



**A Revised LTMP for North Sea *Nephrops***

**NB. This is a draft for further discussion.**

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# 1. The Scope of the Long Term Management Plan

In developing this Long Term Management Plan (LTMP) for the *Nephrops* fisheries of the North Sea the NSRAC has accepted and adhered to the concept of sustainable development. The NSRAC recognises that it is only by taking account of ecological, economic, and social factors within an appropriate institutional structure that development and improvement of the *Nephrops* fisheries can take place without exhausting natural resources.

This LTMP for *Nephrops* has been prepared at a time when reforms to the CFP are being discussed. Those reforms are expected to lead to a greater degree of self-management of fisheries within the North Sea: to adoption of a “stewardship” approach; where authorities delegate management responsibilities to stakeholders within set limits, while retaining the right to intervene if the fishery moves in a damaging direction. There might also be much greater scope for a regional approach. This management plan has anticipated those changes and is intended to work within a new, reformed, regional CFP where participation of fishers and others in management is readily accepted.

Individuals and communities must be involved in any management decisions that will significantly affect them. In developing this plan for *Nephrops* the NSRAC has aimed at a plan that has industry “buy in”. The plan is one which has not simply been passed down from above but has been developed as a result of discussions with fishers and other interested parties, including those responsible for accrediting the *Nephrops* fisheries.

**NB. Those full discussions with industry have yet to take place**

Long Term Management Plans must meet biological and ecological objectives whilst ensuring that fishing businesses are prepared for the economic shocks that are inevitable when exploiting a variable natural resource in an uncertain global economy. There is a real challenge in developing plans for sustainable fisheries that are both biologically orientated and fleet orientated. A series of objectives must be developed which bring together biological and business related factors. The output of the plan must also sit comfortably with the aims of any accreditation schemes being entered into by the fishing industry.

This Long Term Management Plan for North Sea *Nephrops* aims to:

- analyse the current position of *Nephrops* fisheries in the North Sea and state clearly what we are now trying to achieve;
- set out the balance we will strike between economic, social and environmental priorities and outline a series of objectives and future targets;
- describe the instruments we think are needed to reach those targets and deliver sustainability for the *Nephrops* fishery;
- identify the roles and responsibilities of different parties, including stakeholders, in meeting those targets and achieving sustainability;

- outline the institutional changes that will be necessary to ensure that our vision of a sustainable *Nephrops* fishery can be achieved

The Long Term Management Plan is multi-annual, is intended to last for fifteen years and its targets are intended to be reviewed regularly.

## 2. The Long Term Management Plan

### Where we are now

There has been a great increase in the catch of *Nephrops* from the North Sea since the 1950s. The landings have progressively increased in a series of steps. ICES scientists have noted that most stocks appear to be stable in terms of abundance and size composition.

Currently, in the North Sea, *Nephrops* stocks are divided into eight separate Functional Units (FUs). For some of these functional units, like the Fladen ground, *Nephrops* has shown a marked increase in abundance over the years. In others, like the Farne Deep, the population has recently fallen.

The scientific advice from ICES and STECF is that current management of *Nephrops* in the North Sea (both in terms of TACs and effort) does not provide adequate safeguards to ensure that local effort is sufficiently limited to avoid depletion of resources in the functional units. Catches can be taken anywhere in the North Sea and vessels are free to move between grounds, allowing effort to develop on some grounds free of any restriction. This freedom, although it permits flexibility for fishing vessels, may lead to unacceptably high harvest rates from some of the functional units.

A major management consideration for *Nephrops* stocks therefore is whether management should be at the functional unit level rather than a North Sea level. Management at the functional unit level would provide the controls to ensure that catch opportunities and effort are compatible and in line with the scale of the resources in each of the stocks defined by the functional units.

In assessing the North Sea *Nephrops* trawl fishery for accreditation it has already been recommended that there should be a formal stock rebuilding strategy with monitoring to demonstrate recovery. The stock must be above the point where recruitment would be impaired and should be at or fluctuating around a target reference point. In addition ICES should be supported in its recommendation for separate annual assessments and TACs for each functional unit.

Transfer of effort into the North Sea *Nephrops* fishery has occurred recently as an unintended consequence of restrictions imposed on other sectors of the fleet and in other areas, some of them outside the North Sea. This issue must be addressed in the management plan. It is also evident that reduction of discards must form an important component of the plan, and that impacts upon the ecosystem must be addressed.

There is a lack of information available on the level of profitability and return on investment for different vessels within the *Nephrops* fleet. What data there is suggests that fleets appear to be currently over capacity. Excess capacity in a fleet implies unnecessary excess investment in fixed assets which must then achieve higher amounts of profit to generate an acceptable return for that increased investment. As the Net Benefits Report of the UK Cabinet Office pointed out, strict legal enforcement measures will not produce sustainable management where economic incentives are misaligned or where the industry is not profitable or over-capitalised. The economic condition of the fleet must be addressed in any long term management plan.

## Where we want to be - the objectives of the LTMP

### Biological objectives

We consider that the most important objective of the plan for North Sea *Nephrops* is to match overall fishing capacity to the state of fishery resources. Fishing must be at a level which will allow *Nephrops* stocks to renew themselves. Overall the *Nephrops* stocks in the North Sea do not appear to be heavily exploited. STECF has remarked that there does not seem to be an immediate biological risk to any of the stocks assessed by means of underwater television surveys. One conservative objective might be for the *Nephrops* fisheries on those stocks to continue at about the current level, maintaining the existing rate of fishing mortality. However, even under constant fishing mortality, the state of the stock will vary due to fluctuations in recruitment. The overall aim should be to match fishing capacity to a longer-term sustainable yield, accommodating fluctuations in the state of the stocks. STECF (2009) has recommended that management plans be developed with the objective of achieving high long-term yields and low risk to the stocks. It has recommended a precautionary target for fishing mortality of  $F_{0.1}$  should be adopted for North Sea *Nephrops*.

Even with this more sustainable approach, however, there may be a risk to *Nephrops* in some of the functional units. Some of these show evidence of over-exploitation. STECF concluded that given that there does not seem to be an immediate biological risk to any of the stocks assessed by UWTV then this target could be reached through incremental annual reductions in fishing mortality. However, there is a lack of information on some of the functional units (e.g. Botney Gut), where UWTV abundance estimates are lacking.

It is evident that there is a question over the designation and assessment of the functional units. In reviewing the North Sea *Nephrops* trawl fishery for accreditation it has been recommended that there should be a review of the case for assessing the Devil's Hole fishery (and other separate and identified fisheries areas) as a discrete functional unit.

Thus, our management plan for *Nephrops* must consider how fishing mortality on the vulnerable functional units might be limited, while fishing mortality on other functional units is allowed to remain at or below the current level. There are several management options:

- Setting separate TACs for the different functional units. This is a preferred arrangement from a scientific standpoint. However it would give rise to problems of relative stability and in the allocation of TACs, both domestically and internationally. Perhaps quota holders could elect which area their quota could be attached to?
- The inclusion 'of which no more than x tonnes' provisions for functional units which are under threat. However, this adversely affects those dependent on particular functional units, and may place accreditation of the fishery in those areas at risk.

- Basing an overall North Sea TAC on the state of the weakest functional unit. However, this would be unduly precautionary and would also restrict fishing in areas where *Nephrops* were abundant.
- Application of effort restrictions within a functional unit
- A capacity cap in terms of setting out a list of permitted vessels (based on historic activity) allowed to fish within a functional unit
- Gear restrictions – for example restricting gears to single rig within a functional unit

It should be noted that those experts addressing accreditation of the North Sea *Nephrops* fishery have recommended that there should be separate TACs for each functional unit.

STECF has pointed out that there are wider benefits to be gained from the *Nephrops* fishery as a whole moving progressively towards lower fishing mortalities and higher yields. In the North Sea we are currently moving from a state where species which prey upon *Nephrops*, like cod, have been at a very low level, to a state where they may become more abundant. It is necessary to take account of species interactions and other changes to the ecosystem which may have a significant future effect upon *Nephrops* stocks. Ecological systems are dynamic and unpredictable with major effects, for example from climate change, which we cannot influence. Management systems and management plans must be robust in the face of uncertainty.

If the STECF recommendation for moving to lower fishing mortality through incremental annual reductions is to be followed, then measures will need to be introduced which will achieve reductions of fishing mortality in the longer term.

### **Wider ecological objectives**

Ecological sustainability of the North Sea's fisheries is essential not only for long-term species and ecosystem viability but also to underpin economic sustainability. Management practices must be set so as to maintain ecological processes and conserve ecosystem goods and services for the benefit of future generations, while meeting the needs of fishers today. A key goal of the *Nephrops* fishery LTMP is to minimise its impacts on the ecosystem.

We have identified three objectives to achieve this goal:

1. Ensure sustainability of by-catch and by-product species;
2. Minimise interactions with threatened, endangered and protected species (TEPs); and
3. Minimise impacts on benthic habitats and associated communities.

To deliver these objectives it will be necessary to implement a risk assessment to determine the threat posed, particularly with regard to by-catch and by-product species, including those which have TEP status.

Common to each of these objectives is restricting and reducing fishing effort by whatever means are available. The development and implementation of environmentally friendly fishing gear and fishing practices must be encouraged to minimise impacts on the ecosystem.

Options suggested include the following management actions:

- Maintain a limit to the effort applied in the fishery
- Identify and implement Marine Protected Areas, including 'real-time', seasonal and permanent closed areas
- Undertake a risk assessment to determine the vulnerability of by-catch and by-product species to overfishing from *Nephrops* trawling
- Develop mitigation strategies for by-catch and by-product species deemed at high risk of overfishing from *Nephrops* trawling
- Promote the development of environmentally friendly fishing practices
- Monitor discarding and associated impacts, including those on discard-dependent seabird communities
- Undertake a risk assessment to determine the vulnerability of endangered, threatened and protected species to fishing operations
- Improve data recording systems to capture fishing interactions with endangered, threatened and protected species
- Develop management measures to avoid interactions with endangered, threatened and protected species
- Assess impacts on habitat and associated species communities, including benthic communities, ecologically related, associated or dependent species, water column communities
- Assess Impacts on food chains, their structure and productivity/flows
- Assess impacts on the physical environment

To effectively address these impacts the plan should establish a Strategic Research & Monitoring Plan to address the data gaps within the fishery and on its wider environmental impact. This should include fishery dependent and independent data collection, such as that which is currently provided by the various research institutes.

This overall assessment must be delivered in a strategic way and should be re-evaluated periodically to ensure the fishery is delivering on its overall objectives.

