Authority	
	TOTAL	**100**

General Research Area 'B'
Specific Research Topics : Crabs, Other Shellfish and Related Research

A Brown crab movements/migration routes
There has been little ecological research on the brown crab in Orkney waters. Of particular use would be research into movements of brown crab, migration routes and seasonal factors, particularly during spawning periods.

Brown crab spatial and seasonal variations in population
There has been little ecological research on the brown crab in Orkney waters. Of particular use would be research into the distribution of brown crab in different parts of Orkney's inshore waters and over different seasons.

Distribution of juvenile and spawning brown crabs
There has been little ecological research on the brown crab in Orkney waters. Of particular use would be research into the distribution, occurrence and quantity of juveniles, and more detailed information on spawning periods.

B The possibility of a male only brown crab fishery in areas
Research into the establishment of a male only fishery in specific areas, to assess the acceptability of such an option, impact on catch and benefits that would accrue.

Sustainability of the brown crab fishery
Research examining brown crab population size and catch with the aim of investigating what the effects of changing effort would be on future populations.

C Distribution of Queen scallop beds
Identification of scallop beds in Orkney waters, and any seasonal effects.

D Research into the buckie fishery
An examination of population size and distribution of buckies in Orkney waters. An examination of the dependent fishery in terms of effort, catch and economic importance.

E Cockle recruitment
An investigation of the possible enhancement of recruitment to cockle beds.

F Velvet swimming crab
Research into growth patterns in the velvet swimming crab.

G Evaluation of research undertaken by other bodies such as the SFIA
An examination of current and future research to be undertaken by organisations such as the Sea Fish Industry Authority, Marine Laboratory and Academia in the fisheries field. Are there any ongoing research initiatives that would be of relevance to Orkney?

9 **General Research area 'B'.** Below are specific research topics identified from discussions with local creel fishermen that fall in the category of **CRABS, OTHER SHELLFISH AND RELATED RESEARCH.** Exact definitions of the research areas are provided on the opposite page.

Please show your preferences by scoring each one so that the total is 100.

	SPECIFIC RESEARCH TOPIC [See opposite page for additional definition]	**SCORE (Total=100)**
A	Brown crab movements/migration routes; Brown crab spatial and seasonal variations in population; distribution of juvenile and spawning brown crabs	
B	The possibility of a male only brown crab fishery in areas; Sustainability of the brown crab fishery	
C	Distribution of queen scallop beds	
D	Research into the buckie fishery	
E	Cockle recruitment	
F	Velvet swimming crab	
G	Evaluation of research undertaken by other bodies such as the Sea Fish Industry Authority	
	TOTAL	**100**

General Research Area 'C'
Specific Research Topics: Economic Development and Profitability

A Handling of shellfish in the summer to reduce mortalities and improve quality
One problem facing the inshore fishing industry, most notably the processing sector is high levels of mortalities during the summer. Are there alternative or improved means of handling shellfish during processing and subsequent transport that can reduce these mortalities.

B Maximising market prices for catch
An assessment of ways and means to maximise profits in the industry for fishermen and processors.

C Factory processing of buckies
An examination of the practical and economic feasibility of factory processing being undertaken in Orkney.

D Mussel farming
Provision of research to support the development of mussel farming e.g. in Westray.

E New business ventures
Research that could be of benefit to establishing and supporting new fishing enterprises.

F Prevention of increased bureaucracy
There is a need to examine management of fisheries within the UK and Europe, with the aim of (i) identifying unnecessary and confusing bureaucracy, (ii) highlighting the problems associated with this, and (iii) identifying possible alternatives.

G Evaluation of research undertaken by other bodies such as the SFIA
An examination of current and future research to be undertaken by organisations such as the Sea Fish Industry Authority, Marine Laboratory and Academia in the fisheries field. Are there any ongoing research initiatives that would be of relevance to Orkney?

10 **General Research Area 'C'.** Below are specific areas identified from discussions with local creel fishermen that fall in the category **ECONOMIC DEVELOPMENT AND PROFITABILITY.** Exact definitions of the research areas are provided on the opposite page.

Please show your preferences by scoring each one so that the total is 100.

	SPECIFIC RESEARCH TOPIC [See opposite page for additional definition]	**SCORE (Total=100)**
A	Handling of shellfish in the summer to reduce mortalities and improve quality	
B	Maximising market prices for catch	
C	Factory processing of buckies	
D	Mussel farming	
E	New business ventures	
F	Prevention of increased bureaucracy	
G	Evaluation of research undertaken by other bodies such as the Sea Fish Industry Authority	
	TOTAL	**100**

General Research Area 'D'
Specific Research Topics : Environmental Factors

A Ballast water sampling for dinoflagellates
An examination of historical records (if they exist) to see if ballast water is tested for the occurrence of dinoflagellates. If so, to what degree are they present and are they a possible cause of shellfish poisoning in Orkney's waters.

