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Examining changes in Irish fishing practices in response to the Cod Long-Term Plan

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Abstract

In 2009 marked changes occurred in Irish demersal fishing effort due to the implementation of a new cod long-term management plan (CLTP). This replaces previous 'top down' management cod recovery plans, (first implemented in 2002), specifying days-at-sea limits for individual fishers. The new plan specifies a harvest control rule, annual effort ceilings for each European Member State, and rules for adapting fishing effort. The plan encourages cod avoidance measures but leaves Member States to allocate effort to individual fishers. During 2009 effort was allocated through a series of pilot schemes in Ireland. These schemes can be considered as an evolution towards co-management. Industry and state authorities worked closely together to develop strategies for effort management and cod avoidance. This paper examines the impact of these recent effort management measures on the Irish fleet, fishery and métiers affected by the CLTP. Vessel movements within and between

métiers at a high spatial and temporal resolution are described and discussed. Unintended potential impacts resulting from the implementation of management schemes are highlighted. In future, further consideration of fishers' possible responses to policy should be considered prior to implementation, to minimise potentially adverse impacts.

Key words: Cod; Cod Long-Term Plan; Demersal Fisheries; Effort Management, Métiers

Introduction

The levels of fishing pressure exerted on cod stocks in European waters have long been considered to be unsustainable. As a result, several cod stocks have declined to dangerously low levels. In an effort to reduce mortality and rebuild stocks several European Union management initiatives have been applied in the Irish Sea (ICES Division VIIa), to the West of Scotland (VIa), and in the North Sea (IV).

Under the Common Fisheries Policy, Total Allowable Catches (TAC) were established and progressively reduced, yet stocks continued to decline. In 2003 effort management was introduced in conjunction with TACs encompassing the West of Scotland (EC, 2002), this was further expanded in 2004 to include the Irish Sea (EC, 2003). This 'top down' effort management specified the number of days individual vessels were permitted to be at sea, varying with area and gear configuration with the aim of reducing

fishing mortality on various cod stocks according to a cod recovery plan (EC, 2004). In many cases the days were reduced annually, particularly for gear configurations traditionally used to target whitefish, such as bottom otter trawlers with cod-end mesh sizes of 100mm or more. Despite this there was little evidence of commensurate mortality reductions in the stocks according to ICES scientific assessments (ICES, 2010).

The EU Fisheries Council adopted a new cod long-term plan (CLTP) in 2008, as set out in Council Regulation (EC) No. 1342/2008 (EC, 2008). The plan aims to recover stocks and achieve sustainable levels of cod exploitation based on a maximum sustainable yield target of fishing mortality (0.4) by managing fishing pressure on cod stocks by demersal gears within several areas. Implementation occurred in February 2009 through Annex IIa of Council Regulation (EC) No 43/2009 (EC, 2009). The CLTP contains a harvest and effort control rule, as well as many implementing rules and potential derogations to encourage cod avoidance measures. The new plan specifies effort ceilings for each European Member State, developed using historical international fishery dependent effort data. Effort ceilings are defined as the engine power (kW) multiplied by the days a vessel spends at sea, summed over the fleet, giving kW-days. Effort ceilings are partitioned into fishing gear groups for each area covered by the plan. Member States decide how this effort is allocated to individual fishers within their nation. These ceilings become increasingly restrictive over time for cod-catching gears until cod stocks recover. The gear groups covered by the CLTP are described in Council Regulation (EC) No 43/2009 (EC, 2009) as follows:

- Bottom trawls, Danish seines and similar towed gear (excluding beam trawls) of mesh size ≥100 mm (TR1), ≥70 mm and <100 mm (TR2), and ≥16 mm and <32 mm (TR3)
- Beam trawls of mesh size ≥ 120 mm (BT1) and ≥ 80 mm and < 120 mm (BT2)
- Gill nets and entangling nets (excluding trammel nets) (GN1)
- Trammel nets (GT1)
- Longlines (LL1)

Irish fishers primarily utilise bottom otter trawls, and to a lesser extent beam trawls, gillnets, and demersal seines to target a variety of demersal fisheries. These gears account for 70% of all Irish fishing effort. The Irish Sea and West of Scotland fall under CLTP effort restrictions and historically contain important fishing grounds for the Irish demersal fleet. Of the gears regulated by the CLTP, large mesh beam trawls, trammel nets, and longlines are rarely used by Irish vessels. In 2009 Ireland endeavoured to follow the spirit of the regulation by taking actions to reduce cod mortality in these areas by 25% or more. A number of pilot schemes to allocate effort to individual vessels, primarily based on a recent track-record, were implemented. Greater effort was allocated to groups of fishers proven to have had high levels of effort in regulated areas. Effort remained the property of the state and transfer of effort allocations between vessels was not permissible. The first scheme, running from the 1st February to 30th April, was the most restrictive. Conservative allocations were assigned to vessels to ensure adequate effort remained available for later in the year and for

vessels to re-enter the fleet. Two subsequent schemes (1 May – 31 October, and 1 November – 31 January 2010) were adapted based on the experiences and effort uptake from the previous period. These became more relaxed, with unused effort from the previous period redistributed, in most cases giving fishers greater effort allocations as time progressed. The schemes were developed by policy makers and control authorities in detailed consultation with industry representatives and supported by scientific analysis of fisheries dependent data.

This paper explores the impact of this latest form of effort management by examining the changes to the Irish fleet, fishery and métiers affected by the CLTP. A métier can be described as a group of fishing trips with similar vessel characteristics within a fishery (ICES, 2003). Vessel movements within and between métiers at a high spatial and temporal resolution are described and discussed. Focus is on areas under CLTP effort management in which Irish fishers are most active, namely the West of Scotland and the Irish Sea, in addition to areas affected by displacement.

