



‘GHOST FISHING BY LOST FISHING GEAR’

Workshop Briefing Paper

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Executive Summary

This is a briefing paper for a workshop being held in Brussels on 10-11 May 2005 as part of a project for the DG Fisheries and Maritime Affairs of the European Commission on ghost fishing. It is a working document of the final report and thus some sections of it are not complete at this stage, but will be finalised following the workshop. The paper contains the results of work that has been completed to-date, namely a literature review and a survey on net loss and ghost fishing issues in three European fisheries. A cost benefit analysis of gear retrieval programmes and other management options in four fisheries, including the three surveyed, will be included together with the conference proceedings in the final project report.

The final report will include two executive summaries, one technical and one non-technical.

1 Introduction

1.1 What is ghost fishing

The issue of '*ghost fishing*' first gained global recognition at the 16th Session of the FAO Committee on Fisheries in April 1985, and can be defined as the mortality of fish and other species that takes place after all control of fishing gear is lost by a fisherman. Ghost fishing occurs when passive gears such as gill nets, trammel nets, wreck nets, and traps, are lost or discarded and continue to catch commercially important species of fishes and crustaceans as well as non-commercial species of fishes and crustaceans, birds, marine mammals and turtles. Such ghost gears may also damage benthic habitats (abrasion, 'plucking' of organisms, meshes closing around them, and the translocation of sea-bed features), pose problems as a source of litter being washed ashore where it is unsightly, and can potentially entangle with active fishing gear and vessel propulsion systems, raising potential safety issues. Concern over ghost fishing has been heightened now that modern gears are mostly made of non-biodegradable synthetic fibres and persist in the environment. They can therefore theoretically continue to catch fish for long periods of time.

Nets tend to go through 'ghost-fishing' cycles in which they begin by actively fishing. Over time, increasing catch weight causes their collapse and attracts scavenging organisms. Once the nets have been cleaned they may straighten out and resume 'ghost-fishing'. The ultimate length of this cycle depends on environmental conditions. The effect of wind and currents may reduce nets into a self-entangled mass effectively reducing the catching area or break them up altogether. Marine fouling also increases the visibility of nets reducing their catch efficiency over time, so that the rate of ghost fishing gradually declines.

Pots too tend to pass through a cycle of ghost fishing. They tend to be baited when they are set. If the pot is lost, in time the bait or lost catch attracts scavengers, some of which are commercially important species. These scavengers may become entrapped and subsequently die, forming new bait for other scavengers.

1.2 Policy context

The FAO Code of Conduct recognises the impact of lost gears, stating that States should take appropriate measures to minimize catch by lost or abandoned gear (Articles 7.2 and 7.6.9). Under the 'basic' CFP Regulation (2371/2002), measures should be taken for resource conservation and management purposes, and the limitation of the environmental impact of fishing (Article 1). As a source of fishing mortality and impacts on the wider marine environment, there is therefore a clear legal basis for measures to address ghost fishing.

The Commission Communication on Promoting more Environmentally-friendly Fishing Methods (COM (2004) 438), tabled in June 2004, identifies the need to address ghost fishing as part of the drive to tackle unwanted catches more broadly. It was noted that there is a need to take measures to identify ghost fishing gear, encourage the reporting of lost gear and to recover it from the seabed. To this end, the Commission committed itself to developing a set of pilot projects in 2004 covering a wide range of species, fisheries and areas within the Community, in cooperation with Member States, the fishing industry and NGOs. It was further stated that a pilot project would be developed during 2005 to address the problem of ghost fishing in Community waters, including a retrieval system to remove lost gears and methods to reduce the losses of gears. The June 2004 Council welcomed the Communication and invited the Commission 'to develop a pilot project to address the problem of ghost fishing in Community waters which will include a retrieval system to remove lost gears, gear adjustments that lessen the impact of lost gears and methods to reduce the losses of gears'.

1.3 Project ToRs and purpose

The terms of reference for this project are as follows:

- To compile all existing information and studies on monitoring the evolution of lost fishing gear, with particular emphasis on gillnets;
- To identify research gaps, particularly on the means to prevent gear loss and to improve their retrieval, in commercial fishing gears;
- To summarize existing knowledge on the environmental impact of lost gear and how this compares with the environmental impact of active commercial fisheries;
- To explore and summarise the estimated amount of gears lost and their catching efficiency within local fishing grounds;
- To assess the costs and benefits of a possible wide-ranged programme of retrieval of lost gear; and
- To draw-up a work programme for future management and research action.

Given the policy context stated above, this project is therefore intended to assist the Commission in determining how to take forward its commitments on addressing ghost fishing, thereby meeting the Community's commitments under the basic Regulation.

This project builds upon previous initiatives, in particular a EU wide project called FANTARED (EC Project N° 94/095: incidental impact of gill-nets) that examined the impact of lost gill-nets in different fisheries. This past work focused on the incidence of net loss and the biological impacts as well as some management options. A key difference with this work will therefore be the consideration of environmental impacts, the economic cost/benefits analysis of gear retrieval programmes and drawing up of a work programme for future management and research.

1.4 Study methodology

To complete the tasks itemised above, an approach was adopted for the study, based on a number of steps.

STEP 1 – On initiation of the study, an internal **project planning meeting** took place in Brussels. The planning meeting was used to discuss:

- the timetable for each team member's inputs;
- initial ideas on key fisheries to be examined in detail during the project;
- reporting formats;
- literature review and survey strategies;
- technical issues of assessing costs and benefits; and
- study management and quality control.

STEP 2 - A literature and web search was then undertaken to identify the key scientific literature available on the subject as well as the major research institutions that have worked on ghost fishing (see Appendix A, Appendix B and

Appendix C for a full bibliography of references reviewed, and the methodology employed). The literature review also identified key fisheries of interest for the study.

STEP 3 – Surveys were then used to complement and build upon the results of the literature review. Questionnaires (see Appendix D for detail and methodology) were targeted at the specific fisheries identified during Steps 1 and 2. They were telephone and port-based with fishermen operating in the key fisheries identified. The survey work was an important step in the project to generate information both for the workshop (Step 5) and for the costs/benefit analysis conducted in Step 6.

STEP 4 – The results of the survey and of the literature and web search were summarised in a **briefing paper**, which presented options for a possible programme of retrieval of lost gear and identified the needs for future management and research actions.

STEP 5 – This briefing paper and comments from the European Commission then formed the basis of a two-day **consultation workshop with key stakeholders**, held in Brussels. The workshop is to be attended by some key institutional figures and fishermen from each of the selected fisheries (see Appendix E for workshop report). The objectives of the consultation is a preliminary prioritisation of management actions for different gear types and fisheries of a wide-range of management programmes of retrieval of lost gear and priorities for future management and research actions.

STEP 6 – Following the workshop, the study team will estimate and **analyse in detail the costs and benefits of different management possibilities** proposed from an environmental, social, and economic perspective.

STEP 7 - The results of the study will be presented in a **Draft Final Report**, with a **Final Report** issued based on comments made by the EC. The Final Report will be available on both IEEP's and Poseidon's web-sites to assist with dissemination.

Table 1 Study planning

Step	Completed by
Step 1 – Planning meeting	Mid-December 2004
Step 2 – Literature and web search	Mid-February 2005
Step 3 - Survey	End-March 2005
Step 4 – Briefing paper and meeting with Commission	Mid-April 2005
Step 5 – Stakeholder workshop	Mid-May 2005
Step 6 – Analysis of costs/benefits of management options	Mid June 2005
Step 7 - Preparation of Draft and Final Reports	End-June early July 2005

2 Existing information and studies on lost fishing gear

This section examines existing information and studies on the amount of gear lost and the evolution of lost gear, with particular emphasis on gillnets. Until the mid 1990's there was very little research into ghost fishing by bottom set gill, tangle or trammel nets, both globally (Car *et al*, 1992) or in European waters. Much of what had been done had been undertaken in the waters of North America. With increasing concern over the effects of lost gear in European waters, the European Commission funded the FANTARED 1 and 2 projects (EC Project no 94/095 and EC contract FAIR-PL98-4338), pan-European studies into the extent, impact, causes and preventative measures of ghost fishing. It represents the most comprehensive work undertaken in Europe into ghost fishing by static nets and pot fisheries.

Under the FANTARED 2 work, fishermen surveys were conducted, covering a significant part of European static gear fisheries in Norway, Sweden, Portugal, France, Spain and the UK. These fisheries are characterized by their diversity of fishing gears used, target species and the depths and conditions of the fishing grounds. The fishermen surveys and field research (eg net deployment and direct observations through diving and sonar) covered the following areas:

- the importance and reasons for gear loss;
- the areas where the losses occur;
- lost gear retrieval attempts and degrees of success;
- the operational factors determining the loss rate of fishing gear; and
- the degree of interaction among the different fishing methods in the same fishing areas which would lead to an eventual loss.

Following an overview of the scientific framework of ghost fishing mortality and the causes of gear loss, key findings of the FANTARED work in each of the fisheries are summarised with additional information provided from other literature where relevant and available, including that from outside the EU. Details of the FANTARED methodology and findings can be found in the project report. A concise overview of the work is also reported by Dunlin (2000).

The causes of gear loss are important in terms of affecting lost gear evolution, as well as for developing prevention and mitigation measures. As such, they are discussed in section 4.1.1.

2.1 Lost gear evolution and mortality – the scientific framework

Gear loss rates and catching efficiency form the basis of estimating mortality in ghost fishing gear. Catching efficiency is itself determined by the evolution of the lost gear. Attempts have been made to estimate these factors with limited success. The mortality attributed to ghost fishing gear is dependent on the following factors:

- species present;
- species abundance;
- species vulnerability; and
- ghost gear effective status.

These factors were reviewed by ICES (2000). Species present and species abundance, both in regard to mortality, are well-recognised parameters relating to the rate of mortality. Species vulnerability is a less understood parameter. Species vulnerability relates to becoming entrapped, enmeshed, entangled or otherwise caught by the gear. This results in the species becoming more vulnerable to predation or becoming less able to maintain life functions (eg

feeding, oxygen exchange, or seeking protection or defence from oceanographic disturbances).

The effective ghost fishing rate of the gear is dependent on what initial fish capture characteristics remain and the level of exposure of the area to the elements. Synthetic materials have replaced natural materials in many fish capture devices. This includes mobile trawls, gillnets and pots.

2.2 Demersal gillnets

2.2.1 Baltic Sea

Under FANTARED 2, active Swedish gill-netters operating in the Baltic Sea in 1998 were randomly selected, and interviewed (Figure 1). Gear loss was experienced among those vessels operating in open sea conditions, either in coastal waters or in distant grounds. However, it was only among those fishermen fishing for demersal species, (turbot and cod) with bottom nets, that regular gear loss was a usual phenomenon.

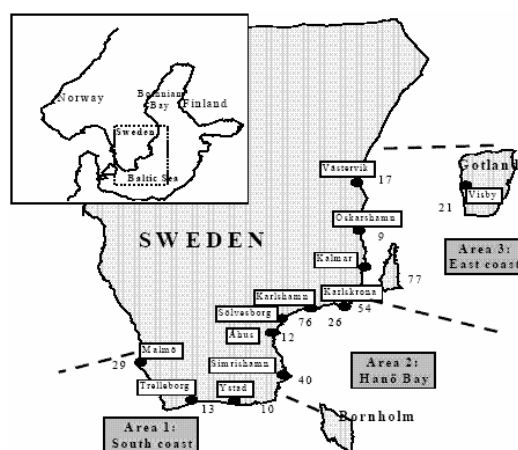


Figure 1 Swedish research areas

Net loss

Data was only presented by region (Table 2). The total estimated loss per year was around 1,500 nets, 155 – 165 km in length, equating to 3.6 – 3.8 nets per active vessel. Static gear loss as a problem in the Baltic Sea is most notable in the bottom gill net fishing fleet fishing in the open sea area well off the coast.

Table 2 Net loss in Swedish net fisheries

	Estimated length of ghost nets/yr/km	Percentage of nets used lost per year	Number of nets lost
South coast	15.36	0.07	142
Hanö Bay	36.8	0.04	342
East coast	100.4	0.28	931
Other	3.6	0.08	33
Total	156.1	0.1	1,448

Because fishing gear conflicts are the main reason for gear loss the areas with higher gear loss rates could be identified. It seems that eventual 'ghost nets' appear in two types (a) longer fleets found apparently in the vicinity of the conflict area and (b) small remnants found randomly over a larger more undefined area.

Net evolution and catch rates

Twenty four nets were set experimentally to investigate gear evolution and catch rates. These are reported at length in the FANTARED 2 report and also in Tschernij and Larson (2003). As with the other country cases, the methodology, conditions and assumptions employed are too extensive to account here and the reader is directed to the original sources for further details. The nets were demonstrated as continuing to catch after loss, with catch rates dropping off to around 20 per cent after three months. This is due to net degradation from storms and currents and capture of fish. From this point, catches continued even though the nets were biofouled and hence visible. Catches appeared to stabilise at around 5-6 per cent after 27 months. This catching efficiency was believed to continue over several years.

It was estimated, depending on the chosen retrieval rate scenario of nets by trawlers, that the total catch of cod by lost nets during the 28 month study period could be somewhere between 3 and 906 tonnes. Compared to the total weight of reported and landed cod catch from the same area and time period (2,8345 tonnes) the lost net catch is between 0.01 and 3.2 per cent. Even this was considered an overestimate as lost gears nearly always encounter trawlers so are damaged more than those in the experiment. Additionally, commercial landings do not include all fishing related mortality eg discards.

2.2.2 North Sea and English Channel

Surveys carried out as part of FANATRED 2 in the UK, France and Norway cover the area of the North Sea and English Channel.

Net loss

Three significant UK métiers were identified and surveyed under FANTARED 2 (Figure 2)

- hake fishery in the English Channel and Western Approaches;
- wreck fishery in all United Kingdom waters; and
- the tangle net fishery around the Lizard – a peninsula in Cornwall.

Key:
 T = Tangle net métier
 H = Hake net métier
 W = Wreck net métier
 ● = Experimental sites



Figure 2 Location of UK métiers surveyed

Results were presented by fishery and are summarised in Table 3.

Table 3 Net losses in UK net fisheries

Métier	Vessels in métier	Type of net loss	Total net loss (km/year)	Equivalent to (nets/year)	Pieces of Netting lost
Tangle	18	Towed gear conflict	24	263	
Hake	12	Towed gear conflict	12	62	
Wreck	26	Snagged on wreck	n/a	n/a	884

- Wreck métier

The *most frequent net loss* occurred in the wreck fishing métier where netting is lost on every fishing trip amounting to 884 pieces of net lost per year or 34 pieces per vessel per year. In all cases the loss of pieces of netting was attributed to it being snagged up on the wreck and either tearing along floatline or leadline. In every instance the main frame of the net (floatline and leadline) was recovered. Pieces were defined as being anything from a few meshes to whole panels and nets were regularly overhauled and torn netting replaced.

- Tangle métier

The *greatest whole net loss* occurs in the Tangle fishing métier where a total of 24km of nets are lost per year. Of the total amount lost, an average of 35 per cent or 13 km is recovered in varying states of repair. The losses were all attributed to conflict with either scallop dredgers, beamer trawlers or trawlers. Losses incurred were either whole fleet loss or partial fleet loss dependant on the angle at which the intrusion into the fleet was made.

- Hake métier

A significant reduction in vessel numbers through decommissioning was mirrored in the net losses incurred in the hake fishery métier. A raised total of 12km of netting was reported of which 50 per cent or 6km was recovered. As in the tangle net fishery, the loss was entirely blamed on gear conflict, with trawlers being highlighted as the main culprits. Whole fleet loss or partial fleet loss was described as the type of loss with part fleet loss being the most common type.

FANTARED 2 also interviewed fishermen on circumstances and causes of nets loss in the different fishing harbour or landing points in the East Channel and North Sea coasts in France (Table 4).

Table 4 Net loss métiers in the East Channel and North Sea, France

	Length of loss net/boat/year (km)	Percentage lost nets/boat/year
Flatfishes & monkfish	1.5	0.42
Cod	1.2	0.24
Wreck	0.4	0.33
Seabass	0.8	2.11
Sole & plaice	2.8	0.20
Plaice	1.1	0.37
Cuttlefish	nc	nc
Total	5.5	

Net evolution and catch rates

The results of net loss simulations and wreck surveys around the UK were reported in the FANTARED 2 report and Reville and Dunlin (2003).

- Wreck site

Following deployment the net quickly snagged on the wreck and bundled up at the ends. This reduced the fishing area from approximately 225m² to a little over 40m² after 10 weeks. Both the fishing areas of the net and the catch rates were seen to rapidly decline over time. Much of the integrity of the net was damaged, probably by abrasive forces resulting from the close contact with the wreckage. Catch rates decline to 18 per cent after 10 weeks and to zero in 10 – 12 months.

Eleven wrecks were also surveyed by divers. Twenty seven nets were observed ranging from full size to only a few centimetres in area. They were partially bundled or broken and no animals (dead or alive) were found in them.

- Snagged net

After 12 months the fragments were observed to have become further snagged on the wreckage with a section of netting stretched and spread out over approximately 10m² of hull plating from the wreck. This section of the netting was found to have entangled one edible crab (alive) on the first visit by divers.

- Open ground

Monitoring of the experimental fleets on open ground was by sequential retrieval using a grapnel. Each of the retrieved replicates produced different results after four weeks in the water. One of the fleets was virtually intact and appeared to be operating at around 90 per cent efficiency after four weeks but contained no gadoid species or hake in the net. Another was at 50 per cent efficiency while the third was lost. In both nets the bulk of species captured were crustacea. This suggests that for much of the time the net was not standing vertically and that it contained decomposing fish for some of the time. Very few skeletal remains were seen and both replicates were clear of marine growths and colonisation. These observations were

similar to those made by Pilgrim *et al* (1985). Based on these findings, the authors were confident that, for all open ground shelf areas the impact of lost nets is extremely limited because they encounter currents and gears.

The lack of replicates means that definitive assessments of impacts of lost nets could be made. The general conclusions drawn, however, were that nets lost under these conditions are an insignificant source of unaccounted mortality.

The FANTERED 1 work, that informed the FANTARED 2 project, included setting nets off the coast of southwest Wales (reported in Kaiser *et al* 1996). Two types of fixed gear, a gill and trammel net, were set one kilometre offshore from a rocky coastal area in southwest Wales, UK. One end of each net was cut free to simulate net loss. The nets were then allowed to fish continually for 9 months, during which time they were surveyed by divers. Several hours after both nets had been set, a large number of dogfish were caught, causing the nets to collapse. Catch rates began to decline within a few days of the initial deployment, probably related to a decline in the effective fishing area resulting from entanglement of fish and biofouling. To begin with, more fish than crustaceans were caught, although this reversed after 43 days. The catch of fish approached zero 70 and 22 days after deployment for the gill and trammel nets respectively. It was estimated that the gillnet caught 226 fish after 70 days and 839 crustaceans after 136 days, while the trammel net caught 78 fish after 22 days and 754 crustaceans after 136 days. Even though the nets were damaged by storm action, the work demonstrated that lost nets could continue to catch commercial crustacean species for at least 9 months after initial loss.

The work did not include any replicates, nor did they attempt to estimate total net loss and hence ghost catch.

2.2.3 *Southwestern Waters*

Surveys covering southwestern waters were carried out in the Cantabrian region (Spain), the Algarve (Portugal) and Brittany (France).

Net loss

- Cantabrian Region

A survey of gillnetting in the Cantabrian region (Spain) was carried out under FANTARED 2 (Figure 3). This region covers four maritime provinces (Asturias, Cantabria, Vizcaya and Guipúzcoa) with over 500 km of coast. Twelve métiers were studied: beta/Red mullet, beta/Hake, miño/Sole, miño/Several species, miño/Shellfish, miño/Scorpion Fish, trasmallo/Red mullet, rasco/Monkfish, volanta/Hake, miño/Monkfish, trasmallo/Inshore species and BETA marisquera/Shellfish.

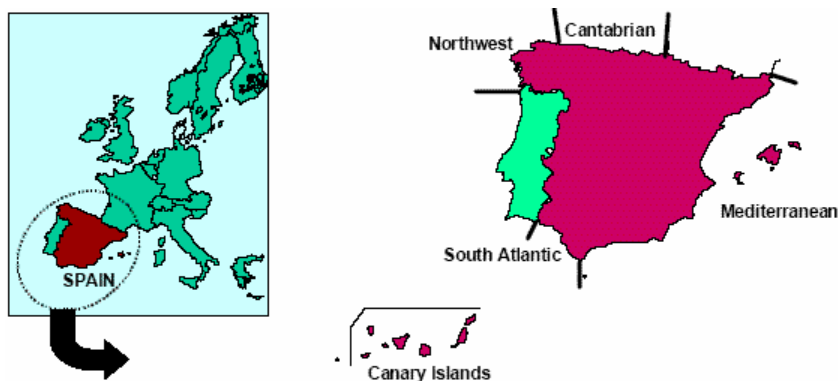


Figure 3 Location of Cantabrian region

An average net loss rate of 13.3 nets per vessel was found. This loss is higher for vessels of over 10 GRT (16.2 nets/vessel), than those of smaller tonnage (10.4 nets/vessel).

The métier with the highest number of net losses per vessel (27,9 nets/vessel/year) is that of rasco/monkfish. Other fishing métiers with high losses, are those bottom set net fisheries close to the coast (beta marisquera/shellfish, trasmallo/red mullet, trasmallo/coastal species) with losses ranging between 7 and 15 nets/vessel/year. The rest of the fishing métiers have losses of less than 4 nets/vessel/year

Extrapolation to the entire fleet by fishing métiers (Figure 4), the biggest losses occur in the rasco/monkfish métier with 2,065 nets lost, 86per cent of which are due to trawl. Another fishing métiers with important losses (774 nets/year) is that miño/different species (41 per cent due to storms and 38 per cent marker dhan loss). It is worth highlighting the fishing métier of red mullet with betas (58 per cent of the nets due to storms and 36per cent to catching on the bottom), beta/hake (storms: 43 per cent; trawl: 34 per cent) and trasmallo/red mullet (storms: 98 per cent) since they lose between 550 and 650 nets per annum. The rest of the fishing métiers, practised mainly in shallow waters (except for the volanta/hake métier), have annual losses of between 100 and 500 nets per annum.

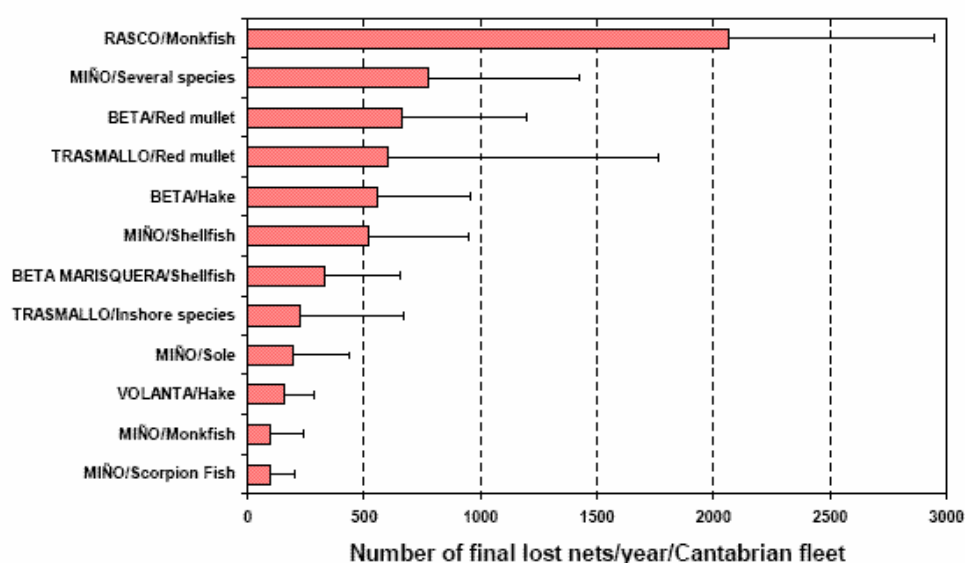


Figure 4 Net loss in the Cantabrian fleet per year by métier

- Algarve

Under the FANTERD 2 project, net fishermen in the local, coastal and hake fisheries of the Algarve (Portugal) were interviewed about the extent and causes of gear loss and retrieval rates. This work is also reported in Santos *et al* (2003a). The number of nets lost in these fisheries was considered to be very low because of fishermen’s success in retrieving their nets. It was estimated that the mean number of panels effectively lost by boat per year were 3.2, 6.0 and 7.4, for the local, coastal categories and hake métier, respectively. The rate of net loss is slightly higher in the hake category due to the greater distance from shore and water depths that they operate in.