### **Economic objectives**

The main economic aim for any fishery must be to achieve economic resilience based on a sustainable level of profit. Profitability is also a necessary precondition for higher compliance with fishery regulations. In economic terms the *Nephrops* plan should aim in the long term (say over the next 15 years) for a modern, safe fishing fleet, able to renew itself, capable of providing a stable supply of fish matched to the needs of the market at reasonable prices. Essentially the plan must provide conditions where all those involved in the industry can achieve the best possible outcome for their businesses – but without specifying in detail how those businesses should operate.

Failure to match fleet capacity to the future state of the resource will both undermine compliance and mean that revenues are flowing into businesses with no chance of long-term profitability. There must also be incentives for individual fishers to move the fishery in the direction of lower fishing mortality while meeting their own aims and objectives. All sectors of the fishing industry have the potential to be profitable, but biological and economic constraints may require some contraction in fleet size.

**We may need to present options here, including removal of latent capacity, restrictive licensing, restrictions of vessel size in inshore areas - twin rigs offshore only etc**

The plan must aim to avoid regulation that makes fleets less efficient or provides perverse incentives which act to the detriment of the fishery and the *Nephrops* stocks. In addition, any change imposed on the fishery must take place at a rate that can be absorbed by individual businesses and communities.

### **The main instruments of the management plan**

The NSRAC proposes that in the absence of full analytical assessments for *Nephrops*, and in the absence of any reference points, there should be a move towards a pragmatic approach in managing the *Nephrops* fisheries, similar to that outlined in the Commission's non-paper on Managing Fish Stocks without Catch Option Tables. Thus, any decrease in the index of stock status derived from UWTV surveys might be accompanied by a decrease in TAC. For precautionary reasons, the decrease might be disproportionate, so that if the index goes down by say 10% the TAC would go down by more than 10%. The reverse would apply as the index of stock abundance increases. An increase of 10% in the stock index might be accompanied by a rather smaller increase in the TAC.

Such an approach does not dispense completely with the need for reference points. For some stocks, there is a rule within the non-paper which says the TAC should increase/decrease on the basis of an abundance index averaged over a number of years (although the year to year changes are capped at 15%). However, there are clauses which override this rule – if the stock is under-fished or over-fished with respect to the long-term sustainable target for fishing mortality ( $F_{MSY}$ ), the TAC should be increased or

decreased to reach that target. ICES scientists have already been asked to decide what the long-term target should be for North Sea *Nephrops*.

The management plan for *Nephrops* must also consider how fishing mortality might be reduced on the vulnerable functional units. The options outlined earlier must be considered.

The wider benefits to be gained from the *Nephrops* fishery as a whole moving progressively towards lower fishing mortalities and higher yields might be achieved by imposing overall reductions in the overall TAC, or by wider application of the measures chosen for the more vulnerable functional units.

Experts advising on the accreditation of the North Sea *Nephrops* trawl fishery have noted that currently the advice for *Nephrops* is based on a fixed harvest ratio rather than traditional biological reference points. They recommend that appropriate and separate target and limit reference points for the stock should be developed and implemented in the longer term, but recognise that this will take some years to achieve. Moreover, although the harvest ratios on which ICES has based its advice are fixed, they are derived from sustainable exploitation rates giving high long term yield. A fishing mortality of  $F_{0.1}$  could potentially be used as an appropriate reference point, although this has not been formally agreed by ICES.

ICES has stressed that it is important that emerging year classes of other species of fish should not be subject to mortality as by-catch in the *Nephrops* fishery. The risk of catching whitefish is currently intended to be reduced by the imposition of catch composition rules and by the application of measures to improve the selection of *Nephrops* and reduce catches of whitefish. Vessels legitimately targeting *Nephrops* may catch quantities of haddock, whiting and cod but they may be forced to discard marketable fish to comply with catch composition rules. The catch composition rules are seen as unnecessarily restrictive and consideration should be given to alternative solutions, perhaps through a discard pilot project.

**We may need to present some options here for reducing by-catches and impacts upon other species**

Reduction in the impact of bottom disturbance from *Nephrops* trawls upon sensitive benthic communities might be achieved by cooperating in the designation of appropriate Marine Protected Areas or areas where there are restrictions in the gears which can be used (for example creel only areas). Alternative towed gears with less bottom contact, larger meshes, and better selectivity profiles may offer a solution in some fisheries. Other measures might include the provision of dropout openings, and “wheeled” foot-gears replacing rock-hoppers.

**Other possible measures?**

## **Future Institutional Structures**

How is the management plan for North Sea *Nephrops* to be applied? The strength of stakeholder involvement should evolve over time in the management of the fishery, the

aim being to develop full 'co-management'. New institutional structures for implementation of this and other LTMPs must now be discussed in the context of reforms to the CFP.

Full text to be added later, when the final position of the NSRAC on CFP reform has been formulated

### 3. Background information

#### The Norway lobster

The Norway lobster, *Nephrops norvegicus* (L.), also called the Dublin Bay prawn, prawn, langoustine or scampi, is a pale orange crustacean which may grow up to 25 cm in length (9-10 in), but is often much smaller. It is found in the north-eastern Atlantic Ocean and North Sea as far north as Iceland and northern Norway, and south to Portugal and Morocco (Figueiredo & Thomas, 1967). It is also found in the Mediterranean Sea, particularly the northern Adriatic. *Nephrops* is common across the North Sea and into the Skagerrak and Kattegat.

*Nephrops* live in shallow, often branching burrows, in soft stable mud at depths ranging from 20m to 800m (Rice & Chapman, 1971; dos Santos & Peliz, 2005). The presence of suitable mud defines the habitat and distribution of the species. Burrows may be up to 10 cm in diameter, over a metre long and penetrate the sediment to a depth of 20-30 cm (Rice & Chapman, 1971; Hillis, 1974). Although *Nephrops* appear to be solitary animals, there may be several animals within the same burrow (Marrs et al. 1996). The burrows may also be shared by a variety of other species, including small fish. *Nephrops* typically remain within their burrows by day and emerge at sunset to forage during the night (Chapman and Rice, 1971; Hillis, 1971). In deeper water this activity changes and individuals may be more active by day (Höglund and Dybern, 1965; Hillis, 1971). At intermediate depths, greatest activity may occur at dawn and dusk (Chapman and Howard, 1979). There is also a seasonal pattern of burrow emergence associated with mating and moulting, and this is most pronounced in mature female *Nephrops*. After spawning, berried females largely remain in their burrows for the entire incubation period, which is generally from late summer until spring (Redant, 1987; Sardà, 1991; Briggs, 1995).

There is marked geographical variation in the density of burrows, and the size and growth rate of *Nephrops* which may depend on physical factors such as the nature of the sediments on the sea bed, temperature and food availability (Tuck et al., 1997; Thompson et al., 1998). There is currently no standard method for determining the age of *Nephrops*.

*Nephrops* are preyed upon by many species of demersal fish (Farmer, 1975), including cod, whiting and skates and rays. *Nephrops* may be more abundant when these fish species are scarce and this has implications for the management of the *Nephrops* and other fisheries.

Currently, in the North Sea (which is ICES Sub-area IV) *Nephrops* stocks are divided into eight separate Functional Units (Figure 1). These functional units were defined by mapping the areas of muddy sediment in which *Nephrops* live. However, additional landings of *Nephrops* are taken from smaller, isolated patches of mud elsewhere in the North Sea in areas such as Devil's Hole. Although small planktonic *Nephrops* larvae are transported by the currents and may be carried from one part of the North Sea to another, it is believed that there is very little exchange of adults between functional units. Adult *Nephrops* are relatively sedentary, seldom moving more than a few hundred metres (Jensen, 1965; Chapman, 1982).

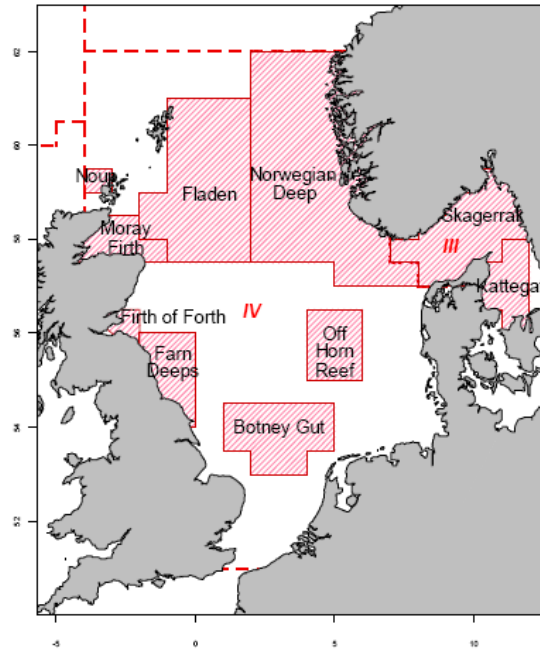


Figure 1: *Nephrops* functional units in the North Sea and Skagerrak/Kattegat region

Within a functional unit, the *Nephrops* distribution may vary in terms of density, size, sex and biological characteristics depending on sediment composition (Tully & Hillis, 1995; Tuck et al., 1997). Some of the functional units are regularly surveyed by means of underwater television (UWTV) mounted on towed sledges. Other units are not regularly surveyed, and information on the distribution and numbers of *Nephrops* in these un-surveyed areas is more limited.

### The *Nephrops* fisheries

The *Nephrops* fisheries began to grow in the North Sea in the early 1950s when demand for shellfish increased. Before that *Nephrops* were hardly exploited – those caught incidentally during the capture of whitefish were often discarded. There has since been a great increase in the global catch of *Nephrops*. North Sea landings have increased in a series of jumps. The UK holds the bulk of the North Sea TAC for *Nephrops* (87% in 2009). Other countries with an interest are Belgium (5%), Denmark (5%) and Holland (3%). *Nephrops* is especially valuable to Scotland, where 80% of the landings take place.

Currently, in the North Sea, *Nephrops* are mainly caught in otter trawls. Originally the trawls were single-rig, but more recently twin-rig trawls and multi-rig trawls have been applied. Scotland has introduced a ban on all Scottish boats using multi-trawl gears; the ban also extends to all British vessels in Scottish waters, limiting the expansion of fishing capacity but also potentially limiting the business efficiency of vessels which are capable of multi-rig trawling.

The *Nephrops* fisheries in the Skagerrak Deep and Kattegat show differences to those in the North Sea. Mesh sizes are larger and are not tailored solely for *Nephrops* as the fishery is a mixed one. Selection grids are used in the Swedish inshore fisheries in the

Kattegat, but as they remove a large part of the fish catch they are not used in the mixed fisheries.

Fisheries in each of the functional units are quite different. On some grounds, like the Fladen, there is predominantly a mixed fishery and whitefish are an important part of the catch. On other grounds there is a small by-catch of white fish which nevertheless can make an important contribution to the earnings of the vessel. On some grounds, like the Firth of Forth, the whitefish by-catch is very small.