Methods

The investigation is based upon examination of fishery dependent data, Irish logbook and Vessel Monitoring System (VMS) data. Irish logbook data from the Integrated Fisheries Information System (IFIS) database was provided by the Department of Agriculture, Fisheries and Food. This encompasses all fishing trips by vessels ≥10

meters from 2003 to 2009. VMS data from 2003 to 2009 was provided by the Irish Navy (F.M.C.).

Irish métiers were developed prior to this investigation by statistically segmenting fishing trips into homogeneous groupings based on species composition profiles, season (using month as a proxy), fishing area, and vessel characteristics including gear type, mesh size range, and vessel length (unpublished data). Details of similar methodology can found in Davie and Lordan (2009) which uses the Irish Sea as a test case.

Logbook and VMS data were integrated using a simple speed rule to identify the majority of fishing operations for a range of gear types (Gerritsen and Lordan, 2011). VMS points relating to fishing activity are then integrated with catch and effort data from the logbooks via a vessel identifier and date. This information can be visualised on a fine spatial scale.

Data manipulation and analysis was carried out using Microsoft SQL Server 2008 Management Studio and R (R Development Core Team, 2008).

Results

The results described below focus on the demersal gear types regulated under CLTP effort management, unless identifiable changes believed to have resulted from the CLTP occurred within non-regulated gear types.

Regulated effort within the West of Scotland (VIa) and Irish Sea (VIIa) for the most part declined in 2009, with effort ceilings not being reached (Table 1). TR1 to the west of Scotland is the exception to this, showing an increase of ~25%, exceeding the 2009 allocation by over 60%. However, the regulation permits Member States to transfer effort between gear categories (EC 1342/2008 Article 17; EC, 2008). Here effort was transferred from the primarily unused TR2 to TR1, the adjusted effort ceiling accounted for the additional effort.

In addition to the implementation of effort ceilings, a number of vessels previously operating within the Irish fleet were permanently removed by the end of 2008 through a decommissioning scheme. Decommissioning had little effect to the west of Scotland, whilst in the Irish Sea large proportions of effort were removed from regulated gear categories (Table 1). Over 50% of 2008 BT2 effort was carried out by vessels subsequently decommissioned. Around a quarter of TR1 and TR2 effort was removed and 13% of GN1 effort. This reduction in effort through decommissioning should be taken into account whilst considering changes in effort patterns.

To the west of Scotland during 2009 cod end mesh sizes <120 mm were prohibited to the east and south of an area VIa management line (depicted in Figure 1) unless targeting *Nephrops* through specific derogation conditions detailed in EC 43/2009 Annex IIIa Article 6 (EC, 2009). Following recent declines, this TR2 gear category showed much reduced effort levels in 2009, attaining 3% of the permitted allocation by December 2009. The majority of vessels utilising TR2 gear in 2008 fished with larger

mesh sizes whilst in VIa during 2009. They were thus incorporated into the TR1 category, explaining the elevated levels of TR1 effort. These vessels also spent time fishing outside the West of Scotland, including ICES Divisions VIIb and VIIj. Several areas show a reduction in TR2 gear effort coupled with increased TR1 gear effort (Figure 2).

A number of changes occurred within the increased West of Scotland TR1 category. Effort within the first months of 2009 was reduced compared to the two preceding years, with February being the most affected (Figure 3). Effort became elevated later in the year. Spatial effort distribution was also affected, with increased intensities deeper than 200 m, west of the VIa management line, and to the east in an area typically fished by TR2 gears (Figure 1). Métiers provided information on the species targeted by the TR1 gear category. Two métiers dominate within the area (Figure 4a): mixed whitefish (pollack, saithe, cod, whiting and dogfish; PSCWD) dominated by saithe, and mixed slope species (ling, witch, forkbeard and hake; LWFH) dominated by hake. Large increases in effort were observed within both these métiers, relative increases of 317% and 97% respectively. In addition a large number of trips are not assigned to a métier in this area, due to variable or unclear target species. In 2009, haddock landings which normally dominate these trips, declined, while greater quantities of monkfish and megrim occurred (Figure 5).

Effort for TR2 within the Irish Sea saw a 35% reduction on 2008 levels (Table 1), 31% below the 1 120 977 kW effort ceiling by December 2009. *Nephrops* are the primary target of this gear category, shown by the dominance of two *Nephrops* directed métiers

(Figure 4b). One *Nephrops* métier is more focused (clean) than the other (mixed) having lower landings of other species. Combined these métiers accounted for ~85% of effort in 2009, the same percentage as in 2008. During the final quarter of 2009 three vessels began using sorting grids to reduce fish by-catch while targeting *Nephrops*. All trips by these vessels whilst using the grids were classified within the focused métier. No change in the distribution of effort over ICES rectangles was seen and effort remained focused within FU15. Comparison of 2009 monthly TR2 effort shows reduced levels within the first half of the year, particularly from February to April (Figure 6). Effort has previously peaked in summer months (June - August) when the primary target, *Nephrops*, has a higher catchability. The 2009 peak in effort was reduced and occurred later than in previous years.

The list of vessels using TR2 gear in the Irish Sea during 2009 was used to obtain monthly area distributions of effort deployed by these vessels. Comparisons to similar lists for 2007 and 2008 revealed changes. The pattern of TR2 effort deployment in February and March declined in the Irish Sea and increased in the northern Celtic Sea (VIIg), this is also seen in June and July (Figure 7). Combined these vessels expend 70-94% of monthly effort using TR2 gear, for the majority of the remainder TR1 is used, mainly within VIIg.

Irish Sea TR1 effort has declined, with reduced effort across the majority of the year. The effort deployed by this gear configuration equates to a 70% uptake of the 79 246kW effort ceiling by December 2009. Although effort has declined, there was no evidence of a change in monthly effort pattern, or spatial distribution compared to

previous years. A number of different métiers operate within the Irish Sea TR1 category. Métiers include targeting of pollack, saithe, cod, whiting, and dogfish (PSCWD), plaice and ray species, and Scottish seining for whiting and haddock. Evidence is seen that TR1 vessels targeting mixed species, such as PSCWD, in the Irish Sea are spending an increased amount of time in additional, alternative areas within the same fishing trip.