- Brittany

Fishermen were surveyed under FANTARED 2 on circumstances and causes of nets loss in the different fishing harbour or landing points on Brittany’s north and west coast.

The results concern 3 métiers:

- flatfishes & monkfish trammel métier,
- spider crab trammel métier and cod gillnet métier,
- wreck gillnet métier targeted on cod and Pollack.

Overall, the average length of lost net was between 0.8 to 2.8 km per year and per boat. The proportion of net loss by year are generally less than one per cent of the length fleet set per year excepted for seabream, seabass, crawfish and wreck nets.

Table 5 Net loss by métier in Brittany, France

	Length of loss net/boat/year (km)	Percentage lost nets/boat/year
Flatfishes & monkfish	4.96	0.50
Spider crab	0.3	0.04
Wreck	0.23	2.81
Total	5.49	

Net evolution and catch rates

- Cantabrian Region

Twenty seven tangle nets used for targeting Monkfish were deployed in the Cantabrian region. The results of this were reported in Sancho *et al* (2003) and FANTARED 2. Catch rates were equivalent to those of commercial gears after 135 days but no monkfish were caught after 224 days. The cumulative monkfish catches in 50m length nets were estimated to be 2.37 specimen. This gave rise to a total of 18.1 tonnes for the entire ghost catch, which constituted 1.46 per cent of the total commercial landings in the area. This was considered an overestimate given that the studied nets were not trawled away. As a concluding point, a very worst case estimate of ghost catch was put at 4.46 per cent of total commercial landings, or 55.3 tonnes.

There was a clear evolution in the composition of captures by ‘abandoned’ nets with time (1 year period), shifting from a dominance of fish to a dominance by scavenging crustaceans and molluscs. Changes in the physical characteristics of the nets could not be directly observed

underwater in these experiments, but likely included loss of surface fishing area, entanglement of nets, sinking of headrope and colonisation of nets by bio-fouling organisms (Erzini *et al.* 1997). These physical changes are expected to alter the physical entangling capabilities of the nets and increase the visual detection of the nets by fishes. The physical increase of bio-fouling might influence in an unknown way the interactions of crustaceans and molluscs with the abandoned gear.

- Algarve

As part of the FANTAERD 2 work described above, and reported in Santos *et al* (2003b), Nets were deployed during spring and autumn approximately 6.5 miles off the city of Faro (Algarve, Portugal) in 65-78 metres of water. Despite seasonal differences it was demonstrated that once a net is lost in the water there is a progressive reduction in its efficiency (of a negative exponential type), which may reach null values after a certain amount of time. Negligible values were reached after 3 and 5 months, for nets lost during spring/summer and autumn/winter periods, respectively. Biofouling was a key factor in the decline in catching efficiency.

The impact of the nets in terms of the total catch in numbers was estimated as 116 and 413 specimens per 100 m of lost net, for the spring/summer and autumn/winter experiments, respectively. In terms of weight this equates to 29.8 and 90.1 kg per 100 m of lost net. Of this, catch, 9 and 86 hake specimens were taken per 100 metres of lost net, for the spring/summer and autumn/winter experiments, respectively, which was equivalent to 20.6 and 27.6 kg per 100 metres of lost net. Based on these figures and gear loss estimates, it was hake loss due to gear loss was estimated to be between 733 and 7,000 specimens and between 1.677 and 2.247 tonnes of hake per year by the Algarve fleet. This is equivalent to a maximum of 0.3 per cent of the total catch (684 tonnes in 1999).

The FANTERED 1 work, which informed the FANTARED 2 project, included setting nets off the Algarve in shallow water. This was partly to develop methodology for the follow up work that came in FANTERED 2. This is reported in Erzini *et al* (1997). Four 100m lengths of monofilament gill and trammel nets were set in 15-18 metres of water and cut lose to simulate lost gear. Divers monitored catch rates and gear structure. Similar patterns were observed in all the nets, with a sharp decrease in net height and effective fishing area, and an increase in visibility within the first few weeks. Net movement was negligible except in the case of interference from other fishing gears. Catch rates were initially comparable to normally fished gill nets and trammel nets in the area, but decreased steadily over time. No sea birds, reptiles or mammals were caught in any of the 8 nets. Catches were dominated by fish (89 per cent by number, at least 27 species), in particular by sea breams (*Sparidae*) and wrasses (*Labridae*). The fishing lifetime of a 'lost' net was found to between 15 and 20 weeks under the study conditions. It was estimated that 100 m lengths of gill net and trammel net will catch 314 and 221 fish respectively over a 17 week period. When the nets were surveyed in the following spring, 8 to 11 months after being deployed, they were found to be completely destroyed or heavily colonised by algae and had become incorporated into the reef.

The catch rate figures in both of these studies are considered largely indicative because the conditions were not truly representative of real fishing conditions. Nets were set in shallow waters (particularly in Erzini *et al*, 1997) so are subjected to more light and hence biofouling. This would cause ghost catch rates in real conditions to be underestimated. Predation from species such as conger eel could also have led to under estimates. Conversely however, they were not subject to being towed away, which is the most common cause of net loss in the fishery and would cause the nets to be damaged. The work does however provide an insight into the magnitude of ghost fishing rates and also the factors in determining how this changes over time.

2.2.4 Mediterranean Sea

Fishermen were surveyed under FANTARED 2 on circumstances and causes of net loss in the fishing harbour or landing points on the French Mediterranean coast (Table 7 and Table 6). Only in the hake gillnet fishery was an estimate made of total net loss. In the other fisheries estimates were considered particularly unreliable.

Table 6 Net loss by métier in the Mediterranean Sea, France

Métier	Length of loss net/boat/year (km)	Percentage lost nets/boat/year
Crawfish	1.2	1.60
Hake	1.2	0.20
Sea bream	1.2	3.20
Scorpion-fish	1.1	1
Red mullet	0.7	0.50
Sole	0.85	0.25
Total	6.25	

Table 7 Net loss in the French Mediterranean hake gillnet fishery

type of vessels	number	min length/day (km)	fleet max length/day (km)	fleet nb fishing days	min set/year (km)	total max set/year (km)	total percent lost	min net/year	lost max net/year
coastal	32	2	4	90	5760	11520	0,15	8,64	17,28
offshore	65	4	8	70	18200	36400	0,2	36,4	72,8

Net evolution and catch rates

Data for estimates of catch rates were very incomplete. However, it was roughly estimated that 46 hake and 36 crawfish could be caught by per kilometre of lost gillnet leading to an annual loss of hake and crawfish respectively of between 2,072 to 4,144 and from 1,605 to 3,209. For the hake fishery this equated to between 0.27 per cent and 0.54 per cent of the total commercial landings.

2.2.5 Norwegian North Sea

Gear loss

Under the FANTARED 2 work, the Norwegian fleet and fisheries combinations were divided into seven fleets and five métiers:

Fleets

1. coastal vessels between 8.0 and 12.9 m North Norway
2. coastal vessels between 8.0 and 12.9 m Southern Norway
3. coastal vessels 13.0 to 20.9 metres N.N
4. coastal vessels 13.0 to 20.9 metres SN
5. deep-sea long liners, southern Norway
6. vessels 21 metres and more, northern Norway
7. deep-sea gill-netters southern Norway

Métiers

1. spawning Fishery for saithe
2. coastal fishery for cod
3. fishery for monkfish
4. fishery for Greenland halibut
5. fishery for blue ling and ling

The number and proportion of nets lost in each métier per year are summarised in Table 8 and discussed further below.

Table 8 Gear loss in Norwegian métiers

	Per cent lost	Number nets lost
Spawning Fishery for saithe	0.09	431
Coastal fishery for cod	0.02	187
Fishery for monkfish	0	0
Fishery for Greenland halibut	0.04	5
Fishery for blue ling and ling	0.04	62

- Spawning Fishery for saithe

All fleets participated in this fishery. Only in the offshore fishery (fleets 5 and 7), was loss of gear reported. Of the total nets deployed in this métiers 431 nets (0,09 per cent) were lost and not retrieved.

- Coastal fishery for cod

In this métier 0,1 per cent of the total deployed nets were lost. Of these 78 per cent were retrieved by the vessel. Fleets number 3 and 6 were responsible for most of the loss. A total of 187 nets were permanently lost (0.02 per cent).

- Fishery for monkfish

In this métier 0.07 per cent of the gear was lost in 1998 and 1999. All of these nets were reportedly retrieved.

- Fishery for Greenland halibut

In this fishery the total loss of gear amounted to 0.61 per cent of the total nets deployed. This is the métier with the highest loss. However 93 per cent of the nets are retrieved and only 5 nets (0.04per cent) were lost completely.

Despite these reportedly low loss rates, between 1983 and 1997 the Norwegian net retrieval programmes recovered 6,759 gill nets with the most conspicuous catches found in Greenland halibut nets from depths over 500m along the continental slope (unpublished data, Norwegian Directorate of Fisheries, reported in Humborstad *et al* (2003)).

- Fishery for blue ling and ling

This métier was regarded as the fishery where loss of gear is most likely to occur. The FANTERED 2 survey found that 0.13 per cent of the deployed nets were lost. However, 67 per cent were retrieved and only 0.04 per cent of the nets (62 nets) were lost and not retrieved.

In the Norwegian gillnet fisheries a relationship between water depth and loss rates was found (Figure 5). (Hareide in FANTARED 2, in Hareide *et al*, 2005)

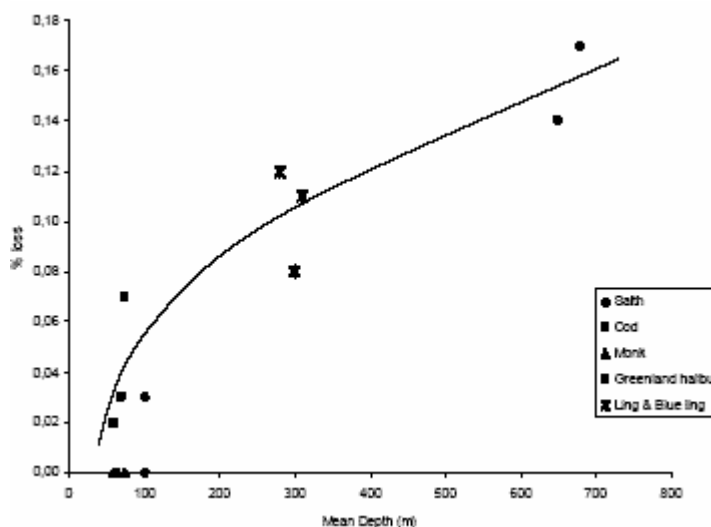


Figure 5 Loss of nets (percentage of deployed nets) by depth in Norwegian gillnet fisheries for the years 1998-2000

Net evolution and catch rates

- Shallow water gillnets

In the FANTARED project, three fleets of six monofilament gillnets were set in Bjørnefjorden, to the east of the Island of Huftarøy in Austevoll, southwest Norway. Two of the fleets were set at a depth of 120 m, and one at 160 m. All stood on a hard clay and stone bottom. The results were not analysed and are too poorly reported to permit reliable interpretation.

- Deepwater Greenland halibut fishery

Humborstad *et al*, (2003) monitored nets set at over 500 metres in the Greenland halibut fishery off mid Norway. They found that the catching efficiency of gillnets decreased with soak time, presumed to be due to weight of the catch causing the headline height to decrease. After 45 days efficiency was 20-30 per cent of equivalent nets in the commercial fishery. These rates corresponded to 28 – 100 kg per net per day per gillnet. Catch rates stabilized at this level and the nets continued to fish for ‘long periods of time’. The authors report that Norwegian net retrieval programmes haul nets that have been fishing for more than eight years. Furevik and Fosseidengen (2000) report that investigations on the Norwegian deep slope gillnet fishery for Greenland halibut suggest that these nets can fish for at least 2-3 years and sometimes even longer.

2.2.6 North East Atlantic deepwater net fisheries

Building on the findings and concerns from the FANTARED work, the DEEPNET project (Hareide *et al*, 2005) examined the deepwater and upper slope net fisheries of the north east Atlantic in more detail. This included an estimation of gear loss. It was considered that the amount of fishing gear used in the deepwater net fisheries, the length of the fleets, and the fact that the nets are unattended much of the time combine to make it highly likely that large

quantities of nets are lost. Such is the concern over the effect of lost fishing nets in these waters that under the 2005 EC-Norway agreement the Head of the Community Delegation informed the Norwegian delegation that the EC intends to develop net retrieval programmes in Community waters (Anon, 2004b).

Net loss

As well as net losses there is also evidence of illegal dumping of sheet netting in the north east Atlantic deepwater net fisheries (largely north and north west of the UK and Ireland). The vessels involved in the deepwater net fisheries are not capable of carrying their nets back to port and only the headline and footropes are brought ashore while the net sheets are discarded, either bagged on board, burnt or dumped at sea.

The amount of lost and discarded nets is not known. Hareide *et al* (2005) note that anecdotal evidence from one shark vessel suggests from a typical 45 day trip approximately 600 x 50m sheets of net (30km) are routinely discarded after having been damaged. Taking the level of effort to be in the region of 1,881 days (based on the German and UK effort data in Hareide *et al*, 2005), then a crude estimate of gear loss by these vessels is made to be in the region of 1,254km of sheet netting per year.

Based on the relationship between water depth and net loss rate (Figure 5) and estimates of net loss in the Greenland halibut net fishery, it was estimated that in the deep slope fisheries these vessels lose approximately 15 nets (750 m) per day.

Net evolution and catch rates

It is not known how much and for how long nets in the deepwater fisheries fish after they are lost. However, given the similar environmental conditions Hareide *et al* (2005) assumed that their evolution and hence catch rates are at least as great as those in the Greenland halibut fisheries studied in FANTARED 2. Very little information is available about the impacts of abandoned sheet netting.

2.2.7 Net fisheries outside Europe

Work has been carried out on lost gill nets in a number of fisheries outside Europe, most of which have been in North American waters. Concern heightened in the early-1980s over the biological and social impacts of persistent garbage and debris in the world's oceans, including by lost fishing gear. This led to four international conferences and workshops being convened on marine debris (1984, 1989, 1994 and 2000) to define the scope and magnitude of the marine debris issue (Shomura and Yoshida, 1984; Shomura and Godfrey, 1990; Coe and Rogers, 1997, McIntosh *et al*, 2001) and to consider appropriate monitoring, educational, and regulatory responses. While all are relevant to lost fishing gear, the fourth in 2000 focused specifically on this issue. The reader is directed to these proceedings for more thorough discussion of the proceeding discussion and ghost fishing from a largely north American/Pacific perspective more broadly.

An overview of the work undertaken in fisheries outside Europe is given here. The case seems to be that much of this work tends to be opportunistic and fragmented in the sense that gear evolution is studied or catch rate of a gillnet, without estimating the implications for fisheries as a whole. As such, much of the knowledge base on ghost fishing appears to have been pieced together over time. This is not to say that it is unreliable or of no value, but more that it is a reflection of the practical challenges studying the effects of lost gear pose.

The first documented work on lost gill nets appears to be that of Way (1977) in Atlantic Canada. A number of other studies followed (eg High, 1985 and Carr *et al*, 1985) but most

tended to be in response to specific incidents of loss or following some opportunistic identification of an accessible lost net.

Gillnets studied in inshore waters of North America demonstrated a collapse in net and subsequent decline in catch rates over time in the same way as those in the FANTARED work. Carr *et al.* (1992) deployed two 100m sections of 130 mm stretched gillnets at 20 m depth in Buzzard bay, Massachusetts, USA. Over a two year period skates, dogfish and a number of finfish were caught early on while lobster and other crustaceans continued to be caught throughout the study. A two year fishing life was also observed in Canadian nets by Way (1976).

Studies have included pelagic or drift gillnets. Gerrodette *et al* (1987) monitored 113mm mesh 9m deep monofilament nets (50, 100, 350 and 1000m in length). They found that the nets collapsed soon after deployment and that relatively few fish or other organisms were caught in the bundle of netting. Mio *et al* (1990) deployed five pelagic gillnets of 2000m length and similarly concluded that they formed a large mass of netting within four months.

Way (1976) reported investigated ghost catch by nets in the deeper waters of Newfoundland and found that they continue catching over several years, although at much reduced levels. High (1985) also observed continued catching after three years of fish and seabirds in pieces of lost salmon gillnet, despite biofouling.

Ten gillnets (50 fathoms each) caught about 9,090 kg of cod in Placenta Bay, Newfoundland (ICES 2000). These nets were actively fished less than six months before being retrieved as ghost gear.

Carr and Cooper, 1987 estimated that in protected, near-shore locations where depths are less than 30 metres gillnets may continue to catch fish at a reduced, yet substantial, rate of 15 per cent of normal the gillnet rate if roundfish and flatfish are present.

Although fifteen years ago, Breen (1990) undertook a review of ghost fishing and the work undertaken at the time. He reported that lost herring gillnets in British Columbia, Canada, continued catching fish for seven years, while Erzini *et al* (1997) report that eight year old gillnets retrieved in Norwegian waters were found to contain fish.

Studies that have attempted to estimate the amount of lost nets in a given area using ROVs or by net retrieval include Barney (1984), Carr and Cooper (1987), Cooper *at al* (1987) and Car *et al* (1985). Fosnaes (in Breen 1990) estimated an annual loss rate of Newfoundland cod gillnets of 5000. Way (1977) retrieved 148 and 167 nets in 48.3 and 53.5 hours of trawling with a grappling device over two years. Car and Cooper (1987) estimated that in an area 64km² traditionally fished by gillnets there were 2,240 lost nets. Canadian Atlantic gillnet fisheries were estimated to suffer a two per cent loss rate (8,000 nets per year) up to 1992 (Anon 1995, Chopin *et al* 1995). The US National Marine Fisheries Service estimates that 0.06 per cent of driftnets are lost each time they are set, resulting in 12 miles of net lost each night of the season and 639 miles of net lost in the North Pacific Ocean alone each year (Davis, 1991, in Paul, 1994¹). More recently, Anon. (2001) (in FANTARED) reported losses of 80,000 net between 1982 and 1992 through out Atlantic Canadian waters.

Nakashima and Matsuoka (2004) investigated the catching efficiency of lost bottom set gillnets through setting nets in three experiments for up to 1,689 days. The nets were observed through underwater observation. Catching efficiency declined to five per cent in 142, during which period the total number of ghost-fishing mortalities was 455 fish. Ghost fishing for red

1 <http://www.earthtrust.org/dnpaper/waste.html>

sea bream, *Pagrus major* and jack, *Decapterus* sp. occurred in the first short period and for filefish *Stephanolepis cirrhifer*, over a longer period.

2.2.8 Summary extent of net loss within European waters

Based on the work undertaken in European waters, the loss of static fishing gears appears to be common in some fisheries. In relation to the total number of nets being set however, the rates of permanent net loss appear to be rather low – well below one per cent of gear deployed annually. To a large extent this is because the level of recovery of nets in most shelf fisheries that are subject to minor damage is now very high because of the almost universal adoption of GPS by fishing vessels (FANTARED 2). However, because the length of nets being set is very high, the total length of netting permanently lost can be high. The extent of net loss in the fisheries discussed above are summarised in Table 9. While loss rates are generally below one per cent, the length of netting lost each year in those fisheries studied alone is over 8,000 km. Applying a loss rate of one per cent to the total number and length nets set in European fisheries would provide a rough estimate of total loss per year.

As noted in section 2.2.6, a possible exception to the low loss rates and numbers is in the deepwater net fisheries in the north east Atlantic. The estimated figures for these fisheries dwarf even the totals from those fisheries studies elsewhere, with a total number of 25,080 nets lost per year at a length of 1,254km.

Table 9 Summary of net loss in selected European fisheries

	Estimated length of ghost nets/yr/km	Percentage of nets used lost per year	Number of nets lost	Pieces of Netting lost
Swedish net fisheries	156.1	0.1	1,448	
UK net fisheries	36		325	884
Spanish net fisheries			~5,500	
French Mediterranean fisheries	6.25			
French North and West Brittany fisheries	5.49			
French North sea and East Channel	5.5			
Selected Norwegian net fisheries		>0.1	685	
Total	209.24		7,958	
Deepwater net fisheries	1,254		25,080	

2.2.9 Summary of net evolution and catching efficiency

Gear evolution is a key variable in determining catching efficiency. Vertical profile and invisibility are the primary characteristics that make gillnet gear effective. Mesh size is also important but less than the former two characteristics (ICES, 2000). Other factors relating to the rate of mortality of gillnets are depth and sea bottom type. Together with the availability of vulnerable species, the lost gear's exposure to environmental incidents such as storms and

surge and fouling are thus key determinants of the effective mortality rate/catching efficiency of ghost gillnets.

The work under FANTERED and wider international studies show that while nets may be set in a wide range of environmental conditions, their evolution and catches show some similar patterns and tendencies. Catching efficiency of lost nets also generally show the same pattern, with changes in species composition over time in most cases, typically from fish to crustaceans.

On rocky bottoms, gillnets may maintain a nearly horizontal configuration with some vertical profile (about one metre altitude) as they are caught around rocks (Carr, 1988). Dependent on the level of exposure to the elements, however, catch rates can near zero over a 8 – 11 month period as the nets become destroyed and fouled (Erzini *et al.*, 1997).

Static nets fished on open bottoms experience an initial sharp decrease in net height followed by a prolonged period of slow decrease in net height and increased degradation and tangling due to catches and biofouling. Fishing rates may nonetheless continue at not insignificant rates, of up to 15 per cent of normal gillnet rates in some cases (Carr and Cooper, 1987; Brothers, 1992).

Nets deployed on wrecks and rocky bottoms tend to degrade rapidly and/or are tangled in the structure of the wreck, resulting in reduced catch rates within months of being set. While studies in Canada showed that nets set in very deep water continued to fish for many years, the effective fishing lifetime of the nets in the FANTAREED study were not more than 6 to 12 months in most cases. The exception was the Baltic where catch rates of 45 per cent of commercial rates were still being recorded after 27 months.

2.2.10 Summary of ghost catches within European waters

Estimates of ghost catches in European fisheries are both limited and approximate. This is even the case in the FANTAREED work, which covered a range of countries with studies spanning several years. To summarise:

- **Baltic Sea** – the total catch of cod by lost nets during the 28 month study period could be somewhere between 3 and 906 tonnes. This is between 0.01 and 3.2 per cent of the total weight of reported and landed cod catch from the same area and time period.
- **Cantabrian region** – total ghost catch of monkfish in tangle nets in the Cantabrian region gave rise to a total of 18.1 tonnes for the entire ghost catch, which constituted 1.46 per cent of the total commercial landings in the area. A very worst case estimate of ghost catch was put at 4.46 per cent of total commercial landings, or 55.3 tonnes.
- **Algarve region** – hake ghost catch was estimated to be between 733 and 7,000 specimens and between 1.677 and 2.247 tonnes of hake per year by the Algarve fleet. This is equivalent to a maximum of 0.3 per cent of the total catch (684 tonnes in 1999).
- **Mediterranean Sea** – an annual loss of hake and crawfish was estimated as being 2,072 to 4,144 and from 1605 to 3209 respectively. For the hake fishery this equated to between 0.27 per cent and 0.54 per cent of the total commercial landings.

The FANTARED work concluded that while impacts on crustacean stocks are difficult to estimate, the Mediterranean work showed 1,500-3,000 individuals possibly being taken by lost nets. Comparison with catch data was not possible because of its absence.

