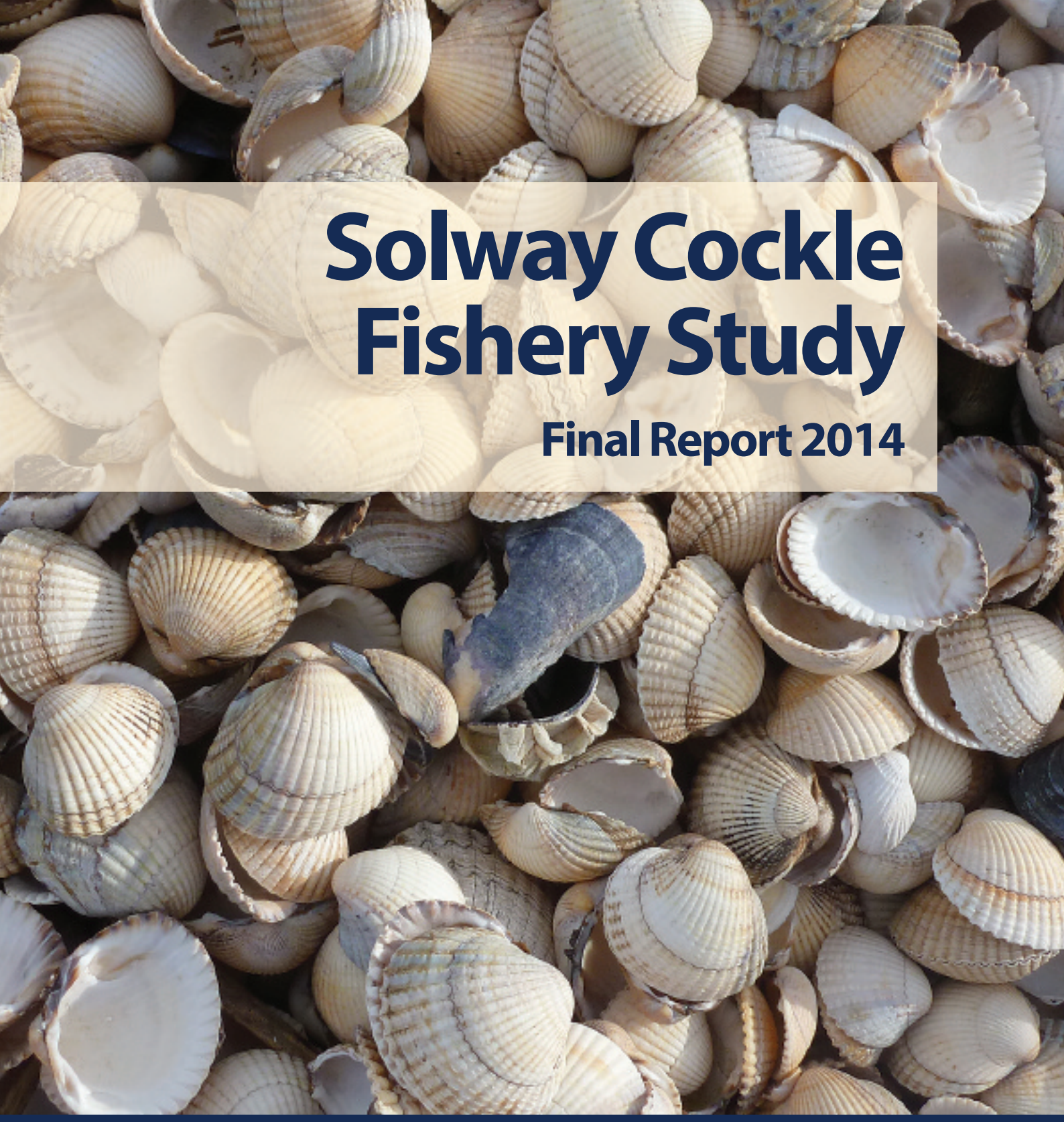

Solway Cockle Fishery Study

Final Report 2014

A review of management options for the Solway Firth Cockle Fishery

Solway Firth Partnership

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Prepared For:	Solway Firth Partnership Campbell House The Crichton Bankend Road Dumfries DG1 4UQ

Tel: 01387 702161
E-mail: info@solwayfirthpartnership.co.uk
Website: www.solwayfirthpartnership.co.uk

Report Authors:	T. D Southall Dr O. Tully

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DUMFRIES & GALLOWAY
FISHERIES LOCAL ACTION GROUP

Contents

Glossary

CFP	Common Fisheries Policy
Defra	Department for Environment, Food and Rural Affairs
EC	European Commission
EEZ	Exclusive Economic Zone
EFF	European Fisheries Fund
EMS	European Marine Site
ETP	Endangered, Threatened and Protected Species
EU	European Union
HCR	Harvest Control Rule
ICES	International Council for the Exploration of the Sea
IFCA	Inshore Fisheries and Conservation Authorities
IFG	Inshore Fisheries Groups
IUU	Illegal, unreported and unregulated
JNCC	Joint Nature Conservation Committee
MCS	Monitoring, Control & Surveillance
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
MoU	Memorandum of Understanding
MPA	Marine Protected Area
MSC	Marine Stewardship Council
NGO	Non-governmental Organisation
Nm	Nautical mile
PI	Performance Indicator
PO	Producer Organisation
RSPB	Royal Society for the Protection of Birds
RBF	Risk based Framework
SAC	Special Areas of Conservation
SG	Scoring Guidepost
SI	Scoring Issue
SPA	Special Protection Areas
SNH	Scottish Natural Heritage
SSMA	Solway Shellfish Management Association
TAC	Total Allowable Catch
UoC	Unit of Certification
VMS	Vessel Monitoring System

Executive Summary

Introduction

1 This project has been commissioned and co-ordinated by Solway Firth Partnership. The funding for the project comes from the European Fisheries Fund Axis 4 programme and Marine Scotland.

2 The project aims to provide a review of recent management experience in the Scottish Solway Firth Cockle Fishery, including, most recently, under the Solway Firth Regulated Fishery (Scotland) Order 2006. The study then reviews potential management options for a future Solway Firth Cockle Fishery. This report forms the main output of the Project.

3 The Solway Firth cockle fishery takes place in a diverse marine ecosystem, with rich and varied wildlife and habitats. It is one of the largest and least industrialised estuaries in Europe. The whole of the inner Solway Firth – both on the English and Scottish sides – is designated as an SPA and SAC under the EU Birds and Habitats Directives as the area supports a number of important habitats and waterbird populations.

4 There are currently no directly employed fisheries managers local to the Solway Firth. Although there are a number of local stakeholders who have previous experience in the management of the fishery, perhaps on the management of the Solway Shellfish Management Association (SSMA), since the Regulating Order has now ceased these individuals currently have no direct management authority. The dedicated Fisheries Officers employed by the SSMA are no longer in position. As such, there is currently no local fisheries management capacity, infrastructure or authority. As a result fisheries science, management, policing and enforcement is currently likely to be co-ordinated centrally, through Marine Scotland.

Stock Management Considerations

5 A 20 year cockle survey time series is available for the Solway. The survey data provides estimates of total biomass, commercial biomass, non-commercial biomass, age structure and maps the distribution of these variables. This is a valuable resource to inform discussions of future management.

6 The survey reveals some evidence of periodicity in the amount of cockles estimated to be in the Solway Firth, with annual estimates ranging from 12,000 to 34,000 tonnes and it can be estimated that the maximum possible cockle carrying capacity of Solway is likely to exceed 34,000 tonnes. This provides some frame against which to view future stock estimates and landings potential. Annual recorded landings have not exceeded 5000 tonnes in the past (4500 tonnes were landed in 1991), but data from the surveys indicate that with careful management this level of harvest should be possible in the future. In some seasons it is possible that the fishery could sustain an even higher harvest than this, but (as discussed later) this raises other more practical management challenges.

7 Based on 20 years of survey and fishery patterns, with the apparent periodicity, in a future well managed fishery the TAC could be expected to be less than 2000 tonnes half of the time and greater than 2000 (and up to 10000) the rest of the time.

8 Theoretically, and having due regard to preservation of spawning potential and ecosystem considerations in any given year, it can be argued that if all cockles in a given fishery were to die prior to the next fishing opportunity (from predation and environmental factors), then there is little reason not to fish the resource down. By contrast, if natural mortality is low and a lot of cockles could contribute to spawning in subsequent years and increase future yields then a much more conservative harvest approach should be considered. The existing survey data can be used to inform managers in relation to this question. These data suggest that the Solway cockle fishery is more similar to the second of these scenarios than to the first. This report has, however, not had access to the raw survey data which holds additional information on the level of age specific natural mortality rates of Solway cockles.

9 There is some evidence indicating that high catches and high harvest ratios (relative to the available biomass) in the early 1990s, was followed by very weak or non-existent recruitment in 1993-1995. In retrospect the fisheries in 1991 or 1992 seem to have been inconsistent with the management objective of protecting spawning and recruitment potential.

10 There is some evidence for a cockle stock recruitment relationship in Solway (but based on a crude analysis on non-commercial and commercial components of the stock). High biomass of commercial sized cockles (high spawning stock) tends to lead to higher abundance of non-commercial cockles in the following year or the following two years.

11 Commercial sized cockles in the Solway are over 2 years old, so good settlement should result in high biomass 2-3 years later. Simple analysis of the data available for the Solway indicates that commercial biomass is somewhat dependent on non-commercial biomass in the previous year, 2 years and 3 years, although environmental parameters also influence survival rate.

12 These indications provide an incentive to manage spawning potential and to minimise mortality on non-commercial size cockles during harvesting operations to ensure future productivity.

13 It would be good practice, even based on this limited evidence, that a much more precautionary approach to opening fisheries would be adopted when biomass is at the low levels seen in 1991 and 1992 in order to protect spawning potential.

14 Further analysis on the available data is recommended, for example to follow numerous age classes through time (cohort analysis), estimate mortality during periods of no fishery and with fisheries (and understand patterns of natural mortality) and inform discussions about minimum landing size. This analysis would characterise the dynamics of cockle stocks in the Solway and provide very useful supporting evidence for future management of the stock.

The development of harvest rules

15 Historically the harvest ratio or exploitation rate was limited to 20-33% of the commercial biomass as a rule of thumb guide. However, this may be more conservative than necessary given that maturity occurs at a small size. In the future it may be helpful to undertake maturity analysis to inform setting of minimum landing sizes and future TACs.

16 Rules which establish the levels of exploitation within a fishery **in advance** have a number of advantages. These can be agreed with stakeholders and evaluated against sustainability criteria in advance. This streamlines the day to day management decision making process and makes the decision making process more transparent. Target and limit reference points should be determined for the fishery, and these should be linked to harvest control rules. These reference points will be difficult to determine analytically but the previous experience with the stock can be used to inform the setting of these points. Harvest rules should at a minimum be developed to respond to situations of low stock biomass (where the stock is close to the limit reference point). Managing to reduce the probability of poor outcomes is a key objective.

17 The limit reference point for managing the cockle stock is the lowest stock biomass at which a fishery would occur. Three issues need to be considered when deciding this limit (i) to protect future spawning potential, (ii) safeguarding the ecosystem services provided by cockles and (iii) recognising the requisite densities to support a commercial fishery. Setting the limit reference point is a management decision that cannot be provided at this point or until the suggested analyses are undertaken. The opinion of scientists, managers and fishermen involved in the fishery during the 1990s should be sought.

18 The target exploitation level should be set no higher than levels which achieve the long term maximum yield. The modern meaning of Maximum Sustainable Yield (MSY) takes into account risk, and may require stock biomass to be maintained at levels well above a point estimate of MSY obtained from a deterministic stock assessment model.

19 Choosing to limit catch even when biomass is very high may allow biomass to remain at a higher level for longer and is more consistent with the MSY objective (or indeed the ecosystem objective). During periods when biomass is very high fishing should be targeted at very high density areas so that the TAC can be taken with least effort and to improve conditions for new recruitment; there is strong evidence that recruitment is very poor in areas where adult density is very high.

20 Given that the biomass will vary year on year the fishery management authority will need to decide how best to harvest a proportion of that biomass each year within the constraints of the reference points that would be agreed. The relative merits of more licences and a shorter season or fewer licences with a longer season are discussed. If the season is fixed and the biomass varies then the number of licences has to change if the TAC is to be completely harvested. By contrast, fixing the number of licences would imply a variable season length or variable quota uptake.

21 Variation in stock abundance and resulting TAC from year to year present a challenge for management in attempting to operate a stable, orderly and well managed fishery, in particular in determining how to vary the number of licences in proportion to the available TAC given that the daily catch potential is limited by working time, fishery methods and seasonal restrictions.

22 In years of large biomass, management may choose to forego some catch if the loss of earnings in abundant years is outweighed by the benefits of increased licence stability and increased future productivity.

23 Very well defined entry and exit rules for the fishery under these conditions need to be set out and agreed and enshrined in management rules, recognising the potential challenges of providing then subsequently removing licences.

24 To avoid the potential destabilising effect of introducing more licences where the TAC is above a given high level, the harvesting rights to a proportion of TAC could be retained or vested in the management authority to be contracted to outside parties (i.e. equivalent to a single season licence).

Fisheries Information & Survey

25 Reliable and timely fishery and fishery independent data are a crucial component of any successful management system.

26 It is recommended that future survey design should follow the same process as earlier surveys which were well designed. The survey should be completed as close in time to the prospective opening date for the fishery as possible because biomass changes rapidly due to growth and mortality. To enable this improved logistical support and participation in surveys is needed. Also analytical procedures should be set up to 'automate reporting' in so far as that is possible. Digitising data and production of the biomass estimate should be possible in 1 week. Therefore a biomass estimate could be available 1 month after the start of the survey.

27 A future management priority should be to reduce the time period required to agree on the conditions by which the fishery can open in any given year. The issues to consider and the decision making process may add considerable cost and delay to the fishery management process, undermining the economics of operation and especially any notions of cost recovery. This period includes time for consideration of potential environmental impacts of the fishery, such as running the bird model and Appropriate Assessments. Developing and documenting management rules that will apply under different environmental and cockle stock scenarios and obtaining agreement of these between relevant competent fishery and conservation authorities, should enable a more efficient system to be developed.

28 Ideally licence holders would participate in cockle surveys in teams led by scientists; this would also improve understanding of where to target, once the fishery opens.

29 A successful fishing season is one where the licence holders take the allowable catch with as low a fishing effort as possible and with as little cost as possible. All information available to facilitate this should be provided to licence holders. Information on the status and location of commercial quantities of cockles should be provided to the licence holders prior to opening the fishery.

30 Licence holders can easily record and report catch, effort and location at a given spatial scale and should be required to do so during the fishing season. This is particularly important if the survey is limited in its precision because of low sampling levels. The fishing data in this case can provide a back up to the survey data.

Fisheries Governance

31 Those with a (demonstrated) history of fishing in the Solway Cockle fishery are likely to make the case for greatest rights for participating in a future fishery, regardless of where they come from. If fishers or sectors (i.e. vessels) are to be excluded from the management system then it is crucial that the reasoning for this be demonstrated against sustainability criteria.

32 The notion of cost recovery is an important aspect of sustainable fisheries management theory. However it is important to recognise that in most cases (especially in the EU), this does not happen (other than through taxation).