Gillnet (GN1) effort uptake was the highest of regulated gears in 2009 with 80% uptake of the 24 713kW ceiling by December 2009. Within the Irish Sea GN1 effort would primarily occur within the first quarter, often targeting cod. This was much reduced in 2009. Effort in February was the lowest seen in recent years (Figure 8a), 88% lower than in 2008. This fishery is part of the Celtic Sea fishery occurring on the VIIa/VIIg border close to the south east coast of Ireland. Effort within VIIg during February was one of the lowest seen over the same period and thus is unlikely to have been fished as an alternative. The distribution of GN1 effort has remained the same, primarily within ICES rectangles 33E2 (decreased 2009) and 33E3 (increased 2009). Distribution within VIIg has also remained consistent, albeit with increased effort in 32E2.

A large shift in the métiers making up the GN1 category occurred in 2009. During the period 2006 to 2008, the primary gillnet métier targeted cod, reaching 89% of effort in 2008 (Figure 4c). This declined dramatically in 2009, accounting for 34% of effort. A substantial effort increase (~35%) occurred in the comparably small hake and forkbeard métier. This métier is not based within the Irish Sea, but rather occurs due to vessels spanning multiple ICES divisions within a fishing trip and the greatest species landings

define the métier classification. The large increase in the presence of effort allocated to this métier signifies the movement of vessels from the Irish Sea into the Celtic Sea and its surrounding waters during a trip.

Beam trawling with ≥80mm and <120mm mesh (BT2) saw very low (32%) uptake of the 507 923kW allowance by December 2009. A substantial amount of effort was removed due to decommissioning of vessels by the end of 2008 (66%). The beam trawl fleet has been subject to a number of decommissioning schemes in the last 5 years. In the majority of months effort is down in comparison with previous years, as would be expected from a substantially reduced fleet. There is little consistency in monthly effort levels between years for this gear category, although a greater reduction in the first quarter is suggested (Figure 8b). Effort distribution has not changed compared to 2008, continuing within the central Irish Sea. Further more, no change occurred in the métier composition, dominated by targeting of ray species, plaice and sole.

Discussion

Large behaviour changes have been observed in the Irish demersal fleet in 2009, particularly within the West of Scotland and the Irish Sea. These changes directly result from the implementation of several management and technical measures, mainly associated with the CLTP (Council Regulation EC 1342/2008; EC, 2008).

Using a number of pilot schemes developed with stakeholder input, the Irish administration allocated the available effort to individual Irish fishers operating within

the West of Scotland and Irish Sea. Irish vessels were actively encouraged to adopt fishing practices that would avoid cod. In the West of Scotland this included fishers avoiding grounds where cod aggregations are known to occur. For example, statistical rectangle 39E3 which was closed under national regulation from 1st February to 31st March 2010 and then again from 1st October 2010 until 31st January 2011. Gear trials were carried out in the Irish Sea incorporating separator panels and grids into otter trawls to improve selectivity. The most active fishery in the Irish Sea (*Nephrops*) was subsequently incentivised to employ these devices with extra effort allocations.

Fisheries management rarely manages the resource, but rather the fishers targeting the resource. In single-species quota management it is the fishers which decide when and where to fish. Within effort management systems, it is the decision-maker. In the previous days-at-sea system the EU made these decisions. Within the new scheme, although the EU sets the effort allocation, it is the Member State which decides how much time fishers may spend in controlled areas. The involvement of stakeholders at this national level within the management process is a step toward co-management, where those directly influenced by management are an integral part of how the fisheries they depend upon can become sustainable resources. The knowledge held by stakeholders and the benefits of their involvement has been a topic of discussion for a number of years (Jentoft and McCay, 1995; Johannes *et al.*, 2000; Rossiter and Stead, 2003). Such stakeholders are slowly being incorporated, unlocking and utilising this knowledge. Having fixed parameters established within the regulation, such as the effort control rule, meant that industry engagement was focused on addressing the objective of cod mortality reductions, developing effective effort management

framework, During discussions, stakeholders were a primary driver in the trialling of separator grids and panels, and investigations into area closures which would reduce cod fishing mortality. The Fisheries Research and Development Corporation in Australia examined co-management in relation to Australia's fisheries (Anon, 2008) stating that "the co-management implementation process is a lengthy one, since it is ultimately about building mutual trust and responsibility based on performance and risk management". The small step Ireland has made towards co-management has been a move in the right direction. Although the process of agreement on measures to be taken has lengthened, it has opened the channels of communication between stakeholders and managers, and has increased "buy-in", co-operation, and support from industry, something that has been lacking in many regulations.

The overall rate of effort uptake throughout the year was low, and by the end of 2009 Irish effort group ceilings had not been reached. During the first pilot scheme (1 February – 30 April), overall usage of regulated gears within the Irish Sea and West of Scotland was lower than the same period in previous years, showing a disruption in normal fishing behaviour. The first month of the new regulation (February) was the most affected with effort, in some cases, less than 50% of previous levels. Throughout this period, fishers felt much uncertainty, and conserved effort allocations for times when fishing returns were expected to be higher. Over the year, the pilot schemes became less conservative, due to low uptake during preceding schemes and effort usage increased.

Many factors can affect effort uptake. In the case of the beam trawl fleet a decommissioning scheme removed vessels that accounted for around two thirds of effort levels in 2008. Consequently this category had the lowest uptake (32%). Individual allocations showed no or little restriction on vessels due to an excess of effort available. This BT2 category however, contributes a relatively small proportion to cod landings.