B Effects of salmon farming on local creel fisheries, particularly shellfish larvae
Does the salmon farming industry, in particular, the production of waste affect local shellfish populations? Are larvae impacted at all?

C Seal culling
An investigation of existing seal populations in Orkney and their impact on the fishing industry. Is a cull warranted? Is a cull defendable?

D The effects of climate change and other natural phenomena on fisheries stocks
An examination of the impact of natural events such as climate change on shellfish populations and their dependent industries.

E Sea temperature change in Orkney waters
Has there been any change in sea-water temperature in Orkney. An examination of records existing for the late 20th century and early 21st century. Research into water temperature variations and their possible impact on shellfish stocks.

F Effects of seismic charges on fish eggs
An examination of past research on the effects of seismic charges on fish eggs.

G Sand eel fishery
Research into the impacts of the sand eel fishery on shellfish stocks.

H Correlations between the occurrence of natural events and bumper shellfish catches
Research into understanding if natural events affect shellfish numbers on a large scale.

I Scallop fisheries research linked to shellfish toxin closures
An investigation of alternative means of monitoring for toxins and an assessment of their actual occurrence in Orkney waters.

J Evaluation of research undertaken by other bodies such as the SFIA
An examination of current and future research to be undertaken by organisations such as the Sea Fish Industry Authority, Marine Laboratory and Academia in the fisheries field. Are there any ongoing research initiatives that would be of relevance to Orkney?

11 **General Research Area 'D'.** Below are specific areas identified from discussions with local creel fishermen that fall in the category **ENVIRONMENTAL FACTORS.** Exact definitions of the research areas are provided on the opposite page.

Please show your preferences by scoring each one so that the total is 100.

	SPECIFIC RESEARCH TOPIC [See opposite page for additional definition]	**SCORE (Total=100)**
A	Ballast water sampling for dinoflagellates	
B	Effects of salmon farming on local creel fisheries, particularly shellfish larvae	
C	Seal culling	
D	The effects of climate change and other natural phenomena on fisheries stocks	
E	Sea temperature change in Orkney waters	
F	Effects of seismic charges on fish eggs	
G	Sand eel fishery	
H	Correlations between the occurrence of natural events and bumper shellfish catches	
I	Scallop fisheries research linked to shellfish toxin closures	
J	Evaluation of research undertaken by other bodies such as the Sea Fish Industry Authority	
	TOTAL	**100**

12 If there is any other specific area(s) of research, not identified in questions 9-11, that you would like to put forward, please elaborate below.

Research area(s):

PART C: THE CONDUCT OF FUTURE RESEARCH

In Questions 13 and 14 we are trying to find out your views on science in general and fisheries science in particular, based on your everyday experiences. It is important for us to try to establish whether your views on science in general are the same as your views on fisheries science in particular, or whether they are different in your judgement. A neutral position to each question is, in all cases represented by a score of 5 on these scales of 0 to 10.

13 For science *generally, and **not** fisheries science in particular*:

(a) on the scale below please circle the position that you believe most accurately reflects your belief in scientific facts and data.

Don't Believe 0___1___2___3___4___5___6___7___8___9___10 *Do Believe*

(b) on the scale below please circle the position that you believe most accurately reflects your faith in or distrust of the motivation of scientists.

Complete Distrust 0___1___2___3___4___5___6___7___8___9___10 *Complete Faith In*

(c) on the scale below please circle the position that you believe most accurately reflects your view on scientific models/predictions.

Highly Doubtful 0___1___2___3___4___5___6___7___8___9___10 *Very Appropriate*

14 For fisheries science *in particular*:

(a) on the scale below please circle the position that you believe most accurately reflects your belief in scientific facts and data for fisheries.

Don't Believe 0___1___2___3___4___5___6___7___8___9___10 *Do Believe*

(b) on the scale below please circle the position that you believe most accurately reflects your faith in or distrust of the motivation of fisheries scientists.

Complete Distrust 0___1___2___3___4___5___6___7___8___9___10 *Complete Faith In*

(c) on the scale below please circle the position that you believe most accurately reflects your view on fisheries models/predictions.

Highly Doubtful 0___1___2___3___4___5___6___7___8___9___10 *Very Appropriate*

15 Although you have been willing to participate in this study to identify a programme of research into the local fishery, would you prefer that there was no research at all undertaken into the local fishery, or would you like to see such research going ahead?