33 Management should consider the degree to which it is realistic for a small scale inshore fishery targeting a comparatively low value and variable fishery to cover the costs of management, especially given that the inshore nature of the fishery means that costs of appropriate assessment and enforcement are comparatively higher? However, in some years the fishery may be very valuable and some arrangements for investing a proportion of the TAC in the management authority to recoup some management costs should be investigated. It is important, however, that management is not reliant on cost recovery in all years as the costs of data provision are independent of the stock biomass or potential value of landings.

34 Over-ambitious attempts to maximise employment opportunities are more likely to lead to increased instability in local employment and a less well developed sense of stewardship in the fishery which in turn undermines future attempts at management.

35 When looking ahead, it is important to include in the consideration of the design of the management system, the sort of fishing jobs that should be created in the fishery. For example, is it better to (i) maximise the number of short term and seasonal opportunities for income, or (ii) create fewer opportunities, with a longer season and a greater share of the income going to fewer fishers.

36 In spite of the acknowledgement of 'significant' illegal, unreported and unregulated fishing (IUU) in the past, there has been no estimate of the quantity of IUU removals, or even an understanding of the scale of IUU compared to TAC. This means it is hard to get a true picture of the past productivity of the fishery. It is understood that neither the determination of TAC, nor the bird model give direct acknowledgement to the amount of removals from the stock from IUU fishing.

37 Illegal fishing undermines fishers faith in the management process and at worst makes licensed and legitimate fishers feel that they are being penalised for their compliance. Beyond a certain scale this can become self-stimulating, with fishers feeling there is little point in complying if they perceive no one else is. If there is no 'peer pressure' to comply then the challenge of enforcement is greater.

38 There have been improvements in the enforcement system (legislative changes and greater emphasis on licensed transport etc) since the time of the last fishery managed by Regulating Order, which should partially ease the problem of IUU fishing. None the less the Solway is a large area with many access points, so it is likely that even with these changes the problem of IUU will remain to some extent.

39 In the future it is clear that liaison with English enforcement will also be important to ensure that there is mutual understanding of the IUU risks, and enforcement strategy on either side of the Solway Firth.

40 The prospects for self policing do not look as immediately positive as in some other fisheries. Encouraging local licensed fishers to engage directly with illegal fishers is not recommended, and should not be necessary if the enforcement system is designed correctly.

Market Considerations

41 The greatest impediment to developing the market and creating a climate for investment is irregular supply. It is therefore important that the focus on the fishery – its scale and operation – comes before consideration of the market.

42 The price of cockle varies considerably and is heavily dependent upon yield (meat weight / whole weight). Yields are higher in the late summer months and fall off significantly into the autumn and winter months. Similarly yields vary according to where the cockles are on the beds, with cockles higher up the shore generally of lower yield. A delay in the opening of the fishery therefore greatly undermines the entire financial model of the fishery, impacts on market opportunities and condemns fishermen to considerably reduced incomes. This also reduces the potential for any future cost recovery from the fishery.

Other Management Models

43 The report highlights the comparative capacity, legislative power and resources available for inshore fisheries management in England and compares these to those available in Scotland. Although a Regulating Order is a legislative tool used in inshore shellfish fishery management both north and south of the border, it is clear that as an inshore management authority the English Inshore Fisheries and Conservation Authorities (IFCA) have access to greater legislative power, budget, capacity and facilities to undertake inshore fisheries management at a regional level. This provides increased scope for undertaking management without a Regulating Order.

44 There are successful examples of inshore shellfish management in Scotland and comparison is made with the Shetland Regulating Order for management of shellfish (although not cockle). However, it is noted that this fishery does not achieve complete cost recovery with both the costs of science and administration being supported. A second example is provided of the Dundalk cockle fishery, in Ireland, where management rules are well developed.

Conclusions

45 For now, it seems the best immediate prospect of implementing successful management within the Solway Firth cockle fishery remains through the adoption of another Regulating Order (or Hybrid Order), but in doing so it should be recognised that this 1967 act of parliament has considerable limitations when it comes to seeking 21st century solutions to long-held management challenges.

46 The immediate challenge for the Solway Firth is to identify who – or rather what sort of group structure - would be willing to take on local responsibility for management under a Regulating Order. It is clear that many of the past challenges identified in this report will need to be addressed even before a suitable grantee is likely to be identified. Above all, if a suitable group structure is to come forward there will need to be a greater commitment from Marine Scotland and central and / or local government to support both the costs and practical challenges of management.

47 Almost whatever the management system that is chosen for the fishery, whatever legislation it falls under and whoever administers and enforces it, it is imperative that the process of opening the fishery following the survey is significantly speeded up to enable fishermen, informed by the latest survey, to be on the beds by late summer at the latest.

48 The indications from this piece of work, both from the consultations and from the review of past stock biology is that there is clearly the potential resource in the Solway Firth to support a cockle fishery which can provide important local employment. In spite of the recent challenges of the past Regulating Order experience and the experience of many years of illegal fishing, the goal of achieving a sustainable cockle fishery in the Solway Firth is still winnable. The Firth looks set to remain productive and this productivity can be protected by good management. Furthermore it appears likely that a viable fishery is also possible without adversely impacting on the important conservation designations of the Solway Firth.

49 However, if the goal of a sustainable cockle fishery is to be achieved, difficult questions will need to be addressed about the possible management model, with frank considerations of the likely legislative, capacity and funding requirements. It is hoped that the recommendations in this report will help stimulate and guide those considerations.

1 Introduction

1.1 Project Background

This project has been commissioned and co-ordinated by Solway Firth Partnership. The funding for the project comes from the European Fisheries Fund Axis 4 programme and Marine Scotland.

Solway Firth Partnership is an independent charitable body set up as a Company limited by Guarantee, whose objectives are perhaps best summarised with reference to the Memorandum and Articles of Association from 2003:

to promote and advance education of the public about working and living sustainably in the Solway Firth ..... and to preserve and protect, for the public benefit, the environment covering the land, coastal zones and waters of the Solway Firth area by seeking to guide, encourage and enhance the integration of environmental, social and economic policies including the sustainable management of pollution, waste, land reclamation, provision of public amenities and other related activities;

In practice this means that the staff of Solway Partnership develop projects and play an active role in supporting and facilitating sustainable coastal and marine management initiatives. This is achieved by bringing people together, adopting a co-operative working approach, and facilitating collaboration between industry, science and government.

Although this study has been commissioned by Solway Firth Partnership it has been carried out by independent consultants, Tristan Southall and Oliver Tully, with the support of Solway Firth Partnership. Oliver Tully is a bivalve mollusc specialist with expertise in bivalve stock assessment and delivery of effective management structures. Tristan Southall is a highly experienced MSC fisheries assessor, and project manager for 'Project Inshore – a Review of English Inshore Fisheries' and is able to bring particular insight into the future potential of bivalve fisheries to enter into certification schemes. Oliver Tully worked on Project Inshore and, in particular, with the NWIFCA which shares management jurisdiction of the Solway with Scotland.

1.2 Project Aims and Objectives

This Solway cockle fishery study is intended to complement the consultation and trial fishery commissioned in 2013 and inform consideration of future management options. The work draws on the findings of the on-going 'Project Inshore' which is currently reviewing management of English Inshore Fisheries using the Marine Stewardship Council (MSC) as a template for good management. This study provides a stand-alone review and reporting output of management options in the Solway cockle fishery.

1.3 Methodology & Consultations

This has been a largely desk based review informed by consultations with key stakeholders. Tristan Southall attended an inception meeting with Pam Taylor, Greg Allan and Michael Cutts in Edinburgh in September 2013. In addition, Oliver Tully visited Dumfries in October 2013 and met with Pam Taylor. The following consultations informed this study:

	Organisation	**Role / involvement**
Greg Allan	Marine Scotland	Inshore Team, TURF trial co-ordinator.
Tommy Clark	Dee Fish	Contractor for Scottish Government TURF trial working with the Scottish Solway Firth Shellfish Growers Co-operative
Michael Cutts	Marine Scotland	Inshore Team
Rob Davidson	Dumfries & Galloway Council	Former SSMA board member
Cllr Alistair Geddes	Dumfries & Galloway Council	Former SSMA Chair
Cliff Henderson	Portling Shellfish	Former SSMA board member
Paul Kenny	AAK Shellfish	Former SSMA board member
Gregor Mackenzie	Marine Scotland	Head of Coastal Operations (Compliance)
Chris Miles	Scottish Natural Heritage	Former SSMA board member
Chris Rollie	RSPB	Former SSMA Board Member
Pam Taylor	Solway Firth Partnership	Solway Firth Partnership Project Manager

Information about the Solway cockle fishery study was provided to the Scottish Solway Firth Shellfish Growers Co-operative, as well as to the constituency MSP, and a range of partner bodies at a meeting in November 2013. A series of inter-agency meetings attended by Marine Scotland, Police Scotland, the Food Standards Agency, Dumfries and Galloway Council and other partners have been held during the course of the project during which Solway Firth Partnership has provided information about the study.

A flyer was produced explaining the purpose of the study and how it integrates with other work underway to inform future management of the fishery. This was widely distributed to local community, agency and industry interests. Solway Firth Partnership issued a press release in November 2013 to raise awareness of the work and this was covered by several local newspapers, BBC News South of Scotland website, Border TV (news article and website), and Solway Firth Partnership's own website. The work was further publicised in Solway Firth Partnership's Tidelines magazine which is widely distributed in the local area.

1.4 Reporting Outputs and Report Structure

This report forms the main output of the Project. This report therefore seeks to provide a thorough review of past and future management for Solway cockles for both the Solway Firth Partnership, but also, it is hoped, a wider set of stakeholders in the Solway Firth cockle fishery. In doing so this seeks to:

- Review existing information on stock status
- Review existing management measures
- Undertake a critical analysis of past management experience
- Undertake a comparison of management practise (and supporting legislation) on both sides of the border
- Explore possible future management scenarios, drawing on examples in other places – both within Scotland & England and elsewhere
- Provide a simple analysis of costs of future management relative to potential benefits.

Note: Context of recommendations & advice.
During this project the team have met or spoken with a range of stakeholders in the fishery, drawn on available fisheries information and past assessments, and referred to a number of other relevant articles. However, no primary research or analysis has been undertaken therefore any recommendations rely heavily on the project team's previous experience in other fisheries. Whilst every effort has been made to ensure that these are relevant for the local fishery it cannot be guaranteed that all potential challenges have been identified or that the recommendations provide for all eventualities. There may still be some unforeseen additional issues that arise once a fuller public consultation exercise is undertaken as part of the process of adopting any future management proposals. Above all this report is advisory and is intended to provide an interpretation of past management experience and provide a helpful discussion and possible guide in the on-going process of seeking to identify the best management model for the Solway Firth cockle

2 Characteristics of the Solway Cockle Fishery

2.1 Background to Commercial Cockle Fishing in the Solway Firth

There is a long and traditional history of cockle fishing in the Solway Firth. The 1980s saw an increase in commercial scale cockle fishing activity, which at times was fairly intensive. This level of activity has been associated with subsequent periods of poor stock recruitment (although other factors may also have been of influence). As a result of this increased activity there was a determination to develop improved local management mechanisms to ensure that the fishery could be sustainably managed. The Solway Shellfish Management Association (SSMA) was established in 2004 with the intention of sustainably managing cockle fisheries on the Scottish side of the Solway Firth. The powers to enable them to do this came with the granting of a Regulatory Order in 2006 which gave the SSMA legal rights to licence, manage and enforce the cockle fishery. This was supported by a comprehensive management plan.

Figure 1: Timeline of key events in the recent history of the Solway Cockle Fishery.

Pre - 1986	Small scale harvesting mainly for local consumption No official recorded landings
1986-1991	First official recordings Steady increase in landings to 4.519t in 1991
1992	Boat dredging banned
1994	Tractor dredging banned
2000	SSMA formed
2002	After several years increasing hand gathering, following increased demand, fishery closed to all
2006	Regulating Order comes into force and fishery re-opnes
2006-2008	Fishery operates for 3 seasons
2009	Fishery closes
2013	Fishery reopens for 3 months on to trial 'TURFs'

However, during the time of the Regulating Order the cockle stocks in the Solway Firth were generally lower than had been expected, consequently the fishery had only a limited period of being open up to the eventual cessation of the SSMA's operation when the Regulating Order ended in 2011.

Since then Marine Scotland have been seeking to facilitate an eventual re-opening of the fishery under a new sustainable management model. With this aim various meetings have been held in 2012 and 2013 to seek to address outstanding areas of concern. The Solway Firth Partnership is supporting this process.

2.2 Ecosystem Characteristics of the Solway Firth

2.2.1 Ecosystem Overview

A detailed account of the Solway ecosystem is provided in Chapter 1 of the 2001 Solway Firth Regulating Order Management Plan. The Solway Firth is a diverse ecosystem, with rich and varied wildlife and habitats. It is one of the largest and least industrialised estuaries in Europe. As a result the area is subject to many designations reflecting this importance both nationally and internationally. These are detailed below.

2.2.2 Local Designations

The whole of the Solway Firth – both on the English and Scottish sides – is designated as an SAC under the EU Habitats Directive. The Annex 1 habitats that are the primary reason for designation are; 'Sandbanks which are slightly covered by sea water all the time', 'Estuaries', 'Mudflats and sandflats not covered by seawater at low tide', 'Salicornia and other annuals colonizing mud and sand' and 'Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)'. In addition, the following Annex II species are present and are therefore also a primary reason for designation; Sea lamprey (*Petromyzon marinus*) and River lamprey (*Lampetra fluviatilis*).

The Upper Solway Flats and Marshes are also designated as an SPA under the EU Birds Directive (79/409/EEC). The extensive flats and marshes of the Upper Solway, with estuarine saltmarsh vegetation, are important for wintering wildfowl (ducks, geese and swans) and waders. In particular, over 12,000 knot and 34,000 oystercatchers over-winter at the site. These species feed on bivalves including cockles.

The Solway estuary is also a Ramsar site, recognising its importance as a wetland for overwintering birds and the rare natterjack toad. Finally, the scenery of the coastal landscape has also been recognised as nationally important, with no less than three National Scenic Areas on the north Solway coast and an Area of Outstanding Natural Beauty on the south coast.

Box 1: Solway Overwintering Wildfowl

Over winter, the Solway SPA area regularly supports 133,222 individual waterfowl (5 year peak mean 1991/2 - 1995/6) including: Redshank *Tringa totanus*, Barnacle Goose *Branta leucopsis*, Golden Plover *Pluvialis apricaria*, Bar-tailed Godwit *Limosa lapponica*, Pink-footed Goose *Anser brachyrhynchus*, Pintail *Anas acuta*, Oystercatcher *Haematopus ostralegus*, Knot *Calidris canutus*, Whooper Swan *Cygnus cygnus*, Curlew *Numenius arquata*, Lapwing *Vanellus vanellus*, Great Crested Grebe *Podiceps cristatus*, Cormorant *Phalacrocorax carbo*, Shelduck *Tadorna tadorna*, Mallard *Anas platyrhynchos*, Scaup *Aythya marila*, Goldeneye *Bucephala clangula*, Ringed Plover *Charadrius hiaticula*, Grey Plover *Pluvialis squatarola*, Dunlin *Calidris alpina alpina*.

http://jncc.defra.gov.uk/default.aspx?page=1980

2.3 Local Fisheries Management Capacity / Roles & Responsibilities

There are currently no directly employed fisheries managers local to the Solway Firth. Although there are a number of local stakeholders who have previous experience in the management of the fishery, perhaps on the management of the Solway Shellfish Management Association (SSMA), since the Regulating Order has now ceased these individuals currently have no direct management responsibility. The dedicated Fisheries Officers employed by the SSMA are no longer in position. **As such, there is currently no local fisheries management capacity or infrastructure.** Any science is currently likely to be co-ordinated centrally, through Marine Scotland, likewise any enforcement. The current prohibition order and the recent trial fishery have both been established centrally by Marine Scotland. Any future management will therefore either need to be conducted centrally (by Marine Scotland) or devolved to a local entity, recognising that this may require capacity building. The options for these are discussed later in the report.