Despite the limitations of these estimates, most of the fisheries that were examined the losses of commercial species attributable to lost static gears were small compared to commercial catches and also compared to other sources of such discarding. Estimated ghost catches are generally believed to be well under one per cent. Even these figures are considered an overestimate as the most common cause of lost gears is gear conflicts. It is thus common for the lost nets to encounter trawlers, so become damaged more than those studied in the experimental work. Furthermore, commercial landings do not include all fishing related mortality eg discards.

A notable exception to this is believed to be in the deepwater net fisheries where conditions (eg water depth) are conducive to both high net loss rates and ghost catch (see section 2.2.5). However, there are currently no reliable estimates as to what the ghost catch rates may be in these fisheries.

One of the main conclusions to come from the FANTARED work and the associated multi-stakeholder workshop was that there is concern over the levels of net loss in the southern Baltic Sea because of the tendency for lost nets to retain a significant fishing capacity for many months. The deep water net fisheries were also singled out for further research and management attention.

2.3 Fish and crab pots

The availability and quality of the information for estimating annual trap loss rates varies considerably. Pot fisheries in three regions have been studied in Europe to the authors' knowledge:

- pot fisheries of the UK;
- traps off of Portugal; and
- red king crab pots of Norway.

These are summarised here with a more general review of the literature, followed by an overview of the causes of pot losses and a summary of gear evolution and catching efficiency.

2.3.1 North Sea and English Channel

Pot loss

In 1999 Seafish in the UK undertook a government funded study to, *inter alia*, investigate the extent and nature of problems associated with ghost fishing by shellfish traps that become permanently lost in UK waters (Swarbrick and Arkley, 1999). The project team undertook a survey of fishermen's experiences of gear loss in the Southwest and Northeast of England and on the West Coast of Scotland. The survey quantified effort levels, identified the main reasons for losing shellfish traps and looked at fishermen's perceptions of the phenomenon.

The survey showed that most fishermen do not believe that lost traps pose a threat to stocks. Many of those interviewed had recovered traps lost for varying periods of time and they seldom contained any catch. In most cases they were damaged and had no residual fishing capability. A more significant source of unaccounted mortality on shellfish species was

claimed to be from netters, beam trawlers and scallop dredgers. The authors noted there are some objective catch data which support these assertions.

While average loss rates were reported in relation to other results eg perceptions of ghost fishing, the results are presented such that total loss rates can not be deduced.

Pot evolution and catch rates

A fleet of twelve pots set off the coast of Wales caught a minimum of 7.08 spider and 6.06 brown crabs per pot per year and killed a minimum of 6.06 brown crabs and 0.44 lobsters per pot per year (Bullimore *et al* 2001). Other species caught in the traps included velvet swimming crab, lobster, ballan wrasse, dogfish, and triggerfish. The pots continued to catch animals into the second year of the experiment. The catch rate declined as an inverse function of time and reached a minimum between 125 to 270 days after initial deployment in August 1995. After this period, catch rate increased again, although it did not attain the rates associated with the beginning of the experiment. Pot loss rates and hence total mortality was not estimated.

2.3.2 Southwestern Waters

Surveys were conducted in 10 ports of the Algarve, South of Portugal, in 2003, stratified by the two main regions as part of FANTARED 2, for both local and coastal fleet components of boats licensed to fish with octopus traps Figure 6.

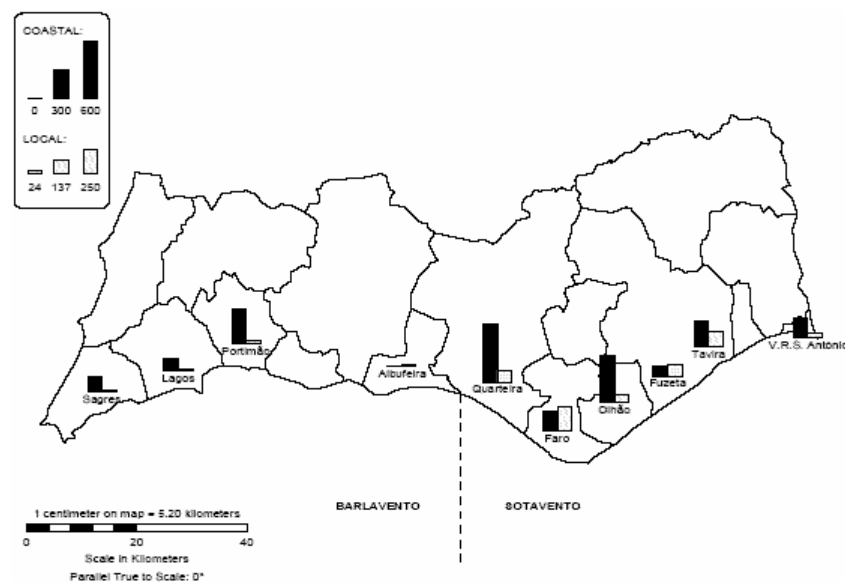


Figure 6 Location of Portuguese ports surveyed

Pot loss

The average number of octopus traps lost at sea per vessel and per year for each port and fleet type is presented in Table 10. On average, the number of small traps (used mostly to catch octopus) lost at sea is higher for the coastal fleet than for the local fleet. In terms of fishing zone, the losses are higher in the Sotavento than in the Barlavento on average (Table 10).

Table 10 Pot losses in Portuguese fleets

Fleet	Zone	Trap type	
		Octopus traps	Cuttle fish traps
Local	Barlavento	30.9 ± 55.4	78.8 ± 147.5
	Sotavento	145.6 ± 102.2	13.5 ± 11.1
Coastal	Barlavento	213.0 ± 213.8	11.3 ± 19.3
	Sotavento	318.5 ± 207.8	10.0

Regarding the big traps (used mostly to catch cuttlefish), the results regarding the fleets are the opposite, such that the local fleet loses more traps than the coastal fleet. In terms of fishing zone, there are again more losses in the Sotavento than in the Barlavento (Table 10).

Absolute figures for permanently lost pots were not determined, even though the recovery rates were estimated. The recovery rates were moderate to high for the Barlavento ‘coastal’ fleet. In the Barlavento local fleet, the boats that attempted to recover traps had a high success rate. In the Sotavento, most of the boats had medium success in recovering the traps, both in the local and in the coastal categories (Table 11). However, because these figures appear to give success rates for those boats that attempt to recover pots, they do not necessarily relate to the numbers actually recovered.

Table 11 Percentage of pots recovered by Portuguese fleets

Fleet	Zone	Success in recovering lost traps		
		High	Medium	Low
Local	Barlavento	68.2	18.2	13.6
	Sotavento	33.3	50.0	16.7
Coastal	Barlavento	40.0	60.0	0.0
	Sotavento	30.0	40.0	30.0

Pot evolution and catch rates

Further to this industry survey work, the FANTARED 2 study included pot deployment off of Faro. However, it was concluded that lost pots should have no impact on octopus stocks as they were observed entering and leaving the traps freely. There were no reports of other species becoming trapped.

2.3.3 Norwegian North Sea

As part of FANTARED 2, and reported in Godøy *et al.*, (2003), an experiment was set up whereby pots were deliberately ‘lost’ for periods of between 5 days and 1 year. A new design of rectangular collapsible pot was the main gear used, while in a single 5 days trial the traditional conical pot was used. In a string of four pots, for example, all 92 tagged individuals left the pots after 4 months, while 61 new crabs entered them. Very few dead crabs were found in the pots. While there were limitations to the experiment design, it was concluded that lost pots do not substantially contribute to crab mortality in these fisheries. The size of the crabs increased with soak time in the rectangular pots, while it decreased with soak time in the conical pots.

2.3.4 Pot fisheries outside Europe

The effects of lost pots have been studied more systematically than in net fisheries (FANTARED 2). In particular, the high value trap fisheries in North America which have

been investigated systematically for many years (eg Blott, 1978; Stevens *et al*, 1993; and High and Worlund, 1979).

Pot loss and catch rates

Anecdotal reports of lobster pot loss rates off New England, U.S. run as high as 20–30 per cent per year (Smolowitz 1978). The reported catch of lobster in pots lost off the New England coast was 5 per cent of the total lobster landings in 1976 (Smolowitz 1978). Along the Maine coast the pot loss rate reported in 1992 was 5–10 per cent (ICES, 2000).

In a one year study of Dungeness crab pots of British Columbia, Canada, the loss rate of crabs from ghost pots was estimated to be 7 per cent of the reported catch (Breen, 1987). This was from an estimated annual trap loss rate of 11 per cent.

A study in Louisiana, USA, resulted in a total catch per pots averaging 34.9 blue crabs, 25.8 died and 21.7 escaped per pot (Guillory, 1993). The turnover of blue crabs was fairly rapid; two-thirds of blue crabs entering the trap either died or escaped within 2 weeks. Conservatively assuming a total of 5,000 commercial trap fishermen each using 200 traps and an annual trap loss/abandonment rate of 25 per cent, approximately 250,000 derelict traps are added each year in the Gulf of Mexico (Guillory *et al*, 2001), with ghost fishing leading to a loss of 4 to 10 million blue crabs each year in Louisiana (GSMFC, 2001). This figure underestimates the actual number of derelict traps because of the cumulative addition of derelict traps over time and exclusion of traps used by recreational fishermen. However, not all derelict traps continue to fish because some are located on land or emergent vegetation, and older derelict traps eventually deteriorate and become incapable of ghost fishing.

Stevens *et al* (2000) conducted a pot retrieval programme off the coast of Alaska using sonar to locate pots and trawl gear to retrieve them. 147 pots were recovered, of which 97 contained organisms. Tanner crab was the most abundant species, with pots having a mean catch per pot of 1.54. The survey was limited in providing a snapshot however rather than estimating ghost fishing mortalities rates.

In the snow crab (*Chionoecetes opilio*) trap fishery in the Gulf of St. Lawrence it was estimated that over 19,000 traps were lost at sea between 1966 and 1989 (Chiasson *et al* 1999). This equates to an average of around 792 traps per year. Hébert *et al* (2001) demonstrated a ghost mortality rate of 94.6 per cent in this fishery. Based on a mean catch rate of 51kg per haul, 1,000 gears were calculated as resulting in killing 84,194 snow crabs, or 48.2 tones per year. It was also demonstrated that catches increase in the new season again to their saturation level, due to the self-baiting effect, which re-initiated a ghost fishing cycle.

A field study of catch rates of lost fish traps in fishing grounds nears Muscat and Mutrah, Sultanate of Oman (Al-Masroori *et al*, 2004), ghost fishing mortality was estimated at 1.34 kg/trap per day, decreasing over time. An exponential model was used to estimate trap ghost fishing mortality. It predicted a mortality rate of 67.27 and 78.36 kg/trap during 3 and 6 months respectively, with trapped fish having a value of 55.565 RO/trap (US\$145) and 64.725 RO/trap (US\$168) respectively. This was not related to total catch value. In an earlier study (Al-Masroori, 2002) it was estimated that trap loss rates might be as high as 20 per cent in this fishery. In the trap fishery of Kuwait financial losses due to ghost fishing may reach 3–13.5 per cent of total catch value (Mathews *et al*, 1987 in Al-Masroori *et al*, 2004).

Pot evolution

In a study on the effect of soak time on legal and non-legal sized red king crabs, Pengilly and Tracy (1998) (in FANTARED 2) found that the ratio of non-legal to legal size decreased with increasing soak time. the average size of crabs caught increased with longer soak times.

Guillory (1993) found that smaller blue crabs (*Callinectes sapidus*) were more likely to escape than larger individuals. Zhou and Shirly (1997) (in FANTARED 2) found that in box-shaped king crab pots the escape rate ranged from 12.5 per cent for legal males to 56.3 per cent for females. They also observed that legal-sized male crabs had the lowest rate of attempted escapes.

High and Worlund (1979) found that the percentage of legal-sized king crabs increased over time in rectangular pots, while it decreased in snow crab pots. They also incidentally observed that snow crabs (*Chionoecetes opilio*), which are considerably smaller than king crab, were more active. Smaller king crabs may be more active than larger ones, and are thus more likely to leave the rectangular pot first.

Comparative fishing trials with rectangular and conical pots in Northern Norway showed that the rectangular pot caught more and larger crabs (Unpublished, in FANTARED 2).

Tagged crabs have been observed to leave the pots after a period of time. High and Worlund (1979) placed tagged king crab in several types of pots and found that those that escaped after 10-16 days had a lower return rate to the pots than those in the control groups. Crabs that escaped after one to four days had almost the same return rate as those in the control group

Tanner crabs (*Chionoecetes bairdi*) that were starved for periods of up to 90 days did not raise their feeding rates after starvation, and suffered mortalities of 40 – 100 per cent during prolonged holding with access to food (Paul *et al* 1994, in FANTARED 2). Dungeness crabs (*Cancer magister*) that received similar treatment suffered 40 – 80 per cent mortality, while the control group, which was fed continuously for 230 days, suffered 20 per cent mortality. More crabs might be susceptible to stress caused by capture, handling, and captivity. In the wild these stresses might translate into poorer ability to forage, feed, reproduce or survive, even after escape from a pot.

All the FANTARED trials with rectangular pots showed that smaller crabs were the first to leave the pots. This may be because smaller crabs had an easier passage through the entrance from inside the pot.

2.3.5 Summary extent of pot loss within European waters

Estimates for pot loss rates are lacking. While the FANTARED work looked at this in Portuguese trap fisheries, and reported loss rates to be low because of successful retrieval, the results are not presented in a manner that permits deduction of total gear loss. The same is true for the studies undertaken in the UK pot fisheries. In both cases however, loss rates were not considered to be high enough to warrant concern because of low loss rates to begin with, high retrieval rates and those pots being lost being subject to damage because of gear conflicts.

2.3.6 Summary of pot evolution and catching efficiency

As with bottom set static nets, the effective catching efficiency of potting gear is dependent primarily on the availability of vulnerable species and the lost gear's exposure to environmental incidents such as storms and surge and fouling.

Pots tend to pass through a cycle of ghost fishing. They tend to be baited when they are set. If the pot is lost, in time the bait or lost catch attracts scavengers, some of which are

commercially important species. These scavengers may become entrapped and subsequently die, forming new bait for other scavengers. In some fisheries, entrapped animals may escape over time.

The FANTARED work supports the findings from the studies in fisheries outside the EU. With the exception of the wire fish traps, the other types of traps studied in the FANTARED project (crab traps – Norway, octopus traps – Portugal) did not show significant degradation over the course of the project. However, unlike nets the catch rates of pots depend to a large extent on the bait and once this has been eaten or has degraded, catch rates decline sharply. In the case of the octopus and the fish traps from Portugal there are essentially no catches three months after deployment. While fish were found to be less able to escape from traps, escape rates for octopus and the king crab were high. Post escapement mortality due to retention in pots for prolonged periods (days or weeks) is a possibility in the case of the crabs. There is little information concerning such unaccounted mortality and this is an area that was considered warranting further research.

Key points to come from the FANTARED and other studies were that catching efficiency is as variable as pot loss rates. Catching efficiency is dependent upon gear design, species behaviour and seasonality, and that entry, escapement and mortality rates is a dynamic process.

2.3.7 Summary of ghost catches within European waters

Although estimates of pot loss rates are largely lacking, ghost catches from pots and traps appear to be believed to be low because of successful gear retrieval and escapement of trapped organisms.

The Norwegian and Portuguese experiments under FANTARED indicate that the unaccounted mortality arising from lost pots and traps is fairly low. The Norwegian work showed that the target species of king crab were able to escape from the traps to some extent with smaller crabs having a better escape rate than the larger. It was concluded that gear loss is not a problem, in particular when compared to other sources of mortality.

The Portuguese work with octopus traps showed that the impact of lost traps on local resources is difficult to estimate. While a large number of octopus traps are lost, most of the catch consisted of octopus. Few other species are caught in these traps. No octopuses were found in the experimental traps after three months and the laboratory experiments showed this species exiting at will. Other species, especially small reef fishes were observed inside the traps, although it is possible that they were using the traps as a shelter and were able to enter and leave freely.

It was found that although escapement from the larger fish traps studied in Portugal ('murejona' fish traps) is harder, the overall impact of ghost fishing fish traps is probably low due to the relatively small numbers lost and also because their lifespan is short compared to the octopus pots.

The ghost catch rates in European fisheries thus appear not to be as high as those reported in some north American fisheries, where levels may be up to seven per cent of commercial catch, or even 20 per cent in fishing grounds nears Muscat and Mutrah, Sultanate of Oman.

2.4 Bottom trawl gear

The larger diameter synthetic multifilament twine common to trawl nets is the key factor that reduces ghost fishing mortality in lost trawl gear. The material has a larger diameter than gillnet monofilament and is visible or of such a size that it can be sensed by the fish. Although lost trawl gear will often be suspended by floats and form a curtain that rises well from the bottom, many of the losses form additional habitat for such organisms as ocean pout, wolfish, and cod and 'substrate' for attaching benthic invertebrates such as hydroids, and sea anemone (Carr and Harris, 1995).

Diving observations, using SCUBA, submersibles and ROVs (Remote Operated Vehicles) have shown that on deep depth substrate and bottom locations where currents are at a minimum, trawl gear usually has an overburden of silt. The webbing is thus quite visible or detectable. Trawl netting, though is often found floating or just subsurface. Much of the synthetic twines are buoyant and sometimes the twine buoyancy is augmented by the trawls buoyant floats that remain attached to major pieces of trawl webbing. This will attract pelagic marine species such as the Carangids (jacks); invertebrates as the attached tunicates and barnacles, and pelagic invertebrates. This webbing, though visible, will attract other marine species that can become entangled (Laist, 1994, in ICES 2000).

2.5 Fish weirs, demersal longlines, and jigging

With fish weirs, demersal longlines, seine nets and jigging the mortality rate is usually low (ICES, 2000; Huse *et al.*, 2002). Ghost mortality is a function of the gear type, the operation, and the location in regard to active ocean features and elements.

2.6 Research gaps

2.6.1 Net fisheries

As with fisheries science in general, uncertainty is a major factor in the reliability of the research into ghost fishing, and is likely to remain so. With this in mind, specific research gaps into the net loss in EU fisheries largely fall under the following headings.

Total gear loss

Estimates for total net loss in EU fisheries is lacking, as evidenced by Table 9. However, based on the EU research done to date, and supported by research elsewhere, it is unlikely to exceed one per cent of the total. What this means in absolute terms is not known. Where this loss rate may be an exception, and an area that demands further research, are the deepwater net fisheries of the north east Atlantic.

Total ghost fishing mortality

Because of the lack of knowledge on total gear loss, total ghost fishing mortality is also lacking. This is compounded by the fact that the research to date has been characterised by conditions that are not entirely representative of the conditions encountered in fishing. Studies are largely conducted in shallow waters that are of higher energy and subject to biofouling more than generally fished in. This is because of the practicalities of surveying deeper set nets.

In those deepwater net fisheries mentioned above, it is not known how much and for how long nets continue fishing. Similarly, very little information is available about the impacts of abandoned sheet netting, which is reportedly commonplace.

Member State and fishery level estimates

The above holds true for both Member State and fishery level estimates, as well as the EU level. This is particularly the case in the fisheries of the ten new Member States and the western Mediterranean. A notable example is the driftnet fisheries of the Baltic, which includes Finland, Sweden, Denmark and Poland. Gillnet loss in the Baltic is considered as a potentially important management concern, therefore these driftnet fisheries are also likely to present issues, not least because they are implicated with the bycatch of the critically endangered Baltic population of harbour porpoise. While research has been done on net loss in Sweden, no work has been done in Germany or Denmark and very little in Poland, where gillnetting effort has increased in recent years (pers. com. Zbigniew Karnicki, Sea Fisheries Institute, Poland).

2.6.2 Pot fisheries

The research gaps in pot fisheries are similar to net fisheries.

Total gear loss and ghost fishing mortality

Reliable estimates for total net loss in EU fisheries is lacking. As in the net fisheries, while it is unlikely to exceed one per cent of the total it is not known what this means in absolute terms. Because of the lack of knowledge on total pot loss, total ghost fishing mortality is also lacking. The information that is available is largely confined to the UK and Portugal.

Member State and fishery level estimates

As with the net fisheries, estimates of pot loss and ghost fishing mortality are largely confined to the 'old' 15 EU Member States. This is not such an issue as in the net fisheries however as European trap fisheries are largely confined to the northeast Atlantic.

2.6.3 Other fisheries

Data on ghost fishing mortality and gear loss for bottom trawl, demersal longline, jigging and fish weir gears is minimal (ICES 2000).

3 Selection of key fisheries for detailed review

3.1 Introduction

Based on the review of information available on the extent of ghost fishing in EU fisheries, Table 12 summarises the main EU net and pot fisheries reviewed together with a summary of the key ghost fishing related issues, research gaps and references.

The fisheries that have been selected for further research are highlighted in grey. These are:

1. Baltic cod net fishery of Sweden and Denmark;
2. net fisheries of Greece;
3. English and French net fishery in the western English channel; and
4. the deepwater net fisheries of the north east Atlantic.

In selecting these fisheries, key European environmental NGOs (WWF, Greenpeace, Seas at Risk) were contacted to enquire whether there were any fisheries that they had particular concerns over ghost fishing. Other than the Mediterranean drift net fisheries (Sergi Tudela, WWF Spain, pers. com.), no fisheries were highlighted as a source of concern.

Because of the varying degrees of information already available on these fisheries and the incidence of lost nets and ghost fishing in each case, the follow up research undertaken for each one differs. In the case of the Greek fisheries, no research has been undertaken on lost nets. The Baltic and English Channel survey however will build upon the work done under FANTARED. Although there are still information gaps, the deepwater fisheries have been studied in greater depth and the data available is sufficient to permit some analysis of the feasibility of a gear retrieval programme. There is also some sensitivity surrounding the fishery with the release and subsequent press coverage around the DEEPNET report (Hareide *et al.*, 2005). Coupled with interview fatigue amongst those participating in the fishery and the relationships being developed by the DEEPNET team, a further survey was not conducted in this fishery.

Table 12 Review of ghost fishing in key EU net and pot fisheries.

Fisheries warranting particular investigation are shaded grey.

Region	Fishery	Countries	Effort levels	Issues	Key Research Gaps	Reason selected / not selected
Baltic	Salmon drift net fisheries	Poland, Finland, Sweden, Denmark, Russia	<ul style="list-style-type: none"> seasonal fishery, peaking September-October and April-May; 24 per cent decline in 2001 compared to 2000; ~ 120 EU vessels complete drift net ban in the Baltic Sea on 1 January 2008; phasing out of drift nets from 1 January 2005: fleet size is to be progressively reduced by 40 per cent in 2005, 60 per cent in 2006, 80 per cent in 2007 and 100 per cent on 1 January 2008 <p>CEC (2003) EC (2004)</p>	<ul style="list-style-type: none"> fishery implicated with bycatch of endangered and protected harbour porpoise; little current or wave action, reducing break up of lost nets. 	<ul style="list-style-type: none"> rate/incidence of loss; cause of losses; lost net evolution; fish stock and wider impacts of loss nets; economic impacts of ghost nets 	<ul style="list-style-type: none"> While potentially significant ghost fishing issues, fishery is being phased out, therefore not selected for further research.