In the North Sea the *Nephrops* fisheries are managed through the setting of an overall TAC. Minimum Landing Sizes apply and is 25mm in the North Sea and 40mm in the Skagerrak and Kattegat. Minimum net mesh sizes are also set, but these also vary with area. By-catch limits have been imposed. *Nephrops* fishers have recently adopted a series of technical measures including mesh size, square mesh panels and twine thickness to conserve fish stocks.

In addition to TACs, days-at-sea regulations introduced under the cod recovery plan have also reduced fishing opportunities for *Nephrops* trawlers. Division of the fleet into white fish vessels, with large mesh nets and fewer days at sea, and *Nephrops* vessels, with smaller mesh nets and more days at sea, has resulted in a transfer of effort into the *Nephrops* fleet. Moreover, pressures on stocks elsewhere have resulted in an influx of vessels fishing *Nephrops* into the North Sea.

**Note:** There is a need for an analysis of the numbers and types of vessels and their capacity, from all nations, operating within the different functional units. There is a general lack of effort data, especially for the under-10m fleet.

## **Markets for *Nephrops***

There are two distinct markets for *Nephrops* from the North Sea: further processing of the *Nephrops* “tails” into breaded scampi, sold into caterers and supermarkets in the UK and Ireland; and packing into trays for sale as “whole” *Nephrops*, mainly sold into Italy, France and Spain.

*Nephrops* are not sold at auction anywhere in the UK; boats are contracted to agents or landing directly to processors. Boats typically align themselves to one agent or factory, but will change should the customer not follow price increases in the market place. Price is driven by supply and demand. In terms of supply, the different FUs have different peak landing seasons determined by weather and spawning pattern of the stock. For instance in the Southern North Sea, the Botney Gut fishery takes place from mid May – September. The fishery is in shallow water, as shallow as 11 fathoms, so that bad weather makes fishing there outside that period impossible. The Farne Deep *Nephrops* are most abundant from Mid September to Mid April. Here weather and location of the FU plays a large role, as the prevailing south westerly's are offshore, thus causing less swell than deeper sea FUs (such as the Fladen Ground). The other FUs in the North Sea have similar characteristics, so that it is possible for an oversupply to develop should settled weather coincide with good fishing periods. As there is no auction mechanism processors are obliged to take landings from their vessels. With delays in communicating to boats, which may be fishing for up to 10 days, a glut can develop, leading to large quantities having to be processed all at once, and working capital resources exhausted

in paying for it. This leads to processors capping volumes from the boats, who in turn seek other outlets for their catch, while the fishing is still good. This can lead to a general oversupply on the market, which forces suppliers to drop prices significantly to discourage vessels to land at all. The reverse can happen during periods of poor weather and undersupply, with processors battling to maintain and win new supply, and prices being bid up much higher than the market can sustain in the long term. Most of the contracts for tails are made over 6 – 12 month time periods, so this erratic purchase price causes processors difficulties.

Difficulties in auctioning *Nephrops* are due to quality variation, perishability and the high cost of *Nephrops*. Attempts have been made, most recently in Fraserburgh, to introduce an auction, but due to a lack of interest it failed to be sustained. The issue lies in the method of processing. The whole langoustine, exported mainly to mainland Europe, needs to be carefully graded, usually by eye, or placed piece by piece on to conveying graders. This laborious task makes up a large part of the processing itself, as the *Nephrops* can snag into each other's claws which without careful handling, causes costly damage to takes place. An auction therefore relies both on grading at sea and trust between boat and processor with regards to the grade and the freshness of the *Nephrops* landed. It would be easier to auction *Nephrops* tails. However, as this is only a small part of the catch by value, it cannot be handled separately without extra transport and administrative costs being generated.

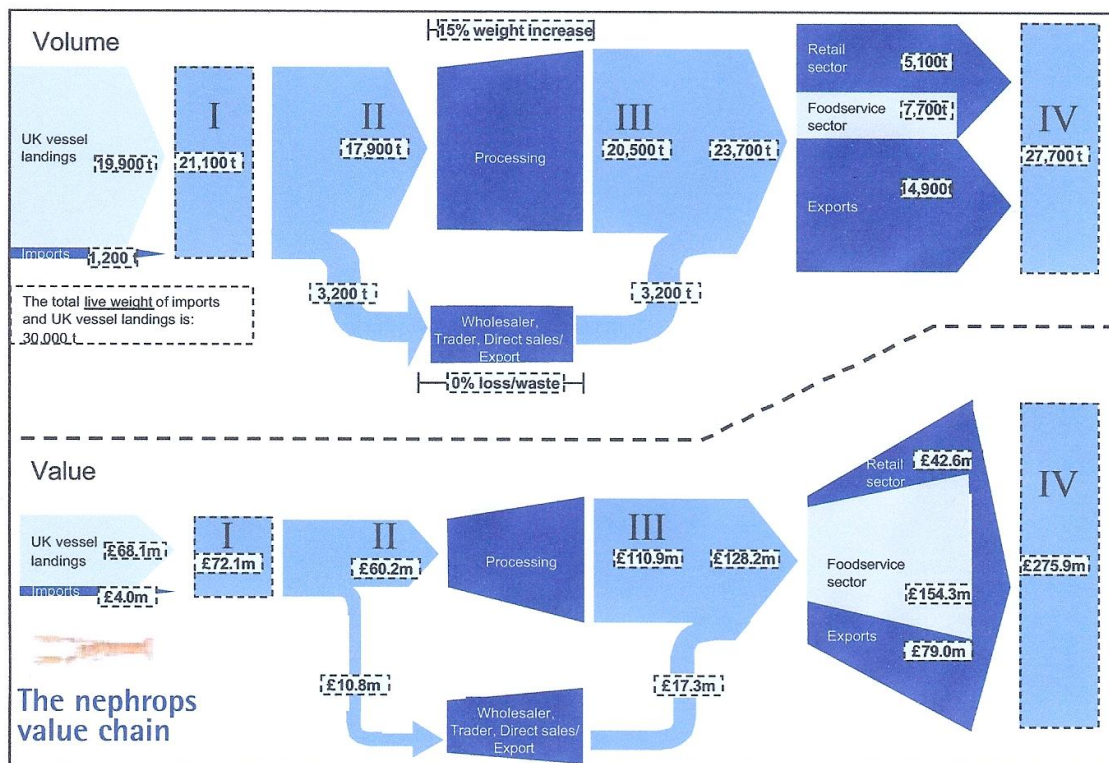


Figure 2: the Nephrops Value Chain, prepared by Seafish.

From the demand side, the UK market for *Nephrops*, according to a recent Nielsen study commissioned by Seafish, is over 5900 tonnes product weight sold in the retail environment and 6118 tonnes sold through caterers (applying rule of thumb ratios of breadcrumb and added water, this equates to roughly 7400 tonnes of *Nephrops* tails or 21000 tonnes of Live weight) of which all but 200 tonnes is breaded and sold either chilled or frozen. The market for whole langoustine sold into mainland Europe is approximately 14000 Tonnes over the last 12 months (according to Seafish landing data). However, the value ex-pier of this is far higher than the tail value, at £57 Million compared to £28 Million. The domestic market is sold largely as frozen breaded *Nephrops* with high levels of competition mainly on price. It traditionally is seen as a cheap food, featuring heavily on pub menus and in freezer cabinets of supermarkets. Meanwhile on the continent, quality is more important with a greater proportion sold fresh with numerous local market nuances needing to be taken into account. For example, the Spanish market dislikes “green sac” in females where the egg sac develops behind the head and discolours the shell. In those markets with relatively high prices the product is seen as a luxury and demand has suffered in the recent onset of recession. In contrast to this, frozen food has enjoyed a renaissance during the recession (due to perceived lower wastage of frozen over chilled, and actual lower prices) and frozen breaded *Nephrops* sales have been buoyant. This has not translated into increasing prices for tails as the reduced demand for whole *Nephrops* means that more *Nephrops* are tailed at sea, producing an oversupply at the time of good demand.

### **Assessment of the *Nephrops* stocks**

Determining the existing status of the North Sea *Nephrops* stocks, and advising on the potential yield from those stocks under different management strategies is the responsibility of ICES. The process of stock assessment is very technical and requires specialist knowledge. The assessments are rarely presented in a form which can readily be understood by non-specialists, including fishermen. As part of this LTMP we believe it is important to express the results of the scientific assessments and the management objectives in clear every-day language.

We have asked JAKFISH, a consortium of scientists whose objectives include providing advice to the NSRAC on the *Nephrops* LTMP, to provide a short commentary on the assessments, and on the alternative management objectives, expressed in simple language. In the meantime, the text below must suffice.

For the North Sea, ICES has defined eight *Nephrops* functional units for the purposes of stock assessment and the provision of advice. These are:

- Off Horns’ Reef (FU 33)
- Botney Gut (FU 5)
- Fladen Ground (FU 7)
- Norwegian Deepes (FU 32)
- Farne Deepes (FU 6)
- Noup (FU 10)
- Moray Firth (FU 9)
- Firth of Forth (FU 8)

Most fish stocks are assessed by monitoring catches and by obtaining for successive years information on the age structure and growth rate of the species. *Nephrops* are crustaceans, which periodically moult. It is not yet possible to determine their age. The very different growth rates of male and female *Nephrops*, and the lack of information on their age, make the use of standard stock assessment and forecasting methods very difficult to apply. Some progress may be possible in the future using length-based assessments.

Historic landings have been uncertain for *Nephrops* stocks, making assessments based on catch data unreliable. Recently, these data have greatly improved (since the introduction of buyers and sellers legislation), but a longer time series of data are required before they can be used fully in the assessments.

Sampling of *Nephrops* landings is carried out at markets & processors to obtain information on the size composition of landings. In addition, discards are monitored at sea. A number of the FUs in the North Sea (FUs 6, 7, 8, 9 and occasionally 10) are also examined directly through underwater television (UWTV) surveys (Bailey *et al.*, 1993; Marrs *et al.*, 1996). A sledge carrying a TV camera is towed across the seabed, and the number of burrows counted along a track. The surveys are carried out at stations in areas of different sediment type, with 10 minute tows at each station. A 1:1 occupancy rate is assumed for the burrows and the total density of *Nephrops* is raised to the total area of that sediment type and summed across sediment types for the FU. Further details of the UWTV survey protocols can be found in the reports from recent ICES workshops (ICES, 2007 & 2009b).

The UWTV surveys provide estimates of abundance which are independent of the fishery itself. STECF (2005) suggested that a combination of an absolute abundance estimate from an UWTV survey and a harvest rate based on an estimate of fishing mortality could be used to calculate appropriate landing limits. This approach has been further elaborated and evaluated by ICES (ICES, 2007 and 2009a).