2.4 Legislative and Regulatory structure

The Regulating Order that was in place for the Solway cockle fishery was enacted by the Solway Firth Regulated Fishery (Scotland) Order 2006. This Order was brought in under the Sea Fisheries (Shellfish) Act 1967. In 2011, after the expiry of the Regulating Order, the fishery closure remained in place – indeed it was further strengthened with the inclusion of recreational fishing in the closure - under the Inshore Fishing (Prohibition of Fishing for cockles) (Solway Firth) (Scotland) Order 2011. This order was brought in under the Inshore Fishing (Scotland) Act 1984, which allows for the closure of access to fisheries.

3 Lessons Learned / Gap Analysis

From the initial concept of the Regulating Order, in the late 1990s, through to the formation of the SSMA, the establishment of the Regulating Order and on up to the eventual closure of the fishery, the winding up of the SSMA and the cessation of the Regulating Order, considerable time, expense, commitment, goodwill, energy and expertise have been expended in pursuit of a well managed fishery. The fact that the management model did not succeed, in terms of meeting the stated objective, was not through negligence or lack of interest. Some aspects of the management model worked well, some less so. In going forward and considering future management options it is important to consider the lessons learned from the experience of the Solway Regulating Order, seek to recognise the positive aspects of the management model and seek to ensure that future management addresses the gaps or weaknesses that contributed to the comparative lack of success of the fishery.

3.1 Stock Status and Stock Assessment (MSC Principle 1)

3.1.1 Historical Landings & Biomass

A 20 year cockle survey time series is available for the Solway. The majority of this work was done by Trevor Howell and colleagues at FRS Aberdeen. The survey data provides estimates of total biomass, commercial biomass, non-commercial biomass, age structure and maps the distribution of these variables.

Annual recorded landings have not exceeded 5000 tonnes in the past (4500 tonnes were landed in 1991). However, as outlined in the previous management plans, there is uncertainty with respect to the total annual outtake during the period 1987-1992 and between 1993-2000. During the latter period all landings were taken by hand gathering and the data is poor. Howell *et al* (2008) estimate that at least 2000 tonnes were landed in the year 2000.

The official landings time series is short compared to the biomass time series (Figure 1). This has positives and negatives for the design of future management.

- On the negative side the historical data does not provide that much information on the response of the stock to fishing
- On the positive side the historical data provides a number of years of biomass and age structure information and probably in the absence of significant fishing mortality and so gives clues about how the stock behaves in the absence of a fishery

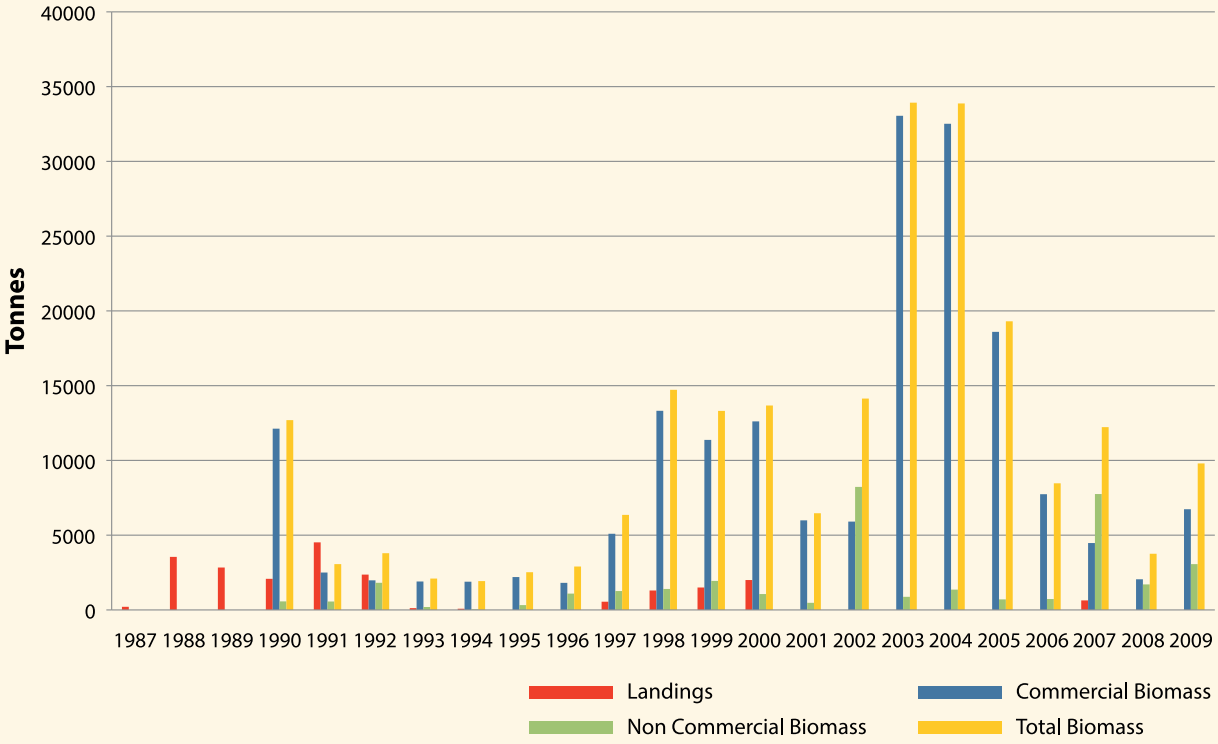
The annual biomass estimates are not strictly comparable as the survey extent varied annually. However, the biomass can be standardised for this as the survey extents are given in the various reports. On the other hand the total area over which cockles are or can be distributed in the Solway is not immediately clear. Therefore in any given year, as the surveys probably covered less than 100% of the extent over which cockles are distributed they are minimum estimates.

The survey reveals some evidence of periodicity in the biomass estimates. In 1990 biomass peaked at about 12,000 tonnes, in 1998-2000 at 14,000 tonnes and in 2003-2004 at 34,000 tonnes. From this it is clear that the cockle carrying capacity of Solway exceeds 34,000 tonnes.

117 km^2 was surveyed in 2003-2004 when biomass was approximately 34,000 tonnes. However, 133km^2 was surveyed in 2000. If cockles can occur on 133km^2 then the carrying capacity is at least 34,000*133/117 or about 38,000 tonnes. This provides some frame against which to view future stock estimates and landings.

As expected total biomass is mainly accounted for by the biomass of commercial sized cockles; these cockles have much higher individual weight than recruiting cockles although they may be less abundant.

Figure 2. Landings and biomass of cockles in Solway during the period 1987-2007.



3.1.2 Recruitment and Biomass

Experience

Two critical questions arise for the future management of Solway cockle stocks (and indeed for any exploited fish stock):

- Is there evidence that previous landings have lead to decline in subsequent recruitment and stock biomass (or is there evidence that biomass of mature cockles influences future recruitment)?
- Will stock biomass re-build if spawning potential is maintained?

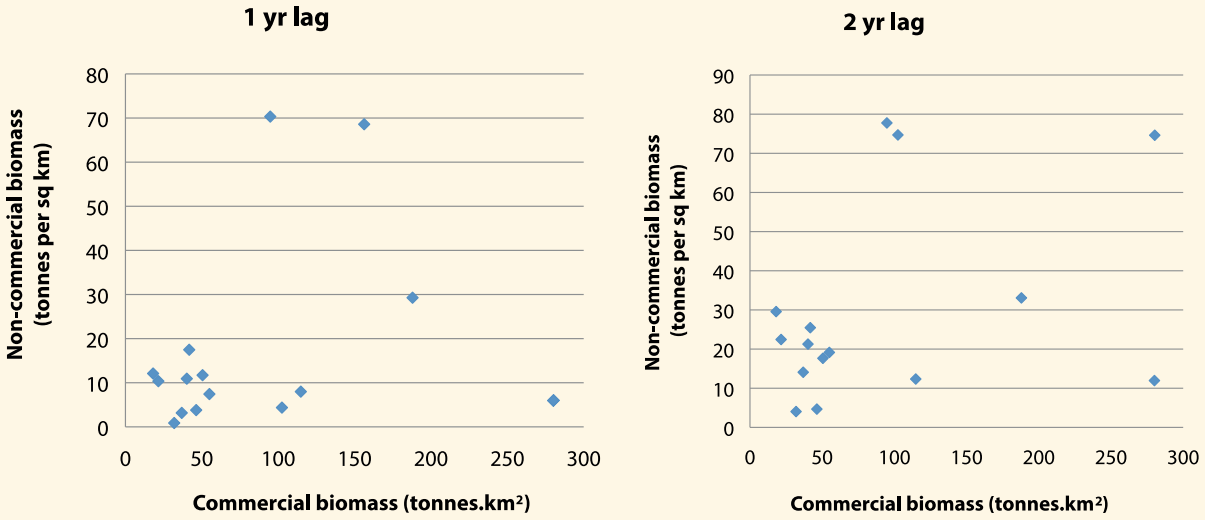
Taking each of these in turn, firstly, is there evidence that previous landings have lead to decline in subsequent recruitment and stock biomass (or is there evidence that biomass of mature cockles influences future recruitment)?

Landings in the historical data series are poorly recorded. However, the years 1991 and 1992 stand out. In these years the total landings, apparently, exceeded the biomass estimates. This is not impossible as the biomass estimates were from a spring survey and would have significantly changed (increased probably during the summer) by the time the autumn fishery opened. Nevertheless in these two years when biomass was low and there was evidence of very low recruitment in both 1991 and 1992 significant landings were made and the exploitation rate (proportion of the stock that was removed) must have been very high and over and above the 20-33% rule of thumb expressed in subsequent management plans. This was followed by very weak or non-existent recruitment in 1993-1995. It took 6 years for the stock to recover to 1992 levels. In retrospect the fisheries in 1991 or 1992 seem to

have been inconsistent with the management objective of protecting spawning potential. There was already evidence in the 1991 survey that biomass from 1990-1991 had declined significantly. This period 1990-1996 suggests that the combination of a fishery in 1991 and 1992 and low stock biomass limited subsequent recruitment in 1993-1996. It would be good practice, even based on this limited evidence, that a much more precautionary approach to opening fisheries would be adopted when biomass is at levels seen in 1991 and 1992 (about 2000 tonnes) in order to protect spawning potential.

There is some evidence for a cockle stock recruitment relationship in Solway (but based on a crude analysis on non-commercial and commercial components of the stock). High biomass of commercial sized cockles (high spawning stock) tends to lead to higher abundance of non-commercial cockles in the following year or the following two years (Figure 3).

Figure 3. Dependency of non-commercial biomass on commercial biomass in the previous year and the previous 2 years suggesting some relationship between stock and recruitment.



The second question to address is whether stock biomass re-builds if spawning potential is maintained? Cockle dynamics is greatly influenced by environmental conditions during the larval phase, settlement and overwintering survival of the newly settled cohort. In the Solway a newly settled cohort will need to get through 2-3 winters before it reaches commercial size. So even if spawning potential is adequately protected and conserved and settlement occurs there is a risk that this recruitment will not survive to commercial size. What is this risk and is there a reasonable likelihood that good spawning stock management will result in economically significant commercial biomass in a reasonable number of years? Also how efficient is this conversion or what tonnage of commercial biomass will result from a given tonnage of non-commercial size cockles?

Commercial sized cockles in the Solway are over 2 years old, so good settlement should result in high biomass 2-3 years later. The survey reports provide information on the biomass of non-commercial (mainly age 0-2) and commercial (mainly 2+ and older ages) size classes. Does high abundance of non-commercial size classes lead to high abundance of commercial size classes, and how often, or does natural mortality (predation etc) dampen or negate this potential? The answer is probably different in each stock but it determines how often a fishery might be possible and therefore indicates to managers what may be expected from the fishery.

Although this analysis is crude (the age structure of non-commercial and commercial classes is not analysed) the data provides some evidence on how non-commercial biomass is translated to commercial biomass in the Solway. As non-commercial size classes may take 1-3 years to grow to commercial size plotting the non-commercial and commercial biomass with lags of 1-3 years provides some evidence. The question here is if the non-commercial biomass is X in year n what is the commercial biomass in year n+1, n+2 and n+3 (Figure 4).

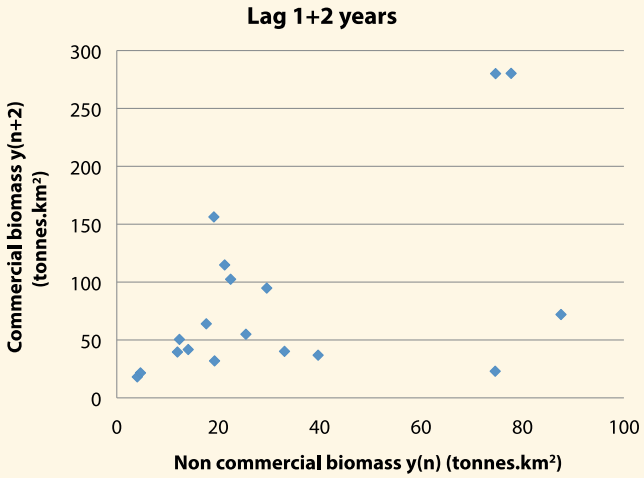
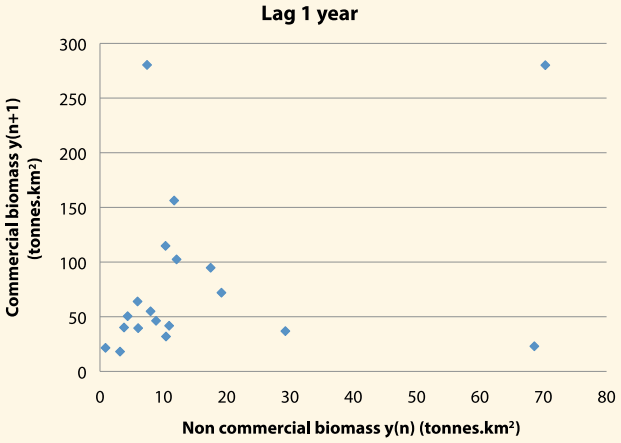
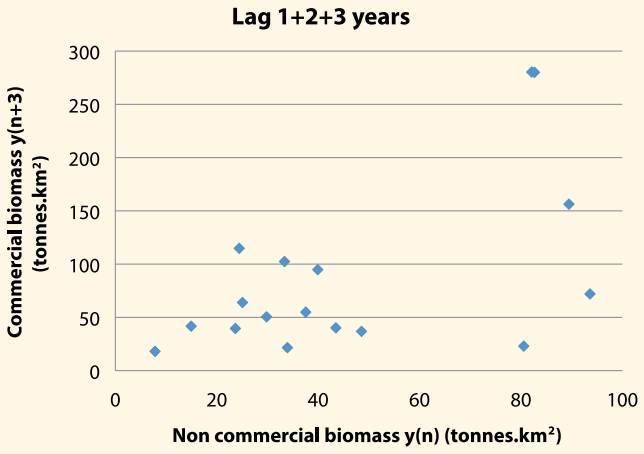


Figure 4. The dependency of commercial biomass on non-commercial biomass lagged by 1, 2 and 3 years. Biomass is in tonnes per square km to standardise for variations in survey extent.



