The Irish Fisheries Science Research Partnership

The Fisheries Resource

Linking Advice, Research and the Fishing Industry

A Mini Conference

BOOK OF ABSTRACTS

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The Marine Institute, Rinville, Oranmore, Co. Galway

TABLE OF CONTENTS

Theme Session 1 – Research Vessel Surveys

Chair: Frank O'Brien

Pros and Cons of Using Commercial Fishing Vessels as Acoustic Platforms for Monitoring Herring off the West Coast of Ireland

(The use of commercial fishing vessels for acoustic surveys monitoring of herring off the west coast of Ireland.)

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Acoustic data obtained from the commercial fishing fleet can potentially provide valuable information for fish stock management and increase the flow of information between fishermen and scientists. However, the utility of such data is complicated and there are few guidelines as to how industry-derived acoustic data might actually be incorporated in fisheries assessments. Here we assess the utility of fishing vessels as scientific platforms and highlight the main problems facing scientists using such an approach via a pilot study conducted off the west coast of Ireland. In this study, acoustic measurements of herring schools were compared from two fishing vessels and RV *Celtic Explorer* that surveyed in parallel during a routine herring survey in June/July 2008. We assess whether or not measurements of fish school morphology (e.g. length, height, area) from industry-derived acoustic data, which are less-dependant on absolute measurements of acoustic backscatter, can provide a supplementary means of assessing variations in commercial fish stocks. Our results indicate a high degree of spatio-temporal variation in school morphology and herring distribution around western Ireland that highlights the importance of a standardised survey design for robust fisheries assessments. In some instances, the use of commercial-grade acoustic data and morphometric descriptors may aid scientific surveys and fisheries management.

Measuring and mitigating uncertainty in *Nephrops* Underwater Television surveys

(Improving Nephrop surveys.)

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Underwater TV surveys (UWTV) are essential to the assessment and scientific advice on management of the main *Nephrops* stocks in Europe. These surveys have been used provide relative abundance indices and most recently they have been used to provide absolute measures of abundance for a number of *Nephrops* stocks in waters around Ireland (FU17 Aran Grounds and FU15 western Irish Sea) and elsewhere. The survey methodology involves towing a camera mounted on a sled over mud patches on the seabed and counting the *Nephrop*s burrow systems. As with any survey process various uncertainties arise and the survey design procedures should measure and mitigate uncertainties. Previously WKNEPHTV 2007 identified and attempted to quantify the main uncertainties in the UWTV survey methodology. This study describes UWTV survey method employed by Ireland and how uncertainty is measured and minimized. Various quality control (QC) process have been implemented including a tool to visualize and estimate navigational and burrow count data collected. There are procedures in place to QC the somewhat subjective burrow counts by individual counters. In addition uncertainties relating to the defined area of the *Nephrops* ground, edge effects and burrow occupancy are discussed.

Keywords: Underwater TV surveys, uncertainty, *Nephrops*, Quality Control.

Spatio-Temporal Dynamics of Atlantic Cod *(Gadus Morhua)* in the Irish and Celtic Seas: Results from a Collaborative Tagging Programme.

(Movements of cod around Ireland from tagged fish.)

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Spatio-temporal dynamics related to sub-structuring of Atlantic cod stocks may affect how the populations in different management areas respond to recovery measures. Using data from mark recovery and electronic tag studies, we test the assumption that there is an exchange of cod between two adjacent cod management areas, one in the Irish Sea (ICES Division VIIa) and the other in the western English Channel and Celtic Sea (ICES Divisions VIIe-k). We evaluate 1522 archived and current mark recovery data (1960's- present day) to assess the seasonal changes in distribution of cod within ICES Divisions VIIa and VIIe-g. In addition, we report on the results of a collaborative electronic data storage tagging (DST) programme of cod in the Irish and Celtic Sea, spanning the years 1999 to 2009. During this time, 693 DSTs have been deployed on cod between 43cm and 110cm, and 54 of the tags have been returned yielding over 2700 days of data. We used a tidal geolocation model to determine the daily locations of each cod to reconstruct in detail the migrations of cod tagged with DSTs. The results are the first to describe fundamental features of cod spatial ecology in the Irish and Celtic Sea, such as the location of feeding and spawning grounds (and the migratory pathways between them), the seasonality of migration and habitat occupation and the potential impact upon sub-stock structure.