A recent ICES Benchmark meeting on *Nephrops* (ICES 2009a) addressed concerns which had previously been raised in relation to factors which could potentially bias the UWTV survey results. The main sources of bias were estimated for each functional unit and an overall bias correction factor introduced which could be used to adjust the estimates of abundance and allow them to be treated as absolute abundance levels. In addition, the workshop calculated harvest ratios equivalent to fishing at different fishing mortality rates for each FU and agreed a protocol for providing a catch options table (ICES, 2009a).

Because full analytical assessments, based on traditional ICES methods, cannot be carried out for *Nephrops* precautionary reference points have not been determined for this species. ICES scientists have suggested that an estimated fishing mortality of  $F_{0.1}$  could be used as a fishing mortality reference point (i.e. as a target for a sustainable fishery). However, currently there are no agreed management objectives for North Sea *Nephrops* stocks. STECF (2009) has recommended that management plans be developed with the objective of achieving high long-term yields and low risk to the stocks. Such plans should be applicable to the separate FUs.

In 2009, ICES based their advice on the approach outlined above, offering a choice of harvest ratio depending on the current estimate of fishing mortality and the recent trend

in UWTV abundance. For FUs without an UWTV survey, no new advice was provided in 2009. However, typically in such cases, ICES advises landings should be determined on the basis that there should be no increase above the recent average.

In its review of the ICES advice, STECF (2009) noted that in the long-term the aim for management should be to exploit *Nephrops* at rates that will give rise to maximum sustainable yield. In the absence of an agreed value or proxy for  $F_{MSY}$  STECF recommended that  $F_{0.1}$  (and an equivalent harvest ratio) should be used as a precautionary target fishing mortality. They also concluded that given there does not seem to be an immediate biological risk to any of the stocks assessed by UWTV, then the  $F_{0.1}$  target could be reached through incremental annual reductions in fishing mortality.

ICES (and STECF) have opined that current management of *Nephrops* in the North Sea (both in terms of TACs and effort) does not provide adequate safeguards to ensure that local effort is sufficiently limited to avoid depletion of resources in functional units. In the current situation catches can be taken anywhere in ICES subarea IV and this could imply inappropriate harvest rates from some regions. More importantly, vessels are free to move between grounds, allowing effort to develop on some grounds free of restriction. This appears to have been a particular problem in the Farne Deeps in 2006 where increased activity by vessels from other parts of the UK occurred.

An overriding management consideration for these stocks is therefore that management should be at the functional unit rather than the ICES subarea level. Management at the functional unit level could provide the controls to ensure that catch opportunities and effort are compatible and in line with the scale of the resources in each of the stocks defined by the functional units.

There are a number of gaps in information which we need to fill if the assessments for *Nephrops* are to be improved:

- If full analytical assessments are to be made (and this may or may not be necessary) then further research is required to enable the age of *Nephrops* to be determined
- Further work is needed to ascertain whether the current division into functional units adequately reflects the distribution of *Nephrops*. Are there other areas containing *Nephrops* which should be incorporated into the assessments? Are there small pockets of *Nephrops* at different locations which should be brought into the assessments?
- It has been pointed out by those considering accreditation of the fishery that current management advice is based on a fixed harvest ratio rather than biological reference points. In a situation where stocks are stable or increasing this can be appropriate, however recent information indicates that some stocks may be declining. Therefore there is a risk of the harvest ratio approach failing to protect these stocks. Action is therefore required in consultation with the appropriate scientific and management bodies to develop appropriate biological reference points for the fishery.

In summary, the main weaknesses in the stock assessments for North Sea *Nephrops* are the uncertainty within ICES concerning the most appropriate methods for assessing stock status, the lack of precautionary reference points and the lack of control of TAC uptake at the functional unit level.

## 4. Major trends

*Nephrops* landings have progressively increased over the years. There have been jumps in the upward trend, perhaps associated with transfers of effort from other fisheries but perhaps also because of rectification of misreporting. The introduction of buyers and sellers regulations in Scotland in 2006 considerably tightened up levels of reporting for *Nephrops*, and landings figures since then are considered to be more reliable. Recent increases in reported landings may just be the result of the increase in reporting levels rather than an increase in actual landings. Effort in terms of hours fished is a non-mandatory record on the log sheets and therefore landings per unit effort do not necessarily reflect changes to the stock. ICES scientists have noted that most stocks appear to be fairly stable in terms of abundance and size composition. Notable exceptions are the Fladen Ground stock which showed a marked increase in abundance and the Farne Deeps stock where the population size dropped in 2007 and unusual changes in the seasonal sex-ratio pattern occurred.

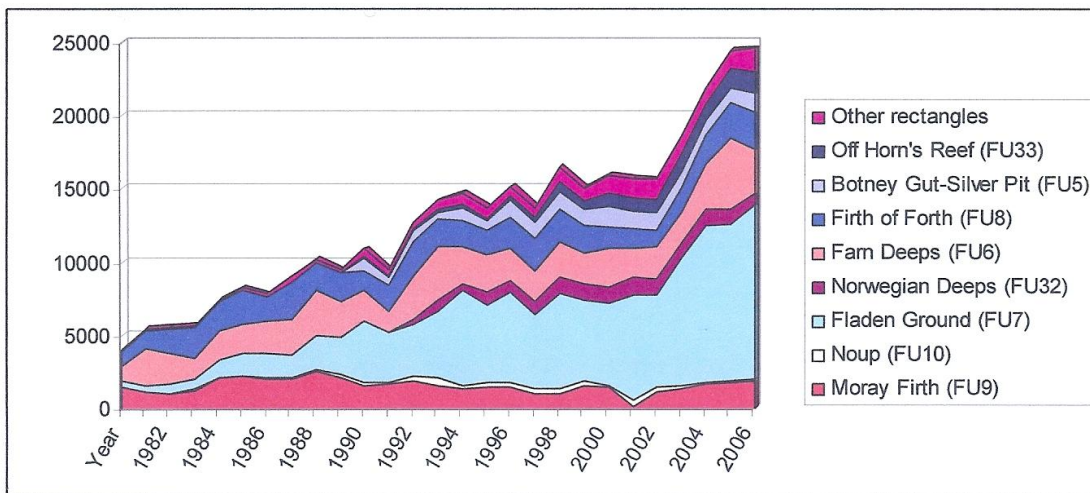


Figure 3: *Nephrops* in ICES Subarea IV. Total landings divided into functional units and other rectangles (tonnes)

In 2009, ICES provided updated assessments and information on stock status for those FUs for which UWTV surveys are available. The advice was presented separately for each functional unit. In addition, there were increasing and significant landings from some isolated patches outside the functional units, most notably the Devil's Hole. In 2008 overall landings in Subarea IV were around 22 100 tonnes, similar to landings in 2005.

Perceived abundance of *Nephrops* from the Fishers Survey conducted by the NSRAC is also increasing but levelling off and even declining at some locations in the most recent years.

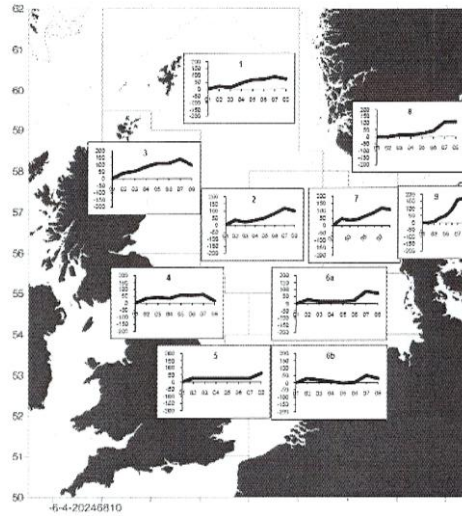


Figure 4: Results of the North Sea Fishers' Survey 2008

Table 1: Nephrops in Subarea IV. Officially reported landings by functional unit

Year	FU 5	FU 6	FU 7	FU 8	FU 9	FU 10	FU 32	FU 33	Other IV	Total
1981		1073	373	1006	1416	36			76	3980
1982		2524	422	1195	1120	19			157	5437
1983		2078	693	1724	940	15			101	5551
1984		1479	646	2134	1170	111			88	5628
1985		2027	1148	1969	2081	22			139	7386
1986		2015	1543	2263	2143	68			204	8236
1987		2191	1696	1674	1991	44			195	7791
1988		2495	1573	2528	1959	76			364	8995
1989		3098	2299	1886	2576	84			233	10176
1990		2498	2537	1930	2038	217			222	9442
1991	862	2063	4220	1404	1519	196			560	10824
1992	612	1473	3338	1757	1591	188			401	9360
1993	721	3030	3521	2369	1808	376	339	160	434	12759
1994	503	3683	4566	1850	1538	495	755	137	703	14230
1995	869	2569	6442	1763	1297	280	489	164	844	14717
1996	679	2482	5220	1688	1451	344	952	77	808	13701
1997	1149	2189	6171	2194	1446	316	760	276	662	15163
1998	1111	2177	5138	2145	1032	254	836	350	694	13736
1999	1244	2391	6505	2205	1008	279	1119	724	988	16463
2000	1121	2178	5580	1785	1541	275	1084	597	900	15060
2001	1443	2574	5545	1528	1403	177	1190	791	1268	15919
2002	1231	1953	7234	1340	1118	401	1170	861	1383	16691
2003	1144	2245	6305	1126	1079	337	1089	929	1390	15644
2004	1070	2152	8733	1658	1335	228	922	1268	1224	18590
2005	1058	3094	10685	1990	1605	165	1089	1050	1120	21855
2006	986	4858	10789	2458	1803	133	1028	1288	1249	24591
2007	1311	2966	11910	2652	1842	155	755	1467	1637	24695
2008*	695	1213	12240	2450	1514	173	675	1444	1673	22077

\* Preliminary

## 5. Mixed Fishery Considerations

Much of the North Sea *Nephrops* trawl catch was originally taken in mixed fisheries, and that is still the case in many areas like the Fladen ground, the Skagerrak and Kattegat and in the Dutch and Belgian fisheries. A range of vessels catch *Nephrops* while at the same time targeting other species like plaice, cod, whiting or haddock. Even where *Nephrops* is the main target a significant income may be obtained from the whitefish species caught. As a result of the cod recovery plan vessels targeting whitefish are required to use 120 mm nets, which lose a large part of the *Nephrops* catch. Such vessels are subject to greater days at sea restrictions.