This analysis suggests that there are generally positive relationships indicating that commercial biomass is somewhat dependent on non-commercial biomass in the previous year, 2 years and 3 years. There have been a couple of years where very high non-commercial biomass has translated to very high commercial biomass. There was also one year where low non-commercial biomass led to very high commercial biomass indicating exceptional survival during that period. At low levels of biomass there is also some evidence of a positive relationship between non-commercial biomass and subsequent commercial biomass.

Non commercial biomass develops to commercial biomass, through a balance between growth and mortality, with different 'efficiency' in different years. The frequency distribution of this 'ratio' (Figure 5) shows a median transfer of 6.8 i.e. for 1 tonne of non-commercial cockles 6.8 tonnes of commercial cockle may develop. This ratio ranges from 0.9-47 however. These indications provide an incentive to manage spawning potential and to minimise mortality on non-commercial size cockles during harvesting operations.



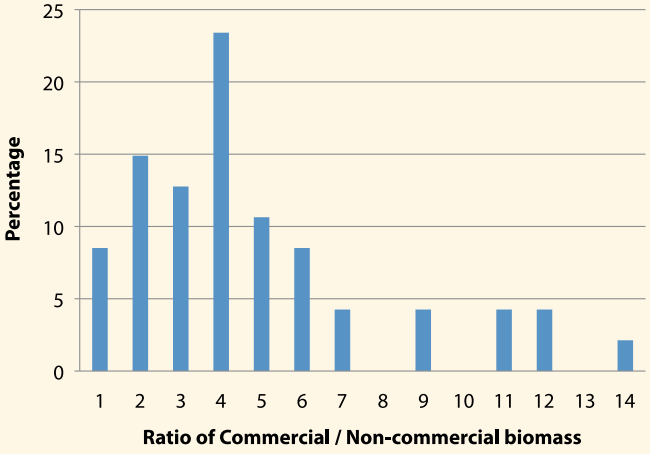


Figure 5. Distribution of the ratio of commercial sized biomass resulting from non-commercial biomass of cockles lagged by between 1-3 years. High ratios indicate stronger conversion (survival) of non-commercial to commercial biomass. Median conversion is 6.8 i.e. the non-commercial biomass results in commercial biomass which is 6.8 times higher.

Recommendations

- There is a wealth of information in the 15 year survey time series that is not analysed here and which could provide much stronger evidence of cockle stock dynamics in the Solway. Each survey reports size and age distribution. It should be possible to follow numerous age classes through time (cohort analysis) and estimate mortality during periods of no fishery and with fisheries. This analysis would characterise the dynamics of cockle stocks in the Solway and provide very useful supporting evidence for future management of the stock.
- Basic information on the growth and reproductive biology of cockles in the Solway is also available and can be used to calculate the optimum minimum landing size at different levels of mortality (which can be derived from a cohort analysis) that gives best yields (per recruit).

3.1.3 Assessing Stock Status in the Future

Experience

The surveys completed throughout the 1990s by FRS were comprehensive and provided all necessary information to the estimation of biomass, its spatial distribution and its size and age structure. Surveys were standard stratified random quadrat surveys distributed over a sampling grid and using teams of people with quad bikes or all terrain vehicles to cover the large area involved.

The surveys involved two phases (in some years at least) which were designed to improve precision in the biomass estimate; phase 1 covered a coarse grid which provided information on distribution and areas where high densities occurred. Phase 2 then concentrated on high density areas so that the biomass within these areas could be better estimated.

Surveys were generally undertaken in spring to provide advice for an autumn fishery. This is not ideal as biomass will change substantially between spring and autumn. In later years the surveys occurred in summer but mainly to provide data for the bird ration model.

Recommendations

- Future survey design should follow the same process as earlier surveys completed by FRS. The survey should be completed as close in time to the prospective opening date for the fishery as possible. To enable this improved logistical support and participation in surveys is needed. Surveys are labour intensive. Also analytical procedures should be set up to 'automate reporting' in so far as that is possible.
- Up to 130km^2 may need to be surveyed. The FRS surveys seem to have taken about 9 days (summer) and presumably longer in spring as two daylight low tides would be less likely. Field staff should therefore plan for at least 2 weeks of field work followed by 1 week of sample analysis for cockle size at age. Digitising data and production of the biomass estimate should be possible in 1 week. Therefore a biomass estimate could be available 1 month after the start of the survey.
- Adequate logistical support and local knowledge of the Solway is important for successful surveys. Ideally licence holders would participate in teams led by scientists; this would also improve understanding of where to target, once the fishery opens. The effort here could be offset against licence fees i.e. the licence holder could choose to pay full licence fee (which would then be used to contract surveyors) or to offset some of that fee against time on survey.

- Where possible GPS devices which are capable of storing position, date, time, catch, sample type and other variables would be used. This saves time later. If sufficient labour is not available for shore based low tide surveys consideration should be given to vessel based dredge or grab surveys. The main limiting factor here is that the sampling efficiency of dredges or grabs may not be well known compared to the 100% efficiency of a quadrat sample. Correction factors would be needed. On the other hand vessel dredge surveys provide larger individual sample sizes and are therefore less likely to be 'locally' biased than quadrat samples and depending on the patchiness of cockle density. Vessel based surveys are limited by tide also but can work landward as tide floods and seaward as it ebbs. A combination of vessel and shore based surveys may therefore be an option depending on local arrangements.
- A successful fishing season is one where the licence holders take the allowable catch with as low a fishing effort as possible and with as little cost as possible. All information available to facilitate this should be provided to licence holders. Information on the status and location of commercial quantities of cockles should be provided to the licence holders prior to opening the fishery. Ideally they would be provided with a map showing local land and marine features which are recognisable (so they can locate themselves in the landscape) and with the density of commercial quantities of cockles, closed areas and other relevant information shown.
- The survey provides an estimate of biomass prior to the fishing season, however this may change in the lead up to the fishery opening, hence the need to reduce delay between survey and fishery. During the season, the fishing operations, of both hand gatherers and dredgers, potentially provide the same information, albeit at a coarser level, as the survey and provides both validation or cross check of the survey estimate and should also signal how the biomass is being depleted during the fishing season (particularly with dredgers). Licence holders can easily record and report catch, effort and location at a given spatial scale and should be required to do so during the fishing season. This is particularly important if the survey is limited in its precision because of low sampling levels.

3.1.4 The Harvest Control Rules (HCR)

Recommendations in setting the TAC

Ignoring the ecosystem considerations, the TAC (i.e. the proportion of the biomass that should be allowed) would be related to the inverse of the natural mortality rate of commercial sized cockles. It is therefore vital to understand patterns of natural mortality. If all cockles are going to die prior to the next fishing opportunity, then they may as well all be fished now. Conversely, if mortality is low and a lot of cockles could contribute to spawning next year and increase in yield then a much more conservative approach should be considered. Further analysis of historic survey data will give clues in this regard.

Under the previous management arrangements unexploited spawning 'reserves' existed in various forms; within sensitive habitats not open to the fishery, in inaccessible areas, in the legal sized cockles that remained on the ground in fished areas (<100% exploitation) and within the size refuge provided by the minimum landing size. The latter provides a significant spawning reserve as cockles are mature at sizes lower than the 22mm or 28mm minimum size used.

The question therefore is whether the spawning potential in the commercial sized cockles in the fished areas needs to be managed at all. It would be beneficial to develop a spawning potential index annually, to map the distribution of this potential and then to consider this in estimating the TAC. The index could also be developed from the historic time series and compared to within year potential. In that way information from the historic survey and the subsequent stock performance could be a useful guide. The index simply involves applying the size at maturity ogive and perhaps information on size dependent fecundity to the size distribution data. The impact of a given TAC in a given area(s) could then be visualised and estimated.

Historically the exploitation rate was limited to 20-33% of the commercial biomass as a rule of thumb guide. However, this may be more conservative than necessary given that maturity occurs at a small size. In the future it may be helpful to undertake the following analysis to inform setting of minimum landing sizes and future TACs.

- Size and age specific mortality rates be estimated from historic survey data

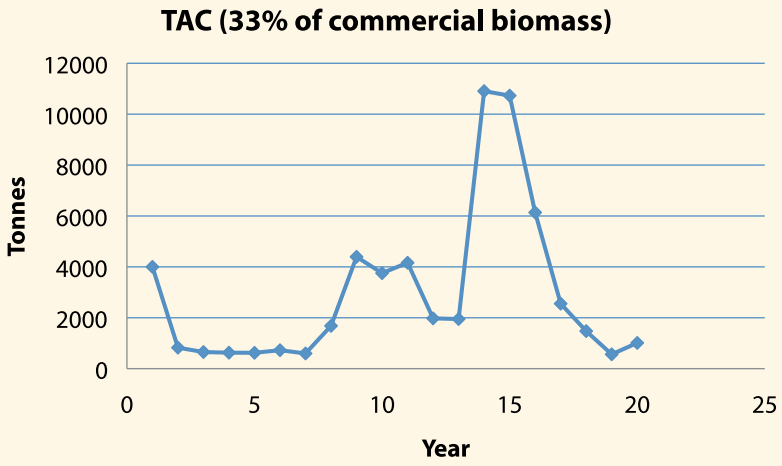
- Growth rate parameters be updated
- A yield per recruit analysis, using the range in mortality rates, growth rates and meat yields found in historic survey data, be undertaken to identify the MLS that optimises yield per recruit. New seasonal data on meat yields may be needed.
- A spawning potential index be reconstructed and mapped from the historic time series and from each future survey to inform the management of spawning stock.

Given the historic range in commercial stock biomass and by allowing 33% of the commercial size stock to be taken, the future TACs may vary from 500-10000 tonnes annually

- Based on 20 years of survey the TAC could be expected to be less than 2000 tonnes half of the time and greater than 2000 (up to 10000) the rest of the time (Figure 6)
- If the 33% rule was applied to all biomass the TACs would be higher
- The fishery would not be viable in all years where the TAC was less than 2000 tonnes as it would depend on how the biomass was distributed spatially
- It may be unsafe to fish when commercial biomass is less than 2000 tonnes (evidenced from 1991 and 1992 fishery)
- The number of years when biomass is less than 2000 tonnes may be less than indicated historically if the stock is well managed (i.e. that the 1991 and 1992 situation is not repeated). The biomass remained above 5000 tonnes for 10 successive years 1997-2007 for instance

Caution: the uncertainty in the historic landings data compromises the interpretation of the biomass series.

Figure 6. TAC which could have been fished based on a harvest rule of 33% of commercial biomass, estimated from survey, between 1990 and 2009.



Other harvest rules (i): The fishing season

There are a number of reasons to keep the fishing season short (but also allow reasonable time for the TAC to be taken)

- The meat quality and yield declines late in the season as winter approaches
- Fishing in early summer will mean foregoing yield that will occur due to growth of cockles
- Fishing in summer may damage recent settlement
- Meat yield is low in summer (or early summer at least)
- As autumn progresses the populations of overwintering waterbirds builds up in the Solway and there would be increased overlap (spatially and temporally) between the fishery and these species if the fishery continued into late autumn
- A season of limited duration potentially limits control and enforcement costs
- Shorter seasons will allow benthic habitats to recover from effects of dredging and hand gathering
- There may be health and safety concerns if a fishery continued into short winter days
- The optimum season would therefore probably be from August to November

Other harvest rules (ii): The minimum landing size

The optimum minimum size can be estimated from a yield per recruit analysis which weighs up the potential yield as a balance of mortality and growth rate. There may be additional market or ecosystem considerations in setting the minimum size.

3.1.5 The Limit Reference Points

Recommendations

The limit reference point for managing the cockle stock is the lowest stock biomass at which a fishery would not occur. Three issues need to be considered when deciding this limit:

There is a stock biomass limit at which a commercial fishery will not be viable. This will depend on how the biomass is distributed. If it is highly 'clumped' then it may still be economically viable to fish but if it is dispersed over a large area then it will not be economically viable to fish it. The density of commercial size cockles is the important variable here. The critical density will be much higher for hand gatherers than for dredgers; it may be economic for dredgers to fish at densities of down to 5-10m^2. Hand gatherers, if they are to gather 150-250kg per tide, will need higher threshold densities.

Ecosystem services provided by cockles (mainly as a prey source for overwintering waterbirds) need to be taken into account when establishing the stock biomass limit below which a fishery should not occur. This will be a significant constraint on the opening of fisheries in some years when biomass is low (discussed further below).

Obviously there is a need to protect some spawning potential and as indicated above, in some years at least, strong spawning potential is followed by good recruitment. The limit reference point cannot be provided at this point or until the suggested analyses are undertaken. The opinion of scientists, managers and fishermen involved in the fishery during the 1990s should be sought.

The fishery has remained closed in the past based on advice that a stable age structure or multiple age classes were not established in the stock. This may be unnecessary given the population dynamics of cockles. The harvest decision should be based on the spawning potential in the system irrespective of how many age classes contribute to that potential. A strategy of rebuilding age structure would seem to be overly ambitious; it may never occur.

3.1.6 The Target Reference Points

Recommendations

The target exploitation level should be set no higher than levels which achieve the long term maximum yield. The modern meaning of Maximum Sustainable Yield (MSY) takes into account risk, and may require stock biomass to be maintained at levels well above a point estimate of MSY obtained from a deterministic stock assessment model.

Size at maturity usually occurs well below the commercial size which tends to protect the spawning potential even at high harvest levels and fish are harvested when most of the individual growth has already occurred. Cockles also have high fecundity and they generally can recover rapidly from low population levels, making them robust to fishing. The rule of thumb 33% exploitation rate for cockle would seem sufficiently precautionary and will not limit the potential of the stock to build to high biomass.

As shown in the historic time series, the Solway stock appears to be able to produce a periodic high biomass (>30000 tonnes) resulting from strong larval settlement coupled with good survival in the first and second winters. This would be an exceptional season, but assuming a 33% exploitation, the TAC in these years could in theory therefore be 10,000 tonnes. This is a very large fishery by any standard and would require significant resources to manage, if it was to be fully exploited. The effect on market price and the capacity of local or other processors to purchase this volume of cockle is not clear. In fact the fleet capacity to harvest this volume may not be available. To set this in context; it would take 50 dredging vessels and 150 hand gatherers somewhere in the region of 90 days to land 10,000 tonnes (given daily tidal restrictions on working hours).

Although fishing opportunity may be foregone it would be more risk averse not to target 33% of such large recruitment events. Instead, these cohorts may progress for 2-3 years in the stock and support annual fisheries when new recruitment is poor. Issuing such large numbers of licences necessary to harvest large biomass creates problems and instability and a significant number would need to be withdrawn when recruitment and stock biomass declined.

Choosing to limit catch even when biomass is very high will allow biomass to remain at a higher level for longer and is more consistent with the MSY objective (or indeed the ecosystem objective as discussed below). During periods when biomass is very high fishing should be targeted at very high density areas so that the TAC can be taken with least effort and to improve conditions for new recruitment; there is strong evidence that recruitment is very poor in areas where adult density is very high.

3.1.7 The Overall Harvest Strategy: Variables and Constants

Recommendations

Given that the biomass will vary year on year the fishery management authority will need to decide how best to harvest a proportion of that biomass each year within the constraints of the reference points that would be agreed. Different strategies could be envisaged;

- A very long season with low daily limits and a low number of licences
- A short season with high daily limit or no daily limits and many licences

For reasons discussed above the season should be short; probably no more than 90 days (August-October). If the season is fixed and the biomass varies then the number of licences has to change if the TAC is to be completely harvested. By contrast, fixing the number of licences would imply a variable season length.