Region	Fishery	Countries	Effort levels	Issues	Key Research Gaps	Reason selected / not selected
	Herring net fisheries	Estonia? Latvia, Lithuania, Poland	<ul style="list-style-type: none"> • Estonia <104 vessels. None? • Latvia 60 vessels (cod and herring) • Lithuania 19 vessels (cod and herring) • Poland. 248 vessels (cod and herring) <p>Anon (2004a), FAO (2001a), Estonian Maritime Administration (2004)</p>	<ul style="list-style-type: none"> • little current or wave action, reducing break up of lost nets. 	<ul style="list-style-type: none"> • rate/incidence of loss; • cause of losses; • lost net evolution; • fish stock and wider impacts of loss nets; • economic impacts of ghost nets 	<ul style="list-style-type: none"> • Rates of loss not believed to be high because vessels typically tend to nets while set over night. Nets also set midwater so less prone to snagging, damage and loss. <p>FAO (2001b)</p>

Region	Fishery	Countries	Effort levels	Issues	Key Research Gaps	Reason selected / not selected
	Cod net fisheries	Sweden, Finland, Denmark, Latvia, Lithuania, Poland	<ul style="list-style-type: none"> • Sweden 398 vessels • Finland 13 vessels • Denmark 380 vessels • Latvia 60 vessels (cod and herring) • Lithuania 19 vessels (cod and herring) • Poland. 248 vessels (cod and herring) <p>Anon (2004a), FAO (2001a)</p>	<ul style="list-style-type: none"> • ghost catch of Swedish cod net fisheries estimated to be between 0.01 and 3.2 per cent; • considered an over estimate as lost gear is damaged by trawlers, so reducing ghost fishing efficiency. Discards also not included in fishing mortality, so ghost mortality relatively even smaller problem; • little current or wave action, reducing break up of lost nets. <p>FANTARED 2 Tschernij and Larson (2003)</p>	<ul style="list-style-type: none"> • economic impacts of ghost nets 	<ul style="list-style-type: none"> • Estimated rate of net loss considered high enough to warrant further investigation. • Only the biological impacts have been considered. A three per cent loss rate could be economically significant given value of cod fishery. • There is a need to cross check net loss figures and subsequently value the cost of ghost fishing. • Retrieval programmes have been ongoing since FANTARED although funding is a constraint.

Region	Fishery	Countries	Effort levels	Issues	Key Research Gaps	Reason selected / not selected
Mediterranean	Drift net fisheries	France, Italy, Morocco, Turkey, Algeria	<ul style="list-style-type: none"> • drift nets still in use, despite EU, IATTC and GFCM ban; • offending EU Member States pledged to phase out drift net use; • particularly large illegal fleet remains in Morocco <p>Tudela (2004), Tudela <i>et al</i> (2005), Anon (2005)</p>	<ul style="list-style-type: none"> • high bycatch (eg cetaceans, turtles) levels in these fisheries; • entanglement in static and abandoned nets believed to have serious impact on monk seal populations <p>Johnson and Karamanlidis (2000)</p>	<ul style="list-style-type: none"> • rate/incidence of loss; • cause of losses; • lost net evolution; • fish stock and wider impacts of loss nets; • economic impacts of ghost nets 	<ul style="list-style-type: none"> • While potentially significant ghost fishing issues, fishery is being phased out, therefore not selected for further research.
	Coastal gillnet fisheries	Spain, France, Italy, Greece, Slovenia, Malta, and Cyprus	<ul style="list-style-type: none"> • Spain ~ 3000 • France ~ 1,500 • Slovenia ~ 10 • Italy 6,000 -8,000 vessels • Greece ~ 16,330 vessels • Malta < 1,700 vessels • Cyprus 500 fulltime + part time vessels <p>STECF (2004)</p>	<ul style="list-style-type: none"> • loss rates generally less than one per cent; • roughly estimated that French hake fishery ghost catch equates to between 0.27 per cent and 0.54 per cent of the total commercial landings. <p>FANTARED 2, Erzini <i>et al</i> (1997), Santos <i>et al</i> (2003a)</p>	<ul style="list-style-type: none"> • loss rates (and hence impacts) in eastern Mediterranean • fish stock and wider impacts of loss nets; • economic impacts of ghost nets 	<ul style="list-style-type: none"> • Currently no information on loss rates in eastern Mediterranean, where gillnetting is a common method. • particularly high effort in Greece, therefore economic impacts may be high, warranting further examination.
North Sea, Irish Sea and western approaches	Wreck nets	Denmark, UK, France	<ul style="list-style-type: none"> • Denmark 435 vessels • UK 100 vessels • France 400 vessels 	<ul style="list-style-type: none"> • while losses are high, it is mainly confined to small section of netting (net panels) designed to tear off; • because of high currents and tangling into reef, 	<ul style="list-style-type: none"> • fish stock and wider impacts of loss nets; • economic impacts of ghost nets 	<ul style="list-style-type: none"> • while biological and economic impacts have not been quantified, the low level of net loss and nature of net evolution suggests

Region	Fishery	Countries	Effort levels	Issues	Key Research Gaps	Reason selected / not selected
				<p>catch rates quickly decline to 18 per cent after 10 weeks and to zero in 10 – 12 months</p> <p>FANTARED 2, Revill and Dunlin (2003)</p>		that the wreck fisheries are not of significant concern.
Western Approaches	Gill, trammel and tangle nets	France UK Ireland	<ul style="list-style-type: none"> • France 400 • UK 100 • Ireland 200 	<ul style="list-style-type: none"> • net loss considered to be under one per cent; • major cause is gear conflict, rendering lost nets of limited fishing • exception is (high value) bass fishery, where loss rate is over two per cent and due to gear conflict only half of the time 	<ul style="list-style-type: none"> • fish stock and wider impacts of loss nets; • economic impacts of ghost nets; 	<ul style="list-style-type: none"> • if loss rate is high enough, combined with high value fisheries, economic impact may be high; • fishery provides geographical balance to the survey work; • vessels numbers higher in western channel than East
Eastern Channel & Southern North Sea		<ul style="list-style-type: none"> • France • UK 	<ul style="list-style-type: none"> • France 340 • UK 30 <p>FANTARED 2</p>	<p>FANTARED 2, Revill and Dunlin (2003), Pilgrim <i>et al</i> (1985), Kaiser <i>et al</i> 1996, Sancho <i>et al</i> (2003)</p>		

Region	Fishery	Countries	Effort levels	Issues	Key Research Gaps	Reason selected / not selected
	Pot and trap fisheries	UK, Portugal, Ireland, France	<ul style="list-style-type: none"> UK ~ 300 >10m vessels Portugal ~ 290 vessels Ireland ~ 800 - 1200 France ? <p>DEFRA (2005), FANTARED 2, DCMNR (2005)</p>	<ul style="list-style-type: none"> loss rates and subsequent ghost fishing efficiency considered to be low enough not to warrant concern <p>FANTARED 2, Bullimore <i>et al</i> (2001), Swarbrick and Arkley (1999), Santos <i>et al</i>, (2003a)</p>	<ul style="list-style-type: none"> total pot loss rates; total ghost mortality; economic impacts of ghost pots 	<ul style="list-style-type: none"> While estimates are patchy, loss rates and subsequent ghost fishing efficiency is considered to be low enough not to warrant further consideration here; project focus is on net fisheries.
North east Atlantic	Deepwater and upper slope monkfish and shark net fishery	UK, Germany and Panama registered, operating from Spain	<ul style="list-style-type: none"> UK 23 vessels Germany 6 vessels Panama 2 vessels 	<ul style="list-style-type: none"> the amount of fishing gear used in the deepwater net fisheries, the length of the fleets, and the fact that the nets are unattended much of the time combine to make it highly likely that large quantities of nets are lost; evidence of dumping of sheet netting; estimated net loss figures for these fisheries dwarf even the totals from those fisheries studies elsewhere, with a total number of 25,080 nets lost per year at a length of 1,254km; stocks are overexploited and biologically vulnerable (eg slow 	<ul style="list-style-type: none"> reliable net loss figures; ghost net evolution; ghost fishing mortality; impacts of dumped sheet netting 	<ul style="list-style-type: none"> A fishery of concern (see issues) and work ongoing into the development of retrieval programmes (Hareide and Connelly pers com). under the 2005 EC-Norway agreement the Head of Community Delegation informed the Norwegian Delegation that the EC intends to develop such schemes in Community waters. <p>(Anon 2004b)</p>

Region	Fishery	Countries	Effort levels	Issues	Key Research Gaps	Reason selected / not selected
				growing) FANTARED 2, Hareide <i>et al</i> , 2005		

3.2 Findings of the survey

This section provides some key findings of the surveys conducted as part of the project. As noted above, surveys were completed in:

- the Baltic cod net fishery of Sweden and Denmark;
- net fisheries of Greece; and
- the English and French net fishery in the western English channel

The deepwater net fisheries of the north east Atlantic were not surveyed due to sensitivity issues discussed in Section 3.1, and coverage by other researchers.

The information contained below is intended to add to/corroborate previous work, and should be read in conjunction with the text already provided Section 2. More quantitative outputs from the survey are used in the cost benefit analysis in Section 6.

3.2.1 *The Baltic cod net fishery of Sweden and Denmark*

Eleven fishermen were interviewed during the study in Sweden, one each from Hörvik, Brantevik, Boda, Hällevik, Nordersund, and five from Simrishamn. In addition, 15 fishermen were interviewed in Denmark, 3 from Nexø, 4 from Rønne, 2 from Klintholm, 2 from Marstal, and one each from Rødvig, Tejn, Svaneke, and Bagenkop.

Extent of gear loss and issues around net recovery

Nets are generally lost when fishing in waters of 25-60m depth. A significant proportion of fishermen reported that typically each year no nets are lost, while a smaller number reported some gear loss each year, typically around 3-5 nets and representing for each vessel a total of a few hundred metres of net, rather than thousands of meters. Generally less than 50 per cent of nets lost are recovered in Sweden, although Danish fishermen report that almost all nets are recovered.

The main determinants of successful recovery appear to be the reason for loss in the first place; fishermen report that where nets are trawled away, it is virtually impossible to recover them at sea (although Danish trawlers catching nets are reported to deliver them to the harbour, where they can be identified because they have tags with vessel number etc).

Trawling/gear conflict, along with merchant shipping, appear to be the major cause of net loss. Bad weather and nets being caught on the seabed are also significant causes of gear loss. In such cases, because each net is positioned with GPS and manually plotted, lost nets may be easily recovered. Due to the fact that trawled nets are likely to be bundled up and therefore to have little ghost fishing potential, these findings imply that the extent of ghost fishing may not be significant. In addition, the problem is reported to have been declining and was a much bigger problem in previous years. In Denmark in particular, interviews suggest that ghost fishing is not a significant issue for the following reasons:

- 10-15 years ago there was an illegal fishery in Polish territory with nets used with no/insignificant buoys and no identification marks. This has now stopped;
- before the development/common use of GPS and other electronic aids a significant amount of nets were lost by fishermen - this is no longer the case;
- because of the relatively high cost of net panels everything possible is done to retrieve them;
- there is a very good communication between the trawlers and the static gear fishermen;

- fishing with nets is to a high degree restricted to areas where trawling is not going on - this is also why nets are rarely lost in deep water areas where trawlers primarily fish (and where the problem with ghost fishing could be most serious because of weaker currents);
- fishing with nets is declining – there are fewer vessels and many are changing to other fishing techniques (longlining/hooks); and
- small quotas make net-fishing in the Baltic of less interest to fishermen from other parts of Denmark (especially from the westcoast).

Attempts at net recovery are generally made using a hook that is dragged along the bottom (either home-made or bought for around Euro 50-300), and unless it is known that net loss has been caused by trawling or merchant shipping activity, attempts are always made to recover lost nets. Given that the extent of net loss is not itself high, fishermen on average spend no more than a few hours each year looking for lost nets.

When nets have reached the end of their useful life, they are generally disposed of in containers in the harbour, with the costs of disposal already contained as part of port fees, so there appears little economic incentive for fishermen to deliberately discard nets at sea to avoid onshore costs of doing so.

Management measures

Generally fishermen felt that mandatory reporting of lost gear could be useful, although it would be of limited benefit for nets lost due to trawling activity. The Swedish Board of Fisheries has been retrieving lost gear each summer for the last four years (section 4.1.5), and better information on where gear was lost would make such searches more efficient. An international database was also suggested in interviews as being potentially useful considering the number of foreign fishermen in the area, some of whom are thought not to drag for lost gear.

A maximum soak time of 48 hours is already in place in Sweden, and marking of buoys with radio-transmitters is also already mandatory enabling nets/buoys to be found (but does not stop some trawlers) and so there was no support for additional gear modifications.

Fishermen sometimes have agreements with the trawlers from the home port and communicate daily with them, and while some domestic trawlers certainly also cause problems, it is reported that it is generally the external trawlers that result in lost nets, including Finnish and Polish fishermen. This suggests that improvements in international communication mechanisms might help.

Some efforts were reported to set up codes of practice by associations and the Board of Fisheries in Sweden, but no one appears to have taken up responsibility for implementation. However, codes of practice were generally supported by those interviewed, especially if extended to fishermen in other countries.

3.2.2 Net fisheries of Greece

The interviews were conducted in Halkida (12), a port at the point where the island of Euboea very nearly joins the mainland; on Spetses (8), an island in the Gulf of Argolis, off the east coast of the Peloponnese; and in Koilada (7), a port on the mainland of the Peloponnese, northwest of Spetses.

The fishermen interviewed were on the whole fairly representative of the coastal fishing sector, in that there were only 4 or 5 who were relatively young (< 50), fished on a relatively

large scale (turnover of €30,000 or more), and used GPS. The remainder, like the sector, are struggling to make ends meet, or (in a few cases) supplement their pensions, and are generally more 'subsistence' in nature than truly commercial.

Extent of gear loss and issues around net recovery

None of the fishermen interviewed stated that they lose net panels, or indeed fleets, on a regular basis, and gear conflict with trawlers was not reported. Rather, they tend, especially in the North Euboean gulf, and in certain areas around Spetses, Trikeri and Dokos, to snag their nets on a fairly regular basis. As an indication, only one or two of the interviewees stated that they snag their nets less than once a week. However, snagging does generally not result in 'net loss', rather just in small fragments of nets being left in the water when nets are tugged free.

Because of the fairly parlous financial state of the coastal net fishers (resulting from falling stocks, an aging population, and competition from poorly policed and often irresponsible trawlers and purse seiners), the fishermen report that they can not afford to abandon nets. Taking into account that weather conditions and tides / currents are not generally challenging, they will go to considerable lengths to retrieve a snagged net, generally leaving only small pieces of the net behind and picking up all the floats, weights and ropes. Thus while their losses are practically never in terms of a panel, or gear, in the course of a season, if they are unlucky with snagging, it could be that they replace a hefty proportion of the net with pieces that they patch in. However, these small pieces of net fragments are not thought to be a problem in terms of ghost fishing as they are likely to quickly roll up being devoid of floats/markers.

Again, because of the near-subsistence level of the majority of the fishermen interviewed, they rarely have a GPS, or the know-how to use one effectively. However, they fish very much the same grounds, within sight of land, year in year out, and know from bearings on fixed points ashore almost exactly where they have laid the net, in the unlikely event that both markers are lost.

Nearly all fishermen perceive dolphins (and to a lesser extent turtles and seals), which are all apparently making something of a comeback in the area, as their major problem in terms of net damage, although it does not result in nets being lost, just portions of them being unusable. Almost all fishermen made some mention of this problem, raising a serious question of the extent of cetacean bycatch in the fishery.

Because they nearly always retrieve lost gear, and because floats and lead lines last for at least 3 years, they tend to strip the old net off the ropes, and dispose of it in the municipal tip. There is therefore no cost involved and no incentive to discard nets at sea, and it appears certain that fishermen do not discard nets at sea.

These findings imply, in corroboration with the FANTARED work in the western Mediterranean, that ghost fishing is not a significant issue in the eastern Mediterranean.

Management measures

These questions were difficult to explain to most fishermen given that ghost fishing was not seen as significant issue, and the results were correspondingly a little inconclusive. However, meaningful comments appeared to be that most were in favour of establishing a code of practice (although its relevance for an aging and poorly-educated population may be questionable), and of mandatory reporting of losses, to the extent that the body to which the report would go to could then dispatch divers to retrieve the net.

3.2.3 *The English and French net fishery in the western English channel*

Eighteen French fishermen and five English fishermen were interviewed during the study, 5 from le Conquet, 2 from Newlyn, and one each from a range of other small fishing harbours/ports.

Extent of gear loss and issues around net recovery

More than two-thirds of all fishermen interviewed reported that, in a typical year, they lose no nets at all. For the smaller number of fishermen who did report losing nets (generally fishing at between 50 and 100m), it was reported that typically only one net was lost a year, and 50-75 per cent of lost nets would subsequently be recovered. Key determinants of the percentage of nets lost that were recovered (using 'creeps') were cited as being: the strength of tides; good GPS fix on the original point of loss; the weather; echo sounders on buoys; and knowledge of trawl activities. An additional interesting comment made was that the larger fleets of lost nets are far more easily relocated than smaller net fragments. In summary it would appear that ghost fishing is not a serious issue in the Western English Channel net fishery.

Causes of gear loss were strongly centred around weather and bottom snagging, with very little reported as lost due to gear conflict. This may in part be due to existing levels of communication between different fleet segments. For example, every first day of the neap tide one fisherman in the SW of the UK collates the location of static nets and informs the producer organisation, which in turn tells French producer organisations.

Disposal of unwanted gear in France takes place through a number of mechanisms: it goes to a waste collection centre for sorting and recycling; it can be returned to a manufacturer; municipal trucks from the city come to collect 'big bags' with unwanted gear inside. In the UK, nets may be disposed of in skips in harbours (with costs contained within harbour dues) or are supposed to be disposed of industrial waste. However, associated charges for industrial waste mean that nets are either bagged as normal waste and taken to community tips, or 'fly-tipped'. But in neither France or England does it appear that fishermen ever just discard unwanted nets at sea.

Management measures

Fishing is generally already well marked by all fishermen, although it would appear that gear loss may be more prevalent for part-time/amateur fishermen who may insufficiently mark their gear, and that management measures might do well to focus on these fishermen. There was also little support from those interviewed for mandatory reporting of losses, principally due to the fact that the small amounts of gear that is lost is usually recovered anyway, either by the fishermen concerned or by another fishermen. Gear modifications too, were generally felt unnecessary/unwanted, as gear is carefully adapted to the local conditions in which it is used. Regarding codes of practice, there already appears to be a good awareness within the industry of the need not to dispose of gear at sea, and indeed of collecting and delivering to shore any lost gear that fishermen may find while fishing, so a formal code of practice may not be necessary as losses are not intentional. Therefore for those losses that may be unavoidable, eg on the few occasions that gear is lost due to conflict with trawlers, better communication between the two groups could perhaps be of benefit. Overall it seems that fishermen were reluctant to have any additional regulation or requirements imposed on them, given that the scale of the problem is perceived to be minimal.

3.3 Comments from the workshop

4 Research gaps, particularly on the means to prevent gear loss and to improve their retrieval, in commercial fishing gears

4.1 Results of literature review

4.1.1 Causes of gear losses

The causes of gear loss are important, both in terms of affecting lost gear evolution (section 2) and for developing prevention and mitigation measures. The causes of the losses (reasons and extent) vary between and within fisheries and fishing métiers, although some common features characterize the losses, particularly the conditions in which they occur. These factors were investigated in key European fisheries under the FANTERED 2 project and are summarized here in decreasing order of relative importance:

- conflict with other sectors, principally towed gear operators;
- increasing water depth;
- working in poor weather conditions and/or on very hard ground;
- working very long fleets; and
- working more gear than can be hauled regularly.

These factors are discussed below in more detail.

There is generally a high economic motivation to retrieve lost fishing gears by using a creeping type gear. In some cases fishing gear losses are therefore temporary and nets are retrieved in a short or long time, depending on the circumstances of the loss. The losses are permanent in other cases, after several failed attempts at net retrieval.

Generally, increasing fishing depth and rougher ground conditions make the retrieval of lost gears more difficult because the use of the creeping gears is less efficient on those grounds.

Losses occurring on ‘open’ fishing grounds are mainly due to interactions with mobile fishing gears. Examples of these include the cod gillnet fisheries in the Baltic; saithe, ling and blue ling métiers in Norway, hake netting in the UK, monkfish fishing with tangle nets in Northern Spanish waters and the hake fishery practiced by the ‘coastal’ Portuguese fleet.

The open ground fisheries usually account for the biggest amount of fishing gears lost. This permanent loss of gears is related to the fact that mobile gears usually move static gears away from their original position making them hard to find. The losses usually involve several panels of nets or a whole fleet.

Gear conflicts vary over time. In some areas, losses due to trawling had reduced in recent years due to improved communications between the skippers from the two sectors. In other areas new ground gears opened hard ground to trawlers that had previously been inaccessible. This has resulted in a greater number of net losses due to trawling.

Gear conflicts are not restricted to static and towed gears. In some areas netters, liners and potters can all be in competition for the grounds. These conflicts however are considered to be much less serious. The gears are not moved any distance and usually the caught mainline is simply cut and released.

In some fisheries (eg Greenland halibut fishery in Norway) on the continental slopes a common reason for permanent losses is often a combination of rough bottom and strong currents that result in the snagging (or ‘hooking’) of the nets on the bottom. In other slope

fisheries, gill nets are set to run down the slope whilst trawlers typically fish at constant depth along the slope – that is at 900 to the gill nets. The retrieval of the nets in these circumstances has little chance of being successful because of the adverse conditions.

Generally speaking, in inshore fisheries the loss of gears has less catch impact than offshore and the claimed retrieval rates are much higher. Thus, although some gear conflicts still occur producing significant losses (for example the trap fisheries in South Portugal) they are not so frequent. In Northern Spanish waters trawling is banned by national fishing regulation under 100 metre depth and this effectively prevents gear conflicts from occurring in inshore waters.

The fisheries on wrecks (British and French fisheries in the Mediterranean) report quite substantial amounts of fishing gears lost by snagging of the nets on the bottom. The retrieval of the gears on those cases is quite complicated and the results are very variable (ie pieces of netting and/or ropes, large bundles of nets badly tangled are recovered).

Sometimes fishermen report temporary losses due to the disappearance of the marker dahns on both ends of the fleet. This commonly occurs when dahns are submerged by the effect of strong currents, dhan ropes are cut by vessel propellers or intentionally cut. In those cases the gears are almost always retrieved using creeping gears because of the almost universal use of satellite location technologies (GPS) among the fishing fleet.

Losses due to storms are less frequent as usually fishermen are aware of approaching rough weather from weather forecast and avoid this risk. However, both these and those due to trawling, have the lowest net retrieval rates as the nets are usually moved away from the place they were set making the search very difficult.

In the deepwater fisheries that were the subject of the DEEPNET work, dumping of sheet netting was also a major reasons for gear ‘loss’.

4.1.2 Prevention and mitigation

The FANTARED work included an exhaustive identification and discussion of ghost gear prevention and mitigation measures. This work is both the most recent and most specific to EU fisheries than anything else in the literature. The FANTARED work classified the management options for addressing lost gear into two groups (Table 13).

It is important note that gear may be a) ‘lost’ and/or b) ‘discarded/abandoned’. The methods used for reducing a) lost fishing gear, and b) discarded fishing gear, may therefore need to be different (Smith, 2001). Fishing gear may not be ‘lost’, but just not easily retrievable, or can become lost when marker buoys are cut by passing vessels or by trawl or seine warps breaking during the fishing process. In some cases, fishing vessels need to cut gear adrift for safety reasons in very bad weather conditions. Given that the loss of fishing gear under these circumstances represents a financial loss to the operator, it is more than likely that an attempt will be made to recover it. The amount of time and effort spent retrieving gear is related to its value, the probability of recovery and the opportunity cost of carrying on fishing. Abandoned fishing gear, on the other hand, implies that the gear has no financial value to the fisher and that leaving it in the sea is a convenient means of disposal for the careless and irresponsible fisher.

Table 13 Preventative and curative ghost fishing measures

Preventive measures	Curative measures
Reducing risks of conflict eg zoning of active and passive fishing	Reporting of gear loss for subsequent gear recovery campaigns
Reducing risks of snagging eg gear modification	Gear recovery campaigns
Reducing efficiency of ghost nets eg biodegradable components	Opportunistic gear recovery through National Demersal Trawl Surveys
Reducing fishing effort eg net numbers, soak time, vessel numbers	
Improving gear recovery eg attachment of transponders	

In addition to these categories of measures a broader strategic approach of establishing codes of good practice and the changed behaviour that should flow from them was identified as a key to linking them both. It is also important to improve communications between fishermen, and between fishermen and enforcement agencies.