- [ ] I would like to see such research being undertaken in the future (Go now to Question 17)
- [ ] I would prefer that no research was undertaken
- [ ] No opinion

16 If to Question 15, you answered " I would prefer that no research was undertaken", or had no opinion would you be willing to see the research go ahead if fishermen could control how the results of the research would be used?

- [ ] Yes, with control over the results by the fishermen, I would be willing for the research to go ahead
- [ ] No, not even with control over the results by the fishermen, would I be willing for the research to go ahead

17 You have been willing to participate in this study to identify a programme of research into the local fishery. Would you be willing to participate in some way in such research? (this could mean attending meetings to review projects, the recording of data from catches landed etc)

- [ ] I would be willing to participate in the research programme
- [ ] I would not be willing to participate in the research programme
- [ ] I don't know

18 How much should the interest(s) of the following groups be taken into consideration in defining the research agenda of fisheries science? Use the following codes: 0 (no relevance), 1 (some relevance) and 2 (lots of relevance)?

- [ ] Orkney Islands Council
- [ ] Orkney Enterprise
- [ ] Scottish Natural Heritage
- [ ] Scottish Environmental Protection Agency
- [ ] Royal Society for the Protection of Birds
- [ ] Orkney Dive Boat Operator's Association
- [ ] Environmental Concern Orkney
- [ ] Orkney Fish Farmers' Association
- [ ] Orkney Marine and Coastal Studies Forum
- [ ] Orkney Field Club
- [ ] Orkney Trout Fisherman's Association
- [ ] Harbours Authority
- [ ] Local Ferries

- [ ] Coastguard
- [ ] NorthLink
- [ ] Sea Fish
- [ ] Inshore Fisheries Branch of the Scottish Executive Environment and Rural Affairs Department (SEERAD)
- [ ] Fisheries Research Service, Marine Laboratory, Aberdeen

THANK YOU VERY MUCH FOR TAKING THE TIME TO COMPLETE THE QUESTIONNAIRE

Finally please feel free to make any additional comments or observations that you wish

THANK YOU FOR YOUR ASSISTANCE WITH THIS PROJECT, IT IS MUCH APPRECIATED

Appendix 8. Stakeholder questionnaire

Project FISHER

(an ESRC funded project undertaken by ICIT)

Enquiry to non - fishing organisations with an interest in the uses of the Orkney Coastal Marine Environment

Background

The International Centre for Island Technology (ICIT), Heriot-Watt University, based in Stromness, seeks to define a programme of inshore fisheries science investigation with the direct involvement and collaboration of local creel fishermen in Orkney. The Economic and Social Research Council (ESRC) awarded funds for this effort in 2002 through its 'Science in Society' research initiative. In the first phase of this study fishermen were asked to take the driving seat in identifying the future research that, in their view, would help the development of the Orkney creel fisheries, foster cooperation and strengthen their collective interest.

WHERE DO YOU COME IN ?

The fishermen recognised that they do not work in isolation, but in a community of other users, and they face a number of public interest issues. They were asked : ***"How much should the interests of the following groups be taken into consideration in defining the research agenda of fisheries science ?"*** Your organisation was one of eighteen listed as having a possible interest and in this second phase we seek to define the nature and extent of your interest and your views about some of the same issues. We emphasise that, where possible, we seek a local Orkney view. In the short questionnaire attached :

In Part 'A' you are asked questions about your organisation and its possible relationship to the fishery.

In Part 'B' you are asked questions about your degree of agreement with some of the research priorities expressed by the fishermen and any additions you would like to make.

In Part 'C' you are asked questions about your attitudes to science in general and to fisheries science in particular.

Thank you for your participation and we would be most grateful if you are able to reply by Friday 10 October 2003. Your contribution is confidential.

Please call Tim Noble on 01856 850605 if you have any questions.

1

PART A : ABOUT YOUR ORGANISATION

Please mark your choices with a tick and write answers where required.

1 Please give the name of your organisation and the contact details of the person making the response.

2 To what extent is fisheries research related to the objectives of your organisation ?
Please write : 0 for none ; 1 for some ; and 2 for a lot. [ ]

3 How much do you believe that each of the following groups should influence the formulation of fisheries research ?
Please answer on a scale from 0 -10 where 0 means no influence

	Fishermen's associations and non-affiliated fishermen
	Fisheries scientists
	Other groups such as you own

4 Please indicate how much the interests of the following groups **(including your own)** should be taken into consideration in defining the research agenda of fisheries science in Orkney.
Please write : 0 for none ; 1 for some ; and 2 for a lot.