Two examples where the TAC is 1000 tonnes and 5000 tonnes are illustrated below. These examples are based on certain assumptions about possible daily landings and income is based on an average price, before costs. This indicates how the number of licences differ, assuming a fixed season length and assuming the full TAC was harvested. In both cases the TAC is divided 30%:70% to hand gatherers and dredgers respectively.

For a TAC of 1,000 tonnes 17 hand gatherers and 8 dredge licences would be needed to take the TAC in 90 days. The daily limits are not regulated limits as such but probably indicate what a hand gatherer or a vessel could take in a day given the low biomass.

Table 1: Possible licence numbers in event of a 1,000 t and a fixed season length

	Hand	Dredge
TAC (t) share out	300	700
Days in season	90.00	90.00
Daily TAC	200.00	1000.00
Potential total catch	306.00	720.00
Licences	17	8
Price per kg	1.6	1.6
Gross earnings per licence per day (£)	320	1600

By contrast, at the other end of the scale, for a TAC of 5,000 tonnes, some 69 hand gatherers and 19 dredge licences would be needed if the full TAC is to be harvested in 90 days. The daily maximum catch of the vessels could be higher in this scenario as stock abundance is higher.

Table 2: Possible licence numbers in event of a 5,000 t and a fixed season length

	Hand	Dredge
TAC (t) share out	1500	3500
Days in season	90.00	90.00
Daily TAC	250.00	2000.00
Potential total catch	1552.50	3420.00
Licences	69	19
Price per kg	1.6	1.6
Gross earnings per licence per day	400	3200
Total value (£)	2,484,000	5,472,000

These scenarios highlight both the potential value of the fishery in terms of employment and worth but also highlight possibly the main difficulty that management will be faced with in attempting to operate a stable, orderly and well managed fishery; how to vary the number of licences in proportion to the available TAC given that the daily catch potential is limited by working time and by the fishery methods and given that the season needs to be of limited duration for reasons discussed above.

Very well defined rules for accessing the fishery under these conditions need to be set out and consideration will need to be given to the potential challenges of providing licences, and subsequently removing licences. One option, is to consider a more stable number of licences, recognising that in years of large biomass abundance, management may set a smaller TAC. Management should consider whether this potential loss of earning in abundant years is outweighed by the benefits of increased licence stability and increased future productivity. One such approach would be where the TAC is above a given high level, and to avoid the potential destabilising effect of introducing more licences, the harvesting rights to a proportion of TAC could be retained or vested in the management authority. Harvesting of this could be contracted to outside parties (i.e. equivalent to a single season licence). The proceeds of harvest could be used to offset management costs, for marketing and promotion, for local fisheries development or other related projects. However, such decisions should be taken in advance, fully consulted upon and agreed and enshrined in the management rules to avoid conflict and delay when stocks are highest.

3.2 Ecosystem Interactions (MSC Principle 2)

Experience

Cockle harvesting disturbs sediments and can lead to loss of fine material, a change in sediment composition and a consequent shift in the marine invertebrate communities, including cockle. This in turn may have a knock on effect on the capacity of these habitats to support overwintering waterbirds.

Consultations with both RSPB and SNH as part of this review exercise have not highlighted any ecosystem impacts of concern from the previous fishery operated under a Regulating Order in the Solway Firth. In short no concern was raised that the Solway cockle fishery –both vessel and hand gathering – had had an adverse impact on the nature conservation in the Solway Firth and in particular the qualifying features of either the SPA or SAC. This suggests that the Regulating Order Fishery was successful in avoiding any adverse environmental impact.

Although no evidence of ecosystem effects were identified during the operation of the Regulating Order, the operation of significant shore based and vessel based fisheries for cockles has the potential to impact on key habitats and species protected in the EMS.

Previous fisheries were limited in geographic scale, frequency and intensity. The system has not been exposed to regular landings of 5000 tonnes of cockles for instance. This scale of fishery seems possible from previous biomass estimates.

Ecosystem effects, particularly on overwintering waterbirds, may take a number of years to take effect. Regular monitoring of waterbirds and marine habitats should go hand in hand with regular large scale cockle fisheries. This information needs to feed into the annual review of any cockle fishery management plan.

Recommendation

Safeguarding the nationally and internationally important features of the Solway Firth was rightly a priority of the previous management model and this should remain so. Above all, maintaining the conservation status of the designated sites and safeguarding against adverse impacts of fishing will be a legal requirement of the new management authority. In the future management it will be important to consider whether these aims may be met more efficiently in a way that does not have unintended impacts on the viability of fisheries operation.

One aspect in particular that seems to be important to consider is the time taken to ensure that potential environmental impacts are considered and safeguarded against in the management decision making process and seek to speed up this process. This seems to add considerable cost and delay to the fishery, undermining the economics of operation and especially any notions of cost recovery.

The legal requirement, under Article 6 of the Habitats Directive and however this is transposed in national legislation, is to appropriately assess fishery plans. The Directive is not prescriptive with respect to the frequency of these assessments. Therefore the frequency is determined by the frequency at which fishery plans are produced; annual plans require annual assessment and multi-annual plans presumably require a one off assessment. A multi-annual management plan is also much more preferable than an annual plan in a number of respects; it provides a longer time horizon for licence holders, managers and investors during which the rules and conditions are known. To enable an Appropriate Assessment of a multi-annual plan the following should be included in the plan:

- The number of years the plan will be in force
- The geographic extent of any fishery over the period of the plan
- The possible range in annual TAC
- The biomass at which a fishery would not occur (the limit reference points)
- Strategy for harvesting episodic high biomass
- The fishing methods
- The amount of fishing effort that would be generated by the range in TAC and given the quota allocations between hand gatherers and dredgers

The appropriate assessment process will evaluate how designated and sensitive habitats are to be protected, if sedimentary habitats subject to fishing will accumulate impact or will recover between fishing seasons, and if the TAC at a given biomass will lead to impacts on waterbirds. The evaluation of these pressures could be included in the management plan or could be completed in response to the findings of an AA. Either way the process only needs to be completed once if the appropriate and complete range of scenarios are included in the management plan. As some uncertainty may always remain on whether continued cockle fishing will have an impact on the EMS or not some monitoring will undoubtedly be recommended and be needed. Key ecosystem indicators relevant to the protected features in the EMS should be carefully chosen and agreed with the Conservation Authorities as necessary.

3.3 Socio-economic & Institutional Aspects (MSC Principle 3)

3.3.1 The Financial Model

Experience

The SSMA ceased operation above all else as a result of lack of income. This was a responsible decision taken by the directors, which was inevitable given the continued scientific advice not to re-open the fishery. In simple terms the financial model for the Regulating Order was for a company (SSMA) to be the grantee of the Regulating Order and operate on a basic cost recovery model where income from the fishery funds science, enforcement and management administration. Although the company board was comprised of various stakeholder representative bodies, along with nature conservancy interests and local council representation, their role as directors is ultimately to ensure that books are balanced.

The costs of operation are significant and largely fixed. These include: the cost of stock assessment, the cost of appropriate assessment, contributions towards the cost of the bird model, the costs of producing cockle bags, direct employment costs of a fishery manager and fisheries enforcement officers, office overheads, vehicles and quad bikes, insurance etc etc, etc. Set against these costs is an income from licences and a levee based on landings which varies significantly from season to season.

When scientific advice indicates that the fishery should remain closed income will fall short - well below operational overheads. Indeed even when the stocks can support a bigger fishery it is not clear whether the company would return a profit. Any new management model for the Solway cockle fishery must look frankly and realistically at the costs of management and explore whether, and if so how, the costs of management can be recouped from the fishery, including in years when the fishery does not open.

Recommendation

The notion of cost recovery is an important aspect of sustainable fisheries management theory. However it is important to recognise that in most cases (especially in the EU), this does not happen (other than through taxation). It is also interesting to consider the case of other Scottish fisheries, both inshore and offshore. The commercial fishing industry targeting quota species is not charged directly for any of the science carried out by Marine Scotland (Science) or for any appropriate assessments. Of course licences and quota is a major overhead for industry, but this does not go toward the direct costs of management, enforcement or science. In some cases this is in spite of these fisheries being very high value and reliable and requiring considerable scientific and enforcement input. Is it therefore realistic for a small scale inshore fishery targeting a comparatively low value and variable fishery to cover the costs of management, especially given that the inshore nature of the fishery means that costs of appropriate assessment and enforcement are comparatively higher?

While it is reasonable to have cost recovery as an aim and even included in the permitting arrangements, the scale of this needs to be carefully considered, especially initially, to ensure that fishers remain profitable (reducing the incentive to fish illegally) and equally important that management remains solvent. Some contribution of central or local government funding (especially initially) is likely to be a crucial factor in establishing the management system, and perhaps also in contributing to some of the on-going costs. Once the fishery is well established and demonstrated to be performing well with profitable fishers then it may be possible to increase the degree of cost recovery, recognising that it is more reasonable for fishers to pay for the costs of management if that management is delivering them a viable commercial opportunity.

3.3.2 Fishers Rights & Numbers

Experience

One of the challenges and causes of delay and legal challenge over the Regulating Order and subsequent fishery closures and openings has been the determination of who should be eligible to fish the fishery and according to what criteria. In particular, some key questions were often raised and repeated such as whether the fishery should be open to vessels or hand pickers, how many licences should be issued and whether to seek to restrict the fishery to 'local' fishers. The final result at the time of the Regulating Order was that there was a decision to grant a relatively large number of licences to hand gathering, vessel dredging and initially tractor dredging. Attempts to restrict the fishery to 'locals' failed on the basis of discrimination.

Recommendations

It should be highlighted that from a purely stock management point of view it makes very little direct difference who fishes the resource or how. Instead the discussion should be phrased relative to the sustainability of the fishery – for example, are vessels easier to enforce, do hand gatherers have less ecosystem impact, do local fishers have a greater sense of stewardship over the resource?

In most cases, those with fishing rights are those with historical track record in the fishery. This is enshrined in the Common Fisheries Policy, both in terms of determining quota division between member states, and within member states in allocating quota according to Fixed Quota Allocations (FQAs). If fishers or sectors are to be excluded from the management system then it is crucial that the reasoning for this be demonstrated against sustainability criteria.

Legal challenges are costly and (at worst) undermine the management system. The licensing system should aim to be non discriminatory, respecting the rights of those with historical access and making management restrictions on the basis of empirical evidence if such challenges are to be avoided.

When looking ahead, it is important to include in the consideration of the design of the management system, the sort of fishing jobs that should be created in the fishery. For example, is it better to (i) maximise the number of short term and seasonal opportunities for income, or (ii) create fewer opportunities, with a longer season and a greater share of the income going to fewer fishers.

Table 3: Relative merits of fewer licensed fishers (example ii above):

Advantages	Disadvantages
More committed and stable workforce – easier to ensure training standards are met	Any cost recovery / licence fee will be shared by fewer individuals
Increased potential for individual income – reducing need to supplement income, or incentive to fish illegally	Greater scrutiny (and possible criticism and legal challenge) on licence selection criteria, which must clearly be shown to be non-discriminatory)
More likelihood that fishers will remain in the fishery even in or following years of low harvest	In years of large stock abundance, the stock may not be fully exploited (especially if hand gathered), so some economic potential is not realised
Greater sense of stewardship in the resource – increasing likelihood of compliance	
More likely to appeal to local residents as a longer term commitment	

Although the political motivation to seek to maximise the amount of possible employment opportunities from the resource is understandable, it should be recognised that over-ambitious attempts to maximise employment opportunities are more likely to lead to increased instability in local employment and a less well developed sense of stewardship in the fishery. It is far better to begin with a smaller number of licensed fishers and demonstrate that the management system works and that fishers are able to make a reasonable income.

3.3.3 Enforcement & Unregulated Fishing

Experience

All stakeholders interviewed as part of this study have highlighted the significant problems with illegal, unreported and unregulated fishing (IUU). It seems to be generally accepted that there was a large amount of illegal activity on the beds in 2005, when stock levels were high, just before the opening of the Regulating Order fishery. Although there were no fisheries prosecutions, there were some public disorder prosecutions. It is suggested that the scale of illegal fishing prior to the opening of the licensed fishery meant that even at the outset licensed fishers in the Regulating Order were unable to catch their share.

There are several issues of concern to a well managed fishery from IUU:

From a stock biology point of view, IUU is not automatically a problem, provided it can be accounted for. In short it makes no difference from a purely biological perspective who catches the cockles provided the appropriate number are caught. It is noticeable that in spite of the acknowledgement of 'significant' IUU, there has been no estimate of the quantity of IUU removals, or even an understanding of the scale of IUU compared to TAC. This means it is hard to get a true picture of the past productivity of the fishery. It is understood that neither the determination of TAC, nor the bird model give direct acknowledgement to the amount of removals from the stock from IUU fishing. Seeking to manage an appropriate rate of exploitation of a population is undermined if one of the potentially biggest sources of mortality is not included in the calculations.

From a stewardship point of view, IUU has a potentially significant impact. Illegal fishing undermines fishers faith in the management process and at worst makes licensed and legitimate fishers feel that they are being penalised for their compliance. Beyond a certain scale this can become self-stimulating, with fishers feeling there is little point in complying if they perceive no one else is. If there is no 'peer pressure' to comply then the challenge of enforcement is greater.

The nature of the Solway Firth – a large inshore area with many access points - means that even for a well resourced enforcement body, effective enforcement is very difficult, therefore seeking to design a system which engenders a strong sense of resource stewardship is essential to the future prospects of management success.

Initially the SSMA employed Enforcement Officers whose role was to oversee the activity of the licensed fishery. However, with only 2 officers and over 40 miles of coastline this was understandably difficult. Furthermore, it was more challenging for them to enforce activities of non-licensed fishermen. This undermined overall faith in enforcement and created a disincentive to comply with regulations, which may well have led to some illegal fishing on the part of lisenced fishers (such as transferring cockles from a licensed bag into an unmarked bag). The greatest risk of influx of unlicensed fishers is when the stocks are highest. There was also a perception that it was possible for vessels to land into English ports without declaring catches. Whether or not this is true, it is important to recognise that there is often as much damage done by the perception of non-compliance, as actual non-compliance.

Recommendation

It is understood that a number of changes have taken place since the Regulating Order which mean that at least some of the issues associated with illegal fishing activity may be ameliorated. In 2006, measures in the Police, Public Order and Criminal Justice (Scotland) Act were introduced to allow the Scottish Fisheries Protection Agency (SFPA) (now Marine Scotland (Compliance)) to use its powers to detect, prevent and deter illegal fishing in areas managed by Regulating Orders. It should be noted however that even with these powers Marine Scotland (Compliance) have only 3 officers for the whole of South West Scotland. In addition The Sea Fishing (EU Recording and Reporting Requirements) (Scotland) Order 2010 gives enforcement officers greater scope to enforce when on land and equipped to fish rather than simply being in the act of illegal fishing, which was a particular challenge in the past.

Additionally, it is understood that there is now greater focus on the transport of cockles within the region as a result of work by both the local authority environmental health and the Food Standards Agency meaning that there is now a movement document which must be with any cockle being transported. This includes the shellfish waters classification and means that it is now much harder to sell any unlicensed landings in the market. This emphasis on market or downstream mechanisms to help enforce the fishery is thought to have increased the overall efficacy of enforcement.