Keywords: Atlantic cod, electronic tag, geolocation, behaviour, migration, habitat use

Extending the Pelagic Acoustic Survey in the Irish Sea – Preliminary Results 2007-2009

(Changing acoustic surveys based on fishermen's knowledge.)

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The timing of the annual herring acoustic survey in the Irish Sea (Division VIIaN) is suggested to be key in our perception of the size of the spawning stock biomass and mortality rates in the stock. This is due to temporal changes in migration patterns onto the Douglas Bank spawning grounds. Based on information from fishers and as a direct result of proposals received from the Northern Irish fishing industry, the timing of the annual acoustic survey was to be investigated. A project was initiated in 2007 that aims to carry out a series of additional (3-4) surveys for five years. These surveys enhance the existing survey time series of acoustic data on movement and biomass of herring in the Irish Sea by extending the temporal coverage of the existing acoustic survey time series. The results from the first three years of the project provide an insight into the migration patterns of herring, both in temporal and spatial terms. It also aims to increase the accuracy of the time series estimates of biomass by age class required for formal stock assessment purposes and contributes to the information source to underpin a long-term management plan for the stock.

Theme Session 2 – Pelagic Fisheries

Chair: John Molloy

Temporal Trends in Stock Composition of Celtic Sea Herring

(The importance of separating autumn and winter spawning in Celtic Sea herring.)

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The herring population to the south of Ireland, in the Celtic Sea consists of autumn and winter spawners. These are assessed and managed together and are exploited by the same fleets. Long-term changes in key biological parameters have been documented. Then, long-term variations in the spawning components were hypothesised to explain a part of these trends. The aim of this study was to elucidate the relative abundance of autumn-spawning and winter-spawning per ICES division in the Celtic Sea (i.e. VIIj, VIIg, and VIIa South). Biological sampling data of catches from 1958 to 2008 were analysed. A classification assigned fish collected to seasonal spawning components (autumn-spawners or winter-spawners) based on the stage of development of their gonads at the time of sampling. The results showed significant variation in abundances of autumn versus winter-spawners over time. In addition, the two spawning groups exhibited very different conditions (length and weight related index) and growth rate parameters for different periods of the study. These results highlighted the long-term variability of seasonal spawning components in the different Celtic Sea areas, providing a better understanding of the stock dynamics and helping building fishery advices. This is of importance for management purposes as it can inform rebuilding plans for Irish herring stocks and help to preserve diversity in herring fisheries around Ireland.

Key words: Long-term dynamics, herring stocks, Celtic Sea, spawning season component.

Long-term Changes in the Biological Parameters of Herring in the Celtic Sea and Southwest of Ireland

(Changes in growth of Celtic Sea herring in the 20th century.)

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The herring fishery in the Celtic Sea and Division VIIj has been commercially important for many years. The Marine Institute has been collecting biological data for this stock since 1959, with earlier historical data available since the 1920s. These data were archived and analysed to examine long term trends in size and weight at age, growth rate, condition factor and maturity ogives. Mean length at age was low in the 1950s, peaked in the 1970s and declined thereafter. Mean weight data, where available showed the same trend. Absolute growth rates were faster in the 1960s and 1970s than in the 1980s and 1990s and more recent year classes were among the slowest growing in the series. Fulton's condition factor also declined significantly, throughout the time series and the maturation for 1 winter ring increased in the early 1970s and has remained at a high level since then. These changes, though not easily explained, do have important implications for the management of the stock. Declining growth results in more individual fish per tonne of landings which exerts a greater fishing mortality than in the past.