	Orkney Islands Council
	Orkney Enterprise
	Scottish Natural Heritage
	Scottish Environmental Protection Agency
	Royal Society for the Protection of Birds
	Orkney Dive Boat Operator's Association
	Environmental Concern Orkney
	Orkney Fish Farmers' Association
	Orkney Marine and Coastal Studies Forum
	Orkney Field Club
	Orkney Trout Fisherman's Association
	Harbours Authority
	Orkney Ferries
	HM Coastguard
	NorthLink
	Sea Fish
	SERAD (Inshore Fisheries Branch)
	Fisheries Research Service, Marine Laboratory, Aberdeen
	Scottish Fisheries Protection Agency
	Fishermen's Associations

PART B : ABOUT THE RESEARCH AND PRIORITIES

A full list of the general research areas and their associated specific research topics identified by the fishermen is attached in a separate schedule. The responses that the fishermen gave in identifying their priorities to the general research areas and specific research topics from this list have been statistically analysed to cluster preference patterns into four groups of research topics A, B, C, D. The topics gaining the highest proportion of the consolidated support in each cluster are ranked for comparison on page 4.

Explanatory notes to table on page 4.

1 The items shown are the preferred topics that received approximately 50% of the total preference score for the list of all topics. A full list of results is included as an attachment.

2 Please note that the term 'V-notching' refers to a scheme whereby female berried lobsters (carrying eggs) are returned to sea with a V-notch cut into their tail. These lobsters will not be marketed. At the moment the scheme in Orkney works on a voluntary basis without compensation. It has in the past been a scheme with compensation.

3 Legend :

R	=	Rank preferred within each cluster.
%	=	Preference score relating to this topic within this cluster.
Econ	=	Economic
Env	=	Environmental

Please read the four sets of research topics (A – D) on page 4 noting the respective similarities and differences between each cluster.

Preference Cluster >>>>>>		A		B		C		D	
Class	**Research Topic**	R	%	R	%	R	%	R	%
Lobster (Econ)	Conservation / replenishment schemes including V-notching compensation schemes.	2	7.2	2 =	6.7	1	27.2	2	14.5
Lobster	Reproductive cycles in Orkney.	4	6.1	9	3.8	4	6.0	-	-
Lobster	V-notching – independent collation of data.	5	5.6	7	5.0	3	8.0	-	-
Lobster	An examination of fisheries models and their flaws.	7	4.0	-	-	-	-	-	-
Crab	Brown crab distribution, movements and migration. Seasonal and spatial variations in population.	1	7.3	6	5.1	2	8.7	-	-
Crab	Velvet swimming crab growth patterns.	3	6.6	2 =	6.7	-	-	-	-
Crab	Brown crab male only fishery feasibility.	6	4.8	-	-	-	-	-	-
Econ.	Better handling of shellfish to reduce mortality from sea en route to final markets.	8	3.9	1	6.8	-	-	-	-
Econ.	Maximising market price for catch.	9	3.7	2 =	6.7	-	-	1	29.3
Econ.	Examine management of fisheries with the objective to reduce bureaucracy.	-	-	-	-	-	-	3	14.0
Env.	Investigating seal populations in Orkney and solutions to impacts on fisheries (culling?).	-	-	5	5.8	-	-	-	-
Env.	Effects of salmon farming on the local creel fishery.	-	-	8	4.8	-	-	-	-

Preference Cluster >>>>>>	A	B	C	D

Thank you. Now please answer the following question

Question 5. Would you please rate your degree of agreement or disagreement with each of these groups (A - D) in the following table. Allocate a number from 0 to 10 (where : 0 signifies total disagreement ; 5 signifies a neutral position and 10 signifies total agreement). Feel free to expand on your answer if you wish.

Group	Rating 0 - 10	Comment
A		
B		
C		
D		

Expand on your comments here if you wish :

Question 6. Would you please describe any fisheries research priorities of your organisation that do not appear in the groups above. You may use either the general and specific research topics described in the attached schedule (the full list identified by the fishermen) or add your own.

PART C: VIEWS ABOUT SCIENCE

In Questions 7 and 8 we are trying to find out your views on science in general and fisheries science in particular, based on your everyday experiences. It is important for us to try to establish whether your views on science in general are the same as your views on fisheries science in particular, or whether they are different in your judgement. A neutral position to each question is, in all cases represented by a score of 5 on these scales of 0 to 10.

7 <u>For science *generally (and NOT fisheries science in particular)*</u>:

(a) on the scale below please circle the position that you believe most accurately reflects your belief in scientific facts and data.

Don't believe 0__1__2__3__4__5__6__7__8__9__10 *Do believe*

(b) on the scale below please circle the position that you believe most accurately reflects your faith in or distrust of the motivation of scientists.