This work was taken beyond the level of academic study to the practical level of working with the fishing industry of the UK, Spain, Portugal, France, Sweden and Norway in developing a netting code of conduct of good practice to minimise gear conflict and gear loss and to agree measures to mitigate the impact of lost gear on commercially important stocks. The points over which agreement was met were:

- only setting the amount of gear that can be handled regularly and efficiently;
- marking gear properly, including the identity of the vessel;
- paying close attention to weather patterns and not setting gear when poor weather is expected;
- ensuring that gear is set in such a way as to avoid conflict with other users, and taking appropriate precautions when fishing in areas of high marine traffic;
- always carrying net retrieval gear aboard; and
- always attempting to retrieve lost gear and reporting its loss where possible.

Regional additions include using radar reflectors, using certain surface buoy combinations for strong current conditions, tagging nets and specifying minimum standards for gear construction.

In the DEEPNET study of the deepwater net fisheries (Hareide *et al*, 2005), a number of fishery specific recommendations targeted at addressing net loss and ghost fishing were made (Table 14).

Table 14 Possible management measures identified by DEEPNET (Hareide *et al*, 2005)

Recommendation	Positives	Negatives
The introduction of restrictions on the length of gear deployed at a given time either by overall length or per fleet of nets. Such restrictions were introduced in the NE Atlantic drift net fisheries for Albacore tuna.	Reduce fishing effort	Difficult to enforce and hard to monitor, although VMS does provide a level of control.

The certification of fishing gear through labelling	Provide better information of fishing effort	Legal responsibility, problems with damaged or repaired gear and potentially easy to circumvent
A requirement that vessels cannot leave gear at sea whilst landing.	Reduces discarding through extended soak times	Difficult to enforce and hard to monitor, although a combination of VMS and adequate marking of gear will provide a level of control
All gears to be marked clearly at either end	Reduce the amount of lost gear and also reduce hazard to other fishing vessels	Difficult to enforce and original EU proposals were too complex to be enforceable
The introduction of measures, which stop the practice of stripping the headline and leadline of nets and dumping of used netting at sea.	Reduce the dumping of nets at sea.	Difficult to enforce and potentially could have the opposite effect.
The spatial management of effort by gear sector, separating towed and static fishing gears	A proven method of reducing the amount of gear conflict and net loss	Probably difficult to administer and enforce in offshore areas and international waters.
Closed areas to protect ecologically sensitive habitats, such as hydrothermal vents, deepwater corals or other characteristic habitats e.g. seamounts.	Reduce the amount of lost gear and protect sensitive habitats	Difficult to monitor and enforce if areas are too small but VMS will allow monitoring of bigger areas. Widespread objection from other sectors of the industry

Related to the marking and identification of fishing gear, the European Commission commissioned a project in 1995 on the development of methods and techniques based on acoustic technology for locating nets on the surface from nets laid on the bottom of the sea (CONTRONET, 1995).

The objectives of the project were *inter alia* to investigate methods for locating underwater nets from the surface and to test and recommend the most suitable acoustic locating methods.

The study concluded that geophysical and acoustic instruments were the most appropriate methods for underwater detection. Acoustic methods (echo-sounder and sonar) were the most successful in detecting nets. Optical methods however had limited success. Active acoustic devices were too expensive and therefore not employed during the study. However, the study found that passive acoustic reflectors make a net detectable over a wider range of approach angles. The project finally recommended the use of a miniature, codified passive-sonar-transponder (microchip) to identify nets. The microchip can be inserted within either the headline or the footrope. The chip would be inexpensive when mass-produced and can be easily incorporated in the net elements during net manufacture. However, the codified identification information can only be detected and deciphered at very short ranges (up to 120 cm).

4.1.3 European preventative instruments

The dumping of fishing gear is illegal under international law. The International Maritime Organisation (IMO) Convention for the Prevention of Marine Pollution (MARPOL) specifically prohibits the abandonment of fishing gear (Annex V, Regulation 3). The accidental loss of fishing gear is however recognised under Annex V, Regulation 6. In accordance with Regulation 9 of Annex V of MARPOL, which was adopted in 1995, all ships of 400 gross tonnage and above and every ship certified to carry 15 persons or more must provide a Garbage Record Book to record all disposal and incineration operations. The date, time, position of the ship, description of the garbage and the estimated amount incinerated or discharged must be logged and signed. The books must be kept for a period of two years after the date of last entry.

At the EU level there are two notable sets of gear marking requirements that should play a role in preventing ghost fishing. The European Commission recognised the importance of marking of fishing gear in 1994 with the adoption of the Communication 'Fishing with Passive Gear in the Community - the need for management, its desirability and feasibility' (COM(94)235). This followed the FAO Recommendations for the Marking of Fishing Gear, which provides legal and technical measures that can be taken by national administrations to ensure that the abandonment of fishing gear is minimised (FAO, 1991).

In March 2005 the European Commission adopted a Regulation (Commission Regulation 356/2005) requiring passive gear (longlines, entangling nets, trammel nets and drifting gillnets) to be marked with the vessel registration numbers. The requirements apply both to gear that is actively fishing as well as gear being carried on board vessels. Such marking is intended to improve the enforcement of technical regulations such as mesh size, hook numbers and effort limitations. The introduction of such tractability should also discourage the dumping of gear that is reported in the deepwater fisheries in particular.

The marking requirements are limited to identifying the vessel to which it belongs. Soak times, setting dates or mesh sizes are not included, all of which would improve further the monitoring of these fisheries. The Regulation does not apply to waters within 12 nautical miles. This will leave many areas, most notably the Mediterranean, rather vulnerable. While this is a further weakness, many of the Baltic countries, where ghost fishing is of particular concern due to low water movements, have domestic regulations on marking requirements in their inshore waters. The Commission Regulation nonetheless applies to deepwater fisheries in Community waters, which is its primary purpose.

An unfortunate implication of the marking requirements applying to gear being carried on board vessels is that it may create an incentive for skippers to dump back at sea any abandoned gear that they may themselves retrieve in the course of fishing, rather than returning it to port for disposal.

A second set of gear marking requirements are contained in the Council Regulation 812/2004, which lays down measures concerning incidental catches of cetaceans in fisheries (OJ L 185, 27.5.2004). The regulation requires driftnets, which are only used in the Baltic until 2008, to be marked with radar reflectors so that the position can be determined.

4.1.4 Locating lost gear

In addition to fishermen interviews, FANTARED 2 also employed seabed surveys to try and determine the extent and nature of gear losses. The aim of these surveys was to investigate the potential for relatively rapid and cost effective inspections of the grounds. The seabed surveys

also aimed to establish whether remote observation techniques (or divers in some cases) could be used for locating lost gear.

Side scan sonar (SSS), remotely operated vehicles (ROV) and divers were employed. Once gillnets were detected by SSS or ROV they were retrieved using a trawler equipped with heavy retrieval gear or grapnel equipment. However, not much lost gear was found and retrieved. The localisation of lost traps by divers, however, was deemed to be successful.

Experience and success rates with the use of SSS were mixed:

- SSS could detect gillnets on soft bottoms, whereas on hard bottoms the signals from gillnets were masked by the stronger bottom echoes. However, areas with lost gillnets are normally on very hard bottom and therefore the use of SSS proved to be of limited practical use;
- SSS was used to locate wrecks, but only the superstructure of the vessel could be observed. For the localisation of gillnets this was not sufficient.
- Problems occurred while operating the SSS at greater depth due to difficulties maintaining its stability.
- While the SSS detected several target in the depth of 50-100 meters, it could not differentiate between lost and commercial nets.
- In general it was experienced that the SSS gave imprecise detection of lost nets. Especially the detection of nets on wrecks seemed difficult, except when the gillnet fleet was set with some distance apart from the wreck.

The use of ROVs also received mixed results. In general it was concluded that the use of ROVs was not very successful. The manoeuvrability of the ROV tended to be hampered by currents, while ROVs did manage to detect lost gillnets on wrecks in deep calm waters.

Underwater surveys by divers were demonstrated to be an appropriate method of quantifying lost traps in shallow waters and in wreck-based studies, but were otherwise of limited use.

A general conclusion of the seabed surveys was that the tested location methods were of limited success. One reason may have been that the trawlers had divided the nets into several pieces, or that precise information where lost gillnets could be found was not available.

4.1.5 Retrieval programmes in Europe

There is generally little published information on gear retrieval programmes. What has been produced is largely documented in internal government reports and covers methodology, success rates and lessons from gear retrieval programmes. Many of these factors were reviewed as part of the FANTARED work, which itself also employed gear retrieval as a research methodology.

In EU waters, to the consultants' knowledge gear retrieval programmes are, or have been, only used in net fisheries in Sweden and Poland. Efforts are currently being made within BIM and Seafish, amongst others, to develop a programme for deepwater net fisheries of the north east Atlantic. Retrieval programmes are also routinely employed by Norway.

Gear retrieval research

FANTARED 2 used gear retrieval as a research method for determining the extent of gear loss. A range of methods was used, including:

- heavy retrieval gear which is also employed by Norwegian retrieval programmes (see below, Figure 10);

- grapnel equipment, consisting of one or two anchors and a block of cement, connected by a 220 m long rope. The grapnel equipment was towed from a boat to 'creep' for nets;
- bottom trawling ('creeper'); and
- a method developed by Sweden in which two vessels tow a 100 m long gear in between them (Figure 7).

While several methods were employed, only the efficiency of the Swedish gear was analysed. It was concluded that the Swedish gear was not suitable for operations in areas with rough waters because of the danger of losing the entire equipment. It was also observed that the employed gear was only able to retrieve 27 per cent of the located netting, because most nets used by Swedish fishermen are not strong enough to be towed on uneven or rocky bottoms.

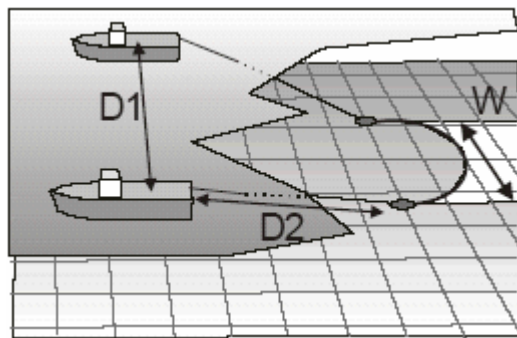


Figure 7 Two vessels towing 100 m long retrieval gear employed in Sweden

Baltic Sea retrieval programmes

In the Baltic Sea gear retrieval programmes have been carried out by Sweden and Poland. Building on the work of FANTARED 2, an experiment was conducted by the Swedish Institute of Marine Research in 2002 to evaluate the results of a four-year development project. The objective of the programme was to design and construct an efficient and cost-effective retrieval system for removal of lost or abandoned gill nets from coastal fishing grounds (Tschernij and Larsson, 2004). The expedition carried out in August 2004 was the fourth in succession following a similar expedition in June 2003. The primary aim was to evaluate the efficiency of new developed retrieval gear ('Large Scale Retrieval Systems') and to compare the efficiency of the new gear to the efficiency of that more usually used i.e. 'the traditional hook and line'. Both of these were different to the gear employed during FANTARED (Figure 7). A secondary objective was to establish an estimation of the momentary amount of lost nets.

In the 2004 expedition, three vessels were equipped with retrieval gear. One was a stern trawler made for pelagic trawling using the new Large Scale Retrieval System. The others were experienced gill net vessels using hook and line equipment. The survey was conducted for nine days along the Swedish South coast. With the help from fishermen the areas of gear conflict could be identified and the operation area was mapped accordingly (Figure 8). The area was then divided into three sampling areas: (1) off-shore reefs operated only by gillnet vessels, (2) coastal waters with conflicts operated mostly by Swedish fleets and (3) 'coastal or off-shore' fishing grounds with conflicts operated by multi-national fishing fleets.

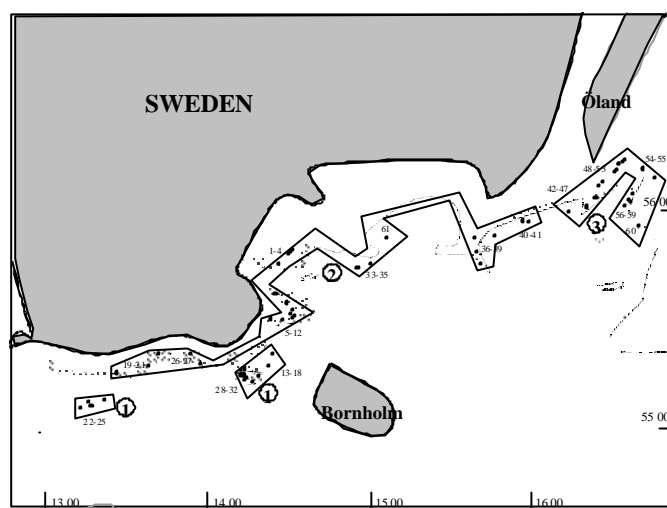


Figure 8 Area of operation for the Baltic Sea retrieval programme

The three vessels together removed 25 km of netting from the sea. Of this amount the one vessel using the new retrieval equipment retrieved 50 per cent. The new gear had a relative net retrieval efficiency 2.4 times higher than the alternative gear (Table 15). The cost of retrieving one kilometre of lost netting using the new retrieval gear was approximately €600, which is €200 less than with the alternative gear.

Table 15 The overall results for the three participating vessels

Vessel	Metod	No of tracks	Tot. tow time (h)	Retrieved (km)	% zero retriev.	% fleets 0<x<1km	% fleets x>1km	No of cod caught	Efficiency m/h
Kungsö	Test	61	47.1	12.49	54	38	8	204	265.0
Trion	Ref-1	56	55.5	7.46	64	30	5	425	111.0
Mulan	Ref-2	66	57.1	5.03	82	15	3	83	111.0
Total		183	159.7	25.0	123	50	10	712	156.4

Based on the amount of netting retrieved in the towed 61 tracks, it was estimated that the targeted areas of 260 km² can host 380 km of netting with a cod catch between 6 and 10 tonnes. The 712 retrieved cod weighed around 709 kg (Table 16).

Table 16 Estimated cod catch by area and vessel

Area type	Catch kg per vessel			Total kg	kg per km netting	
	Kungsö	Mulan	Trion		method-1	method-2
1	14	0	380	393	3.6	57.9
2	61	0	2	63	14.6	12.1
3	128	83	42	253	28.6	19.4
Total	203	83	423	709	16.3	28.4

The Sea Fisheries Institute in Poland carried out a net retrieval programme in 2004. The project was conducted for 10 days with an estimated cost of €15,000. The Sea Fisheries Institute considered the project to be of limited success because lost gear is not considered a major problem, as suggested by the local industry (pers. com *Zbigniew KARNICKI*, Deputy Director, Sea Fisheries Institute, Poland).

Norwegian gillnet retrieval

Permanent routine retrievals are only known to be operated by Norway. The Directorate of Fisheries has organised retrieval surveys annually since 1980. In the period 1983 – 2003, 9,689 gillnets of 30m standard length (approximately 290km) have been removed from Norwegian fishing grounds. In 2004 a lost gillnets retrieval survey was conducted with the aim of removing as much lost gear from fishing grounds as possible (reported in Kolle *et al* 2004). Hareide *et al* (2005) report that the key to success in this operation is accurate positional information to enable well-targeted retrieval effort. This is possible through a scheme that is supported by fishermen and operated with a broad consensus as to its value.

The 2004 survey used information gathered by the Directorate since 2000 through questionnaires regarding the position and amount of lost gear. Skippers of 210 gillnet vessels were contacted either directly in ports or by telephone and information on position and depth for 860 lost nets were collected. Of these nets, 699 were Greenland Halibut nets, 30 were nets targeting ling, 27 saithe, 90 cod and 12 redfish.

According to the amount of reported lost fishing nets the area of operation was chosen along the north coast of Norway (Figure 9).

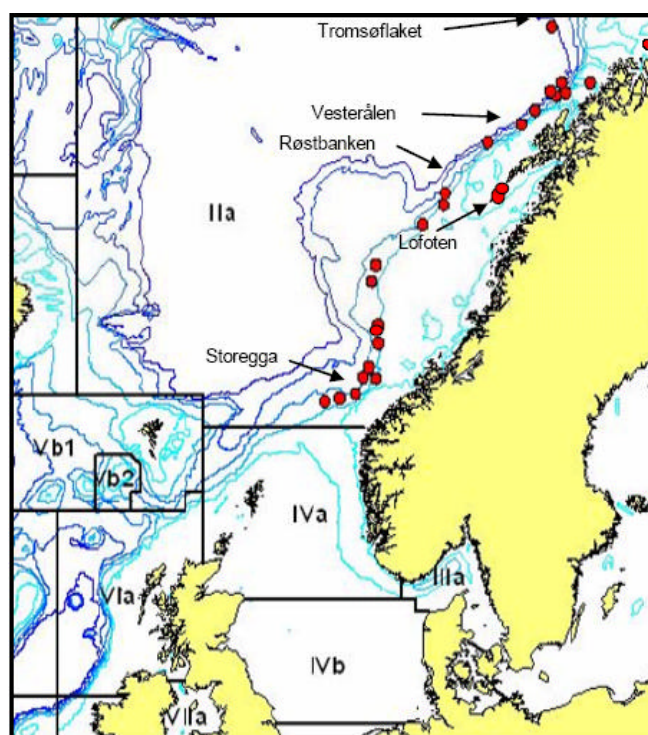


Figure 9 Positions of lost nets reported in 2004

For the survey a trawler was equipped retrieval equipment ('creeper'), which is used as standard on these surveys, with lost nets being hauled onto a net drum of the survey vessel (Figure 10). The deck arrangements included a single trawl lane, two main trawl winches (12 tons), two sweeper winches, two Gilson winches, one net drum and a crane.

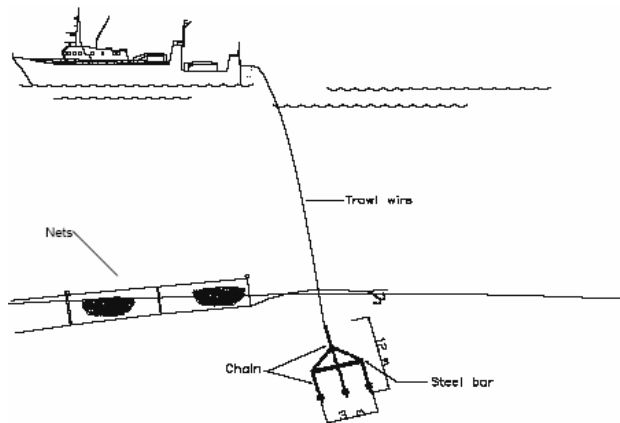


Figure 10 Retrieval gear used by the Norwegian Directorate of Fisheries.

In a total of 103 hauls, 589 nets were retrieved from depths between 500 and 800 meters. Of these 465 were Greenland halibut nets from depths between 500 and 800 meters together with quantities of longlines, dahn lines, anchors etc. Of the 8,935 kg of fish in the retrieved nets, 7320 kg was Greenland halibut, with 42 per cent of the halibut still alive. The fleets, varied between 30 and 50 nets, of 30 meters each. The normal length of fleets was 35 nets. The fish caught per fleet varied between 0 and 1700kg. The mean catch per net was 15,17 kg per fleet. In the Greenland halibut nets the catch was highest (Table 17).

The total cost of the Norwegian gear retrieval survey is around €181,500 (NOK 1.5 million) (Table 18). While the boat is hired on a tender, so varying cost between years, boat hire and fuel account for two thirds of total costs.

Table 17 Total catch of fishing gear, fish and crabs during the Norwegian annual retrieval survey for lost gear in 2004

	N.Norw.	S. Norw.	Total
Number of hauls	61	42	103
Number of nets			
Greenland halibut nets (500-800 m)	272	193	465
Ling nets (150-400m)	1	59	60
Cod nets (100 -200 m)	44	0	44
Halibut nets (150 m)	0	5	5
Saithe nets (50-150 m)	15	0	15
Total number of retrieved nets	332	257	589
Catch (kg)			
Greenland halibut (<i>Reinhardtius hippoglossus</i>)	3840	3480	7320
Cod (<i>Gadus morhua</i>)	20	0	20
Ling (<i>Molva molva</i>)	0	200	200
Tusk (<i>Brosme brosme</i>)	0	600	600
Redfish (<i>Sebastes marinus</i>)	30	50	80
Rough head grenadier (<i>Macrourus berglax</i>)	230	0	230
Skates (<i>Raja hyperborea</i> & <i>Raja radiata</i>)	0	200	200
Deep water crab (<i>Lithodes maja</i>)	285	0	285
Fish and crabs total	4405	4530	8935
Other fishing gear			
Dan lines (m)	4952	4200	9152
Longlines (m)	1200	0	1200
Dredges/ anchors (no)	6	4	10
Wire (m)	50	0	50

Table 18 Cost of the Norwegian gear retrieval survey

	Cost, NOK	Cost, €
Boat hire and fuel for one month	1.1 million	133.000 €
Collecting information (Fishermen's survey)	0.12 million	14.520 €
Survey labour cost, travel, report writing etc.	0.28 million	33.880 €
Total cost	1.5 million	181.500 €

The gillnets that are retrieved during the survey up are sent to a refuse disposal plant. The crew on the vessel recycle some of the gear, such as rope, floats and anchors, but this is not organized.

The North-East Atlantic

Norway, the UK (Seafish) and Ireland (BIM) are working together to develop a gear retrieval programme. Discussions are in an advanced stage, with a proposal currently with DG Fisheries and the UK Department for Environment, Food and Rural Affairs (DEFRA) on establishing a pilot programme.

The planned survey builds upon the FANTARED and DEEPNET (Hareide *et al.*, 2005) work, experiences of Norway (described above) and sporadic attempts at the retrieval of nets lost in Irish waters, which were reportedly largely ineffectual given the huge area, over which these fisheries are conducted (Anon, 2002, reported in FANTARED 2). The survey aims to retrieve as much lost nets as possible. It is planned to potentially extend the survey to a second area west of Scotland, which has been identified as an area with potentially large amounts of lost gear (reported in Anon, 2005b).

A survey on lost nets is planned for August/September 2005 on the Rockall bank and the adjacent slopes (North East Atlantic) in depths between 200 and 1200 meters (Figure 11), funded and managed by the BIM and the Marine Institute in Ireland (Anon, 2005b). An Irish registered trawler suitable for the work will be contracted through BIM and the Marine Institute.

The study is based on Norwegian experiences with retrieval programmes and will employ the same methodology and equipment. It will consist of two phases: the first phase involves an intense period of information gathering, including interviews of gillnet skippers in order to obtain positional data on lost nets. Information will also be obtained from NEAFC, the Scottish Fisheries Protection Agency and the Irish Navy.

The second phase will be the survey itself: A commercial stern trawler with the appropriate deck layout, adequate winch power and capacity and a large wide net drum from hauling lost gear will be hired for the survey (Figure 10). An approximate breakdown of the costs of the study is given in Table 19.

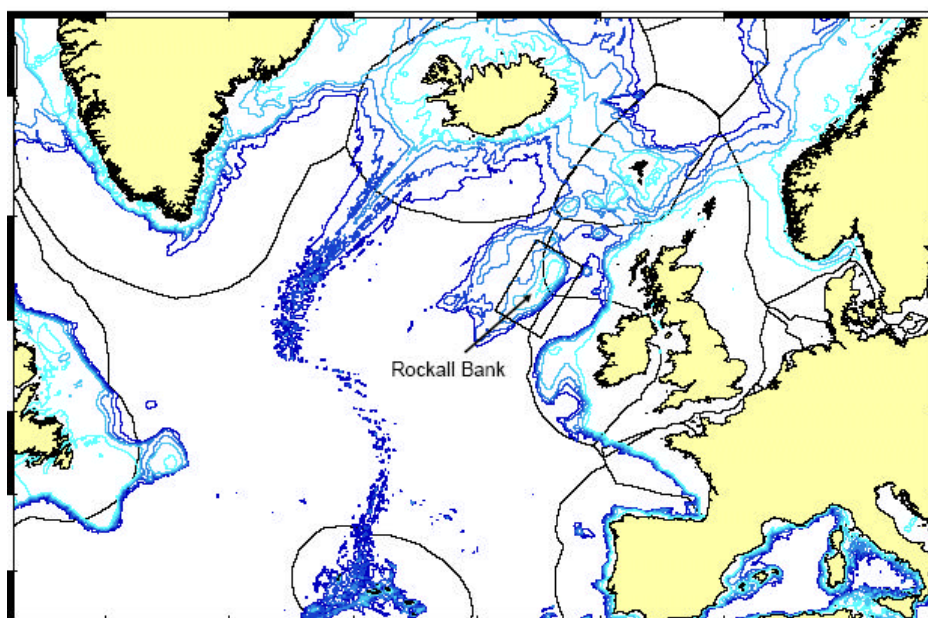


Figure 11 Proposed survey area

Table 19 Estimated costs for deepwater pilot retrieval survey

Budget Item	Total Cost in €
Boat hire 20 days at €5,000 day	€100,000
Fishermen's Survey (consultant time costs)	€15,000
Retrieval Gear	€15,000
Total	€130,000

4.1.6 Retrieval programmes outside Europe

Outside of European waters, several countries operate ad hoc gear retrieval programmes in response to well publicised or exceptional events taking place. One of the best known of the ad hoc exercises takes place in Hawaii and is well described in Donohue *et al* (2001). There a gyre in the Pacific tends to direct marine debris towards the north-western Hawaiian Islands.