In the future it is clear that liaison with English enforcement will also be important, to ensure that there is mutual understanding of the IUU risks, and enforcement strategy on either side of the Solway Firth.

In the future enforcement of hand gathering may be easier with some sort of rotation of beds, so that only certain areas are open at a time. However, some stakeholders to this study reported that spatial restriction of hand gatherers does not work, so the extent of spatial restriction should not be too great. The continuation of the scheme of labelled bags for licensed landings also seems sensible. Although in itself this is not a failsafe solution, it is a contributory factor in overall improved compliance.

There is much talk of self policing. This is in part because of the large spatial scale of the fishery and the difficulty therefore in enforcement. It is interesting to note that the latest version of the MSC standard does include some provision for the recognition of more informal approaches to control and enforcement. Factors which are likely to contribute to the success of such informal approaches include; social disapproval, prevailing norms, accessibility to the resource and ability to smuggle catches on-shore without detection. In many cases therefore the characteristics of the Solway fishery means that informal approaches are less likely to work, not least due to the easy access to the resource, the multiple landing sites and the history of illegal fishing. The prospects for self policing do not look as immediately positive as in some other fisheries. Encouraging local licensed fishers to engage directly with illegal fishers is not recommended, and should not be necessary if the enforcement system is designed correctly, however the suggestion to provide licensed fishers with a text number to report illegal activity may be of merit.

3.4 Other Considerations

3.4.1 The Market

Experience

A challenge for the fishery has been to ensure that there is a viable market for the cockle and that the sales value can be maximised. More recently there has been greater focus (including in the evaluation of the recent tender for the trial fishery) on seeking to add value, such as through secondary processing in the local area.

There have been a number of challenges in the context of the market for the Solway fishery. The market for live cockle is relatively small, with only the best size grades, and is very dependent on yields. The late operation of the Solway fishery has meant that yields are lower and prices, especially in the live market, are lower, as a result of increased competition from cockle beds further south where yields remain higher later in the season.

A significant potential market is therefore for cooking and canning, although there remain challenges in this area of the market, such as getting the right size grades and yields, and effective disposal of shells. The potential to develop increased local cooking and processing exists however, if the fishery can supply the needs of those processors.

The greatest impediment to developing the market and creating a climate for investment is irregular supply. It is therefore important that the focus on the fishery – its scale and operation – comes before consideration of the market. Once the scale and operation of the fishery are determined, possible market mechanisms may be explored.

In looking at economic models seeking to inform decisions about appropriate licence fees and appropriate number of licences it is critical to recognise that the price of cockle varies considerably and is heavily dependent upon yield (meat weight / whole weight). Yields are higher in the late summer months and fall off significantly into the autumn and winter months. Similarly yields vary according to where the cockles are on the beds, with cockles higher up the shore generally of lower yield. A delay in the opening of the fishery therefore greatly undermines the entire financial model of the fishery, impacts on market opportunities and condemns fishermen to considerably reduced incomes. Such delay should be seen as unacceptable in any future management system.

3.4.2 Vessel v Hand gathering

There has been a lot of discussion over many years about the relative merits of hand gathering or a vessel based fishery. Some of the relative advantages and disadvantages are outlined below:

Table 4: Relative merits of hand gathering v vessel harvesting.

	Hand Gathering	Vessel
Total Catch	Catch up to 150-250kg per person per day. Years of good spat fall would require a huge number of man days to fish available resource which is not possible due to the seasonality and likely numbers or pickers, therefore the resource would be underexploited."	Total catch likely to meet quota, even in good years.
Access	Restricted by access – both in terms of permissions and safely reaching distant beds.	Less restricted by access.
Catch Profile	Need higher densities of cockles, more likely to fish lower yield cockles in the upper shore and unable to fish channels.	Able to fish lower density beds and a larger array of beds including channels.
Income	Limits on seasonality and physical constraints of hand gathering mean that the cockle fishery (in its current form) will only contribute to a partial salary for pickers and additional forms of income will always be required – almost regardless of the available quota or number of pickers, unless more cockles can be gathered per day (by a change in operational practice).	There is the potential for the fishery to enable vessels' crews to earn a full time equivalent earning, by catching all available quota. This will depend on the number of vessel licences issued annually.
Employment turnover	Likely to be a transient workforce, with high turnover of pickers, requiring additional work at other times of the year.	More likely to be permanent fishers, involved in other licenced fishing throughout season.
Administration	Large cost of administering.	Simpler administration
Management cost recovery	Given that a single picker is unlikely to derive a full time equivalent income from the fishery it is difficult to charge a large licence fee, therefore total cost recovery is likely to be less, even when numbers of pickers are large.	A profitable vessel based fishery potentially allows greater incomes to those involved and allows greater cost recovery. The number of licences however will be lower than for hand pickers
Enforcement	Many more individuals covering a wide area. Hard to quickly distinguish (particularly at a distance) between licenced and non-licenced pickers. Hard to monitor other compliance, other than at central distribution point.	With a restricted number of licenced vessels, it should be comparatively easy to enforce (licence parameter could include VMS to track vessel position).
Disturbance – birds	Large number of hand gatherers potentially disturb feeding birds at low tide.	Possibly increased disturbance on roosting birds. Although overall numbers and time of disturbance less than hand gathering.
Other ecosystem Impacts	Localised benthic impacts per picker, but impact more widespread if large numbers. Dynamic nature means likely rapid recovery. Pickers may concentrate in upper shores and finer sediments which have longer recovery times compared to coarser sediments on lower shore.	Benthic impacts per vessel may be greater but dynamic nature means likely rapid recovery. Vessels unlikely to work in upper shore where there are finer sediments which take longer to recover from impacts.

It is not clear what has informed the current determination that the fishery be a hand gathering only fishery and from this external perspective it appears possible that this has not been subject to full analysis. It has been notable in the stakeholder consultations as part of this exercise that there has been relatively little opposition to vessel based fisheries and no argument has been presented of a greater negative ecosystem impact. The 2007/08 SSMA Management Plan states:

"Numerous studies have shown that hydraulic fishing does not affect the overall community of the sandflats in the long term or sediment characteristics on shores which receive a moderate level of wave disturbance. The only major casualty is the cockle population when it is over fished, the exception being if hydraulic dredging is carried out on sheltered shore with a delicate infauna and Zostera beds. Measures have been drawn up to exclude vessels from sensitive areas where they could potentially cause damage".

Instead the concerns about vessel based fisheries seems to be due to a perceived difficulty in enforcement and a perception the vessels can just clear out the fishery in no time. Both of these perceived threats should be possible to adequately address in the management system.

In the view of this project team a vessel based fishery offers a number of potential benefits which should be considered before a decision is taken to remove all vessels from the fishery. Above all it will enable the TAC to be taken in good years and potentially allow higher cost recovery (as the TAC is more likely to be taken). It is likely that in years where biomass is high that significant fishing opportunity will be lost if the fishery is restricted to hand gatherers. From the biological perspective it makes little difference whether the cockle is fished by hand or by vessel, and based on this short consultation the relative ecosystem impacts between hand gathering and vessel gathering are not proven, nor subject of significant concern. In these circumstances it is the fishery control and enforcement, the socio-economic dimension and, to a lesser extent, the market dimension that should therefore influence management decision over which method of exploitation is preferred.

4 Other Management Models

4.1 Comparison of Management Powers in England

The Solway Firth is divided between Scotland to the north, and England to the south with the jurisdictional divide running roughly down the centreline of the Firth. Consequently the fisheries of the Firth come under different governance structures depending on where they are in the Firth.

Although there are some commonalities in governance structures which both comply with such as EU Common Fisheries Policy rules on licensing, common organisation of the market, nature conservation etc., in the more local context of inshore fisheries management the differences are more pronounced.

IFGs v IFCAs

In Scotland, Inshore Fisheries Groups have been established around the coast over recent years with the aim "to improve the management of Scotland's inshore fisheries out to 6 nautical miles and to give commercial inshore fishermen a strong voice in wider marine management developments"[1]. These are non-statutory bodies which are not referred to in the Marine (Scotland) Act 2010. As such they are advisory and should the constituent stakeholder group agree upon an approach to management this would need to be implemented by Scottish Ministers making use of powers provided in other legislation, such as the Sea Fisheries (Shellfish) Act 1967[2] (as used to establish the Solway Regulating Order) or the Inshore Fishing (Scotland) Act 1984 (as used to close the Solway fishery once the Regulating Order had expired)[3].

1 http://www.scotland.gov.uk/Topics/marine/Sea-Fisheries/InshoreFisheries/IFGsMap
2 Regulating Orders, granted under the Sea Fisheries (Shellfish) Act 1967 are also used in England for management of some inshore shellfish fisheries.
3 Inshore Fishing (Prohibition of Fishing for cockles) (Solway Firth) (Scotland) Order 2011

The Inshore Fishing (Scotland) Act 1984 essentially allows ministers to prohibit within a defined area (and if necessary a defined period):

- all fishing for sea fish;
- fishing for a specified description of sea fish;
- fishing by a specified method;
- fishing from a specified description of fishing boat or fishing gear;

These powers are relatively blunt and inflexible and it is not always clear how the decision making processes would work in order that such powers be applied in a local area. In theory agreement within an IFG could be a powerful pre-cursor to the application of these powers, but ultimately decision making, application and enforcement of any resulting Act remains centralised with Marine Scotland with only limited local capacity. Consequently, although IFGs have been established in some areas for some time, there have been relatively few binding initiatives implemented.

On the southern side of the Solway Firth, in English waters, the North Western Inshore Fisheries and Conservation Authority (IFCA)[4] has jurisdiction out to 6nm. Inshore Fisheries and Conservation Authorities (IFCAs) replaced the existing Sea Fisheries Committees from April 2011. As well as managing inshore fisheries, they took on new conservation duties as set out in the Marine and Coastal Access Act 2009. The national vision for IFCAs is:

"To lead, champion and manage a sustainable marine environment and inshore fisheries, by successfully securing the right balance between social, environmental and economic benefits to ensure healthy seas, sustainable fisheries and a viable industry"

The Marine and Coastal Access Act 2009 sets out the powers of the IFCAs. These go some way further than the powers of the old Sea Fisheries Committees and also appear to provide greater scope and flexibility than the powers available to ministers in Scotland in the Inshore Fishing (Scotland) Act 1984.

For example, Section 155 of the Marine and Coastal Access Act (2009) empowers IFCAs to make bylaws in order to carry out their duties, although these do not come into effect until confirmed by the Secretary of State[5]. Section 156 of the Act sets out the types of management measures that may be taken, which provides managers with an extensive range of possible measures which includes:

- restrictions on gears, vessels, seasons or areas,
- permits and the ability to both charge for and limit the number of permits
- ability to limit the amount taken by either individuals or vessels
- ability to require certain data collection and monitoring measures

Section 157 of the Act introduces the possibility for byelaws to include different provisions for different cases or different circumstances, including (in particular):

- different parts of an IFC district;
- different times of the year;
- different descriptions of sea fisheries resources.

Section 157 part c in particular indicates that the byelaw may include provision to adapt management measures in response to different stock status indicators. This appears to pave the way for introducing harvest control rules, relative to reference points, indicating what management measures would be taken in event of changes in stock status.

Use by IFCAs of these increased powers, including this apparent scope for introducing adaptive fishery management measures, remains relatively untested since the act came into force in 2009. However this is likely due to the current workload on reviewing byelaws resulting from the transition from Sea Fisheries Committees and it is likely that these increased powers will be increasingly used in the future.

In particular the ability to restrict fishing by means of permit or quota or linking this to descriptions of fisheries resources goes considerably beyond the powers apparent in the Inshore Fishing Scotland Act 1984.

4 http://www.nw-ifca.gov.uk/

5 Although section 157 of the act does give the IFCAs powers to make emergency byelaws in event of urgent need or unforeseen circumstance, it is not anticipated that this would be the appropriate route by which to introduce adaptive management measures for local stocks.

It is also worth doing a comparison of capacity and resources available for local inshore management. The North Western IFCA has a budget for 2013/14 of £1.3 million. The majority of the income comes from local authority levy. Less than 10% of annual income comes from permitting fees. The NWIFCA has two offices in Carnforth and Whitehaven and 5 small industrial units used as workshops, remote offices and storage. The NWIFCA employs some 20 full time equivalent staff including managers, administrators, enforcement officers and a science team. The Patrol vessel FPV 'Solway Protector' has a crew of 3 and 6 shore based officers patrol the inshore fisheries using rigid inflatable boats and quad bikes.

By contrast, the IFG covering the South West of Scotland has no such authority, capacity or resources.

4.2 Shetland Shellfish Regulating Order

One often cited example of a successful Regulating Order operating in Scotland is the Shetland Shellfish Regulating Order. This is indeed a successful fishery (several species now MSC certified), but does not necessarily provide a direct comparison with the Solway cockle fishery. As well as clear geographic, biological and socio-economic differences, it is above all important to highlight some of the differences in the financial model. Firstly, there is greater direct financial support from the Shetland Isles Council, secondly the costs of science are lower and much of the assessment work is carried out by the North Atlantic Fisheries College without direct charge to the Management Organisation. These two factors are hugely important for the financial model. On the income side there is greater potential income due to the larger number of vessels and species covered by the Order. Furthermore some of the costs which the Solway Regulating Order had to face, such as legal challenge and enforcement are not such significant challenges in Shetland.

4.3 Fishery Natura Plans for cockle in Dundalk Bay (2011-2016)

The following fishery example is included as this offers particular relevance to the idea of predetermining the scenarios at which different management actions will be taken. These kind of decision rules (Harvest Control Rules) are increasingly recognised as being an important element in successful fisheries management. In simple terms, a harvest control rule (HCR) simply states what stock level the fishery is targeting, what measures will be used to reach there, and what management actions will be taken and at what points (reference points) to ensure that management response to a declining stock status is appropriate and timely to prevent impairing the ability of the stock to recruit future generations.

Fishing area

The proposed fishing area covers a total of 77.8km^2 of intertidal sand flat in Dundalk Bay. This larger area has been defined to allow for the inter annual variability in location of commercial densities of cockles and to enable the fleet to avoid areas that may have concentrations of juvenile cockles. In any given year the actual area fished will probably be between 10-20kms as was the case during the period 2007-2009. The area fished in any given year is determined by the distribution of cockles at densities over 4m^2 as advised by annual surveys.

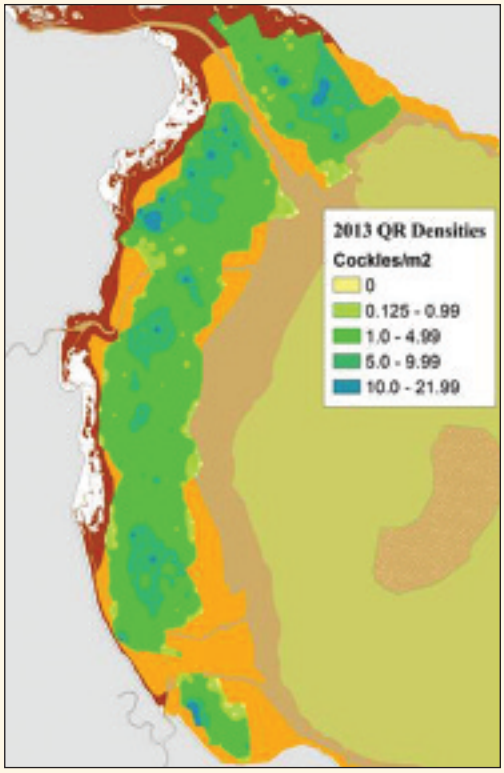


Figure 7. Distribution of cockles in Dundalk Bay in June 2013. The underlying habitats are shown and include upper shore sandy mud and mid-shore sands. Cockle abundance is highest along the mid shore. This pattern is consistent year on year. Densities of cockles in the system are usually low (relative to other commercial beds) but growth rate is high.