Unlike beam trawling, division of effort within certain gear categories resulted in many individual vessels finding their allocations restrictive, for example Irish Sea gillnetting early in 2009. The Irish Sea *Nephrops* fleet which is the primary TR2 activity was particularly affected by restrictive individual allocations. This is in contrast to the previous cod recovery plan (EC, 2004) managed through days-at-sea, where effort within the equivalent mesh range group was not perceived to be restrictive (STECF, 2009). A small number of *Nephrops* vessels within the Irish Sea TR2 category began using separator panels (~15) and sorting grids (~4) in the fourth quarter to increase their individual effort allocations following gear trials. These technical control measures are similar to the Swedish grids shown to reduce the fish component of catches (Valentinsson and Ulmestrand, 2008; Drewery *et al.,* 2010). During Irish trials, fish catches, including cod, were reduced by ~85%, while retaining the majority of *Nephrops* (D. Rihan, pers. comm.). Adoption of these technical measures was therefore considered to be a very effective cod avoidance measure. However, in 2009 overall usage was low and unlikely to have had a measurable impact on the stock. Uptake of this gear by Irish fishers is a business decision taken at an individual vessel level where a loss of revenue (~30%) arising from reduced commercial fish and *Nephrops*

components of the landings must be balanced against the restrictiveness of the vessels effort allocation and/or fishing opportunities elsewhere.

The Irish Sea *Nephrops* fishery usually follows the seasonal emergence behaviour of *Nephrops*, increasing effort when catchability is very high during neap tides in the summer months. In previous years, a small effort peak occurred around March, with the main fishing period running from June to August. The main seasonal peak in effort was delayed in 2009 to August/September. Reduced effort in earlier summer month's likely results from fishers "saving" their effort for later in the management period when catchability of *Nephrops* would be expected to increase. Changes in fishing pattern can have marked economic consequences. Ultimately Irish *Nephrops* landings declined by ~25% in 2009 compared to the previous two years, a drop of ~800 t. The effort reduction within the Irish Sea by this primary gear category (TR2) may have reduced fishing pressure on a wide variety of Irish Sea stocks, not just the intended cod stock, such as Nephrops for which landings declined. Effort restrictions within a mixed species area limit the fishing pressure not only on the species in need of recovery, but on all other species caught with the same gear (targeted catch, by-catch, and discards), which may have beneficial effects to stock sizes. A similar theory was discussed by Andersen and Rice (2010) in relation to community effects of rebuilding plans.

Some TR2 effort normally expended in VIIa was displaced to other *Nephrops* fisheries, including those undertaken in ICES Division VIIg. The displacement of effort to areas beyond those regulated by the CLTP may have a negative impact on other stocks through increased fishing pressure. Although in this case the overall annual effort in

VIIg was also reduced in 2009, due to decommissioning. The seasonal distribution of effort changed in VIIg. This was substantial during the first half of the year, and resulted in a different exploitation pattern. Effort Displaced into alternative fishing grounds can result in increased vessel crowding and competition for resource between vessels. Although not specifically examined within this study, such observations were made within a North Sea study by Poos and Rijnsdorp (2007) which resulted in decreased value per unit effort (VPUE).

Some reduction in Irish Sea TR2 effort also can be linked to the 2008 Irish decommissioning scheme which included a number of TR2 vessels, accounting for approximately 25% of 2008 effort. However, decommissioning is unlikely to explain the observed changes in monthly effort patterns. These behavioural changes are not thought to be due to reduced availability of target species as little change in the status of the *Nephrops* stock targeted by the Irish TR2 fleet (FU15) occurred in 2009 (ICES, 2010).

The large decline in TR2 activity to the west of Scotland in 2009 resulted in effort levels totalling just 3% of the effort ceiling. This stems from technical measures implemented in 2009 preventing the use of TR2 cod-end mesh sizes in the area unless targeting *Nephrops* (EC 43/2009 Annex IIIa Article 6; EC, 2009). Mixed demersal fish, rather than *Nephrops*, had previously been the primary target for Irish vessels within the area. Displacement of TR2 effort into surrounding areas was not evident. Effort by vessels previously active in TR2 in VIa declined in both the adjoining areas of VIIb and VIIa, and these vessels instead switched to a larger mesh size (TR1) in VIa and other areas.

An advantageous side effect of this change is improved species and size selectivity within catches (D. Rihan, pers. comm.).

In contrast to other "effort groups", total effort in TR1 in VIa increased in 2009 by ~25%. This increased level would have exceeded the original allocation ceiling by over 60%. However, the transfer of effort from the largely unused TR2 category to TR1 (under EC 1342/2008 Article 17 (EC, 2008)) allowed effort to remain below the adjusted ceiling (72% of the limit). The additional effort was distributed in two main areas, the original TR2 focus ground on the Stanton Bank, and to the west of the VIa management line. Nearly half of Irish TR1 and TR2 fishing effort was spent west of the line in 2009 (45%), which is considered to be carrying out cod avoidance under the plan (EC 1342/2008 Article 13(d) (EC, 2008)) by fishing depths greater than 200m. Although catches of large cod are known to occur in this area (up to depths of ~400 m), reported landings in 2009 were low. It does however increase the fishing pressure on the targeted slope species, particularly on monkfish and megrim which both showed increased landings.

The Irish effort ceiling for gillnetting within the Irish Sea is relatively low and individual allocations were particularly conservative in February when the core fishery, targeting cod, normally occurs. This fishery primarily takes place close to the VIIa-VIIg boundary, depending on the spatial distribution of Celtic Sea cod around spawning time. Cod gillnet landings from VIIa were much reduced in 2009, although landings in the adjacent VIIg rectangles were not reduced. Therefore, an unintended impact of the Irish Sea effort regime may have been a reduction in fishing mortality on the Celtic Sea

cod stock through reduced effort and landings in this gillnet fishery, rather than the intended reduction in mortality on the Irish Sea stock.