Keywords: Atlantic herring, Celtic Sea, growth rate, condition factor, maturation

The Rebuilding Plan for Celtic Sea Herring and Steps Towards Developing a Long Term Management Plan

(The science behind the development of the Celtic Sea Management Plan.)

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The Celtic Sea herring is a commercially valuable resource on the south coast of Ireland. It is managed by means of a TAC and technical measures set out in EC regulations. However the local management of the Irish fishery, which takes most of the catch, is largely driven by a stakeholder committee. This committee consists of fishermen, processors and has a high degree of scientific input.

Since 2007, ICES advised that fishing should not proceed unless accompanied by a rebuilding plan. Development of this plan began in 2008. This plan was evaluated in 2009 following a request from the EU to ICES and found to be precautionary within the current stock dynamics. The forecast and subsequent advice was based on the rebuilding plan. An important element of the plan states that when the SSB is deemed to have recovered to a size equal to or greater than B_{pa} (44,000 t) in three consecutive years, the rebuilding plan will be superseded by a long-term management plan. This paper outlines the development of a rebuilding plan, with the involvement of the committee and recent developments towards a long term management plan for the fishery.

Long Term Trends of Mackerel Spawning Locations and Associated Environmental Conditions

(Changes in spawning locations of mackerel over the last 30 years.)

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ICES triennial mackerel (*Scombus scombrus*) egg survey data for 11 surveys spanning 30 years (1977-2007) were used to investigate spatio-temporal changes in mackerel spawning location. Stage 1 mackerel eggs were analysed using spatial statistics including the centre of gravity (the most probable location of an egg taken at random from the population), the inertia (the spread around the centre of gravity), and the anisotropy (the spatial direction of the inertia). Results demonstrated an inter-annual North West shift in stage 1 egg location, alongside an intra-annual shift north during the spawning season. The inertia is increasing as the mackerel spawn further north and the anisotropy generally follows the direction of the shelf edge. The annual centre of gravity of SST (the most likely SST experienced an egg pulled randomly from the population) remains within a small window over the survey years of 12-14^{0}C. The annual centre of gravity of chlorophyll was also determined and this remains within a small window of 0.2mg/M^3. The results suggest that the mackerel are using environmental cues to maintain approximately the same environment at spawning. This has potential impacts on the fishing industry in terms of understanding and determining future quotas, the timing of fisheries opening and/or closing, and conservation management of important spawning grounds.

Theme Session 3 – Inshore Fisheries

Chair: Richard Fitzgerald

Managing for Sustainable Exploitation of Dredging in Intertidal Mudflats

(The ins and outs of dredging in Natura sites.)

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A number of intertidal mudflats in Ireland support commercial fisheries for valuable bivalves such as cockles and mussels which are fished by hydraulic and non-hydraulic dredges. These fishing gears can have significant impacts on sediments and benthos and recovery from these impacts, including recovery of the target commercial species, may be protracted in certain environments. Many of these environments are also protected under the Habitats and Birds Directives which requires that fishing (and other) activities do not affect the long term integrity of such habitats.

Annual pre-fishery stock assessment surveys are used to estimate biomass of cockles. Exploitation is limited using a series of measures including limited entry, spatial restriction, closed seasons, size limits, total allowable catch and a minimum catch rate condition for closure using near real time data as detailed in a fishery management plan.

Impact and recovery of sediments and benthos is assessed using a before, after, control, impact (BACI) experimental design. Post fishery habitat use by intertidal birds is assessed in relation to prior spatial pattern and intensity of fishing effort.

Where the fishery occurs within a Natura 2000 site the fishery management plan is assessed against the conservation objectives for the Natura site using the impact and recovery data to assess the significance of the impact in relation to the requirement to maintain the long term integrity of the habitat. Generally, recovery of habitat and benthos from a previous impact will need to be demonstrated prior to a subsequent fishery being opened.

Estimating Exploitation Rates on Shrimp Using Standardised Catch Rate Depletion Methods

(Estimating the proportion of shrimp stock taken in a fishery.)