Complete distrust 0__1__2__3__4__5__6__7__8__9__10 *Complete faith in*

(c) on the scale below please circle the position that you believe most accurately reflects your view on scientific models/predictions.

Highly doubtful 0__ 1__ 2__3__4__5__6__7__8__9__10 *Very appropriate*

8 <u>For fisheries science *in particular*:</u>

(a) on the scale below please circle the position that you believe most accurately reflects your belief in scientific facts and data for fisheries.

Don't believe 0__1__2__3__4__5__6__7__8__9__10 *Do Believe*

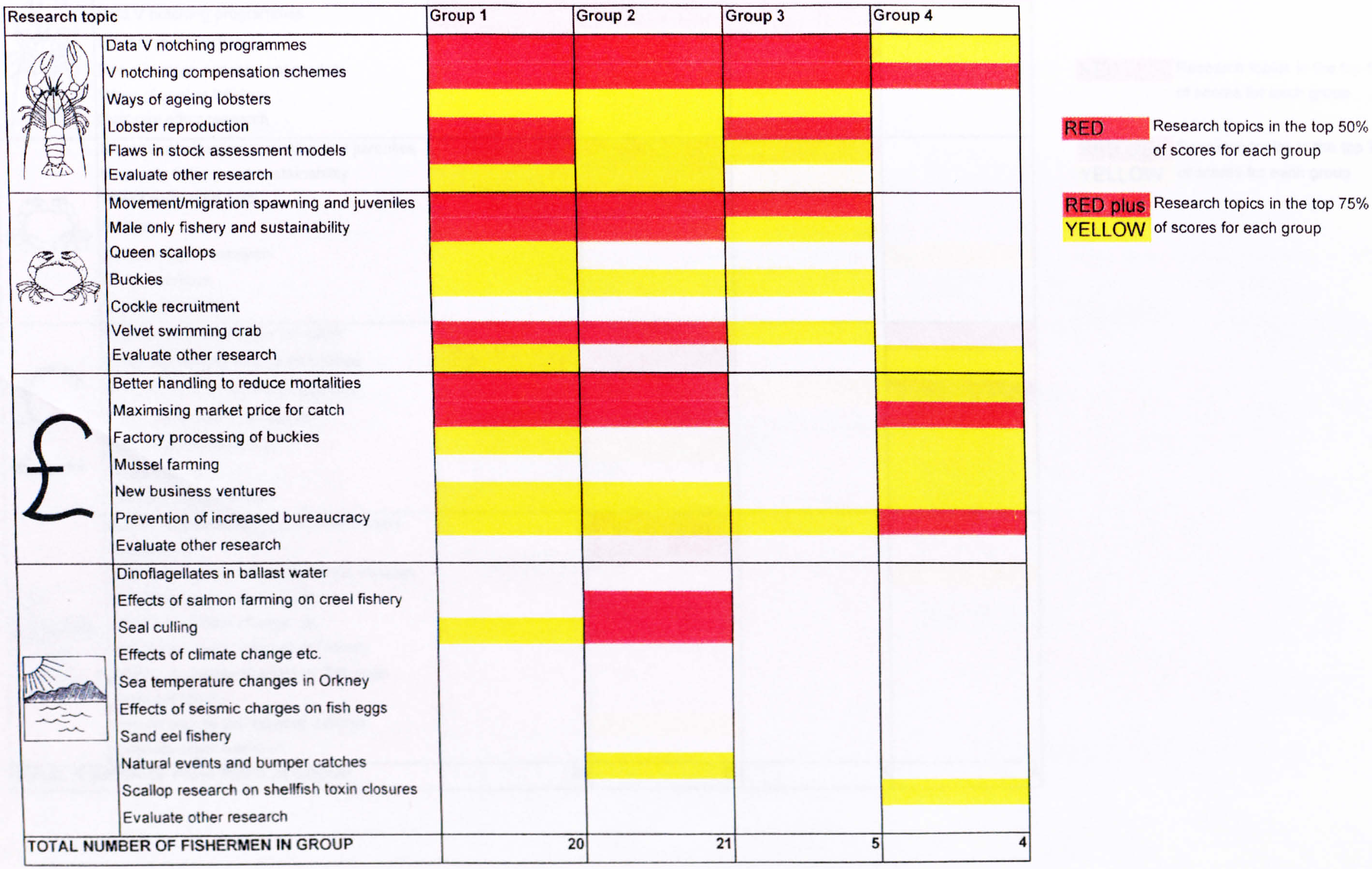
(b) on the scale below please circle the position that you believe most accurately reflects your faith in or distrust of the motivation of fisheries scientists.