*Nephrops* vessels are permitted to use smaller meshes. By-catches of cod in the inshore *Nephrops* fisheries of the North Sea are currently fairly small (ICES 2009c). However, the *Nephrops* fishery at the Fladen has a by-catch of cod and ICES has stressed that it is important that emerging year classes should not be subject to mortality as by-catch. Two of the three retained by-catch species, cod and whiting, are currently considered outside biological limits although effective management strategies have been imposed to assist their recovery. These two species, as well as haddock, may be discarded. The risk of catching whitefish is reduced by the imposition of catch composition rules and by the application of measures to improve the selection of *Nephrops* and reduce catches of whitefish. Efforts are being made in Scotland through the Conservation Credits scheme, requiring vessels targeting *Nephrops* to use gear with larger square meshed panels (110 mm). Further selective measures are being considered.

*Nephrops* fishers are especially concerned about measures which regulate the catch composition to a minimum percentage of *Nephrops*. Vessels legitimately targeting *Nephrops* may catch quantities of haddock, whiting and cod but they may be forced to discard these marketable fish to comply with catch composition rules. The technical conservation regulations which specify catch compositions in relation to a number of mesh ranges require discarding to take place if the vessel is to fish legally.

There is a gap in our knowledge of by-catch and discards of whitefish and other species for all sectors of the fleet. Those experts advising on accreditation of the North Sea *Nephrops* trawl fishery have noted that the discarding of cod, haddock and whiting is not routinely recorded. It is not clear which sectors of the fleet may be discarding, and whether there are inshore/offshore differences, or differences between different grounds

Days-at-sea regulations and cod recovery measures have reduced opportunities for directed whitefish fishing. The STECF effort database suggests that effort transfer to the smaller mesh *Nephrops* fisheries of the North Sea took place shortly after the introduction of the regulations. In addition, restrictions on fishing in other areas, including western waters, has also resulted in effort being transferred to the North Sea. Any further reductions in whitefish effort can be expected to result in a transfer of further effort into the *Nephrops* fishery, perhaps with an impact upon the by-catch.

Transfer of effort into the North Sea *Nephrops* fishery has been the unintended consequence of restrictions imposed elsewhere and on other sectors of the fleet. This issue must be addressed in the LTMP. It is also evident that reduction of discards must form an important component of the LTMP.

## 6. Ecosystem Considerations

Any LTMP must consider ecological, as well as social, and economic objectives. In particular, the plan must address the complexity of natural ecological processes and adopt an adaptive management approach in the face of uncertainty. We have already commented on the relationship between *Nephrops* and predatory fish and have pointed out that increasing abundance of cod, in particular, may have an impact upon *Nephrops* populations.

We have mentioned concerns over by-catch and discards of non-target whitefish. There may also be a problem with the capture of undersized species including other crustaceans, fish and small *Nephrops*. The LTMP must address the issue of discarding by vessels fishing for *Nephrops*.

There is a gap in the information available on by-catches in the *Nephrops* fisheries in different areas and by different sectors of the fleet. There is also a lack of ecological indicators for this fishery which could be used to examine trends in impact upon other organisms. These gaps must be addressed.

Impact upon sensitive seabed habitats has been raised as a problem by Environmental NGOs. There is concern over the impact of trawling upon areas of seabed by weighted ground lines and otter doors. Organisms which might be particularly affected by trawling include the sea pens (sea pens are colonial corals supported by internal skeletal structures which live partly imbedded in fine sediments on the sea floor, extending well above the sea surface) and echinoderms (including sea urchins, sea cucumbers, crinoids, starfish and brittle-stars). Towed fishing gears such as otter trawls and beam trawls can alter the physical structure of the seabed. The impact on benthic communities and ecosystems will vary with the sensitivity and natural disturbance of the seabed. The high mud content and soft nature of *Nephrops* grounds means that trawling readily marks the seabed, and trawl marks may remain visible for some time. Twin-rigged and multi-rigged trawls may have a more detrimental effect on *Nephrops* habitat and the sea bed as they employ heavy weights to couple the gears together.

Burrowing fauna can be seen re-emerging from freshly trawled *Nephrops* grounds, implying that there is some resilience to trawling. Nevertheless, technical measures to reduce seabed impacts should be encouraged.

The loss of locked up carbon from disturbed sediments may need investigation.

A number of ecosystem objectives have been discussed. The target of ecological sustainability for all North Sea fisheries acknowledges the need to minimise the impacts of fishing on the ecosystem.

Ecological sustainability of the North Sea's fisheries is essential not only for long-term species and ecosystem viability but also to underpin economic sustainability. Management practices must be set so as to maintain ecological processes and conserve ecosystem goods and services for the benefit of future generations, while meeting the needs of fishers today. A key goal of the *Nephrops* fishery LTMP is to minimise its impacts on the ecosystem. To achieve this objective, an appraisal of the environmental

impact of the fishery will be necessary. Across the area in which the fishery operates the ecosystems should be investigated, and the conservation status of important species and habitats determined. Then the impacts on the ecosystem by the fishery can be assessed. For example, in the trawl fisheries for *Nephrops*, the catch and discard of non-target species (by-catch or by-product) will affect the ecosystem and species populations, particularly by the favouring of scavenger species and removal of top predators. Such factors and impacts have to be accounted for and addressed by the plan if it is to meet its overall goals.

In addition, the plan should ensure that cross-boundary issues are identified, and addressed. Equally, the plan should ensure that the long-term dynamics of ecosystems are incorporated into the development of objectives and targets, particularly with respect to the potential impacts of climate change on the North Sea system.

## **Objectives**

Three key objectives have been proposed to achieve this goal:

- 1) Ensure sustainability of by-catch and by-product species;
- 2) Minimise interactions with threatened, endangered and protected species (TEPs); and
- 3) Minimise impacts on benthic habitats and associated communities.

To deliver these objectives it will be necessary to implement a risk assessment to determine the threat posed, particularly with regard to by-catch and by-product species, including those which have TEP status.

Common to each of these objectives is restricting and reducing fishing effort through licence limitation, gear restrictions and the continued temporal and spatial closures developed through a strategic harvesting strategy. Also, the development and implementation of environmentally friendly fishing gear and fishing practices will be encouraged to minimise impacts on the ecosystem. These strategies are outlined in Table 2.

Table 2: Management goals, objectives and strategies for the management of the North Sea *Nephrops* fishery

Management Goal	Objective	Options for strategic actions to meet objectives
<p>1. Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.</p>	<p>1a. Minimise fishery impacts on by-catch and by-product species</p>	<ul style="list-style-type: none"> <li>• Maintain a limit on the amount of gear used in the fishery.</li> <li>• Identify and implement Marine Protected Areas, including 'real-time', seasonal and permanent closed areas.</li> <li>• Undertake a risk assessment to determine the vulnerability of by-catch and by-product species to overfishing from <i>Nephrops</i> trawling.</li> <li>• Develop mitigation strategies for by-catch and by-product species deemed at high risk of overfishing from <i>Nephrops</i> trawling.</li> <li>• Promote the development of environmentally friendly fishing practices.</li> <li>• Monitor discarding and associated impacts, including those on discard-dependent seabird communities</li> </ul>

Management Goal	Objective	Options for strategic actions to meet objectives
	1b. Avoid the incidental mortality of endangered, threatened and protected species	<ul style="list-style-type: none"> <li>• Undertake a risk assessment to determine the vulnerability of endangered, threatened and protected species to fishing operations.</li> <li>• Improve data recording systems to capture fishing interactions with endangered, threatened and protected species.</li> <li>• Develop management measures to avoid interactions with endangered, threatened and protected species.</li> </ul>

Management Goal	Objective	Options for strategic actions to meet objectives
	1c. Minimise fishery impacts on benthic habitat and associated species communities	<ul style="list-style-type: none"> <li>• Maintain a limit on the amount of gear used in the fishery.</li> <li>• Identification and implementation of Marine Protected Areas, including 'real-time, seasonal and permanent' permanent closed areas.</li> <li>• Promote the development of environmentally</li> </ul>

		<p>friendly fishing gear and fishing practices</p> <ul style="list-style-type: none"> <li>• Assess impacts on habitat and associated species communities, including benthic communities, ecologically related, associated or dependent species, water column communities</li> <li>• Assess Impacts on food chains, their structure and productivity/flows.</li> <li>• Assess impacts on the physical environment</li> </ul>
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To effectively address these impacts it will be essential that the fishery establishes a Strategic Research and Monitoring Plan to address the data gaps within the fishery and on its wider environmental impact. This should include fishery dependent and independent data collection, such as that which is currently provided by the various research institutes. This overall assessment must be delivered in a strategic way and should be re-evaluated periodically to ensure the fishery is delivering on its overall objectives.

The extent to which the Management Plan is achieving the range of stated goals and objectives should be assessed using a combination of indicators designed to measure performance of the fishery. These performance indicators may be biological or non-biological. Each performance indicator is measured against a limit reference point that may be quantitative or non-quantitative. Limit reference levels represent the minimum acceptable level of fishery performance. If performance falls below limit reference levels, measures to improve performance must be developed. The performance indicators, with associated measurement frequencies and limit reference points for the ecosystem impacts of the *Nephrops* fishery, are shown in Table 3.

Table 3:. Performance indicators measured for 5-year assessment of ecosystem impacts for the North Sea *Nephrops* Fishery

<b>Objective</b>	<b>Performance Indicator</b>	<b>Measurement Frequency</b>	<b>Target Position of Performance Indicator</b>
1a & 1b	Undertake a by-catch risk assessment.	Within first year and reviewed every 3 years	Completed or Uncompleted
1a	Develop mitigation strategies for high-risk species.	Prior to the conduct of the next risk assessment	Completed or Uncompleted
1a	Measure the success of each mitigation strategy.	Within 1 year of development of the mitigation strategy	Successfully reduced the risk
1a	Measure the effectiveness of mitigation strategies by assessing differences in consecutive risk assessments.	5 years after the previous risk assessment	Reduced number of species deemed at high risk
1a	Promote the development of environmentally friendly fishing practices, including education and training.	Within first year and reviewed every 3 years	Completed or Uncompleted
1a	Monitor discarding and associated impacts, including those on discard-dependent seabird communities		
1b	Develop measures to record interactions with endangered, threatened and protected species.	Within 5 years	Completed
1b	Develop measures to reduce interactions with endangered, threatened and protected species.	Within 5 years	Successfully reduced the risk
1c	Maintain permanent closed areas	Annual	Completed
1c	Develop strategies to assess impacts on benthic habitats and associated communities	Within 5 years	Completed
1c	Develop strategies for assessment of	Within 5 years	Completed

	Impacts on food chains - structure - productivity/flows		
	Develop strategies for assessment of Impacts on the physical environment - physical habitat - water quality	Within 5 years	Completed

## Strategic Research and Monitoring Plan

The strategic research and monitoring plan below describes the research and monitoring requirements for the *Nephrops* fishery to achieve the Goals and Objectives of this Management Plan. It is not intended to be a definitive list of all research needs for the fishery over the life of this Plan. In this context, the research needs are defined by the Goals for which they are required. The identification of the research needs and priorities for the fishery will be an on-going requirement and should be a priority and central to management plan as a whole. Equally the monitoring of performance against the ecological indicators is related to the performance of the fishery as a whole. The deployment of an effective vessel monitoring system (VMS) and accessibility to its outputs, along with logbook data, to improve the capture of data by the fishery, is likely to assist the delivery of multiple objectives within the plan.