Some of this is 10-20 years old and much is trawl netting. Retrieval programmes have also been employed in Canada and Greenland. A pot retrieval programme has been trailed off the coast of Alaska with mixed success.

Canada

Fisheries retrieval programmes in Canada date back to at least 1976 when the Department of Environment in Newfoundland (Canada) carried out a project to locate and recover lost gill nets.

The purpose of the project was to retrieve as many nets as possible but also determine the effectiveness of the designed gear and to ascertain to what degree, if any, the ghost nets were fishing and what effects they were having on groundfish stocks. During a preliminary phase of the project as much information about lost gill nets was gathered from local fishermen as possible. According to this information the operation area was selected (Trinity Bay and Cape Bonavista). A vessel was chartered for 20 days and equipped with 'creeping gear', 'drag gear' and 'retrieval gear'. In total, 148 nets were retrieved Newfoundland (at a depth of 140-192 fathoms) resulting from 67 hours of towing. They contained 3053 kg of groundfish and 1463 kg of crab. The average amount of groundfish taken by one 'ghost net' was approximately 20 kg, the average amount of crab was 10 kg. On the average, 86 per cent of all species taken were alive, 11 per cent were dead and 3 per cent decayed. However, 98.7 per cent of all crabs taken were still alive.

In the same year in Notre Dame Bay (approximately 190 fathoms deep), 167 nets were recovered in 54 tows. However, more recently (1990), attempts to survey lost nets on the Grand Banks (up to 98 fathoms) did not detect any gear. Fifteen hours were spent in trying to retrieve gear, using the same equipment used in 1976. No gear was recovered.

A later report from 1995 (Bech, 1995a) is largely technical in content, reporting on methodology and results. There is no discussion of costs or benefits. It was noted that there was a recovery rate of 12 per cent (12 nets), which was similar to a 1984 programme rate of 15 per cent. Of those recovered, none were 100 per cent effective at fishing, 33 per cent were fishing at a 75 per cent effectiveness, 58 per cent at 25 per cent and 8 per cent were totally ineffective. It was concluded that in this fishery the effect of ghost fishing is not as high as believed but that lost nets do cause problems for long-liners.

A second report in 1995, a study on 'Prevention of Ghost Fishing in Atlantic Canada', (Bech, 1995b) undertaken by the Fisheries and Marine Institute of Memorial University for the Department estimated the cost of lost gear retrieval as follows:

- design and testing of practical retrieval equipment \$305,000 (€98,250)
- ghost gillnet retrieval (Atlantic-wide program) \$800,000/year (€20,000/year)
(Limited focus to selected areas only)

The prevention of lost gillnets was considered much more cost effective. Unlike retrieval programs, have recurring yearly costs, prevention has a one-time, upfront cost. Specific prevention measures were identified as:

- limiting the amount of gear to that which can be handled properly by a particular size vessel and crew;
- the implementation of de-activating technologies and biodegradable materials;
- marking of gear and return incentive programs; and
- the implementation of acoustic detection systems to assist in the initial and subsequent retrieval of gears during normal operation or in the event of gear loss.

- Another option is to prohibit the use of gillnets. Although many would argue that this might be seen as a step forward for conservation, the same could also be said for many other gear types.

A 1998 Standing Committee on Fisheries And Oceans report to the Canadian Fisheries and Oceans Department noted that projects designed to retrieve gillnets using special equipment had been undertaken, with mixed success (Standing Committee on Fisheries and Oceans, 1998). At the time the Department of Fisheries and Oceans Canada was reviewing these options (DFO, 1998).

USA

In Washington State (USA) the Northwest Straits Commission (NWSC) in conjunction with the Washington Department of Fish and Wildlife (WDFW) started a program to identify and remove derelict fishing gear in 2001. The Commission has identified four fundamental steps for a successful recovery program:

- locating gear;
- verifying and setting priorities for removal;
- removing gear; and
- reusing, recycling and disposing of gear.

In 2005, NWSC and WDFW organized a gear retrieval project, which was funded by the National Oceanic and Atmospheric Administration (NOAA) to remove derelict fishing gear in Burrows Bay, Washington (NRC, 2005).

The operation was conducted for eight days. The project used divers to retrieve the nets, which had previously been identified during dive surveys conducted by WDFW. A total of 50 gillnets were retrieved. Of the 50 gillnets removed, 32 (64 per cent) were characterized as newer nets and 18 (36 per cent) was considered older nets. However, all but five of the gillnets removed were believed to present some level of lethal threat to marine life due to their generally good condition and/or the presence of suspensions off the seabed.

In 2002, the Washington Department of Fish and Wildlife developed guidelines for the removal of derelict fishing gear. These guidelines address the different types of derelict fishing gear commonly found in the Washington's marine environment, the circumstances under which removal should be attempted, the qualifications of the removal team, common methods that may be employed to locate and remove derelict gear, procedures for determining that the project can be conducted in accordance with the guidelines, disposal or recycling options, and the removal and disposal documentation and reporting process (WDFW, 2002).

Greenland

In June 1995, a gillnet retrieval project was set up in the area outside Ilukssat, between Nuaarsuk and Kingitoq in Greenland to clean the traditional Greenland halibut fishing grounds of lost nets (Bech, 1995). The survey consulted local fishermen about the areas with a high number of lost gillnets.

Dredging was conducted from 30-foot fishing vessels and a small shrimp trawler. A special type of grapnel consisting of a steel pipe with barbs welded on with 90° space was used for the dredging.

Within 7 days a total amount of 101 dredges retrieved 12 gillnets and 80 longlines. The nets were retrieved from depths between 200 to 350 meter, surfacing a total catch of 375 kg fresh Greenland halibut. However, the project concluded that the used retrieval gear was ineffective

due to the fact that the barbs often broke or bended and retrieved fishing gear was lost easily during the hauling process.

South Korea

In South Korean waters there is an international fishery for Alaska Pollock, which straddles the country's 200 mile zone. Reports of high levels of net loss prompted the government to fund a retrieval programme, which has run since 1998. An (2001) (in FANTARED 2) described the retrieval of over 10 tonnes wet weight per nautical mile towed in several of these exercises although these extraordinary amounts have not been explained comprehensively (FANTARED 2).

Australia

On 30 November 2004 the Australian Government Minister for the Environment and Heritage, Senator Ian Campbell announced that the Gulf of Carpentaria will be cleared of derelict fishing nets and other debris under a \$2 million Australian Government programme to save threatened marine and coastal animals from entanglement². At present this largely entails a beach clean ups although gear retrieval may be considered as part of the programme

Alaska pot retrieval

Stevens *et al* (2000) used a pot retrieval system based on sonar identification as part of a study into the extent of ghost potting. Sonar was considered a very effective tool for locating pots and allowed targeted retrieval using trawls. However, random trawling for pots was more efficient in retrieving pots in some cases. There was no feasibility study or evaluation of the methodology as an ongoing management tool as it appeared to be used only for the purposes of the research programme.

4.1.7 Key lessons from retrieval programmes

Drawing on the research from FANTARED, the literature and experiences reviewed above and the review of gear retrieval by Smith (2001), a number of lessons can be summarised.

The type of gear suited for gear recovery varies with environmental conditions, with a range of gear types illustrated in Appendix F. The typical recovery method consists of dragging a creeper designed to snag the gear along the sea bottom until the gear is found. With light gear, such as traps and lines, the effect of tide and/or wind on the vessel is sufficient to generate a dragging motion. Where there is little or no wind or tide, the vessel must use power to drag the creeper slowly along the sea bottom. Too much tension on the creeper wire should be avoided as the lost line or trap attachments could break. In this respect, when there are very strong tides, the vessel must tow the creeper slowly against the current.

With heavy gear, the creeper operation can be much more active. The vessel's power can be used to a greater extent and a far higher tension can be kept on the creeper wire. In such cases a weight must be connected to the wire some distance ahead of the creeper to ensure that good ground contact is made and that the creeper moves horizontally. Monitoring the tension in the wire carries out the creeping operation. Successful contact with the gear is indicated by an increased tension.

Another method of retrieving fishing gear or any other item lost on the sea bed is to use a different type of fishing gear (generally trawls). Although this may not be as effective as

² see <http://www.deh.gov.au/minister/env/2004/mr30nov04.html>

creepers, the cost of lost fishing is, to a certain extent, avoided. However, the vessel must fish in the same area as that in which the gear was lost. Attachment of the creeper to the toes of the net increases the chances of snagging lost gear.

A simple fishing ground clean up method on relatively clean ground is to sweep the area with a trawl net. Even if recovery is not complete, the damage done to set nets and/or traps would be sufficient to ensure that ghost fishing does not continue. This system should not be used on or close to reefs or in very shallow water. In the latter case it could cause danger to the vessel and its crew.

Knowing the exact location of lost gear greatly enhances chances of recovery. Close to shore this can be achieved by using landmarks; artisanal fishers are skilled in this method. The fall in the cost of GPS systems also means that in most cases the position can be known and recorded in offshore waters.

It should be stressed that the research into gear retrieval and lessons from programmes employed routinely is that there are several drawbacks with curative measures that mean they should not be relied upon to resolve the problem of gear loss:

- only small areas of fishing ground can be covered in retrieval campaigns so very precise information on the location of lost gears is essential – requiring, in turn, accurate reporting of gear losses by fishermen;
- they do not prevent fishermen from suffering economic losses through lost gear, lost fishing time and lost catch;
- retrieval gears have a limited recovery efficiency;
- lost gears remain at sea for a period of time between loss and retrieval often resulting in some catch of commercial species; and
- the retrieval of gears is costly.

Source: FANTARED 2

4.2 Research gaps

A research gap is an evaluation of the FANTARED developed code of conduct. Significant efforts were employed in this work with a range of stakeholders and international input. It would be useful to know how successful and replicable the work was and the factors in determining this. This would then support the decision on whether to pursue this as a management option in other fisheries, and the factors to consider in developing such codes.

There is virtually nothing in the published literature on the feasibility of gear retrieval programmes. What has been done is largely restricted to estimations of the costs of ghost fishing (and hence the cost of having no clear up programme) in terms of value of ghost catch, (eg Al-Masroori, 2002, Mathews *et al*, 1987 in Al-Masroori *et al*, 2004) and, separately, the cost of gear retrieval programmes (eg Tschernij and Larsson, unpublished). As gear retrieval programmes are largely documented and developed within government administrations, it is difficult to determine the extent of this research gap or whether it is simply confined to the grey literature.

4.3 Comments from workshop

5 Summary of existing knowledge on the environmental impact of lost gear and how this compares with the environmental impact of active commercial fisheries

5.1 Results of literature review

In addition to the removal of ‘target’ fish species (discussed under section 2) and the associated wider ecosystem impacts of this mortality, lost gear can impact on the environment more broadly. This includes impacts on commercial and non-commercial non-target species, as well as impacts to benthic environments. As a type of persistent synthetic material, lost gear interacts biologically in two main ways (Shomura and Yoshida, 1985, in Laist 1997):

- entanglement, whereby the loops and opening of debris entangle or entrap animals and their habitats; and
- ingestion, whereby debris is intentionally or accidentally ingested.

Lost gear also has a negative aesthetic impact as a source of litter at sea and on beaches, and can potentially entangle with active fishing gear and vessel propulsion systems.

5.1.1 Biological impacts

Incidence

A comprehensive review of the impacts of marine debris globally, including lost gear, was undertaken by Laist (1997). Entanglement was considered by far the most likely cause of mortality than ingestion. Fishing gear (monofilament line, nets, and ropes) was found to be the most significant source of entanglements in all documented records for sea turtles, coastal and marine birds, marine mammals and fish and crabs. The greatest source of this material was considered to be commercial fishing operations, although recreational fishing and cargo vessels ships were also considered potential sources.

Effects

The effects of entanglement are largely mechanical. They result in exhausting and eventual drowning; impair mobility, feeding and reproduction. The affected animal may become snagged on underwater or land-based features such as rocks or trees or else, resulting in trauma. All of these impacts may affect behaviour, such as diving depth and time spent at sea. Impacts to benthic environments may be through smothering, abrasion, ‘plucking’ of organisms, meshes closing around them, and the translocation of seabed features for example. With large nets, the area impacted may be considerable.

Impacts

It is estimated that over one million birds and 100,000 marine mammals and sea turtles die each year from entanglement in, or ingestion of, plastics (Laist, 1997). Furthermore, at least 135 species of marine vertebrates and 8 species of marine invertebrate have been reported entangled in marine litter (Laist, 1997). However, the species-level impacts of entanglement in marine debris are unclear. For most seabirds (particularly procellariiform seabirds, penguins, grebes and loon, toothed whales and fish), evidence is lacking or based on isolated or infrequent reports. In this case, entanglement is unlikely to have an effect at a population level. Species such as Gray whales, California sea lions, northern elephant seals, northern gannets, herring gulls, shags, have large or increasing populations where entanglement may

be a chronic low-level source of mortality but having little effect on population numbers. However in the case of endangered or threatened species such as some sea turtles, even low-level entanglement may affect populations directly and so be an obstacle to population recovery.

Much of the data in Laist's review and subsequent work relates to species outside the EU. While this is useful for drawing lessons, species of direct relevance to the EU for which evidence is available appears largely confined to northern gannets and herring gulls. Perhaps most significant however is that for sea turtles which are considered to be particularly vulnerable to the effects of entanglement and are afforded protection under the habitats Directive.

Notable cases of reported impacts of lost gear on non-commercial species include the following:

EU cases

- Fishermen complain that lost nets in Algarve are at such a level that they interfere with normal fishing practices, possibly leading to further gear loss, and that reefs are smothered to the extent that reef fish may have reduced access (Erzini *et al* 1997);
- Inshore nets set by Erzini *et al* (1997) eventually became incorporated into the reefs and provided a complex habitat through forming a base for colonising animals and plants;
- A gillnet set experimentally in inshore waters of the UK by Kaiser *et al* (1996) caught three shags when brought into the shore by wave action. While this may be unrepresentative of normal fishing operations which are in deeper waters, this is thought to be a potential problem when nets are washed ashore and may vary seasonally according to breeding habitats of birds such as auks (Teixeira 1986);
- Entanglement in static fishing gear and abandoned nets (ghost fishing) are thought to cause a serious impact on monk seal (*Monachus monachus*) in the Mediterranean, as reviewed by Johnson and Karamanlidis (2000). This is a population suffering rapid decline despite being listed as a critically endangered species and fishing related mortality considered as unacceptable. Prior to the establishment of a protected area, the extensive use of gill nets constituted a major threat to the survival of the small surviving monk seal colony in the Desertas Islands of Madeira. It was reported in 1998 that animals had been dying frequently by entanglement in lost nets (Anselin and van der Elst 1988, in Johnson and Karamanlidis (2000)). It was subsequently reported that a major clean-up operation, coupled with an initiative to have fishers convert from net gear to long lines effectively solved the problem (Neves 1991, in Johnson and Karamanlidis (2000)). It is not currently known what the situation is now in this and other areas.

Non-EU cases

- In 1978, 99 seabirds of five species, two salmon sharks, one ragfish and over two hundred chum and silver salmon were found in a 1.5km long lost salmon driftnet in the western North Pacific (DeGange and Newby 1980);
- off Newfoundland, it was estimated that over 100,000 marine birds and mammals were killed in a four year period by ghost fishing (JNCC, 2004);
- the incidence of entanglement of marine mammals in floating synthetic debris in the Bering Sea has been related to the growth in fishing effort and the use of plastic materials for trawl netting and packing bands. In the north east Pacific, it was estimated that 15 per cent of the mortality of young fur seals (*Callorhinus ursinus*) could be attributed to net debris, with the average seal expected to encounter 3 to 25 pieces of net debris annually (Fowler, 1987 in Goñi, 1999).

- In Australia, Australian sea lions are most frequently entangled in monofilament gillnet that most likely originates from the shark fishery, which operates in the region where sea lions forage. In contrast, New Zealand fur seals are most commonly entangled in loops of packing tape and trawl net fragments suspected to be from regional rock lobster and trawl fisheries (Page, 2004).

Research Gaps and limitations

There is a lack of data in the biological environmental impacts in European waters. A key problem with entanglement data the world over (see Table 20) is that it is rarely possible to determine whether animals found in lost gear became entangled during active fishing or in lost gear or gear fragments. Reports of fish species entanglement were considered by Laist (1997) to be especially incomplete, although the work of FANTARED has since filled this gap to some extent.

Table 20 Factors complicating the analysis of marine entanglement trends

Detection	Sampling and reporting biases
Entanglements occur as isolated events scattered over wide ranges	Virtually no direct, systematic at-sea sampling has been done and there are few long-term surveys.
Entangling debris is not easily seen on live animals at sea because animals may only be partially visible at great distances	Sampling methodologies are inconsistent
Dead animals are difficult to see because they float just beneath the surface and may be concealed within debris masses	Standings represent an unknown portion of total entanglements
Dead entangled animals may disappear quickly because of sinking or predation.	Shore counts of live entangled animals are biased toward entanglement of survivors carrying small debris
	Entangled animals spend less time ashore and more time foraging at sea
	Some entanglements reflect interactions with active rather than derelict fishing gear
	Many entanglement records may remain unpublished or anecdotal and cannot be compared geographically or temporally
	Few data is available for periods before 1980

While many of these data limitations are difficult to address, Laist (1997) considered there to be a need to better document and monitor entanglement rates. At sea observations of sea turtles were considered especially promising as well as land-based surveys for entangled seals and seabirds that come to shore to nest and breed. Indeed, in the context of the EU, research should be undertaken in these two areas, focusing on those species afforded protection under the habitats Directive, including cetaceans, Mediterranean Monk seal and Saimaa seal, otters, turtles, houting, and the European and Adriatic Sturgeon.

5.1.2 *Aesthetic impact of lost gear as a source of litter*

The significance of the aesthetic impact of fishing gear as a source of litter will vary by region. The aesthetic impacts will be particularly important in areas where tourism is significant, such as the Mediterranean.

Incidence

A study into the economic and social impacts of marine debris in the northeast Atlantic (Hall 2001) identified lost ropes and nets as a problem both on beaches and to the fishing industry, with fishing vessels being perhaps the main source of discarded fishing net, line and rope. However, detailed data is not available.

Golik (1997) reviewed the types, quantities and behaviour of debris in the Mediterranean Sea. There appears to be very little research into the incidence and impact of marine litter, including that originating from fishing, in the Mediterranean (Golik, 1997). Bingel (1989) (in Golik, 1997) attempted to estimate the quantity of fishing gear lost in the Mediterranean Sea, based on an extrapolation of data from the Turkish industry losses based on vessel numbers, coastline length and shelf area:

Basis of Extrapolation	Gear Loss t/year
Vessel Numbers	3342
Coastline Length	2803
Shelf Area	2637

Evidence from a five country UNEP survey suggested that fishing gear was generally relatively rare along the beaches of the Mediterranean (UNEP/IOC/FAO 1991, in Golik, 1997).

In the UK, fishing debris such as line, nets, buoys and floats is the second biggest source of beach litter at 14.6 per cent. It would appear that fishing as a source of litter is on the increase, been the highest recorded in 2003 (Marine Conservation Society 2004). The proportion of litter originating from fishing gear is also over twice that reported in nationwide beach clean ups in the USA, where fishing or boating gear comprised 6.1 per cent of the total litter items collected by number in 1988 (O'Hara, 1990). Included were 1,281 metal crab or fish traps.

Research Gaps and limitations

As noted above, there is a lack of EU and national level data on both the incidence and aesthetic impact of lost fishing gear as source of marine litter. The most comprehensive data available covers fishing gear as a source of marine debris in the UK, with some estimates for the Mediterranean region as a whole.

5.1.3 *Comparison with active gears*

The assessment of ecosystem impacts of lost gears in Europe has been largely confined to the impact on stocks of commercially important marine species. Impacts on species that are commercially unimportant tend to receive less attention. This is often because it is very difficult to determine whether impacts are incurred before or after gear is lost.

Nets

Gillnets have little impact on the benthic fauna and the bottom substrate (Huse *et al.*, 2002). The bottom line of gillnets are produced of lead ropes of various dimensions. Cod net lead ropes, for example, often have a diameter of 12 mm and a weight of 250 g per m. The pressure on the bottom sediments is therefore very low. Gillnets may be dragged along the bottom by strong currents and wind during retrieval, potentially harming fragile organisms like sponges and corals. In many areas where gillnets are used, the water is deep or the current is periodically strong, necessitating the use of heavy anchors (>100 kg) which may cause localised impact.

To be completed, especially in light of survey results

Fishery	Commercial Catch	Ghost Catch

Pots and traps

In general, passively-fished traps are advocated on an environmental basis for having a lesser impact on habitat than mobile fishing gear such as trawls and dredges (Rogers *et al.*, 1998; Hamilton, 2000; Barnette, 2001) as well as being a less energy intensive fishing method (Brown and Tyedmers 2005). The potential physical impacts of ghost traps depend upon the type of habitat and the occurrence of these habitats relative to the distribution of traps (Guillory 2001). In general, sand- and mud-bottom habitats are less affected by crab and lobster traps than sensitive bottom habitats such as submergent aquatic vegetation (SAV) beds or non-vegetated live bottom (stony corals, gorgonians, sponges) (Barnette, 2001). Research on pot fishing in UK waters also suggested that pot fishing does not have immediate detrimental environmental impacts (Eno *et al.*, 2001)

Observations of the physical impacts of ghost blue crab traps on SAV in the Gulf of Mexico suggest that crab and lobster traps have a low impact on SAV habitat (Barnette, 2001). Stephan *et al.* (2000) concluded that although each individual trap has a relatively small footprint, Atlantic Coast SAV habitat could be impacted because of the large number of crab traps.

The impact of derelict traps on sensitive habitats differs from that of actively-fished traps. The effects of trap deployment and recovery would be less in derelict traps than in actively-fished traps while the opposite would be true for the effects of smothering. Jennings and Kaiser (1998) suggested that the frequency and intensity of physical contact are important variables when evaluating the effects of fishing gear on the biota. In conclusion, derelict traps, while individually occupying a small area, may impact SAV because of their large number and potential smothering effect (Guillory 2001).

5.2 Costs of lost gear

The costs of marine litter, with the fishing industry being one of many sources, to the UK tourism, clean ups and fishing industry are estimated by Hall (2001) and the Marine Conservation Society (2004).

5.2.1 *Costs to fishing industry*

Marine litter results in lost revenue for fisheries, due to the time and effort involved in sorting debris from the catch, while larger items may actually tear fishing gear. A survey of fishermen in Shetland reported that 92 per cent had accumulated marine debris in their nets; 69 per cent had had their catch contaminated and 92 per cent had snagged their nets on debris on the seabed. Many had also had problems with fouled propellers and blocked intake pipes. Costs associated with the time spent to clear and repair nets and from lost catch due to contamination can reach up to £2,000 per incident, and amounted to between £6,000 and £30,000 annually based on one incident per year and a 40-hour working week. Fouled propellers and pierced hulls can also endanger human life, if the vessel cannot return to port, or cannot steer to avoid collision (Global Marine Litter Information Gateway, 2004).