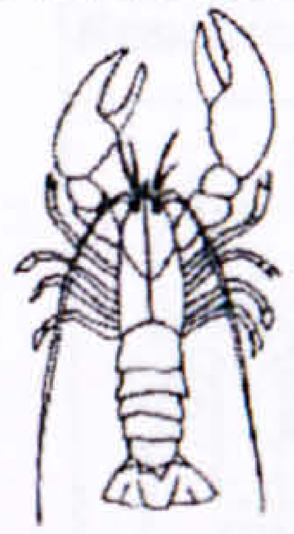
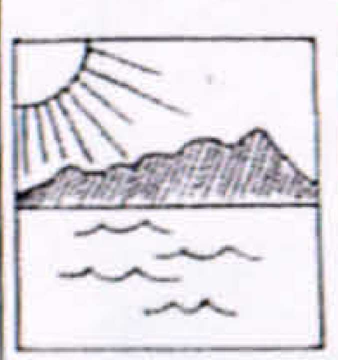
Complete distrust 0__1__2__3__4__5__6__7__8__9__10 *Complete faith in*

(c) on the scale below please circle the position that you believe most accurately reflects your view on fisheries models/predictions.

Highly doubtful 0__1__2__3__4__5__6__7__8__9__10 *Very appropriate*

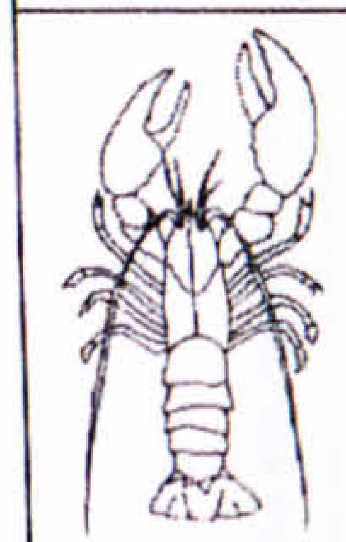
Appendix 9. Colour chart replicates 1-3



Research topic		Group 1	Group 2	Group 3	Group 4
	V notching compensation schemes	RED	RED	RED	RED
	Data V notching programmes	RED	RED	RED	YELLOW
	Lobster reproduction	RED	YELLOW	RED	
	Flaws in stock assessment models	RED	YELLOW	YELLOW	
	Ways of ageing lobsters	YELLOW	YELLOW	YELLOW	
	Evaluate other research	YELLOW	YELLOW		
	Movement/migration spawning and juveniles	RED	RED	RED	
	Male only fishery and sustainability	RED	RED	YELLOW	
	Velvet swimming crab	RED	RED	YELLOW	
	Buckies	YELLOW	YELLOW	YELLOW	
	Evaluate other research	YELLOW			YELLOW
	Queen scallops	YELLOW			
	Cockle recruitment				
£	Maximising market price for catch	RED	RED		RED
	Better handling to reduce mortalities	RED	RED		YELLOW
	Prevention of increased bureacracy	YELLOW	YELLOW	YELLOW	RED
	Factory processing of buckies	YELLOW			YELLOW
	New business ventures	YELLOW	YELLOW		YELLOW
	Mussel farming				YELLOW
	Evaluate other research				
	Effects of salmon farming on creel fishery		RED		
	Seal culling		RED		
	Scallop research on shellfish toxin closures				YELLOW
	Dinoflagellates in ballast water				
	Effects of climate change etc.				
	Sea temperature changes in Orkney				
	Effects of seismic charges on fish eggs				
	Sand eel fishery				
	Natural events and bumper catches		YELLOW		
	Evaluate other research				
TOTAL NUMBER OF FISHERMEN IN GROUP		20	21	5	4