## Independent Monitoring System

Fishery independent surveys are an important feature of the plan, not only to aid the assessment of prawn stocks, and aid the overall fishery management process, but also to play a crucial role in monitoring the fishery's broader ecological performance.

An independent monitoring system, which details by-catch based on research trawl surveys should be developed for the *Nephrops* fishery. The fishery independent trawl-sampling program should be developed to assess the spatial and temporal changes in;

- 1) The species diversity of teleost fish and sharks, skates and rays,
- 2) The numbers, biomass and size of different elasmobranchs,
- 3) The numbers, biomass and size of selected teleost fish,
- 4) The biomass of benthic flora and fauna, including;

Echinodermata, Anthozoa, Hydrozoa, Polychaetes, Crustacea, Mollusca, Bryozoa:

5) Post-trawl survival of selected animals .

The following defines how certain terms will be interpreted in application of the guidelines.

By-catch - species that are discarded from the catch or retained for scientific purposes, and that part of the “catch” that is not landed but is killed as a result of interaction with fishing gear. This includes, but is not restricted to, discards of commercially valuable species.

By-product - species that are retained because they are commercially valuable but are not the main target species.

**Possible by-catch indicators for the North Sea**

- 1) The species diversity of teleost fish and sharks, skates and rays,
- 2) The numbers, biomass and size of different elasmobranchs,
- 3) The numbers, biomass and size of selected teleost fish,
- 4) The biomass of benthic flora and fauna
- 5) Post-trawl survival of selected animals

## 7. Uncertainties

Although ICES consistently advises that the fisheries should be managed by functional units, in recognition of the relatively localised and isolated nature of *Nephrops* stocks, *Nephrops* continue to be managed as if they were a single North Sea stock. Moreover, some of the functional units are of uncertain status. In considering the North Sea *Nephrops* fishery for accreditation it has been recommended that catch from the Farne Deeps functional unit be excluded from the unit of certification.

Differences in the importance of *Nephrops* to different Member States means that there are differences in the level of commitment to scientific research into *Nephrops* and in the collection of data to support scientific assessments. In the main, scientific studies of *Nephrops* are confined to the UK and Denmark. There are few data available for some of the functional units. For example, for some of the FUs with lower levels of landings (e.g. Botney Gut), there is no UWTV abundance estimate and in addition, commercial sampling data (length frequency information) have often only been gathered in recent years. The management plan will need to consider whether additional information is required for management to be effective, and how that additional information might be obtained.

One uncertainty for the *Nephrops* fisheries is the extent to which fishing grounds may be affected by international and national initiatives to introduce marine protected areas (MPAs). The Netherlands portion of Botney Gut is about to be designated a Natura 2000 Special Area of Conservation (SAC) under the Habitats and Species Directive, which may affect the activities of fishers from all Member States. Further threats may develop from proposals to site wind-farms and other energy-based developments.

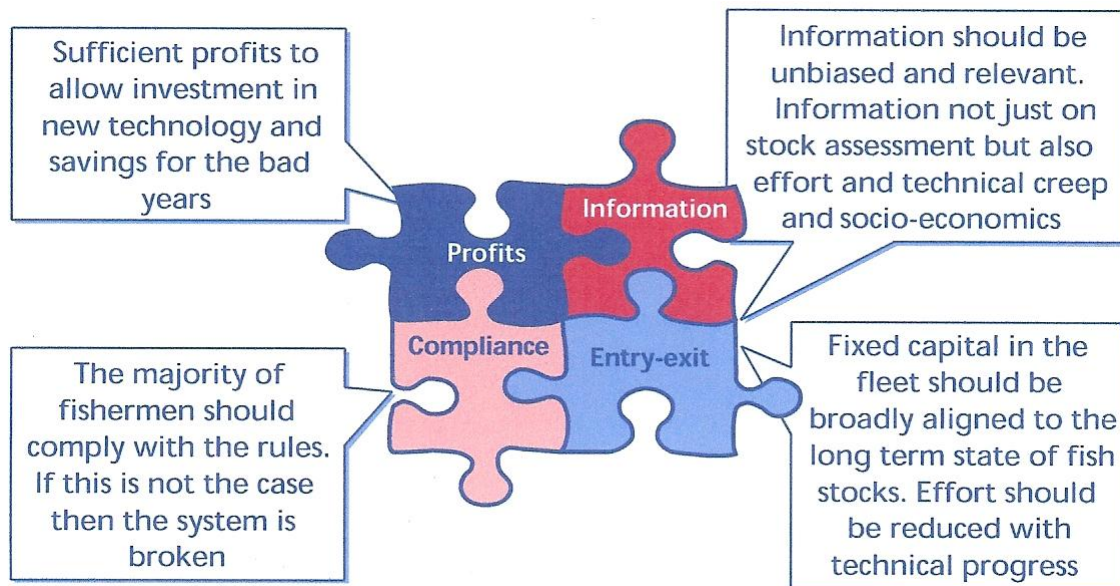
**A case can be made for defensive mapping of fishing effort for *Nephrops* in the North Sea, using VMS and other sources, for protective purposes, to ensure that any displacement of effort as a result of MPA and wind-farm proposals can be evaluated.**

A particular problem for *Nephrops* from a management standpoint is the absence of a full analytical assessment. It is most unlikely that analytical assessments will be available for the different *Nephrops* stocks in the foreseeable future. In these circumstances it may be more appropriate to move towards a more pragmatic management approach.

## 8. Defining Objectives

The Report on Long-term Management of North Sea Fisheries produced for the NSRAC pointed out that it is only by taking account of ecological, economic, and social factors within an appropriate institutional structure that development can continue without exhausting natural resources. It went on to point out that the overall goal of achieving sustainable fisheries could not be achieved by prioritising any one of the components of sustainability to the exclusion of others – for example targeting a high biomass or making profit maximisation the only goal. All aspects of sustainability had to be considered together.

This point has been echoed within the Net Benefits Report from the UK Cabinet Office. There is a management jigsaw, where all the separate issues must mesh together to create the overall picture:



Ecologically, the general reductions in mortality rate on some functional units being called for by scientists might be brought about by agreeing a time scale for reducing fishing mortality significantly and by agreeing a mechanism for applying it to the different functional units.

Economically, fishing businesses must be to achieve economic resilience based on sustainable level of profit. There is also a need to rationalise and harmonise various management measures and regulations that make fleets less efficient.

Socially, it is preferable for change to take place at a rate that can be absorbed by businesses ports and communities, especially if change is imposed through regulation. It is also important for stakeholders to be involved in any decisions that will have significant impact upon them.

## Biological Objectives

The main biological objective is to avoid over-exploiting the resource. *Nephrops* in the North Sea must remain at or close to their full reproductive capacity and must be kept away from a state where they would be unable to replace themselves. There must be a low risk of the stocks showing a reduced production potential. They must be well above the lowest observed level of biomass.

Scientists within the JAKFISH project have been asked to describe the optimum level of exploitation which is desirable from a biological standpoint – expressed in ordinary everyday language.

*Nephrops* stocks in the North Sea for which assessments are available are considered to be stable in terms of abundance and size composition (except for the Farne Deeps). Indeed, *Nephrops* on the Fladen and other grounds have showed a marked increase in abundance in recent years. However, the Farne Deeps stock showed a population size drop in 2007 and unusual changes in the seasonal sex-ratio pattern have also occurred which may have been due to increased effort in the fishery on this functional unit. ICES has therefore made it clear that *Nephrops* should be managed by functional unit, rather than at an over-arching North Sea level.

We have already mentioned the need for management plans to take account of species interactions and other changes to the ecosystem which may have a significant effect upon *Nephrops* stocks. Within the North Sea there is a risk that a recovery of whitefish stocks, and especially cod, may result in increased predation upon *Nephrops*, leading to a decline in the available resource. The management objectives must deal with this uncertainty.

Assessments of the *Nephrops* functional units within the North Sea utilise a number of approaches, including TV surveys, length composition information, and basic fishery data such as landings and effort. Owing to uncertainties in the accuracy of historic landings and to inaccurate effort figures in some fisheries, increasing attention is paid to the TV survey information and size composition data as an indicator of stock abundance and trends.

STECF (2009) has recommended that management plans be developed with the objective of achieving high long-term yields and low risk to the stocks and that the plans should be applicable to the separate functional units. A decision rule is required for setting the TAC. The usual harvest control rule which appears in a management plan sets a particular target fishing mortality  $F$  when biomass is above  $B_{PA}$ , but if biomass falls below  $B_{PA}$  (but is above  $B_{LIM}$ ) the  $F$  is reduced accordingly - following a sliding scale down to some fixed lower level which is applied if  $B$  falls below  $B_{LIM}$ . For other species these rules have depended on traditional methods of assessment and the reference points are derived from assessment results. The lack of an analytic assessment and forecast for *Nephrops* means that any decision rule for this fishery may have to be based on the UWTV survey abundance. The current approach of applying a harvest ratio (to the TV abundance) equivalent to fishing at an  $F_{0.1}$  could be part of the harvest control rule. However, there are currently no agreed or even proposed biomass reference points (based on the TV abundance or otherwise) to which a reduction in  $F$  might be applied. Moreover, it is not even clear whether fishing mortality for *Nephrops* can be determined with any accuracy.

It may be more appropriate in managing *Nephrops* to move towards a more pragmatic management approach, similar to that outlined in the Commission's non-paper on Managing Fish Stocks without Catch Option Tables. Thus, any decrease in the index of stock status derived from UWTV surveys might be accompanied by a decrease in TAC. For precautionary reasons, the decrease might be disproportionate, so that if the index goes down by say 20% the TAC would go down by more than 20%. The reverse would apply as the index of stock abundance increases. An increase of 20% in the stock index might be accompanied by a rather smaller increase in the TAC. This aim of this type of approach would be to move *Nephrops* stocks in the direction of lower fishing mortality and higher yields.