5.2.2 *Costs to tourism*

Of the £11 billion a year UK seaside and maritime leisure industry, some two thirds of this relates to seaside holidays (Maritime Technology Foresight Panel, 1996). A study of beaches in the Firth of Forth found beaches with the highest aesthetic quality were those that were cleaned regularly (Somerville *et al.*, 2003). Recreation and tourism are particularly affected by the presence of sewage related debris. An ENCAMS survey of beach users found that a clean beach was the biggest factor influencing a visit to the beach. Beach litter, and in particular broken glass, followed by sanitary items were found to be the biggest cause of offence to beach users (ENCAMS, 2003).

5.2.3 *Clean up costs*

Repeated beach clean-up efforts reduce the amount of debris on the shore in the short term, but these reactive efforts can be expensive and time consuming, and do not directly address the source of the problem. Local authorities, and ultimately local taxpayers, bear the financial burden of clearing litter on UK beaches. In a survey of 56 local authorities in the UK, the annual expenditure on beach cleaning ranged from £15/km in West Dunbartonshire to £50,000/km in Wyre and came to a total of £2,197,138 (Hall, 2001). Local authorities, industry and coastal communities spend approximately £14 million a year to clean up coastal marine litter in England and Wales (Environment Agency, 2004). Harbour authorities also have to pay for the costs of keeping navigational channels clear of litter. A survey of 42 harbour authorities reported that up to £26,100 is spent per year in some ports, to clear fouled propellers and remove debris from the water (Hall, 2001).

5.3 **Research gaps**

5.4 **Comments from workshop**

6 Assessment of the costs and benefits of management options

6.1 Introduction

Ghost fishing has a number of costs/negative impacts on fishers and others that may be environmental, social, or economic/financial in nature. By inference, reducing ghost fishing through certain management measures (see Table 14) will have certain benefits, but may also involve related costs. Table 21 presents some of the possible costs and benefits of reducing ghost fishing in areas where it is deemed to be a problem, some related to management measures related to preventing net loss in the first place, and some related to reducing the extent of ghost fishing once net loss has taken place.

Table 21 Summary costs and benefits of reducing ghost fishing

	Costs	Benefits
Environmental	<ul style="list-style-type: none"> Some negative impacts on scavenger species that may depend on 'ghost' nets and pots Potential impacts of resource productivity if ghost nets acting as reefs once fouled, rather than actively catching fish 	<ul style="list-style-type: none"> Reduced unintended fish mortality of commercial/target species Reduced unintended mortality of non-target species (marine mammals, birds, reptiles, etc) Reduced abrasion, 'plucking' of organisms, and translocation of sea-bed features Reduced littering of beaches
Social		<ul style="list-style-type: none"> Enhanced employment in fishing communities resulting from increasing catch levels associated with reduced unintended fish mortality
	<ul style="list-style-type: none"> Could potentially impact (positively or negatively) on some gear manufacturers and employees if fishermen switch gear 	
Economic	<ul style="list-style-type: none"> Potential costs to fishermen from modified gear in the form of: <ul style="list-style-type: none"> Increased costs of nets Possible reduced target/intended catch rates Reduced handling efficiencies Cost (to fishermen or administrations) of retrieval programmes/activities to remove lost/discarded gear, or other management measures e.g. costs of time required for better communication, costs of better marked gear, etc Management costs of monitoring the extent of ghost fishing and the impacts of any management measures Costs of further research required Management costs of enforcement of any new regulations associated with 	<ul style="list-style-type: none"> Enhanced income/value-added resulting from reduced ghost fishing mortality which is therefore able to be caught by fishermen Multiplier effects of increased fishing income Reduced gear/engine entanglement with lost/discarded gear, resulting in less sorting/disentanglement time, more fishing time, and reduced costs of any gear lost as a result of entanglement³ Improved incomes through reduction in lost gear and associated lost fishing time involved with searching for lost gear, associated with measures to reduce number of lost nets Improved catches as fish are not 'wary' because of ghost-nets (as in Bech, 1995a)

³ Marine litter (some of it from ghost fishing) may result in lost revenue for fisheries, due to fouled propellers and blocked intake pipes, and can also endanger human life, if the vessel cannot return to port, or cannot steer to avoid collision

6.2 Costs and benefits of possible gear retrieval programmes

Clearly not all the costs and benefits in the table above associated with different management options are quantifiable within the scope of a relatively small study such as this. However, the Terms of Reference require a particular focus on retrieval programmes through ‘an assessment of the costs and benefits of a possible wide-ranged programme of retrieval of lost gear’.

Following the workshop to be held in Brussels in May, analysis will be completed to meet this requirement of the ToR. The focus on retrieval programmes is felt to be especially relevant given the extent to which a number of countries/administrations are already engaged in such activities, or are planning to do so, but perhaps without any detailed economic assessment of whether the benefits of doing so outweigh the costs. It is hoped that the methodology developed during this study might be of use to others in assessing whether retrieval programmes generate greater net benefits than other management measures.

In completing the cost/benefit analysis, for each fishery a fishery-wide model will be constructed based on the survey work completed during the study and other relevant data sources, with a number of key variables used to assess the net benefits of a retrieval programme. These variables will include:

- total vessel numbers in the fishery;
- costs of nets/floats/ropes used by fishermen;
- number of nets/floats/ropes lost and not recovered by fishermen;
- cost of retrieval programme;
- percentage of total nets lost that are recovered by retrieval programme;
- average age of recovered nets (affecting their re-use, their depreciated value);
- value of re-usable nets/floats/ropes recovered by retrieval programme;
- average time after loss that nets are recovered (affecting the extent to which they are ghost fishing at time of retrieval);
- rate of decline in ghost catch over time (i.e. ghost catch as a % of active catch), and the level of ghost catch at time of retrieval. This variable, in association with the preceding one, is likely to be especially important as it may be the case that by the time a (yearly?) retrieval programme is implemented, the ghost net is making only very small ghost catches, and thus the benefits of preventing this ghost catch may be minimal);
- value-added per tonne of fish catch in active gear; and
- value-added ‘saved’ from the ghost catch prevented for later extraction by fishers, based on fish catch as a proportion of stock biomass.

It is not expected to be possible within this study to be able to quantify the following:

- environmental costs/benefits of retrieval programmes in a specific fishery;
- bio-economic benefits of stock improvements;
- social costs/benefits of retrieval programmes
- income multiplier benefits of higher catches resulting from increased stock biomass following reduced ghost fishing;
- reduced gear/engine entanglement with lost/discarded gear, resulting in less sorting/disentanglement time, more fishing time, and reduced costs of any gear lost as a result of entanglement; and

- improved catches if fish become less ‘wary’ because number of ghost-nets is reduced.

6.3 Costs and benefits of other management options

While not strictly within the ToR, the study team will also attempt to quantify some costs/benefits associated with other management measures, based on:

- those which show most support from within the industry, as evidenced by the surveys completed; and
- those which participants at the workshop feel offer most potential

Attempts will be made to apply/amend the model developed for retrieval programmes, to other management measures. Again, it is hoped that the model will be adapted and developed but others in assessing the costs and benefits of other management measures. Additional quantifiable variables might include:

- the value of saved leisure time resulting from fishermen spending less time searching for lost gear, if management measures reduce the extent to which gear is lost in the first place;
- the value-added that could be generated through additional fishing if reduced time spent looking to lost gear resulted in greater catches being able to made (of non-quota species);
- costs of modified gears to reduce ghost fishing once nets are lost;
- costs of better communication and/or development and implementation of codes of conduct;
- costs of monitoring the extent of ghost fishing and the impacts of any management measures;
- costs of enforcement of any mandatory/regulatory management measures; and
- value of gear that is prevented from being lost where management measures are successful in reducing gear loss.

6.4 Ranking of management options

Given the findings of Sections 6.2, 6.3, for each of the fisheries examined in detail during the study, recommendations will be made, where possible, on the most appropriate management options.

7 Work programme for future management and research action

Based on above. Concrete proposals, timeframes and responsibilities.

Appendix A References

- Al-Masroori H.S. (2002), *Trap ghost fishing problem in the area between Muscat and Barka (Sultanate of Oman): an evaluation study*, MSc. Thesis, Sultan Qaboos University, Sultanate of Oman.
- Al-Masroori H., Al-Oufi H., McIlwain J.L. and McLean E., (2004) *Catches of lost fish traps (ghost fishing) from fishing grounds near Muscat*, Sultanate of Oman Fisheries Research, Volume 69, Issue 3, October 2004, Pages 407-414.
- Anon. (2001). The gillnet: a controversial fishing gear requires responsible fishermen. Fisheries and Oceans Canada, Fisheries Management Sector, FDP Project N°. 260: 10 p.
- Anon (2004a) *Economic Performance of Selected European Fishing Fleets*. Annual Report 2004. December 2004. Concerted Action (Q5CA-2001-01502) ISBN: 90-5242-958-8.
- Anon (2004b) Agreed Record of Conclusion of Fisheries Consultations Between the European Community and Norway for 2005. Brussels, 26 November 2004.
- Anon (2005a) *Driftnets and loopholes The Continued Use of Driftnets by the Italian Fleet*. RSPCA and Humane Society International Report.
- Anon (2005b), *Pilot study on retrieval surveys for lost nets at Rockall, 2005*
- Anselin, A. and Van der Elst (eds.) 1988. *Monk Seal Bulletin 7*: 1–5. Institut Royal des Sciences Naturelles de Belgique. Brussels
- Barnette M.C. (2001) *A review of fishing gear utilized within the Southeast Region and their potential impacts on essential fish habitat*, NOAA Tech. Memo., NMFS-SEFSC-449.
- Barney W. (1984), *Lost gillnet retrieval project 1983-1984*, Fisheries and Oceans, Fisheries Development Branch, Newfoundland Region, FDB-1983-84-26, Newfoundland, Canada.
- Bech, G (1995a) *Retrieval of lost gillnets at Ilulissat Kangia*, Scientific Council meeting, Greenland Fisheries Institute, NAFO.
- Bech, G (1995b) *'Prevention of Ghost Fishing in Atlantic Canada'* undertaken by the Fisheries and Marine Institute of Memorial University for the Department, March 31, 1995.
- Bingel, F. (1989) *Plastic in the Mediterranean Sea*, IOC/UNESCO: 1-65
- Blott A.J. (1978) *A preliminary study of timed release mechanisms for lobster traps*, Mar. Fish. Rev. 40, 40-49.
- Bullimore B. A., Newman P. B., Kaiser M. J, Gilbert S. E., Lock K. M., (2001) *A study of catches in a fleet of 'ghost-fishing' pots - lost fish traps* - Statistical Data Included Fishery Bulletin, April 2001.
- Breen P. A., (1987) *Mortality of Dungeness Crabs Caused by Lost Traps in the Fraser River Estuary*, British Columbia., North American Journal of Fisheries Management: Vol. 7, No. 3, pp. 429–435.
- Breen P.A. (1990), *A review of ghost fishing by traps and gillnets*, in: Shomura, R.S., Godfrey M.L. (Eds.), (1989) *Proceedings of the Second International Conference on Marine Debris*,

2-7 April 1989 Honolulu, HI, November 26-29, 1984, NOAA Tech Memo NMFS, US Department of Commerce.

Brothers G. (1992) Lost or abandoned fishing gear in the Newfoundland aquatic environment. Marine Stewardship in the Northwest Atlantic. Presented at the Symposium on Marine Stewardship in the Northwest Atlantic, St. John's, Newfoundland. November. 1992.

Brown J and Tyedmers P (2005) Production of Fish. In Sporrang N, Coffey C, Brown J and Reyntjens D (eds) *Sustainable EU fisheries: facing the environmental challenges*. FISH/IEEP Conference report, European Parliament, Brussels, Belgium, 89 November 2004. ISBN 1 873906 49 8

Carr H.A., Amaral E. H., Hulbert A.W. and Cooper R. (1985), *Underwater survey of simulated lost demersal and lost commercial gill nets off New England*, in: Shomura, R.S., Yoshida H.O. (Eds.), Proceedings of the Workshop on the Fate and Impact of Marine Debris, Honolulu, HI, November 26-29, 1984, NOAA Tech Memo NMFS, US Department of Commerce.

Carr H.A., Cooper, R.A., (1987) *Manned submersible and ROV assessment of ghost gillnets in the Gulf of Maine*, in: Proceedings of the Oceans'87, The Ocean- An International Workplace, vol.2, Halifax, NS, pp. 984-986.

Carr H.A. (1988) *Long term assessment of a derelict gill net found in the Gulf of Maine*, Oceans '88 (Proceedings of the Marine Technology Society): 984-986.

Carr H. A., Amaral E. H., Hulbert A.W. and Cooper R., (1992) *Underwater survey of simulated lost demersal and lost commercial gill nets off New England*. In Marine debris: sources, impacts and solutions (J. M. Coe and D. B. Rogers, eds.), p. 171–186, 1990, Springer, New York, NY.

Carr H.A., Harris J. (1994) *Ghost fishing gear: have fishing practices during the few years reduced the impact?* In: Coe J.M., Rogers D.B. (Eds.), Seeking Global Solutions, Miami, FL, Springer-Verlag, New York.

CEC (2003) Proposal for a Council Regulation laying down measures concerning incidental catches of cetaceans in fisheries and amending Regulation (EC) No 88/98. COM(2003) 451.

CEC (1994). Fishing with Passive Gear in the Community - the need for management, its desirability and feasibility' COM(94)235FINAL. Communication from the Commission of the European Community.

Chiasson, Y.J., DeGrace, P., Moriyasu, M., Bourgoin, A., and Noel, D. 1992. A retrospective look at the development and expansion of the southwestern Gulf of St. Lawrence snow crab, *Chionoecetes opilio*, fisher. Canadian Technical Report of Fisheries and Aquatic Sciences. 1803 17

Chopin F., Inoue Y, Matsuhita Y., Arimoto T. (1995), *Sources of accounted and unaccounted fishing mortality*, in: Baxter B., Keller S. (Eds.), Proceedings of the Solving By-catch Workshop on Considerations for Today and Tomorrow, University of Alaska Dea Grant Collage Program Report No 96-03, pp. 41-47.

Coe, J. M. and D. P. Rogers (eds.). 1997. *Marine Debris: Sources, Impacts, and Solutions*. Springer-Verlag, New York, NY. 432 pp.

CONTRONET (1995) Project N° 95/028: Study of Alternatives for Net Location and/or Identification: Technical Control Devices (CONTRONET).

Cooper R.A., Carr H.A., Hulbert A.H. (1987), *Manned submersible and ROV assessment of ghost fishing on Jeffery's and Stellwagen banks*, Gulf of Maine, NOAA undersea Research Programme, Research Report, No. 88-4.

DCMNR (2005) Updated information (04 February 2005) regarding applications received under the Scheme for the Licensing of Traditional Pot Fishing Vessels in the Irish Inshore Fleet. Department of Communications, Marine and Natural Resources. <http://www.dcmnr.gov.ie/Marine/Sea+Fisheries/>

DeGange, A. R., and Newby T. C., (1980) *Mortality of seabirds and fish in a lost salmon drift net*, Marine Pollution Bulletin 11:322323.

DFO (1998) Government response to the report of the Standing committee on fisheries and oceans, *The East Coast Report*, September 1998. http://www.dfo-mpo.gc.ca/communic/reports/east-est/eastresponse_e.htm

Donohue, M.J., R.C. Boland, C.M. Sramek, G.A. Antonelis. 2001. Derelict Fishing Gear in the Northwestern Hawaiian Islands: Diving Surveys and Debris Removal in 1999 Confirm Threat to Coral Reef Ecosystems. *Marine Pollution Bulletin* Vol. 42, No. 12, pp. 1301-1312. PII:S0025-326X(01)00139-4.

Dunlin G., (2000) *A model of European-wide cooperation between industry and the establishment*, in: Proceedings of the International Marine Debris Conference On Derelict Fishing Gear And The Ocean Environment, August 6–11 2000, Hawai'i Convention Center Honolulu, Hawai'i.

EC (2004) Council Regulation (EC) No 812/2004 of 26.4.2004 laying down measures concerning incidental catches of cetaceans in fisheries and amending Regulation (EC) No 88/98. *Official Journal of the European Union*. L 150/12

EC contract FAIR-PL98-4338, A study to identify, quantify and ameliorate the impacts of static gear lost at sea 2003 (FANTARED 2).

EC Project n° 94/095:incidental impact of gill-nets. FANTARED.

Environment Agency (2004). Beach litter. <http://www.environment-agency.gov.uk/yourenv/eff/water/213925/267642>

ENCAMS (2003). The management of Britains resort beaches. August 2002.

Erzini K., Monteiro C. C., Ribeiro J., Santos M. N., Gaspar M., Monteiro P., Borges T. C., (1997) *An experimental study of gill net and trammel net 'ghost fishing' off the Algarve (southern Portugal)*, Marine Ecology Progress Series, 1997,158:257-265.

Estonian Maritime Administration (2004). Estonian Ship Registers Record of 2004 <http://www.vta.ee/atp/?id=1785>

FAO (2001a) The Republic of Poland. FAO Country Profile. <http://www.fao.org/fi/fcp/en/POL/profile.htm>

FAO (2001b) *Driftnets*. FAO Gear type fact sheet <http://www.fao.org/figis/servlet/geartype?fid=220>

- Fao (1991) Recommendations for the Marking of Fishing Gear. Supplement to the Report of the Expert Consultation on the Marking of Fishing Gear. Victoria, British Columbia, Canada, 14-19 July 1991. 48p. ISBN 92-5-103330-7
- Fosnaes T (1975) Newfoundland cod war over use of gill nets. *Fish News Int.* 14(6):40-43.
- Fowler C.W. (1987) Marine debris and northern fur seals: A case study. *Mar. Poll. Bull.* 18:326-335
- Furevik D.M. and Fosseidengen J.E. (2000) Investigation on naturally and deliberately lost gillnets in Norwegian waters. Working Document to the Fisheries Technology Fish Behaviour Group. Harlem Netherlands, April 10-14, 2000.
- Gerrodette T., Choy B.K. and Hiruki M., (1987), *An experimental study of derelict gill nets in the central Pacific Ocean*, Southwest Fish Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI., Southwest Fish. Cent. Admin. Rep. H-87-18, 12p.
- Global Marine Litter Information Gateway (2004). *Effects of marine litter on economy and people*. <http://marine.litter.gpa.unep.org/facts>.
- Godøy H., Furevik D. M., and Stiansen S., (2003) *Unaccounted mortality of red king crab (Paralithodes camtschaticus) in deliberately lost pots off Northern Norway*, Fisheries Research Volume 64, Issues 2-3, November 2003, Pages 171-177.
- Golik A, (1997) *Debris in the Mediterranean Sea: types, quantities and behaviour*, in: Marine Debris Sources, Impacts, and Solutions Series: Springer Series on Environmental Management, Coe, James M.; Rogers, Donald (Eds.), 1997, XXXV, 432 p. ISBN: 0387-94759-0.
- Goñi R (1998) Ecosystem effects of marine fisheries: an overview. *Ocean & Coastal Management*. Volume 40, Issue 1 , 1998, Pages 37-64
- GSMFC (2001) Gulf States Marine Fisheries Commission webpage. Accessed February 2005 <http://www.gsmfc.org/derelicttraps.htm>
- Guillory V, McMillen-Jackson A, Hartman L, Perry H, Floyd T, Wagner T, and Graham G (2001) *Blue Crab Derelict Traps and Trap Removal Programs*, Gulf States Marine Fisheries Commission Publication No. 88, May 2001.
- Guillory V, (1993) *Ghost Fishing by Blue Crab Traps*, North American Journal of Fisheries Management: Vol. 13, 1993, No. 3, pp. 459-466.
- Hall K (2001) *Impacts of Marine Debris and Oil: Economic and Social Costs to Coastal Communities*, KIMO international.
- Hamilton, A.N., Jr. (2000) *Gear impacts on essential fish habitat in the Southeastern region*, U.S. Department of Commerce, Southeast Fisheries Science Center Pascagoula Facility, Unpubl. Rep.
- Hareide N-R, Garnes G., Rihan D., Mulligan M., Tyndall P, Clark M., Connolly P., Misund R., McMullen P., Furevik D. M., Humborstad O-B, Høydal K. and Blasdale T., (2005) A preliminary Investigation on Shelf Edge and Deepwater Fixed Net Fisheries to the West and North of Great Britain, Ireland, around Rockall and Hatton Bank.

Hébert M., Mironb G., Moriyasua M., Vienneau R. and DeGrâce P.(2001) *Efficiency and ghost fishing of snow crab (Chionoecetes opilio) traps in the Gulf of St. Lawrence*, Fisheries Research Volume 52, Issue 3 , July 2001, Pages 143-153.

High W.L., (1985), *Some consequences of lost fishing gear*, in: Shomura, R.S., Yoshida, H.O. (Eds.), Proceedings of the Workshop on the Fate and Impact of Marine Debris, Honolulu, HI, November 26-29, 1984, NOAA Tech Memo NMFS, US Department of Commerce.

High W.L. and Worlund D.D. (1979), *Escape of king crab, Paralithodes camtschatica*, from derelict pots, U.S. Dep. Commer., NOAA Tech. Rep. NMFS-SSRF-734, p.11.

Humborstad O-B, Løkkeborga S, Hareideb N-R and Furevika D M, (2003) *Catches of Greenland halibut (Reinhardtius hippoglossoides) in deepwater ghost-fishing gillnets on the Norwegian continental slope*, Fisheries Research Volume 64, Issues 2-3, November 2003, Pages 163-170.

Huse I., Aanonsen S., Ellingsen H., Engås A., Furevik D., Graham N., Isaksen B., Jørgensen T., Løkkeborg S., Nøttestad L., Soldal A.V. *A desk-study of diverse methods of fishing when considered in perspective of responsible fishing, and the effect on the ecosystem caused by fishing activity*. Bergen, July 2002.

ICES (2000). Fisheries Technology Committee ICES CM 2000/B:03 Working Group On Fishing Technology And Fish Behaviour IJmuiden, The Netherlands 10–14 April 2000.

Jennings, S. and M.J. Kaiser. (1998), The effects of fishing on marine ecosystems, Adv. Mar. Biol., 34:201-352.

JNCC (2004) Ghost fishing website <http://www.jncc.gov.uk/page-1567>

Johnson, W.M. & Karamanlidis, A.A. 2000. When Fishermen Save Seals. Monachus Guardian 3. Internet edition: <http://www.monachus.org/mguard05/05covsto.htm>

Kaiser, M. J., Bullimore, B., Newman, P., Lock, K. & Gilbert, S., (1996) *Catches in 'ghost fishing' set nets*, Marine Ecology Progress Series, 145:11-16.

Kolle J., Olsen V.J., Hareide N.R., (2004) *The Norwegian Retrieval Survey for lost Gillnets*, Cruise report from the Norwegian Directorate of Fisheries, 7 pp.

Laist, D. W. (1997) *Impacts of Marine Debris: Entanglement of Marine life in marine debris including a comprehensive list of species with entanglement records*, in: Marine Debris Sources, Impacts and Solutions Series: Springer Series on Environmental Management, Coe, James M.; Rogers, Donald (Eds.) 1997, XXXV, 432 p. ISBN: 0-387-94759-0.

Marine Conservation Society (2004) Beachwatch – The 11th Annual Beach Litter Survey Report, Marine Conservation Society, Ross-on-Wye, UK.

Maritime Technology Foresight Panel (1996). Report of the Working Group on Coastal Waters and Maritime Leisure, pp 3-4.

Mathews C.P., Gouda V.R., Riad W.T., Dashti J. (1987), *Pilot study for the design of a long life fish trap (Gargoor) of Kuwait's fisheries*, Kuwait Bull. Mar.Sci.9, 221-234.