Fishing is a dynamic industry where economic, biological and management changes induce tactical and strategic decisions and are reflected through modified fishing behaviour The Irish demersal fleet is no exception. Vessels change behaviour throughout the year, fishing a number of grounds, targeting a variety of different métiers, and switching between gear configurations. This flexible behaviour has been shown through the identification of métiers (unpublished data). When individual vessel effort allocations were restrictive vessels moved to alternative fishing grounds rather than "tie-up". Area-specialisation was found to be an important response of vessels to a closed area (plaice box) in the North Sea (Poos and Rijnsdorp, 2007). Vessels with previous experience of fishing elsewhere were more likely to move to alternative grounds, whilst those with previously strong area-specificity were more likely to stop fishing during the closure (Poos and Rijnsdorp, 2007). The importance of previous effort within fishing grounds was also suggested within modelling of fisher location choice (Hutton *et al.*, 2004) The displaced effort in 2009 did not lead to significant increases in effort outside areas regulated by the CLTP primarily because the impacts were negated by the decommissioning scheme. In the future any displacement of effort will result in increased fishing pressure on other stocks, ecosystems and environments in areas outside of the CLTP, such as those in the Celtic Sea or slope species beyond the 200m depth contour in the West of Scotland.

Similar effects have occurred after effort was displaced from newly closed, and marine protected areas. Increased pressure exerted in alternative grounds may diminish the intended overall beneficial effects on stock recovery (Kelly *et al.,* 2006; Suuronen *et al.,* 2010). Increased pressure in previously low effort areas may also occur to the detriment of the ecosystem and environment (Dinmore *et al.,* 2003). The reduction of available effort and its displacement to alternative areas demonstrated by the Irish fleet may have a similar effect on alternative stocks and species.

This study highlights both predictable and unforeseen consequences of restrictive management measures. In VIa for example, the large shift from shelf to slope fisheries was predictable. Less predictable was the switch of so many TR2 vessels to TR1 in 2009 rather than to areas outside of the CLTP. The response of TR2 vessels in the Irish Sea to spend more time fishing other *Nephrops* grounds was largely predictable. However, the seasonal shift in effort patterns and the extent to which effort was reduced were not foreseen. The previous level of effort in Irish Sea TR2 was reduced by 35% relative to 2008 and was only 76% of the effort limit. Some of this behaviour can be linked to vessels wanting to establish track record in areas outside the CLTP, such as the Celtic Sea, in anticipation of the extension of effort regulation to these areas. Changes of behaviour within individual fishing trips also occurred. An increase in the number of vessels fishing in very different grounds within a trip is further evidence of the instability in normal behaviour caused by the restrictive effort management.

Overall, the 2009 CLTP allocation ceilings were not reached by regulated gears, with the exception of TR1. Irish fleet cod landings in 2009 were reduced by over 50% in the

West of Scotland and by 32% in the Irish Sea. These areas also displayed low discard rates on observed trips (4% and 11% respectively; all gears combined). These reductions in landings combined with low discarding rates, are believed to have delivered Irish cod mortality reductions in excess of those stipulated by the CLTP for 2009. However, Irish catches constitute a relatively small component of annual total cod catches from the Irish Sea (12% of the landings as used by the ICES assessment and 6% of the removals as estimated in the assessment) (ICES, 2010). To the west of Scotland the percentages are even smaller (2% of the catch used in the ICES assessment and 0.6% of the estimated removals) (ICES, 2010). Therefore, the expected reductions in the partial fishing mortality affected by Ireland will only be beneficial to the cod stock if the CLTP has resulted in similar reductions in cod mortality from other fleets.

Effort was mainly displaced rather than reduced (although decommissioning negated the impact of this displacement on other grounds in 2009). Retrospective exploration of the fine scale changes of behaviour in response to management action is very important to elucidate the effectiveness of the measure and identify potential unwanted consequences. However, the type of analysis presented here should also be conducted at an international level to fully understand the impact of the measures. This is true of any large scale management measures encompassing multinational fleets.

A currently expanding area of research is attempting to predict the complex, multifaceted fleet and fisher responses to management scenarios through simulation and modelling. Examples include random utility models (Vermard *et al.*, 2008; Andersen *et*

al., 2010), individual-based models (Bastardie *et al*., 2010), dynamic-state variable models (Poos *et al.*, 2010) and models like ISIS-Fish (Pelletier *et al.*, 2009). These are aided by retrospective analyses of responses, which can provide valuable insight into decision making behaviour, which is not always rational or logical. Many of the current works simplify various aspects of dynamics. Increasing model complexity by incorporating a greater number of facets would also bring the addition of greater uncertainty (Bence *et al.*, 2008) which would have to be addressed. Response prediction is being brought within reach through data collection and development of modelling techniques, such as Bayesian approaches, are evolving to incorporate a greater number of facets, such as socio-economical and political dimensions. In addition to acknowledgement of the effects, and incorporation, of uncertainty into models such models.