Such an approach does not dispense completely with the need for reference points. For some stocks, the Commission's non-paper sets a rule which says the TAC should increase/decrease on the basis of an abundance index averaged over a number of years (although the year to year changes are capped at 15%). However, there are clauses which override this rule – if the stock is under-fished or over-fished with respect to the long-term sustainable target for fishing mortality ( $F_{MSY}$ ), the TAC should be increased or decreased to reach that target. ICES scientists have been asked to decide what the long-term target should be.

The approach outlined above would certainly be valid if the TAC we were starting from was equivalent to a sustainable  $F$ . However, although that might be the case for some of the functional units in the North Sea; it may not be so for all of them. We have already mentioned that there are differences between the functional units. If a TACs was set at the North Sea level this approach would not safeguard all the functional units. There is therefore an issue over whether the TAC should be set for the North Sea, or for the various functional units. It may be necessary to restrict the quantities taken from a particular functional unit. There are several ways of achieving this aim:

- Through setting individual TACs for the different functional units. Although this would lead to problems in allocating quotas to member states and within member states
- Through a '*no more than*' clause. Thus, the TAC set for the North Sea would be accompanied by a statement '*of which no more than x tonnes shall be taken from*'. The '*no more than*' figure might be set to enable local fishers to remain operating as otherwise this measure would penalise those unable to transfer to other functional units.
- By applying effort restrictions within a functional unit
- By setting a capacity cap in terms of setting out a list of permitted vessels (based on historic activity) allowed to fish within a functional unit
- Through gear restrictions – for example restricting gears to single rig in particular functional units

A further factor to be borne in mind is that the natural mortality upon *Nephrops* may currently be especially low because of the decline in cod stocks. Cod recovery may elevate natural mortality, requiring large reductions in fishing mortality in the future.

It is expected that the quality of fishery data available for the *Nephrops* stocks will continue to improve. The UK registration of buyers and sellers legislation (since 2006) has led to more accurate landings information from these stocks and within a few years this should improve the basis for assessment and forecasts of catch. Stock monitoring continues, and enhanced work on observer trips on-board commercial vessels should furnish additional data on by-catches and discards. However, if future management is to be based largely on the results from UWTV surveys then it is important to extend these surveys to cover all the functional units. This will require action by all Member States significantly engaged in the *Nephrops* fishery.

How do we deal with catches from outside the main functional units or include new functional units? ICES scientists collate catches from outside the main FUs and include them in their N Sea advice document. Although they do not officially provide advice for the non-FU areas, they do usually provide 'guidance' on future landings from these areas – typically average landings over the most recent 3 years. The Devil's Hole is the most important non-FU area – some commercial sampling and occasional TV surveys are carried out by Marine Scotland Science.

## **Economic Objectives**

Figures published by Seafish for Scottish vessels only, show that for >10m *Nephrops* vessels in 2007, those using single rig trawl (106 vessels, average length 14.4m) achieved average fishing income of £183,000, while those using twin rig trawl (100 vessels, average length 19.9m) achieved average fishing income of £532,000. At first sight the income per crew member is not large.

Further examination of the economic information, in particular estimations of capital invested is necessary to determine the level of profitability and return on investment within *Nephrops* fleets throughout the North Sea. Until that is done it is difficult to set clear economic objectives or to develop options for the future. An understanding of the journey to be made between current performance and desired performance may be important for the management plan to achieve the desired objectives.

The overall economic objective might be to achieve a modern, stable and profitable fishing industry; with a fishing fleet able to renew itself; able to provide a supply of fish matched to the requirements of the market at appropriate prices for the processing industry and consumers; operating in a way which would enable the costs of all the participants to be met.

It is important to recognise that the markets for *Nephrops* are now quite volatile and current 2009 prices are low. At the same time retailers are increasingly insisting on products which can be guaranteed to originate from a sustainable fishery. The costs of achieving certification of a particular fishery are substantial, and may not provide an adequate return on investment.

One starting point is to consider what the market wants. The preferences of buyers may differ from country to country, however, and in the case of *Nephrops* many of the ultimate consumers are in southern Europe and elsewhere.

Economic issues which might be addressed through the setting of objectives within the LTMP include:

Whether the fleet is the right size and type and has the right balance in terms of overall profitability and in terms of the fishing opportunities available

Whether there is scope for further growth in the market, and the implications of that growth for management of the fisheries

What degree of overall economic stability should be sought? If the fleet is currently acceptably profitable, and stocks stable, should we aim to maintain that position?

Dealing with the problems of technology creep and the introduction of more efficient fishing methods (like multi-rig trawls) at a time when greater stability in fishing capacity is being sought.

Issues over the maintenance of open access to inshore fishing grounds (see section on Social Objectives below)

Issues over the extent to which effort should remain mobile over the different functional units within the North Sea

**NB These possible goals need to be examined in more detail and choices made.**

**One of the major problems in setting out the economic goals and objectives is a lack of data on the economics of the *Nephrops* fishery. The collection of appropriate data from all Member States engaged in the fishery should be a priority.**

Perhaps the major economic risk for the *Nephrops* fisheries is likely to come from excess fishing capacity. Fishing capacity is the maximum quantity of *Nephrops* over a period of time that can be caught by the fishing fleet if it is fully utilized. Table 4 below shows that, in the North Sea *Nephrops* single rig trawl >10m fleet segment, if all participating vessels had delivered 80% of the maximum days at sea achieved, then only 41 vessels, rather than 50, could have landed the same volume of *Nephrops*. This indicates that the vessels in the fishery are not being used to generate income as much as they could be and that the total volume of fish landed could have been landed by fewer vessels and therefore with less capital invested, and therefore generating a higher return on capital employed.

This table suggests that Scottish North Sea *Nephrops* fleets are already over capacity judged by a technical measure, and recent reports on fleet financial performance support that assessment, showing low levels of profit.

Table 4: Economic data from Scottish vessels

	No. of vessels	Sum of days at sea	Sum of landings (Tonnes)	No. of vessels required if all did max days at sea	No. of vessels required if all did 80% of max days at sea
NS Nephrops single rig trawl > 10m	50	7,163	3,987	33	41
NS Nephrops twin rig trawl > 10m	100	18,934	21,803	64	80
WoS Nephrops single rig trawl > 10m	112	18,396	7,305	66	83
WoS nephrops twin rig trawl > 10m	32	5,938	3,999	20	25
Pots and traps under 10m	169	22,645	4,853	69	87

• Capacity utilisation, 2007  
 Source: Profitable Futures for Fishing: First Interim Report, Seafish, 2009

	Segment Total	Average Per Vessel
Number of Active Vessels	106	
Length (m)		14.4
Power (kW)	9,327	187
VCU	7,902	158
Registered Tonnage (GT)	2,225	44
Days at Sea	7,163	143
Volume of Landings (Tonnes)	3,987	80
Value of Landings (£)	£9,124,397	£182,488
Vessel Age (years)		28

• 2007 - NS Nephrops single rig trawl over 10m (Scottish vessels)  
 Source: Profitable Futures for Fishing: First Interim Report, Seafish, 2009

	Segment Total	Average Per Vessel
Number of Active Vessels	100	
Length (m)		19.9
Power (kW)	39,224	392
VCU	30,975	310
Registered Tonnage (GT)	14,002	140
Days at Sea	18,934	189
Volume of Landings (Tonnes)	21,803	218
Value of Landings (£)	£53,145,899	£531,459
Vessel Age (years)		18

- 2007 – NS Nephrops twin rig trawl over 10m (Scottish vessels)

Source: Profitable Futures for Fishing: First Interim Report, Seafish, 2009

Excess capacity in a fleet implies unnecessary excess investment in fixed assets which must then achieve higher amounts of profit to generate an acceptable return for that increased investment. Because fishing is a fairly risky business venture, the required return on investments should be quite high compared to alternative business investments. Capacity in the *Nephrops* fishery may already be too high (judging from the relative low profitability of individual vessels) and total capacity is likely to increase within the North Sea *Nephrops* fisheries as more vessels enter the fishery, attracted by the high value of the product, the stable state of the stocks, the pressure on other stocks, the lack of barriers to transfer into the fishery and into the area from another under the open access provisions of the CFP, and also as existing vessels become more capable due to the inevitable technology creep resulting from the ingenuity of fishers in developing increasingly efficient gears. Technology creep alone is estimated by the Commission to result in a 2-4% increase in fishing capacity every year. Such an expansion in capacity may threaten the economic stability of some, if not all, sectors of the fleet as well as threatening the stability of *Nephrops* stocks. Increase in capacity leads to poor economic performance and low resilience to external pressures, including pressures on the stocks. Fishing capacity must be limited in order to protect returns on investment.

Excess capacity will also have an impact upon *Nephrops* stocks. The impact on stocks of expanding capacity can only be limited by limiting total fishing effort (number of vessels or days at sea) or by limiting fishing efficiency (for example by controlling improvements to the efficiency of fishing gears).

In developing economic objectives it will be necessary to explain to the different industry sectors how they might benefit from developing a management strategy for *Nephrops*. It is important to recognise, however, that it is not the role of any LTMP to instruct fishing enterprises on how they should operate or take their own economic decisions, or to micro-manage the industry. This plan is a management plan not a business plan.

## Social Objectives

It has become increasingly apparent that it is not only ports and coastal communities which benefit from fisheries. People in centres elsewhere and even away from the coast also derive income from it and are affected by any changes in the fishery. The important social objective is to ensure that changes do not harm the resilience of the fleet and all those people engaged in the industry. It is important to retain fairness and equity in managing changes to the fishery and to ensure that any human impacts fall within reasonable bounds and do not take place at a speed which is difficult for dependents to deal with.

One of the principal social issues relates to fleet mobility. *Nephrops* catches can be taken anywhere in the North Sea and this can result in very heavy harvest rates from some functional units. As vessels are free to move between grounds, effort may develop on some grounds without restriction. This movement of effort has been a particular problem in the Farne Deeps but it may occur on other grounds.

There are particular problems where such heavily exploited grounds are situated close inshore. In many cases the larger vessels are able to spread their fishing over several functional units. However, small local vessels may only be able to fish local grounds, and they may be disadvantaged by a large influx of more nomadic vessels. They will also be disadvantaged by measures which are adopted to protect the affected functional units. Mobility of effort may be a disincentive to local fishermen to take conservation measures on grounds in their proximity as any benefits may be wasted if larger additional vessels can join the fishery. One option which may need to be considered is strengthening the fishing rights of local vessels, or vessels which commit themselves to particular conservation measures. This might be done through effort or capacity capping for a particular functional unit.