RED Research topics in the top 50% of scores for each group

RED plus YELLOW Research topics in the top 75% of scores for each group

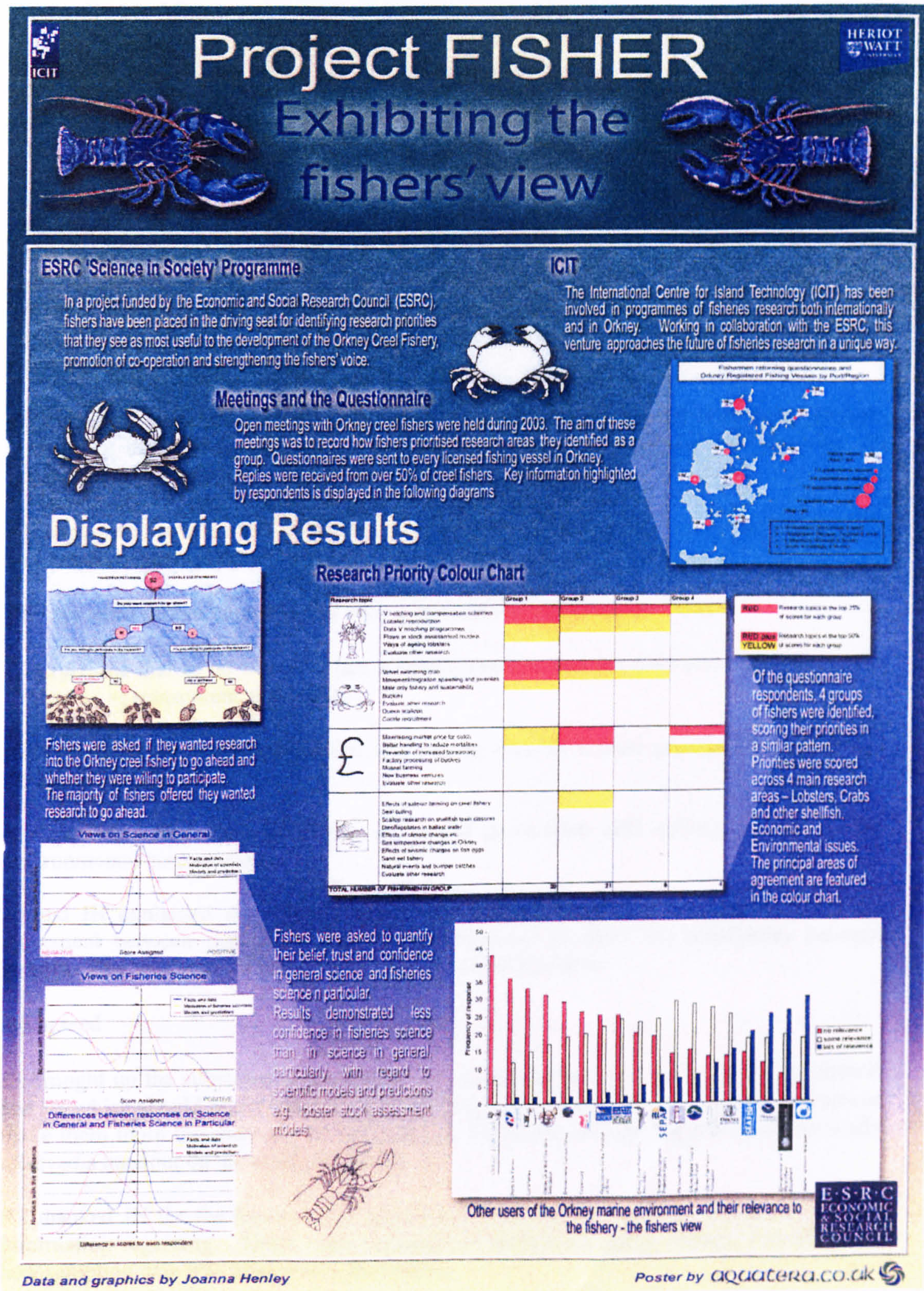
Research topic		Group 1	Group 2	Group 3	Group 4
	V notching compensation schemes	RED	RED	RED	YELLOW
	Lobster reproduction	RED	YELLOW	YELLOW	
	Data V notching programmes	YELLOW	YELLOW	YELLOW	GREY
	Flaws in stock assessment models	YELLOW	GREY	GREY	
	Ways of ageing lobsters	GREY	GREY	GREY	
	Evaluate other research	GREY	GREY		
	Velvet swimming crab	RED	RED	GREY	
	Movement/migration spawning and juveniles	RED	YELLOW	YELLOW	
	Male only fishery and sustainability	YELLOW		GREY	
	Buckies	GREY	GREY	GREY	
	Evaluate other research	GREY			GREY
	Queen scallops	GREY			
	Cockle recruitment				
£	Maximising market price for catch	YELLOW	RED		RED
	Better handling to reduce mortalities	YELLOW	RED		GREY
	Prevention of increased bureacracy	GREY	GREY	GREY	YELLOW
	New business ventures	GREY	GREY		
	Factory processing of buckies	GREY			GREY
	Mussel farming				GREY
	Evaluate other research				
	Seal culling	GREY	YELLOW		
	Effects of salmon farming on creel fishery		YELLOW		
	Scallop research on shellfish toxin closures				GREY
	Dinoflagellates in ballast water				
	Effects of climate change etc.				
	Sea temperature changes in Orkney				
	Effects of seismic charges on fish eggs				
	Sand eel fishery				
	Natural events and bumper catches		GREY		
	Evaluate other research				
TOTAL NUMBER OF FISHERMEN IN GROUP		20	21	5	4