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Area	Effort Group	2003	2004	2005	2006	2007	2008	2009	Effort Ceiling (kW)	Uptake (%)	Removed (%)
West of scotland	TR1	496 438	316 478	308 680	323 880	530 291	435 213	549 302	310 005	163%	0%
	TR2	1 039 254	967 586	767 637	712 743	384 398	196 959	17 989	481 938	3%	0.2%
	TR3	2 198		342	160	317	11 321	1 323	21 327	0%	0%
	BT1									NA	0%
	BT2		28 827	5 068	6 335				3 914	NA	0%
	GN1	19 967	20 763	192	3 554	13 348	9 949	3 276	6 400	44%	0%
	GT1			5 410	449				1 946	NA	0%
	LL1	7 200	18 400	3 000		9 750			1 013	NA	0%
	Total	1 565 057	1 352 054	1 090 329	1 047 121	938 104	653 442	571 890	826 543	63%	
Irish Sea	TR1	358 717	134 382	87 264	84 551	140 395	73 005	60 348	79 246	70%	23%
	TR2	1 194 559	1 345 089	1 464 650	1 458 922	1 582 409	1 311 141	853 165	1 120 977	69%	28%
	TR3	900	90	3 305	960		436		9 646	NA	0%
	BT1									NA	0%
	BT2	783 381	411 353	511 814	481 404	550 534	374 493	173 927	507 923	32%	66%
	GN1	76 613	60 551	26 671	29 533	45 084	40 958	22 213	24 713	80%	13%
	GT1						1 327	1 237			0%
	LL1		800				149		62	NA	0%
	Total	2 946 207	2 775 422	2 503 899	2 401 100	2 754 585	2 196 165	1 533 442	1 742 567	58%	

Table 1. West of Scotland (VIa) and Irish Sea (VIIa) kW-days for cod long-term plan effort groups (Council Regulation No.1342/2008), 2003-2009. Details 2009 effort ceilings allocated to Ireland (EC, 2009), uptake from January to December 2009 (%), and 2008 effort by subsequently decommissioned vessels (Removed %). Definitions of effort groups are given in the text.

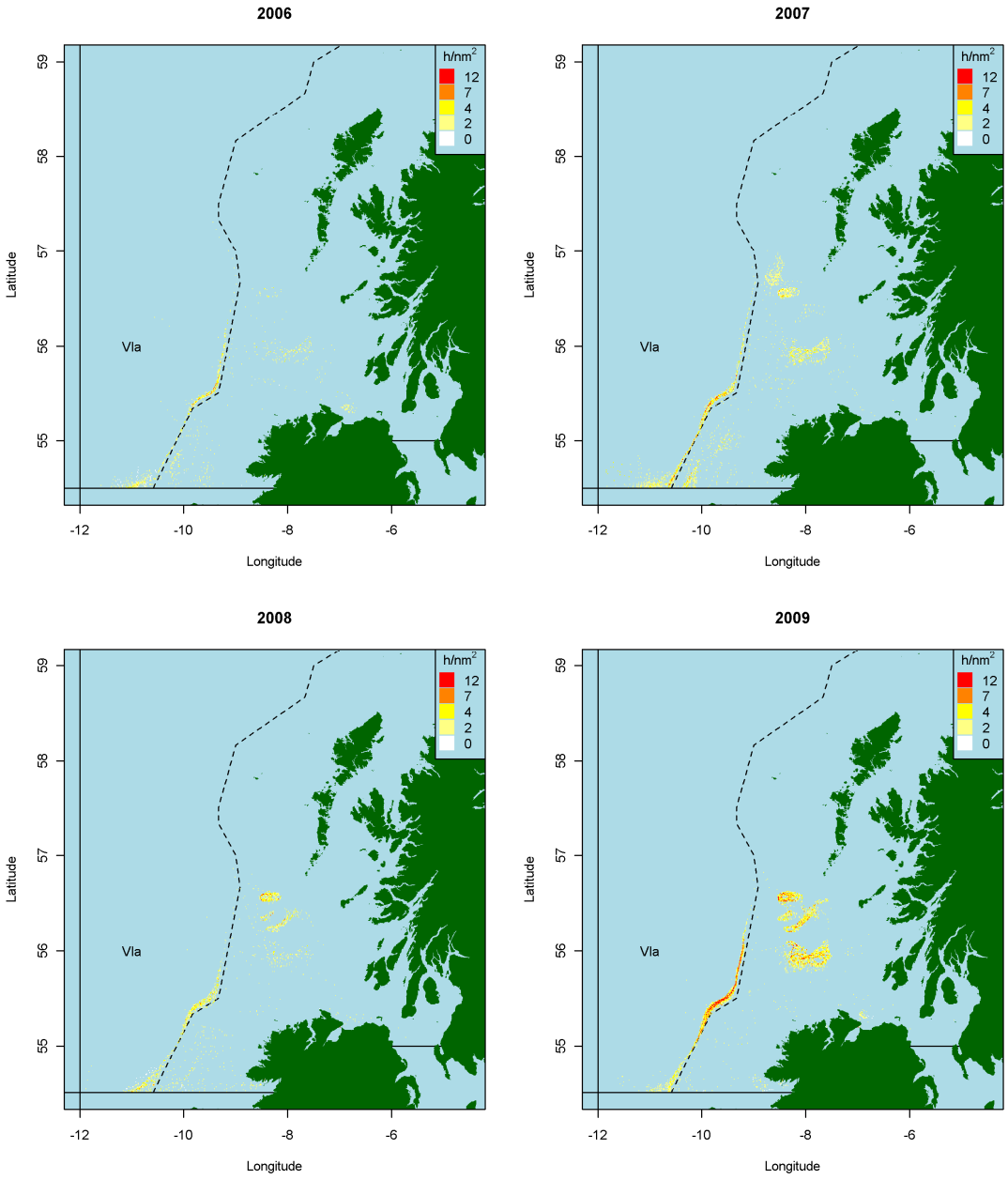


Figure 1. Irish VMS based TR1 fishing effort as hours per square nautical mile (h/nm^2), 2006-2009 to the West of Scotland (VIa). Dashed line depicts the VIa management line as detailed in EC 43/2009 Annex IIIa Article 6 (EC, 2009).