McIntosh N., Simonds K., Donohue M., Brammer C., Mason S., and Carbajal S. (eds) (2000) Proceedings of the International Marine Debris Conference On Derelict Fishing Gear And The Ocean Environment, August 6–11 2000, Hawai'i Convention Center Honolulu, Hawai'i.

Mio S., Yoshida K., Matsumura S., Kato M., Watanabe Y. and Mito K., Outline of 1988 survey of behaviour of the drifting nets and entanglement of marine organisms. (Document submitted to the annual meeting of the International North Pacific Fisheries Commission, Tokyo, Japan, 1988, October), 5 p, Fisheries Agency of Japan, Far Seas Fisheries Research Laboratory, 5-7-1 Orido, Shimizu, Japan 424.

Mio S., Domon T., Yoshida K. and Matsumura S. (1990) *Preliminary study on change in shape of drifting nets experimentally placed in the sea*, in: Shomura, R.S., Godfrey M.L. (Eds.), Proceedings of the Second International Conference on Marine Debris, 2-7 April 1989 Honolulu, HI, November 26-29, 1984, NOAA Tech Memo NMFS, US Department of Commerce.

Nakashima T. and Matsuoka T., (2004) *Ghost-fishing ability decreasing over time for lost bottom-gillnet and estimation of total number of mortality*, Nippon Suisan Gakkaishi 70 (5), 728-737.

Natural Resources Consultants, Inc. (NRC) (2005) *Final Report*, SRFB/NOAA CRP Deception Pass/Point Roberts Derelict Gear Removal Project

Neves, H.C. (1991). The Monk Seal (*Monachus monachus*): Conservation and Monitoring on the Desertas Islands – Madeira. In: Seminar on Conservation of the Mediterranean Monk Seal – Technical and Scientific Aspects., Antalya, Turkey, 14 May 1991, Council of Europe Press, Strasbourg, France. Environmental Encounters No. 13: 21-24.

O'Hara K.J., *National marine debris data base: Finding on beach debris reported by citizens*, In Proceedings of the Second International Conference on Marine Debris, 1989, ed. Shomura R.S. and Godfrey M.L., U.S. Department of Commerce, NOAA-TM-NMFFS-SWFSC-154:379-391

Page B., McKenzie J., McIntosh R., Baylis A., Morrissey A., Calvert N., Haase T., Berris M., Dowie D., Shaughnessy P.D. and Goldsworthy S.D., (2004) *Entanglement of Australian sea lions and New Zealand fur seals in lost fishing gear and other marine debris before and after Government and industry attempts to reduce the problem*, Marine Pollution Bulletin, Volume 49, Issues 1-2, July 2004, Pages 33-42.

Pilgrim D. A., Smith, M. H. Trotter F. J. (1985) *A ghost-net experiment in shallow water near Plymouth*, Internal Report No 1232. Sea Fisheries Industry Authority, Industrial Development Unit.

Revill A. S. and Dunlin G., (2003) *The fishing capacity of gillnets lost on wrecks and on open ground in UK coastal waters*, Fisheries Research Volume 64, Issues 2-3 , November 2003, Pages 107-113.

Rogers, S.I., M.J. Kaiser, and S. Jennings (1998) *Ecosystem effects of demersal gear: a European perspective*, Pages 68-78 in: Dorsey E.M. and Pederson J.(eds.) Effect of Fishing Gear on the Sea Floor of New England. Conservation Law Foundation, Boston, Mass.

Sancho G, Puenteb E, Bilbaob A, Gomez E and Arregib L., (2003) Catch rates of monkfish (*Lophius spp.*) by lost tangle nets in the Cantabrian Sea (*northern Spain*), *Fisheries Research* Volume 64, Issues 2-3, November 2003, Pages 129-139.

Santos M. N., Saldanha H., Gaspar M. B. and Monteiro C. C. (2003a) Causes and rates of net loss off the Algarve (southern Portugal) *Fisheries Research* Volume 64, Issues 2-3 , November 2003, Pages 115-118.

Santos M. N., Saldanha H. J., Gaspar M. B. and Monteiro C. C., (2003b) Hake (*Merluccius merluccius L., 1758*) ghost fishing by gill nets off the Algarve (southern Portugal), *Fisheries Research* Volume 64, Issues 2-3, November 2003, Pages 119-128.

Shomura, R.S., Godfrey M.L. (Eds.) (1990) *Proceedings of the Second International Conference on Marine Debris*, 2-7 April 1989 Honolulu, HI, November 26-29, 1984, NOAA Tech Memo NMFS, US Department of Commerce.

Shomura, R.S., Yoshida, H.O. (Eds.), (1984) *Proceedings of the Workshop on the Fate and Impact of Marine Debris*, Honolulu, HI, November 26-29, 1984, NOAA Tech Memo NMFS, US Department of Commerce.

Smith A. 2001. Ghost fishing. UN Atlas of the Oceans. <http://www.oceansatlas.com/>

Smolowitz R.J. (1978a), *Trap design and ghost fishing: discussion*, Mar. Fish. Rev. 40, 59-67.

Somerville, S., Miller, K., and Mair, J (2003). Assessment of the aesthetic quality of a selection of beaches in the Firth of Forth, Scotland. *Marine Pollution Bulletin* 46: 1184-1190.

Standing Committee on Fisheries and Oceans (1998) *The East Coast Report*. An interim report tabled in the House of Commons, Canada <http://www.parl.gc.ca/InfoComDoc/36/1/FISH/Studies/Reports/FISHRP01-E.htm>

STECF (2004) *European Union Mediterranean Fisheries and exploited Resources*. Commission Staff Working Paper. Report of The Subgroup on the Mediterranean Sea (SGMED) of the Scientific, Technical and Economic Committee for Fisheries (STECF) SEC (2004) 772 http://europa.eu.int/comm/fisheries/doc_et_publ/factsheets/legal_texts/docscom/en/sec_2004_772/index_en.htm

Stephan, C.D., R.L. Peuser, and M.S. Fonseca (2000) *Evaluating fishing gear impacts to submerged aquatic vegetation and determining mitigation strategies*, Atlantic States Marine Fisheries Commission, ASMFC Habitat Manage. Ser. No. 5.

Stevens B.G., Vining I., Byersdorfer S. and Donaldson W. (2000) *Ghost fishing by Tanner crab (*Chionoecetes bairdi*) pots off Kodiak, Alaska: pot density and catch per trap as determined from sidescan sonar and pot recovery data* Fish. Bull. 98:389–399.

Stevens, B.G., J.A. Haaga and W.E. Donaldson (1993) *Underwater Observations on Behaviour of King Crabs Escaping From Crab Pots*. AFSC Processed Report 93-06.

Swarbrick, J. and Arkley K. (1999) *The evaluation of ghost fishing preventors for shellfish traps*, Sea Fish Industry Authority, Hull, UK. MAFF Study MF0724

Teixeira A M, (1986) *Razorbill losses in Portuguese nets*, Seabird 9:11-14.

Tschernij V. and Larsson P. -O., (2003) *Ghost fishing by lost cod gill nets in the Baltic Sea*, Fisheries Research Volume 64, Issues 2-3, November 2003, Pages 151-162.

Tschernij and Larsson (unpublished) *A new Large-Scale Retrieval System for Removal of Lost Gill Nets from Coastal Fishing Grounds*.

UNEP/IOC/FAO (1990), *Assessment of the state of pollution of the Mediterranean Sea by persistent synthetic material, which may float, sink or remain in suspension*, Mediterranean Action Plan Technical Report 56:1-103

Way E. W. (1976) *Lost gill net (ghost net) retrieval project, 1976*, Environment Canada, Fisheries and Marine Service, Industrial Development Branch, St. Johns, Newfoundland.

Washington Department of Fish and Wildlife (2002) *Derelict Fishing Gear Removal Guidelines*, <http://www.nwstraits.org/Documents/DG-Guidelines.doc>

Appendix B Bibliography

In table format. To be completed

Anon. (2001). The gillnet: a controversial fishing gear requires responsible fishermen. Fisheries and Oceans Canada, Fisheries Management Sector, FDP Project N^o. 260: 10 p.

Blott, A.J. 1978. A preliminary Study of Timed Release Mechanics for Lobster. Marine Fisheries Review. May-June 1978: 44-49. Stevens, B.G., J.A. Haaga and W.E. Donaldson. 1993. Underwater Observations on Behaviour of King Crabs Escaping From Crab Pots. AFSC Processed Report 93-06.

Breen, P.A. 1985. Ghost Fishing by Dungeness crab traps: A preliminary report. Can. Man. Rep. Fish. Aquat. Sci. No. 1848: 51-55.

Breen, P.A. 1987 Mortality of Dungeness Crabs caused by lost traps in the Fraser River Estuary, British Columbia. North American Journal of Fisheries Management 7: 429-435.

Breen P.A. 1990. A review of ghost fishing by traps and gillnets. In Shomura RS and Godfrey ML (editors) Proceedings of the Second International Conference on Marine Debris. 2-7 April 1989 Honolulu, Hawaii. U.S. Dept. Commer. NOAA Tech. Memo. NMFS. NOAA-TM-NMFS-SWFSC-154. 1990.

Breen P.A. 1990. A review of ghost fishing by traps and gillnets. Proc. 2nd Int. Conf. Marine Debris 2-7 April 1989 Hawaii. NOAA Tech. Memo 154: 561-599.

Breen P.A. 1990. Report of the Working Group on Ghost Fishing. Proceedings of the Second International Conference on Marine Debris. II: 1216-1225.

Breen, P.A. 1990. A review of ghost fishing by traps and gillnets. Pages 571-599 in: . R.S. Shomura and M.L. Godfrey (editors), Proceedings of the Second International Conference on Marine Debris, 27 April 1989. Honolulu, HI. US. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-154.

Carr, HA, AJ Blott & PG Caruso. (1992). A study of ghost gillnets in the inshore waters of southern New England. pp. 361-367 MTS '92: Global Ocean Partnership., Marine Technology Society, Washington, DC.

Carr, H.A., and J. H. Harris. 1997. Ghost fishing gear: have fishing practices during the past few years reduced the impact. In J.M. coe and D.B Rogers (editors), Marine debris, sources, impacts and solutions. Springer-Verlag New York, Inc. p. 141-151.

Carr, H. A., E.H. Amaral, A.W. Hulbert and R. Cooper. 1985. Underwater survey of simulated lost demersal and lost commercial gill nets off New England. In R.S. Shomura and H.O. Yoshida (editors), Proceedings of the Workshop on the Fate and Impact of Marine Debris, 26-29 November 1984, Honolulu, HI, US Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-54. p. 439-447.

Eisenbud, R., The pelagic driftnet, 1985, *Oceanus* 27(4):76.

High, W.L. and D.D. Worlund. 1979. Escape of King Crab, *Paralithodes camtschaticus*, From Derelict Pots. NOAA Technical Report. NMFS SSRF-734: 13 P.

Potter E. and Pawson M. G., Gillnetting, Laboratory Leaflet Number 69, MAFF Directorate of Fisheries Research, 34 pp.

Saldanha H. J., Sanchob G., Santos M. N., Puentec E., Gaspara M. B., Bilbaoc A., Monteiroa C. C., Gomezc E. and Arregic, The use of biofouling for ageing lost nets: a case study. Fisheries Research Volume 64, Issues 2-3, November 2003, Pages 141-150.

Appendix C Literature review methodology and sources of information

A literature and web search was undertaken to identify the key scientific literature available on the ghost fishing as well as the major research institutions that have worked on the issue. The literature review also identified key fisheries of interest for the study.

The review covered the identification of reasons for gear losses, the evolution of lost fishing gear and the evaluation of the environmental impacts of lost gear. It also focused on identifying gaps in the research already done and in presenting a list of monitoring and retrieving programmes and any data resulting from them. Both EU Member States and those outside were considered.

Information was generated from a wide variety of sources. These included:

- Databases of journal abstracts (eg Agricola 1992-2001/2, CAB International Abstracts 1992-2002, Econlit 1969-2002, Sociological Abstract 1986-2001/2, Aquatic Science and Fisheries Abstracts 1992-2002, Aquatic Biology, Aquaculture and Fisheries Resources Abstracts 1992-2002);
- Individual requests made to staff at research institutions known to the consultants; and
- The Internet using search engines such as Google.

The search strategy for all journal databases and website searches was based on the following key words:

- ghost fishing;
- unintended fishing;
- lost fishing gear;
- pot loss;
- pot retrieval;
- net loss;
- net retrieval;
- trap loss;
- trap retrieval;
- unintended fishing;
- phantom fishing;
- discarded fishing gear;
- abandoned gear;
- gear retrieval;
- gear identification
- gear recovery;
- redes fantasma;
- reti fantasma;
- mortalité halieutique fantôme;
- pêche fantôme; and
- FANTARED.

Individuals and institutions involved in key research were also contacted directly by telephone and email about their work.

Appendix D Survey questionnaires and methodology

Step 3 of the study methodology entailed conducting primary research into the selected fisheries through surveys:

1. Baltic cod net fishery of Sweden and Denmark;
2. net fisheries of Greece;
3. English and French net fishery in the western English channel; and
4. the deepwater net fisheries of the north east Atlantic.

The purpose was to fill information gaps identified during the literature review and to generate data for both the workshop and the cost benefit analysis. Because of the varying degrees of information already available on these fisheries and the incidence of lost nets and ghost fishing in each case, the follow up research undertaken for each one differed. In the case of the Greek fisheries, no research had been undertaken on lost nets before. The Baltic and English Channel survey however built upon the work done under FANTARED. Although there are still information gaps, the deepwater fisheries have been studied in greater depth and the data available was sufficient to permit some analysis of the feasibility of a gear retrieval programme. There was also some sensitivity surrounding the fishery with the release and subsequent press coverage around the DEEPNET report (Hareide *et al.*, 2005). Coupled with interview fatigue amongst those participating in the fishery and the relationships being developed by the DEEPNET team, a further survey was not conducted in this fishery.

Questions were developed and translated into a Microsoft Access database. Questions were asked relating specifically to each gear type being used. As illustrated below, these included the technical and cost specifications of gears used, catch rates and compositions, loss rates and causes and recovery rates and factors. More generic information was also asked in relation to reducing gear loss.

The questionnaire was piloted and modifications to the questionnaire design made where necessary. It was then rolled out in the selected fisheries. Thirty fishermen was the target number of interviews for each fishery, split between countries in the Baltic and Channel fisheries. In some cases however this was not possible because of reluctance on behalf of interviewees and fishermen been out at sea for long periods of time. While not desirable, this was not considered a significant problem as very similar findings were generated after several interviews:

Fishery	Countries surveyed	Number of Interviews
Baltic cod net fishery	Sweden	11
	Denmark	15
Greek net fishery	Greece	27
Western English Channel net fishery	England	5
	France	18
North east Atlantic deepwater net fisheries	None	0
Total		76

Fishermen were identified in different ways, depending on the fishery. In Sweden the industry has been actively working with government researchers on the issue of lost nets. Cooperative individuals were therefore identified by the National Board of Fisheries. In Denmark no work had been done on gear loss or retrieval. Interviewees were therefore randomly selected. This was also the case in England and France, although efforts were made to select cooperative fishermen and those that had been involved in the FANTARED work previously.

Fishermen from the Baltic and Channel fisheries were interviewed by telephone as the interviewers had good contacts that were willing to cooperate. Because of difficulties in locating Greek fishermen, interviews were conducted at the portside, with interviewees randomly selected within this context.

Form A: Gear Specific Information (separate sub-forms for gill nets, tangle nets, trammel nets and other nets)

Contact

ID (number)	Name	Tel.	Email
Fishery:	Town	Country	Best time to call
Home port	Vessel type	Vessel length	0

Gill Net Sub-form	Landings - Marketable spp	Gear losses									
Months gear is used per year <input type="text" value="0"/>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Species</th> <th style="text-align: right;">% by wt</th> </tr> </thead> <tbody> <tr><td><input type="text"/></td><td style="text-align: right;"><input type="text" value="0"/></td></tr> <tr><td><input type="text"/></td><td style="text-align: right;"><input type="text" value="0"/></td></tr> <tr><td><input type="text"/></td><td style="text-align: right;"><input type="text" value="0"/></td></tr> </tbody> </table>	Species	% by wt	<input type="text"/>	<input type="text" value="0"/>	<input type="text"/>	<input type="text" value="0"/>	<input type="text"/>	<input type="text" value="0"/>	Av. no. of nets lost / year <input type="text" value="0"/> Typical depth of loss <input type="text" value="m"/> Bottom conditions <input type="text"/>	Percentage of gear units lost you are unable to recover <input type="text"/> What factors influence whether a recovery attempt is made and the time spent? <input style="width: 100%;" type="text"/> On avg. how many hours per month is spent attempting lost gear recovery? <input type="text" value="0"/> What % of this time is lost fishing time as opposed to extended time spent at sea? <input type="text" value="0"/> What factors dictate the success of recovering lost gear? <input style="width: 100%;" type="text"/> What specialist equipment is used for gear recovery? <input style="width: 100%;" type="text"/> How much does it cost? <input type="text" value="€0"/> On average what %age of nets are re-usable after recovery? <input type="text" value="0"/> On average what %age of buoys etc are re-usable after recovery? <input type="text" value="0"/> How is lost gear located? <input style="width: 100%;" type="text"/> How is unwanted gear disposed of? <input style="width: 100%;" type="text"/> What is the cost of disposing unwanted gear (£/month)? <input type="text" value="€0"/> How much time is spent disposing /repairing recovered gear? <input type="text" value="hrs/month"/> Contact ID: <input type="text"/>
Species	% by wt										
<input type="text"/>	<input type="text" value="0"/>										
<input type="text"/>	<input type="text" value="0"/>										
<input type="text"/>	<input type="text" value="0"/>										
Length of single net units (m) <input type="text" value="m"/>	Landings - Non-marketable spp	<i>Rank reason for loss from 1 to 10:</i> Bad weather: <input type="text" value="0"/> Caught on bottom: <input type="text" value="0"/> Deliberate discard: <input type="text" value="0"/> Gear conflict: <input type="text" value="0"/> Loss of dhans/markers: <input type="text" value="0"/> Ripped panel: <input type="text" value="0"/> Strong currents/tides: <input type="text" value="0"/> Signal loss: <input type="text" value="0"/> Vandalism: <input type="text" value="0"/> Merchant shipping: <input type="text" value="0"/> Other loss reason (specify): <input style="width: 100%;" type="text"/> <input style="width: 100%; height: 50px;" type="text"/>									
Average no of nets per fleet <input type="text" value="0"/>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Species</th> <th style="text-align: right;">% by wt</th> </tr> </thead> <tbody> <tr><td><input type="text"/></td><td style="text-align: right;"><input type="text" value="0"/></td></tr> <tr><td><input type="text"/></td><td style="text-align: right;"><input type="text" value="0"/></td></tr> <tr><td><input type="text"/></td><td style="text-align: right;"><input type="text" value="0"/></td></tr> </tbody> </table>	Species	% by wt	<input type="text"/>	<input type="text" value="0"/>	<input type="text"/>	<input type="text" value="0"/>	<input type="text"/>	<input type="text" value="0"/>		
Species	% by wt										
<input type="text"/>	<input type="text" value="0"/>										
<input type="text"/>	<input type="text" value="0"/>										
<input type="text"/>	<input type="text" value="0"/>										
Average no of fleets set: <input type="text" value="0"/>	Total volume landed per annum <input type="text" value="mt"/>										
Average soak time of nets <input type="text" value="hrs"/>	Total value of landings per year <input type="text" value="€0"/>										
Mesh size <input type="text" value="mm"/>	What proportion of your catch is quota controlled species? <input type="text" value="0"/>										
Cost of each net panel <input type="text" value="€0"/>											
Cost of buoys, markers etc <input type="text" value="€0"/>											
Life span of each net panel <input type="text" value="months"/>											
Life span of buoys, markers etc <input type="text" value="months"/>											

Record: of 1

Form B: Generic Information

Contact			
ID	6	Name	Jon Turtle (Ben Loyal)
Tel.	07811 135326	Email	
Fishery:	Western Channel Net Fishery	Town	
Country		Best time to call	
Home port		Vessel type	
Vessel length	0	<input type="button" value="Gilnet"/> <input type="button" value="Tanglenet"/> <input type="button" value="Trammel net"/> <input type="button" value="Other net"/>	
<p>How frequently are nets snagged or misplaced/lost? <input type="text"/></p> <p>Time lost from unsnagging gear (hours) <input type="text" value="0"/></p> <p>Cost of unsnagging (£/year) <input type="text" value="€0.00"/></p> <p><i>A number of things could be done to reduce gear loss and subsequent ghost fishing, could you pls comment on how effective you think each of the following might be:</i></p> <p>Mandatory reporting of losses <input type="text"/></p> <p>Setting of maximum soak times <input type="text"/></p> <p>Mandatory marking of fishing gear <input type="text"/></p> <p>Gear modifications <input type="text"/></p> <p>Development of agreements <input type="text"/></p> <p>Development of codes of practice <input type="text"/></p> <p>Better recovery methods <input type="text"/></p> <p>Any of other effective methods? <input type="text"/></p> <p>What measures do you take to reduce gear loss? <input type="text"/></p> <p>Are you aware of any on-going measures to reduce gear loss and ghost fishing? <input type="text"/></p> <p>What research would be useful to reduce the incidence of gear loss and ghost fishing? <input type="text"/></p> <p>Do you have any other comments on the issue of gear loss and ghost fishing? <input type="text"/></p>			

Appendix E Workshop report

Appendix F Typically used retrieval gear (after Smith, 2001)

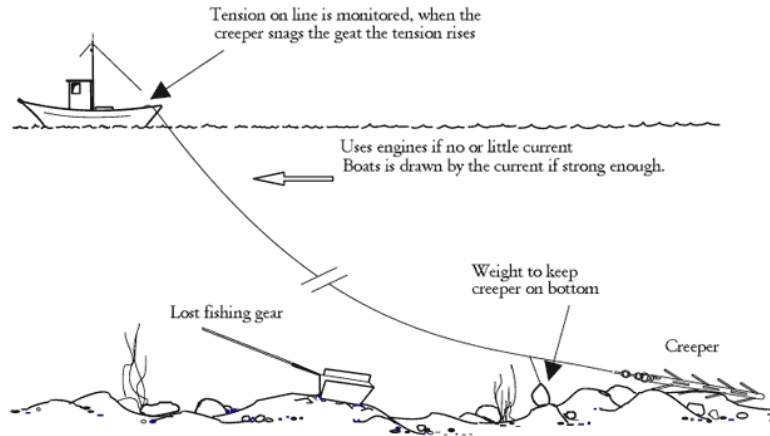


Figure 1 Arrangement for creeping for fishing gear

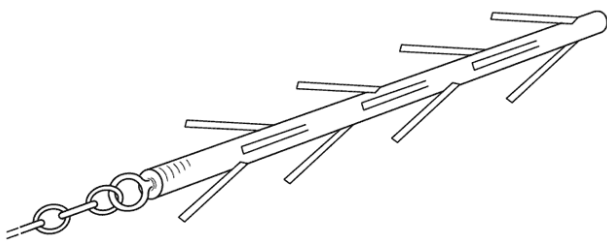


Figure 2 Rod crawler (Various sizes according to the gear)

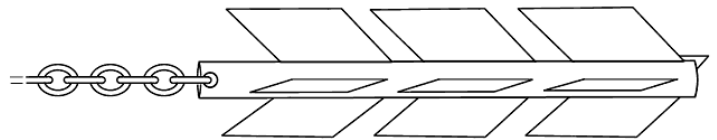


Figure 3 Plate crawler (Various sizes according to the gear)

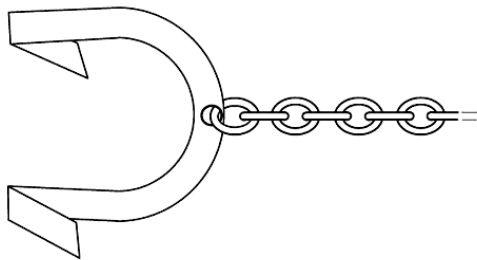


Figure 4 Horseshoe crawler (Generally used for lines)



Figure 5 Chain crawler (Various sizes according to gear)