Fishery control rules and justification

Various fishery control rules, representing a series of complementary safeguards against over exploiting the stock, that minimise ecosystem effects and that ensure economic viability of the fishery are included in the management plan. Specifically these are rules in relation to:

1 Harvest rates

The harvest rate (% of biomass) rules will determine the Total Allowable Catch (TAC) in any given year of the plan. The following rules, (justification is provided), will apply:

- At biomass <750 tonnes AND density of cockles >17mm is less than 4m^2 harvest rate is zero.
  - 750 tonnes = k/4 or 0.25 of the carrying capacity (k) and population growth rate at this biomass is less than optimal
  - The population response to harvest rates is likely to be variable and unpredictable at low biomass
  - Zero harvest rate was used in 2010 when biomass was 814 tonnes
  - The stock will rebuild more quickly
- At biomass between 750-3000 tonnes harvest rate is 0.33
  - 1650 tonnes = k/2 and the point at which population growth rate (productivity) is at a maximum
  - This harvest rate will lead to landings of between 250-1000 tonnes which is within the range of previous harvests and within the possible range for MSY
  - This harvest rate was used in 2007 and 2009 and is a rule of thumb rate for cockle fisheries in the UK
- At biomass >3000 tonnes harvest rate is 0.50
  - Higher harvest rates at high biomass are justified because stock productivity at high biomass is likely to be lower
  - Population is less sensitive to higher harvest rates at high population sizes
  - Natural mortality is high in this stock and yield per recruit is highest at ages 1-2. Delaying harvest will lead to loss of yield. At higher biomass growth rate may be density dependent leading to further loss of YPR and high adult density may impede recruitment. Although YPR could be improved at lower biomass by applying higher harvest rates the risk of high harvest rates at low biomass outweighs the potential benefits.

Any proposed change to the harvest rates as outlined above will trigger a review of the entire plan

2 Minimum legal landing size

The legal landing size will be 17mm shell width but operationally, as reflected in the bar spacing used on the grader on board the vessels, the effective minimum landing size will be 22mm shell width.

3 The in season depletion of catch per day

- When catch rates decline to 250kg per vessel per day the fishery will close irrespective of other harvest rules. In calculating the catch per vessel per day:
  - the first weeks fishing will be excluded because operators are fine tuning gear at the start of the fishery
  - only vessels that have fished the entire tidal period each day for at least 2 days each side of the high tide will be included
  - The catch data will be provided by fishermen and will be cross checked with SFPA issued gatherers' dockets

4 Spatial control on fishing to protect seed cockles

- Where necessary the plan will incorporate spatial controls to exclude fishing in areas where seed cockles are concentrated. Typically these areas are on the upper shores. This will be decided on an annual basis based on the biomass survey
- The total area that the fishery will have access to during the period 2011-2016 is approximately 60km^2 but annually, as the distribution of cockles is mainly on the mid and lower shore, the expected area over which the fishery will occur will be between 10-20km^2

5 Seasonal closures to protect waterbirds and allow recovery of habitats

- The fishery will close on November 1st provided this is preceded by a period of 14 weeks during which the fishery is open to allow sufficient fishing opportunity to take any available quota. Otherwise the closing date will be later as required.

6 Daily catch allowances to ensure equitable distribution of catch

- A daily maximum catch of 1000kg per vessel will generally apply provided this is sufficient to allow the quota to be taken in 14 weeks

7 Gear specifications

- The dredge blade width will be 0.75m in the case of suction dredges and 1.0m in the case of non-suction dredges

8 Days per week and time restrictions

- Fish tides 4.2m or higher provided this is sufficient to allow the quota to be taken in 14 weeks
- Fishing will be allowed on one tide per day only

9 Access and conditions on the Natura permit

- The number of permits should be limited to 33 as in 2009
- The permit should be transferable across vessels as the capacity of the vessel is not relevant as an indicator of fishing power in this fishery and to facilitate operators who wish to change vessels
- The permit is not saleable or otherwise transferable to persons other than to relatives of the 1st or 2nd degree

10 Hand gathering as in 2009

- The number of hand gathering permits will be limited to 20 (as per take up in 2009)
- Hand gathering will be limited to the Annagassen and north Bull areas for health and safety reasons

Stock productivity

The sustainable rate of harvest of cockles in Dundalk Bay is unknown. In reality there is probably no stable sustainable yield as recruitment is environmentally dominated and natural mortality (M) is high and variable. The feasibility of harvesting also depends on how the biomass is distributed and densities (m-2) of cockles on the sand flat.

The biomass of cockles was estimated annually by independent survey in 2004 and 2007-2010. Maximum biomass of 3588 tonnes was recorded in 2008 (Table 5). Based on these biomass estimates and assuming that 3588 tonnes is the carrying capacity and M is 0.5, crude estimates of MSY, based on method of Gulland (1971) and Garcia et al (1989), are in the region of 100-700 tonnes (Table 5).

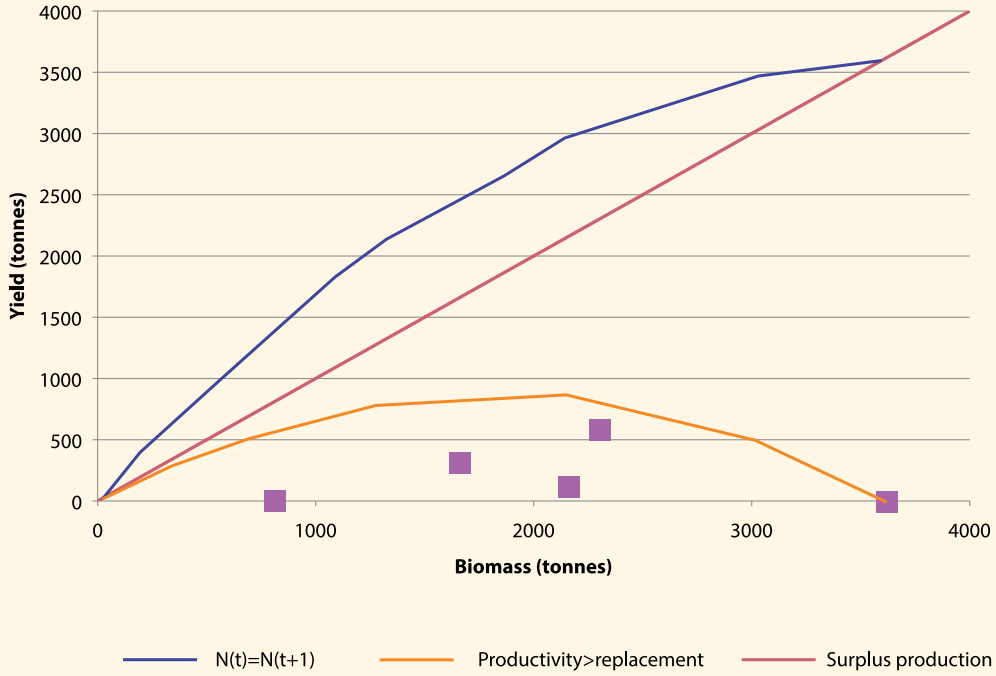
Table 5. Annual biomass estimates and yield (landings) of cockle in Dundalk Bay.

Year	Biomass	Yield	MSY, Y=01	MSY, Y>02
2004	1654		306	
2007	2277	600		709
2008	3588		664	
2009	2158	120		444
2010	814		151	
			373	577

1 = Gulland (1971), MSY=0.5*M*B, 2=Garcia et al (1989). M = 0.5

A discrete logistic growth model, assuming that the 2008 biomass is the carrying capacity (K) and that the rate of population growth (r) is 1 suggests that the maximum surplus production is about 870 tonnes at half of the carrying capacity (k/2).

Figure 8. Phase diagram of discrete logistic growth showing surplus production in relation to population biomass for Dundalk cockles. Annual biomass and yields are shown for the period 2004-2010. K=3588, r=1 (the population grows monotonically to a stable equilibrium).



These crude estimates of productivity of the stock together with experience of yields and catch rates during the period 2007-2010 provide some empirical framework for developing harvest control rules that may be biologically realistic, consistent with experience for this stock and acceptable to industry based on harvest control rules accepted in fishery plans in 2007, 2009 and 2010.

5 Conclusions & Recommendations

5.1 Legislative & Administrative Context

Attempts at developing sustainable fisheries management models based on effective adaptive stock management of Scotland's Inshore Fisheries resources (of which the Solway cockle is just one example) are badly hampered by a lack of legislative power, lack of infrastructure and capacity, and a lack of long term financial commitment. Attempts at centralised, more top down management models using the powers in the Inshore Fishing (Scotland) Act (1984) are hampered by the lack of flexibility in the available management measures and the lack of regional management authority to administer any such management. Attempts at more devolved, more bottom up management models using the powers in the Sea Fisheries (Shellfish) Act 1967 to enable a local grantee to undertake management within a Regulating Order are hampered by the challenges in finding a suitable grantee, challenges in ensuring sufficient cost recovery to meet the costs of management and challenges of management administration and enforcement. Although Inshore Fisheries Groups (IFGs) have been designed to facilitate the development of management of inshore fisheries in Scotland, their non-statutory, voluntary and multi-sector representative structure mean that they are only able to be advisory, and ultimately the legislative tools, capacity and finance to actually implement inshore management is limited as outlined above.

The new Common Fisheries Policy (REGULATION (EU) No 1380/2013) details new policies in relation to regionalisation. This goes further and is more explicit that that contained in the old, now repealed Common Fisheries Policy (COUNCIL REGULATION (EC) No 2371/2002). This provides greater clarity on what Member States are able to do with management of stocks within their jurisdiction. Article 20 addresses the degree to which any measures may be applied within a Member States jurisdiction and states:

- *Member States may take non-discriminatory measures for the conservation and management of fish stocks and the maintenance or improvement of the conservation status of marine ecosystems within 12 nautical miles of its baselines provided that the Union has not adopted measures addressing conservation and management specifically for that area or specifically addressing the problem identified by the Member State concerned. The Member State measures shall be compatible with the objectives set out in Article 2 and shall be at least as stringent as measures under Union law.*

In short, this appears to give Member States greater scope for introducing management measures within 12nm, where it is demonstrated that there is a need and where the Union has not already adopted management measures.

The new CFP certainly seems to pave the way for member states to take a proactive approach to managing those species and stocks whose management is yet to be clearly addressed at an EU level. The question for member states then, is to what extent they wish to take a management lead on those species, and within the member state where will responsibility lie for making the case for, developing and implementing adaptive stock management. For resources in Scotland's inshore waters it will be important to consider whether the existing legislation, administration and financial model is adequate to take advantage of this opportunity and ensure that Scotland's valuable inshore resources are indeed well managed.

In addressing the issues in relation to Solway cockle it is important to highlight these bigger issues. For now, it seems the best immediate prospect of implementing successful management within the Solway Firth cockle fishery remains through the adoption of another Regulating Order (or Hybrid Order – see box), but in doing so it should be recognised that this 1967 act of parliament has considerable limitations when it comes to seeking 21st century solutions to long-held management challenges.

Those local stakeholders that became involved in the development, management and administration of the previous Regulating Order in the Solway Firth should be commended for their committed effort in seeking to enable a potentially good source of local sustainable employment and value added opportunities to be developed in the region. It is clear that all those involved committed considerable, time, effort and expertise to the Regulating Order. Unsurprisingly there is a considerable sense of disappointment on the part of those same stakeholders that the Regulating Order was not ultimately able to deliver on its aims of ensuring a sustainable and viable industry in the Solway cockle fishery. However it is clear that it was also an experience that left many of the directors feeling tired, exposed and subject to criticisms, such that many concluded it was somewhat of a never to be repeated poisoned chalice.

In this context, the immediate challenge for the Solway Firth is to identify who – or rather what sort of group structure - would be willing to take on local responsibility for management under a Regulating Order. It is clear that many of the past challenges identified in this report will need to be addressed even before a suitable grantee is likely to be identified. Above all, if a suitable group structure is to come forward there will need to be a greater commitment from Marine Scotland and central and / or local government to support both the costs and practical challenges of management.

5.2 Management Timeline

It is clear that delays in management not only frustrate the industry but also undermine the entire viability of the fishery. Fishermen are denied opportunity to fish the beds when densities are highest, days are longest, yields are greatest and price is highest. The process of (i) stock survey, (ii) stock assessment, (iii) running of the bird model, (iv) TAC decision making, (v) appropriate assessment and finally (vi) administering the opening of the fishery is too cumbersome and too slow. As a result of this process the fishery often does not open until November by which point the opportunities of making a viable income are enormously reduced. To add insult to injury, fishermen have to pay for a management process which unreasonably prevents them from fishing (in many cases the eventual opening is an indication that the only reason for not opening sooner was procedural delay). This means that in the years of the Regulating Order, the TAC, when set, has typically not been met. Furthermore, the likelihood of illegal fishing is greatest during this summer / autumn period, when licensed fishers are not allowed to target the resource, meaning that, at worst, the most accessible stocks may already have been targeted by the time the beds open.

Almost whatever the management system that is chosen for the fishery, whatever legislation it falls under and whoever administers and enforces it, it is imperative that the process of opening the fishery described above is significantly speeded up to enable fishermen to be on the beds by late summer at the latest.

The initial survey at the start of that timeline cannot reasonably be pushed too early in the season and should remain as close to the optimal opening time of the fishery as possible. This means that time savings will have to be achieved in the remaining steps of the process. A simplified decision making process based on agreed Harvest Control Rules, using scenarios of different stock levels and different bird populations should facilitate this provided that the complete set of scenarios are outlined in a multi-annual management plan and can be subject to a single Appropriate Assessment. The authors are not aware of other fisheries requiring an Appropriate Assessment to be

Box 2: Cockle re-laying

In 2007 Poseidon Aquatic Resource Management Ltd and the Centre for Marine & Coastal Studies, produced an "Aquaculture Strategy for the Solway Firth". This referred to the possibility of cockle relaying, in particular at times of heavy spatfall as a means of deriving maximal commercial exploitation from the resource, a technique which the report notes has been successfully carried out in Poole Harbour. The re-laid seed are maintained at a lower stock density and consequently growth rates increase (Huntington et al 2007). The technical merits of this recommendation are not discussed here, but should there be an interest in such a scheme, even in the future, in order to facilitate that, consideration should be given to the application of a Hybrid Order, rather than a Regulating Order. A Hybrid Order essentially enables small areas within a Regulated fishery to be used for relaying / aquaculture purposes.

carried out annually. Every reasonable argument should be made so that the licence period for which the Appropriate Assessment applies should be for the period of the Regulating Order, not the annual fishing licence. If legal advice suggests that it is required for an annual fishing licence period then consideration should be given to issuing licences for a longer period but with inbuilt flexibility on setting catching opportunities (i.e. the licence conditions reflect the harvest control rule). This could enable catches to be set to zero for periods, and subsequently increased without this "reopening of the fishery" requiring a new round of licensing and having to be subject to Appropriate Assessment. This should be possible if the Appropriate Assessment is carried out on the different scenarios of fishing opportunity, outlined in a harvest control rule with a binding management plan.