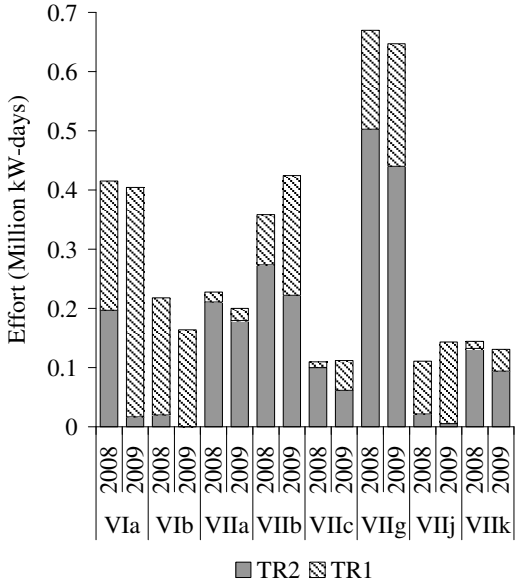


Figure 2. TR1 and TR2 gear effort (kW-days) deployed during 2008 and 2009 by Irish fleet vessels having fished to the West of Scotland (VIa) with TR2 gear during 2008.

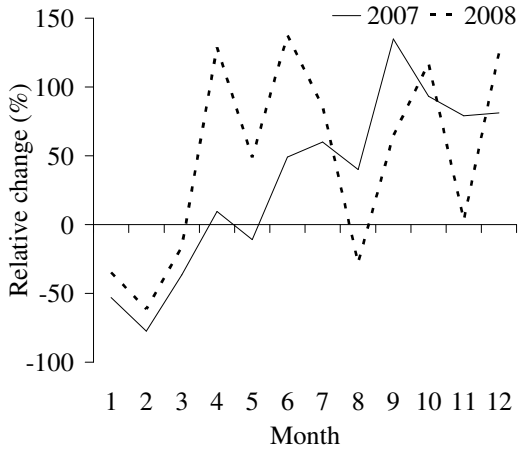
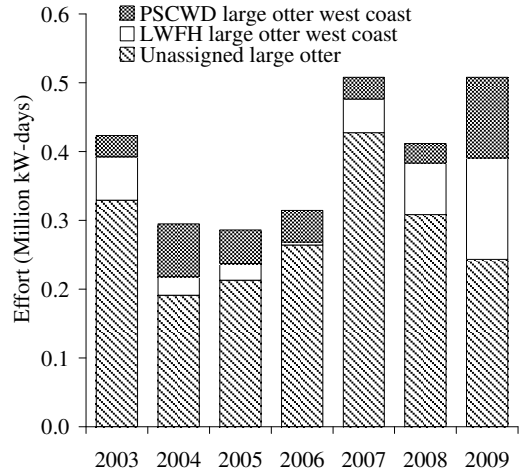
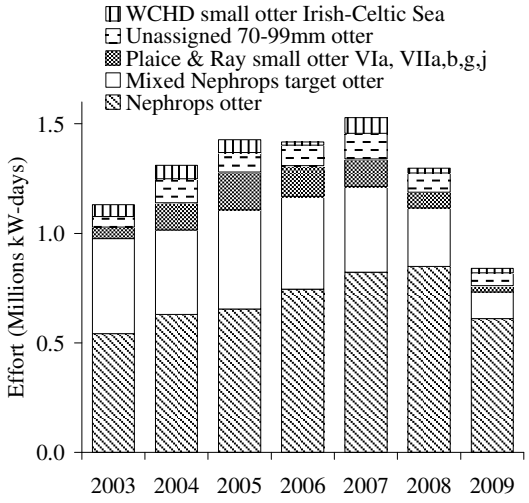


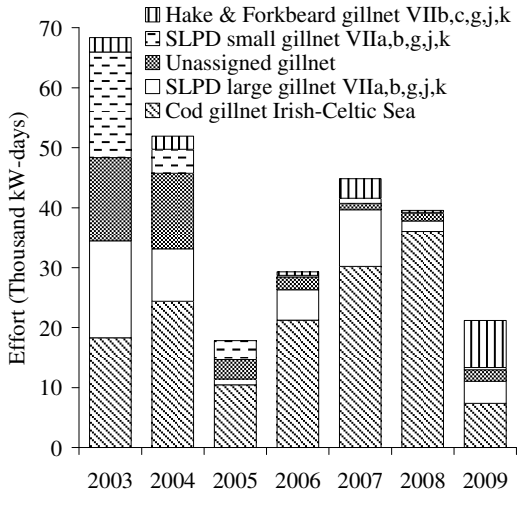
Figure 3. West of Scotland (VIa) Irish fleet percentage relative change in TR1 2009 monthly kW-days to 2007-2008 levels.


PSCWD large otter west coast
LWFH large otter west coast
Unassigned large otter
Effort (Million kW-days)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
2003
2004
2005
2006
2007
2008
2009

a)


WCHD small otter Irish-Celtic Sea
Unassigned 70-99mm otter
Plaice & Ray small otter VIa, VIIa,b,g,j
Mixed Nephrops target otter
Nephrops otter
Effort (Millions kW-days)
0.0
0.5
1.0
1.5
2003
2004
2005
2006
2007
2008
2009

b)


Hake & Forkbeard gillnet VIIb,c,g,j,k
SLPD small gillnet VIIa,b,g,j,k
Unassigned gillnet
SLPD large gillnet VIIa,b,g,j,k
Cod gillnet Irish-Celtic Sea
Effort (Thousand kW-days)
0
10
20
30
40
50
60
70
2003
2004
2005
2006
2007
2008
2009

c)

Figure 4. KW-days effort breakdown of the main métiers within the Irish fleet, 2003-2009 a) TR1 West of Scotland, b) TR2 Irish Sea, and c) GN1 Irish Sea. N.B. Large otter – ≥100mm mesh bottom otter trawls; PSCWD – pollack, saithe, cod, whiting, and dogfish; LWFH – ling, witch, forkbeard, and hake; WCHD - whiting, cod, haddock, and dogfish; SLPD – saithe, ling, pollack, and dogfish.