**NB. The NSRAC needs to develop a view on this, including a series of options for dealing with the problems which have arisen and are likely to occur again. This kind of problem (of protecting local stocks) also occurs with other species, and the CFP currently has not developed effective mechanisms for protecting local stocks in a non-discriminatory way. Options for dealing with this problem need to be developed.**

**One gap in information on the *Nephrops* fishery is the lack of information on downstream multipliers, and the benefits obtained by processors and those components of the industry closest to the market.**

**Scottish Inshore Fisheries Groups are in the process of developing management plans for fisheries within 6 miles**

## 9. Instruments

NB. The measures to be taken to achieve management objectives need to be set out as a series of options for agreement by fishers themselves at the ports. The sections above need to be developed further and the agreed objectives need to be stated in a very clear way at the very beginning of the plan.

Currently a TAC is applied to *Nephrops* across the North Sea. This approach has not been effective in controlling the impact of the fishery upon all the *Nephrops* stocks and there is an issue over whether the TAC should be set for the North Sea, or for the various functional units. Some functional units may require additional measures to protect them if stocks fall outside given parameters. We have previously considered a number of options for achieving this, for further discussion. Some of those measures might require clearer definition of the vessels attached to particular functional units, perhaps in terms of their commitment to a particular conservation code or agreement to restrictions on fishing method.

In terms of impacts upon other stocks, the *Nephrops* fishery, especially in Scotland, has already gone some way in reducing impacts upon whitefish stocks. Scientists have stressed the importance of not subjecting emerging year classes to capture. This problem is already being addressed through the use of more selective gears and initiatives are in place to reduce the discard problem with respect to small fish. Efforts are being made in Scotland through the Conservation Credits scheme, requiring vessels targeting *Nephrops* to use gear with larger square mesh panels (110 mm). There is the possibility of linking mesh size changes to new Minimum Landing Sizes. There may still be some scope for improving gear selectivity. The introduction of Real Time Area Closures (RTCs) may be effective in some areas in reducing impact upon young fish. The imposition of permanent or seasonal restrictions on fishing in cod nursery areas offers an additional tool.

The NSRAC recognises the wish of the Commission to eliminate discarding by 2012. By-catch and discards are amongst the most serious challenges in seeking sustainable fisheries and reducing them is part of 'the ecosystem approach' to fisheries management. It is also part of the process for achieving certification of a fishery, as discard reduction is often a requirement for receiving certification. However, the Commission has not yet defined what it means by "discards" and whether the term refers to all finfish and crustaceans in the by-catch or to commercial/quota species only. The *Nephrops* fleets will continue to trial measures to improve selectivity and is now confident that further improvements can be achieved. Any initiatives taken will need to be monitored and their efficacy assessed.

NB It is possible the *Nephrops* could provide a pilot project for dealing with discards. The Commission previously mentioned the possibility of a series of discard pilot projects, but has recently given less emphasis on this as a result of the Commissioner's own wish to introduce a discard ban for all fisheries.

There is legitimate concern by fishers over catch composition rules in the *Nephrops* fishery which force the discarding of species like cod. It is recognised that there is a need to discourage excessive targeting of white fish by vessels using smaller mesh gears without quota to land the fish. However the catch composition rules can result in

discarding even where quota is available and whitefish are not being targeted. Some thought needs to be given to resolving this problem. Perhaps now that cod is recovering in the North Sea there is scope for easing the catch composition rules, as part of an adaptive approach.

It is acknowledged that bottom disturbance from *Nephrops* trawls may have an impact upon benthic communities and ecosystems. Emerging proposals to establish marine protected areas in the North Sea may facilitate study of these impacts and provide some basis for the protection of especially vulnerable organisms. Alternative towed gears with less bottom contact, larger meshes, and better selectivity profiles may offer a solution in some fisheries. Other measures might include the provision of dropout openings, and “wheeled” foot-gears replacing rock-hoppers.

Measures will need to be put forward as part of a strategy for dealing with expected increases in fishing capacity within the *Nephrops* fishery. The main options are:

Setting a limit to fishing effort (number of vessels, days at sea, fuel restrictions, kW restrictions)

Limitations in fishing efficiency (for example by restricting the use of twin-rig and multiple-rig gears)

Acceptance that there will be a decline in economic performance of vessels if no action is taken.

Measures to meet social objectives have still to be discussed. There is an issue over the extent to which local fishers should receive preferential treatment within a particular functional unit.

Taken together, these measures should ensure that the *Nephrops* fisheries are stable, sustainable, well managed and profitable.

It may be useful at this stage to prepare a table of objectives, against which different instruments could be developed, as in the following over-simplified examples:

<b>Objectives</b> <i>Where do we want to go?</i>	<b>Instruments</b> <i>How do we get there?</i>
Keep <i>Nephrops</i> close to current population levels	Raise and lower TACs by means of a simple rule, matched to an UWTV index
Protect especially vulnerable functional units	Apply a ‘no more than’ rule to the vulnerable units
Reduce discarding of emerging whitefish year-classes	Adopt additional robust and proven technical measures
Ease catch composition rules catch composition rules in the <i>Nephrops</i> fishery which force the discarding of species like cod.	Adopt additional robust and proven technical measures
Take account of cod recovery, which may result in a significant increase in natural mortality for <i>Nephrops</i> stocks	Prepare for the possible introduction of a large reduction in the <i>Nephrops</i> TAC(s)
Reduce impact of bottom disturbance from <i>Nephrops</i> trawls upon sensitive benthic communities	Define a series of appropriate marine protected areas

Develop a strategy for dealing with expected increases in fishing capacity within the <i>Nephrops</i> fishery	Set limits to fishing effort within each of the functional units
Moderate transfer of effort into the North Sea <i>Nephrops</i> fishery from other regions	Set a limit to fishing effort upon <i>Nephrops</i> within the North Sea

NB. The above section needs extensive further discussion. We have only made a start in considering the measures to be adopted as part of the management plan.

## 10. Timeframe

The NSRAC sees the LTMP for *Nephrops* fisheries as a gradual sequential response to risk operating over a period of about 15 years. The plan needs to be responsive and adaptive, changing as circumstances change.

## 11. Conclusions

*To be considered*

## 12. Review of Progress & Adaptive Management

*To be considered*

### 13. References

- Bailey, N., Chapman, C. J., Kinnear, J., Bova, D. and Weetman, A. (1993). Estimation of Nephrops stock biomass on the Fladen Ground by TV survey. ICES CM 1993/K:34 (mimeo).
- Briggs, R. P. (1995) Variability in northwest Irish Sea Nephrops populations. Fisheries Research, 23, 175-187.
- Campbell, N., Dobby, H. and Bailey, N. (2009) Investigating and mitigating uncertainties in the assessment of Scottish Nephrops norvegicus populations using simulated underwater television data. ICES J. Marine Science, 66:646-655.
- Chapman, C. J. (1982) Nephrops tagging experiments in Scottish waters 1977-1979. ICES CM 1982/K:22 (mimeo)
- Chapman, C. J. & Howard, F. G. (1979) Field observations on the emergence rhythm of the Norway lobster Nephrops norvegicus, using different methods. Marine Biology, 51, 157-165.
- Chapman, C. J. and Rice, A. L. (1971). Some direct observations on the ecology and behaviour of the Norway lobster, Nephrops norvegicus (L.) using different methods. Marine Biology, 10, 321-329.
- Farmer, A. S. D. (1975) Synopsis of data on the Norway lobster Nephrops norvegicus (Linnaeus, 1758). FAO Fisheries Synopsis No. 112, pp1-97.
- Figueiredo, M. J. & Thomas, H. J. (1967) On the biology of the Norway lobster, *Nephrops norvegicus* (L.). Journal du Conseil. 31: 89 – 101.
- Hillis, J. P. (1971). Effects of light on Nephrops catches. ICES CM 1971/K:03 (mimeo).
- Hillis, J. P. (1974) A diving study on Dublin Bay prawns Nephrops norvegicus (L.) and their burrows off the East coast of Ireland. Irish Fisheries Investigations, Series B (Marine), 12, 1-9.
- Höglund, H. and Dybern, B. I. (1965) Diurnal and seasonal variations in the catch composition of Nephrops norvegicus (L.) at the Swedish west coast. ICES Shellfish Committee Document. 146 (mimeo).
- ICES (2007). Workshop on the use of UWTV surveys for determining abundance in *Nephrops* stocks throughout European waters. ICES Document CM 2007/ACFM:14. 310pp.
- ICES (2009a) Report of the Benchmark Workshop on *Nephrops* (WKNEPH), 2–6 March 2009, Aberdeen, UK. ICES CM 2009/ACOM:33. 156 pp.
- ICES. (2009b). Report of the Study Group on Nephrops Surveys (SGNEPS), 28 February– 1 March 2009, Aberdeen, UK. ICES CM 2009/LRC:15. 52 pp.
- ICES. 2009c. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 6 - 12 May 2009, ICES Headquarters, Copenhagen. ICES Document CM 2009/ACOM:10.

- Jensen, A. J. C. (1965) Continued investigations on Nephrops in the Skagerrak, Kattegat and the North Sea. ICES Shellfish Committee Document 119 (mimeo).
- Marrs, S. J., Atkinson, R. J. A., Smith, C. J. and Hills, J. M. (1996) Calibration of the towed underwater TV technique for use in stock assessment of *Nephrops norvegicus*. EC DGXIV Final Report, Study Project 94/069. 155pp.
- Redant, F. (1987) Reproduction and seasonal behaviour of the Norway lobster, *Nephrops norvegicus*, in the Central North Sea. ICES CM 1987/K:32 (mimeo).
- Rice, A. L. & Chapman, C. J. (1971) Observations on the burrow and burrowing behaviour of two mud-dwelling decapod crustaceans, *Nephrops norvegicus* and *Goneplax rhomboides*. *Marine Biology*, 10, 330-342.
- dos Santos, A. & Peliz, A. (2005) The occurrence of Norway lobster (*Nephrops norvegicus*) off the Portuguese coast. *Journal of the Marine Biological Association of the United Kingdom*. 85: 937 – 941.
- Sardà, F. (1991) Reproduction and moult synchronism in *Nephrops norvegicus* (L.) (Decapoda, Nephropidae) in the Western Mediterranean: Is spawning annual or biennial? *Crustaceana*, 60, 186-199.
- Thompson, I. S., Whitmore, J. E., Hillis, J. P. and Carroll, J. (1998). Temporal and spatial variations in the age structure and growth rates of *Nephrops norvegicus* in the Western Irish Sea. ICES CM 1998/CC:12 (mimeo).
- Tuck, I. D., Chapman, C. J. and Atkinson, R. J. A. (1997) Population biology of the Norway lobster, *Nephrops norvegicus* (L.) in the Firth of Clyde, Scotland. I. Growth and density. *ICES Journal of Marine Science*, 54, 125-135.
- Tully, O. & Hillis, J. P. (1995) Causes and spatial scales of variability in population structure of *Nephrops norvegicus* (L.) in the Irish Sea. *Fisheries Research*, 21, 329-347.