Similarly running the bird model on the different scenarios in the management plan should enable the annual delay in running the bird model to be avoided.

5.3 Viable Employment

It is the view of these authors that it is better from the point of view of resource stewardship to have fewer fishers deriving a decent and potentially full time wage from the fishery, than many, many part time fishers deriving periodic income from the fishery and seeking work elsewhere at other times. Seeking to enable fishers to derive an as near as possible full time earning from the fishery should be the aim of management, as opposed to seeking to enable as many fishers as possible to derive occasional income. Fewer fishers, working a longer season is more likely to bring stability and stewardship to the fishery, which in turn may lead to increased local value added opportunities, increased potential for cost recovery, and an increased effectiveness of more informal approaches to enforcement. Consultation and engagement of fishers in the management process also becomes easier.

Again in the view of these authors, there are distinct advantages to a vessel based fishery and this should not be ruled out. A hand gathering only fishery will inevitably mean that in times of larger TACs the resource will be underexploited (unless huge numbers of pickers are licensed). If it is to be a hand gathering only fishery, thought needs to be given to the potential for hand gatherers to achieve a greater return. It should be recognised that the survey is a service for the industry and should be used to assist fishers in fishing the grounds with the highest density. This enables a more targeted approach to fishing and potentially reduces the impact. It is understood that the fishers in the current trial were not aware of the results of the survey so were effectively fishing blind. Another idea associated with increasing the viability of hand gathering is the use of some form of cockle transport vessels / crew support vessels. These have been successfully used in other cockle fisheries, such as in the Netherlands, and enable larger volumes to be safely collected from distant beds or beds which are inaccessible by land.

As part of this review exercise a simple economic model has been constructed to help shape deliberations. This has been a very quick and simple exercise, with multiple variable input parameters, subject to change or challenge. However this has very starkly illustrated some of the likely challenges, which have been discussed in this report, such as the potential for cost recovery, the likelihood of fully catching a TAC and the possible ranges in income. Given the quick and simple nature of this exercise, these figures are not published here, however this has illustrated the critical need for a more refined economic model to inform an understanding of the economic viability implications of management decisions over the cost of licenses, the impact of delayed opening, the implications of a hand or vessel only fishery etc.

5.4 A Viable Fishery?

The indications from this piece of work, both from the consultations and from the review of past stock biology is that there is clearly the potential resource in the Solway Firth to support a cockle fishery which can provide important local employment. In spite of the recent challenges of the past Regulating Order experience and the experience of many years of illegal fishing, the goal of achieving a sustainable cockle fishery in the Solway Firth is still winnable. The Firth looks set to remain productive and this productivity can be protected by good management. Furthermore it appears likely that a viable fishery is also possible without adversely impacting on the important conservation designations of the Solway Firth.

However, if the goal of a sustainable cockle fishery is to be achieved, difficult questions will need to be addressed about the possible management model, with frank considerations of the likely legislative, capacity and funding requirements. It is hoped that the recommendations in this report will help stimulate and guide those considerations.

Appendix 1 – References

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Appendix 2 – Characteristics of Good Management

The following section on the Characteristics of Successful Management was first written by the author of this report in relation to "Project Inshore", a Seafish led project which sought to address management gaps identified in the management of inshore fisheries in England[6]. These characteristics are generic and are therefore equally applicable to discussions about the best management model to employ in the Solway Cockle fishery. The content has been tailored to suit the Solway discussion. Many of these characteristics are directly linked to the Marine Stewardship Council (MSC) performance criteria, which in turn is informed by the FAO Code of Conduct for Responsible Fisheries. For simplicity, these characteristics are therefore set out in the order of the MSC principles, although some of the characteristics are not explicitly stated in the MSC model.

Principle 1

Principle 1 introduces the idea that successful adaptive stock management should seek to understand and manage all fishing mortality upon that stock, or management unit. This includes all catches from all fleets, any mortality of discard species, or any unreported landings. The following characteristics are of key importance:

Clear management units

It is essential for management to clearly identify what it is managing. Where are the boundaries to the stock or management unit that is being managed and what is the rationale or assumptions on which this management unit has been defined? This is an important pre-requisite of management action. By clearly stating the assumptions (such as degrees of larval mixing), these are not only openly acknowledged but they can also be tested over time with thorough review and evaluation.

Collection of appropriate information

Information is essential for management. This information should be tailored to the needs of any stock assessment or management analysis. Where fishers are involved in this collection of information, the reasons for the data collection should be explained and it should be demonstrated how this information is used. Data should be collected at an appropriate spatial scale – to correspond to the management jurisdiction and the conduit for information should be via the managers.

Understanding of stock status

Small fortunes can be spent on getting a more precise understanding of stock status and this is entirely justified in large high value, commercially important fisheries. But for smaller scale, lower value fisheries it is also possible to make precautionary, informed and adaptive management based on simpler and less data hungry and expensive assessment models. Of course any loss of precision needs to be acknowledged and uncertainties identified and where necessary an increased level of precaution needs to be built into the management decision making process.

A pre-defined adaptive management response

In simple terms, a harvest control rule (HCR) simply states what stock level the fishery is targeting, what measures will be used to reach there, and what management actions will be taken and at what points (reference points) to ensure that management response to a declining stock status is appropriate and timely to prevent impairing the ability of the stock to recruit future generations. The MSC standard does provide more description and requirements about the exact characteristics of these rules, but the key principle is that they are both transparent and pre-determined. This means that negotiations over management response do not have to occur at times of reduced catches, as these decisions are effectively taken and evaluated before a need arises.

Engaging stakeholders in the process of determining the harvest control rules greatly enhances the likelihood that these rules will be adhered to and eases the process of their application. In some cases this may also allow economic considerations to be included in the decision making process – provided this is not seen to be anti-competitive and it can be demonstrated that management actions are taken before there is a biologic risk to the stock. Working with stakeholders to agree on decision rules also means those stakeholders, in particular fishers, have a better understanding of the reasons for management action.

6 http://www.seafish.org/industry-support/fishing/project-inshore

Review & Evaluation

Periodically it is important that the performance of the management system is reviewed holistically; is the stock responding to management actions as expected; are the underlying assumptions appropriate; are the tools used to set the exploitation rate appropriate; is the stock assessment model appropriate or should others be tested. This can be done as an internal exercise but having an external review often provides the benefit of fresh perspective and consideration of alternative approaches. This is part of the ongoing process of management refinement and improvement.

Principle 2

Principle 2 considers the impacts of fishing gears on the ecosystem. In an MSC assessment this would be the particular gear that is under assessment (and defined in the UoC) however for a wider fishery management remit, as might be included in a fisheries management plan it may be more appropriate to consider the impact of all gears targeting the resource in the management area.

Key considerations for Principle 2 would be to identify vulnerable species and habitats, assess the status of those on an on-going basis, and implement appropriate management to ensure that impacts are either minimised or mitigated. Much of this has already taken place and continues to take place in the Solway Firth. Recent work to identify sites for protection and undertake impact assessments of activities on those sites and ensure that high impacts are avoided counts toward being able to demonstrate good Principle 2 management. In addition, the following actions should be considered.

Data – discards, ETP interactions and ecosystem impacts

As with Principle 1, data is a critical element of good management. Appropriate data provides managers with a quantitative understanding of the impacts of a fishery on an ecosystem. From an MSC assessment point of view, a lack of data on impact of fisheries or an over reliance of qualitative data will lead to more precautionary (lower) scores. In preparation for a full assessment, provision of appropriate data of gear impact (ideally independently verified, or in some cases based on risk assessment) will assist in the scoring process. Data enables managers to make changes where warranted, but equally it may provide support for managers not taking precautionary management action, where it can be demonstrated that it is not necessary.

Information of ecosystem characteristics / distribution.

Information about the ecosystem in which the fishery takes place is also important and this can provide an understanding of changes over time. In many cases this information will already exist (for example through national habitat mapping projects), in which case it would not be necessary for managers to require any local primary research.

Understanding of spatial distribution of fishing (appropriate to scale of potential impact)

It is important for managers to understand where fishing takes place so that the relationship with the underlying ecology can be considered. However this understanding only need be appropriate to the scale and intensity of the fishery. Before requiring all vessels to have VMS or Succorfish, managers should be clear on what the reasons for that are. In collecting data for Principle 1, capturing a spatial element can be useful for understanding catch per unit effort patterns. This can also help identify changes in fleet patterns over time. Inshore fishers are themselves increasingly keen for their spatial patterns to be understood and recorded, both so they can demonstrate that certain vulnerable habitats may already be avoided or for highlighting commercially important fishing grounds in time of increasing competition for space with other marine industries.

Review mechanism to allow for management action in event of ecosystem impacts or risk caused by fishing (supported by decision rules where appropriate).

As with Principle 1, some form of review is an important pillar of management. This enables managers to review available information and be assured that the management in place is appropriate. If not management can propose an action, either spatial, temporal or technical, as appropriate, and subsequently review the response to that management action.

Codes of Conduct – industry led

In a number of MSC certified fisheries some form of Code of Conduct has proved valuable. In some cases this simply sets out what is existing good practice, but it can be an opportunity to highlight that good practice. In other cases it is an opportunity for the fleet to think about actions in event of certain ecosystem impacts, and the appropriate response or mitigation to any such impact. In many cases these can include incident reporting forms. This information can be used by managers to demonstrate either that existing management is appropriate or that management response can be tightly tailored to address an identified issue of concern. Both data (referred to above) and meaningful codes of conduct can contribute to considerably increased Principle 2 scores in a full MSC assessment, but are also good practice in a well managed fishery regardless of any aspirations for certification.

A Code of Conduct provides a valuable opportunity for the fleet to set out how they ensure that both impacts and perceived impacts are indeed minimised. Where a Code of Conduct calls for action by the fleet, consideration should be given to how it can be verified that the fleet is indeed undertaking that action.

Principle 3

There is considerable cross over between Principle 1 and Principle 3. Principle 3 seeks to capture the apparatus and processes of management. There are some important characteristics of good management that are not contained in the MSC Principle 3, but which should none the less be part of the management consideration. In particular notions of capacity and profitability are not explicitly mentioned. Fisheries with excess capacity or fisheries that are not profitable are less likely to succeed and less likely to engender a sense of stewardship. The notion of profitability is not inviting excess, and is not limitless, but should rather be about ensuring that whilst seeking to maximise the number of fishers sustainably engaged in the fishery, this is not to the detriment of all. Other characteristics of successful management in Principle 3 are:

Appropriate jurisdiction to stock management scale

This mirrors Principle 1. Simply put, it is about ensuring that management decisions are likely to produce the expected stock level response, by selecting an appropriate scale of management prior to commencing management action. This is why some stocks need coastal states engagement, some can be managed within the EU and some can be managed locally as an inshore resource. Seeking to manage cockles through international agreement would be futile and would fail to safeguard local populations, whilst seeking to manage mackerel within a single inshore jurisdiction would fail to address the majority of fishing mortality that occurs on the stock when it is not in the local area and would therefore also be similarly futile.

Limited entry / ring fencing / community ownership / stewardship of resource

The relationship between a common resource and private ownership is sometimes somewhat grey in fisheries management and has and will likely again be tested in the courts. Any new approach to management which seeks to limit access to the resource must be fair, non-discriminatory and equitable. Ideally this should also set out possible routes for new entrants to join the fishery. Should access to fisheries not be intended to be an ownership right, then this should be set out in management. Some form of limited access is likely to greatly increase the sense of stewardship in the resource which in turn may lead to increased support for sometimes unpalatable management actions, if it is known that those fishers taking the pain will also be the beneficiaries of any gain. The increased sense of stewardship can increase the role that informal approaches such as peer pressure can play in enforcement, stimulating good compliance and at best, reducing costs of enforcement. A key test here is what would happen to exploitation patterns (and how much control would managers have over that) if the price were to double. If it is concluded that many other boats not previously in the fishery would come and exploit the resource and the management system allows this, then the management is unlikely to succeed in meeting its objectives.

Stakeholder engagement in management process

For inshore fisheries, perhaps more so than offshore or cross jurisdiction fisheries (i.e. those managed at an EU level) there is an increased potential to engage fishers in the management process. This is not only about seeking to obtain appropriate and accurate data of fisheries performance but also in engaging them in the development of decision rules and critically in providing feedback on management performance. There are many examples where annual fishery meetings play an important role in engaging fishers in the process of management. This can be an opportunity to provide an update on stock status, outline any changes to management rules and the reasons for any such changes and highlight any enforcement priorities. Of course it is also an opportunity for managers to listen to the concerns, ideas and information from the fleet. This addresses many of the MSC criteria relating to consultation, provision of explanations for how information is used, understanding of management processes etc. Above all this has the potential to give a real sense of stewardship in "our" fishery. Of course sometimes such engagement may be initially challenging, but should in time lead to a more inclusive and supported approach to management.

Define fishery specific objectives and decision-making processes

Stakeholder engagement in the management process can also be fruitful when it comes to setting out both the fishery specific management decision making processes and the objectives which will guide those management decision making process. The act of explicitly setting out how management decisions will be taken is critically important to determining the overall success of management. Part of this will be about setting the Principle 1 harvest decision rules into a wider management context; how will the rules be applied, by whom, how often and when? However there may be many other management decisions which Principle 1 alone cannot address; how many permits should be issued; what gears should be permitted; what area or seasonal closures (if any) should apply; what technical conservation measures should be in place; what will the enforcement regime be; what are the sanctions for any infringements; what is the consultation and appeals process? These, and many more besides, are all important management questions so in describing the management framework in a Fisheries Management Plan, the process for reaching these decisions should be set out. Typically decisions are taken in the context of pre-stated objectives and the success of management decisions should be judged against how well those decisions deliver against objectives. So as well as setting out the decision making process, the management plan should clearly highlight what the objectives are and include within these the ecosystem objectives demonstrating how the wide ecosystem impacts of undertaking the fishery are taken into account by management.

Research and information collection tailored to the needs of management

It is important that a relationship exists between science and managers, to ensure that the needs of management can be best addressed by research, and so that the results of research can be best presented to management to enable a management response. In international fisheries this close relationship can sometimes be difficult to achieve however in smaller locally managed fisheries the relationship can and should be both clear and mutually beneficial.

Management & enforcement appropriate to the scale (and risk) of the fishery

Enforcement need only be appropriate to the scale of the fishery, but management will need to determine what that is. The MSC standard introduces the notion of informal approaches to enforcement, where the design of the management system engenders a collective sense of stewardship of the resource and incentivises positive compliance with the management regime. Notions such as restricted access, along with open and transparent decision making processes and explanation of how fisheries information is used (all described above) all help engender that sense of stewardship. Of course such self policing stewardship is an aspiration, which may be difficult to achieve, especially initially. It is therefore important for the fisheries management plan to set out what the formal approaches to enforcement will be and what physical checks will be required to ensure compliance.

Review and Evaluation

Finally, as with both Principle 1 and Principle 2 there is a requirement for periodic review and evaluation of the performance of both the parts of the management system (for example, control & enforcement or data collection) and a holistic evaluation of how the constituent parts of the management system are working together to deliver the management objectives. Which of the objectives are being met, which are not and what are the reasons for the observed patterns in meeting those objectives.

Solway Firth Partnership

Prepared for:

Solway Firth Partnership
Campbell House
The Crichton
Dumfries
DG1 4UQ
01387 702161
info@solwayfirthpartnership.co.uk