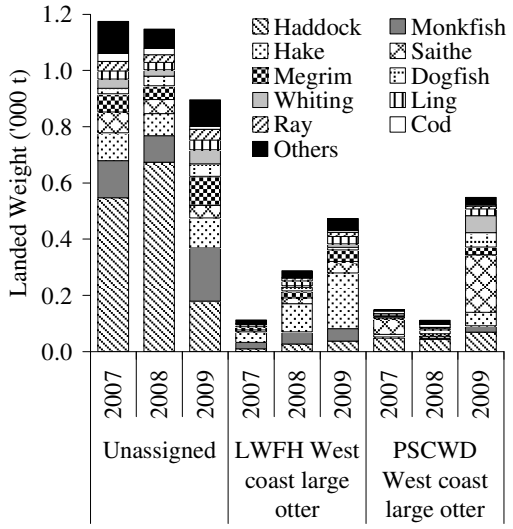


Figure 5. Top 10 species, by live weights in TR1 landings ('000 t) for the main Irish fleet métiers fishing to the West of Scotland (VIa), 2007-2009. All other species landed are grouped as "Others". N.B. Large otter – ≥100mm mesh bottom otter trawls; LWFH – ling, witch, forkbeard, and hake; PSCWD – pollack, saithe, cod, whiting, and dogfish.

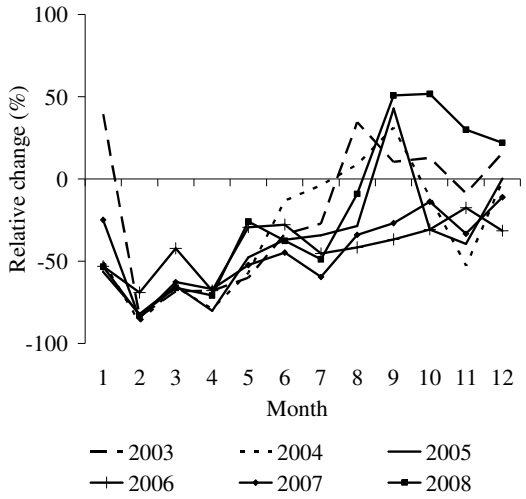


Figure 6. Irish Sea (VIIa) Irish fleet TR2 gear percentage relative change in 2009 monthly kW-days to 2003-2008 levels.

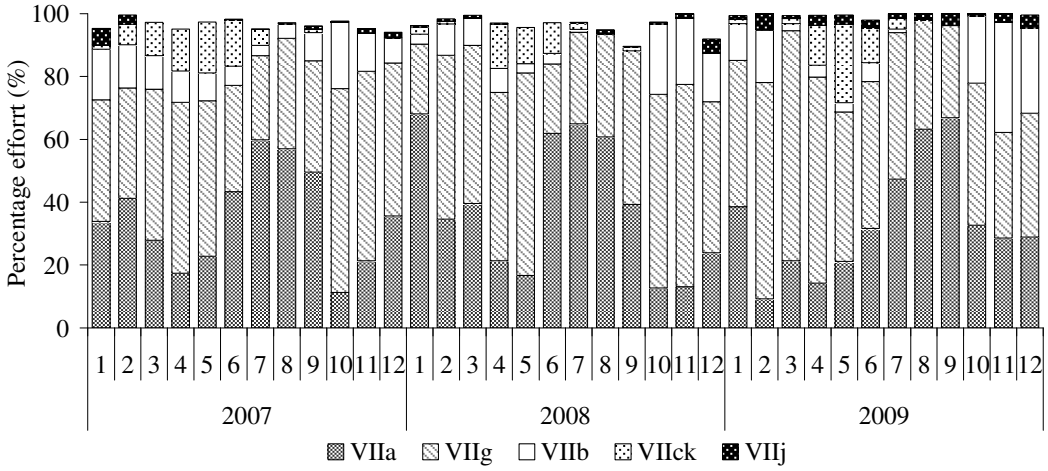
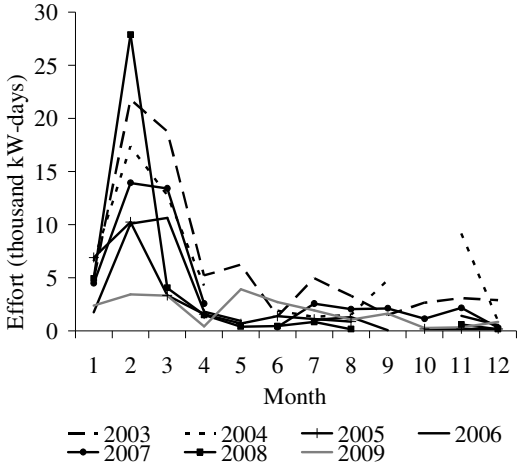
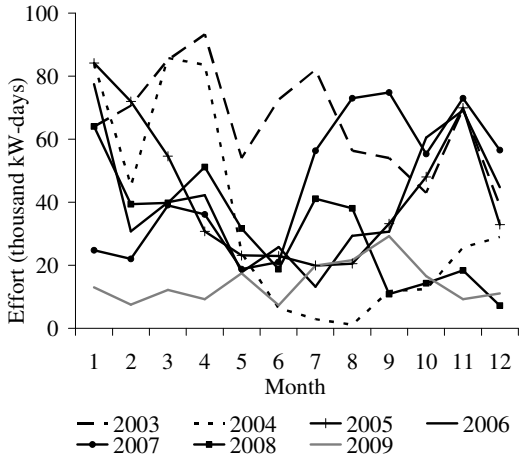


Figure 7. Monthly percentage area distribution of Irish fleet TR2 gear effort for 2007, 2008, and 2009 deployed by Irish vessels which operated within the Irish Sea with TR2 gear during the respective year.



a)



b)

Figure 8. Irish Sea (VIIa) Irish fleet monthly kW-days effort, 2003-2009 for a) GN1 and b) BT2.