RED — Research topics in the top 25% of scores for each group

RED plus YELLOW — Research topics in the top 50% of scores for each group

RED plus YELLOW plus GREY — Research topics in the top 75% of scores for each group

Appendix 10. Fisher poster



Appendix 11. Minutes of final Project Fisher meeting

Present:

JS - Professor Jon Side
JH – Miss Joanna Henley
TN – Mr Tim Noble
TT – Mr Tommy Thomson
MF – Mr Martin Foulis
RS – Mr Robert Smith
DG – MR Duncan Geddes
(Present but left early)

Minutes

TN opened the meeting at 7.00pm

TN and JH gave a short presentation of the results of the fisher questionnaire and conclusions made. The following round table discussion and comments made during the presentation are outlined below.

RS expressed his concerns that the 50 useable questionnaires returned in no way represents a majority decision by fishers. RS further explained that he did not complete the questionnaire for fear it would count towards this 'majority'.

TN explained that if around 90 of the 163 Orkney creel fishers were active and full time, 50 was a reasonable number

RS expressed further concerns that each questionnaire represented a 'vote'.

JS explained that in no way was this a voting exercise and the activities throughout have tried to be as transparent as possible.

JS commented he was surprised that seal culling was not a more popular research choice among fishermen.

MF explained that most fishermen are afraid to mention seal culling for fear of the environmental consequences.

JS and JH explained the analysis carried out on the results was not only to show the agreement between fishers on research priorities but to show the differences between groups. This was referred to as a great success of the research.

All agreed

JS brought up the subject of a booklet being worked on now and in the future by himself and JH which should outline some further flaws in stock assessment models and will aim to make them more transparent. He directed this comment towards RS who had previously received a handout on the subject form JH.

RS thanked JH for the handout and mentioned to JS three matters he would like further information regarding. These were estimates of natural mortality, fishing mortality and how sampling data gets used within the models.

RS commented that he believes sampling techniques are ultimately flawed, with reference to his past experience of inadequate spatial and temporal sampling by visiting fisheries scientists.

Js replied that he believed sampling of stocks twice a year by the scientists from the Marine Laboratory in Aberdeen was not sufficient.

MF added that sampling data used now is still that which was used during the 1960's and therefore prehistoric and irrelevant.

JS agreed he was probably not far off.

JS stated that a similar questionnaires based approach had been used on other stakeholders in the marine environment

RS expressed that stakeholder involvement is merely a 'new fashion'. He continued that fishers have no voice against politicians

TN suggested a good example of the contrary was Shetland, where the politicians are fishing politicians.
JS and RS objected that Shetland was a completely different situation than Orkney, having very little rocky shore etc.

RS replied that the only solution to limiting regulating orders etc. was to break the rules and go through the court, with the belief you are in the right.

JS in response suggested even civil disobedience needs structure.

JS expressed that he felt the main tragedy of this programme of research was that there is no vehicle for fishers, as for stakeholder organisations, to give a united view. He continued, that fishers need to build a capacity to represent themselves.

All agreed this was necessary

JS continued that the fundamental problem is getting fishers to meetings as this evening attendance highlights. This is the one concrete conclusion of the project he continued.

MF suggested that fishers can't be bothered and will only come if there is a crisis within the fishery.

MF thanked JS, TN and JH for carrying out the work. TT agreed

RS thanked the above for adding to his unease.
TN closed the meeting at 9.00pm

Appendix 12. Installation viewing questionnaire

INSTALLATION VIEWING

1. Is it easy to follow the progression through the various arts-based methods of interpretation?
Yes ☐ No ☐

2. Arrange the following methods of interpretation used, in order of descending transparency/accessibility (starting with the most transparent/accessible first).

Original order	Order of descending transparency
Table of figures	
Colour chart	
Circles with icons	
Coloured Venn diagram with icons	
Installation	

3. Is that which you chose as most transparent, your preferred display? If yes, why and if not, which is your preferred method?
Yes ☐ No ☐

Reason: Alternative choice:

4. Is your preferred method:
a) Likely to hold your attention for longer? Yes ☐ No ☐
b) Most aesthetically attractive? Yes ☐ No ☐

5. In your opinion, which method of those above, communicates the most information?

6. Is being able to walk around the installation an advantage, and why?
Yes ☐ No ☐

Why?

7. Is there any aspect of the installation that you don't understand? Please specify. If so, how would you present it differently?

8. Have you seen any of the information on display before?
Yes ☐ No ☐

9. If you answered yes to the above question, do you feel you have an improved understanding of the information after viewing what is on display?
Yes ☐ No ☐

10. On a scale of 1-5, to what extent has the use of arts media influenced your answer to the above?

If you have any other comments please use other side of paper