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Shrimp (*Palaemon serratus*) is a valuable component of the pot fisheries for crustaceans in inshore waters in Ireland. Shrimp are short lived, and as such are vulnerable to recruitment failure if spawning stock is depleted and/or if environmental conditions during the larval and early juvenile phases cause higher than usual mortality. Estimation and limiting exploitation rate is important to safeguard spawning stock.

Depletion of standardised catch rate data was used to estimate exploitation rate on the dominant cohort in the catch, 1+ female shrimp, in the south coast fishery. Isolating the 1+ female cohort removed effects of recruitment on catch rate. On a weekly basis during the fishing season the weight of 1+ females per unit of effort was estimated using the sex and age structure of the catch and, using weekly information on the mean size of 1+ females, was converted to numbers of 1+ females per trap to remove the effects of growth on catch rate. The catch rate, of numbers of 1+ females, was standardised for catchability effects by statistically removing effects of temperature, wind direction, wind strength, gear soak time and air pressure using a general linear model. The resulting standardised catch rate generally showed a linear relationship with cumulative catch, not evident in the raw catch rate data, suggesting a depletion effect due to fishing. Seasonal exploitation rates, estimated from the relationship between standardised catch rate of 1+ female shrimp and cumulative catch, during the season, varied from 53-63% in 3 Bays on the south coast. Although longer term data are required to determine the sustainability of these exploitation rates, inter-annual variability in catch rates between 1998 and 2005 was high and showed no overall decline.

Designing Technical Conservation Measures to Optimise Egg Production in Lobster Stocks

(Increasing lobster stocks through v-notching, minimum and maximum landing sizes.)

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Management of lobster stocks in Ireland relies solely on technical conservation measures such as minimum landing sizes to limit fishing mortality on the stock and to conserve spawning potential. Such measures can be effective given that discard mortality is very low and maybe close to zero. Two measures are currently in force, a minimum landing size of 87mm and a ban on the landing of v-notched lobsters. A third measure, which would ban the landing of lobsters over 127mm, has been discussed and agreed by the Lobster Advisory Group.

The relative benefits and combined effect of these measures was assessed using an individual based egg per recruit model. The model requires information on natural mortality, maturity, growth and the resilience of the v-notch in relation to moulting. New information on growth and v-notch repair, for the model, was obtained from multi-annual mark recapture data obtained from tag information returned by fishermen in the period 2002-2008.

The assessment shows that it is difficult to achieve target egg production of 25% of the unfished level using technical measures alone and without adjustment of fishing mortality on the exploited portion of the stock. Egg production could be increased to over 10% of the unfished level by maintaining the MLS, v-notching at a rate of 2.5% of legal sized catch and introducing a maximum size of 127mm. This would also require substantial increases in the level of v-notching over the average levels achieved in the period 2004-2008.

Theme Session 4 – Making the most of Information

Chair: Michael Keatinge

Unlocking the Power of VMS Data to Inform Fisheries Assessments and Advice

(Linking VMS and logbook data, providing a more detailed picture of Irish fisheries.)

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Vessel Monitoring Systems (VMS) automatically collect positional data from fishing vessels every two hours. Although these data are mainly collected for enforcement purposes, they can also provide fisheries scientists with a very detailed and nearly complete account of fishing activity. VMS data can be linked to the catch data from the logbooks, which allows scientists to produce detailed maps of fishing effort, catches and catch-per-unit effort (cpue). These maps show highly structured patterns at scales much finer than that of ICES rectangles. The data can be used to inform fisheries science and advice in a large number of ways. Some examples include:

- Detailed time-series of the spatial distribution of fishing effort, catches and cpue.
- Effort, catches or cpue in specific locations can be quantified. This can be used to evaluate or propose closed areas or estimate cpue time-series for particular fishing grounds like *Nephrops* grounds
- By comparing the spatial distribution of effort and cpue data, it will be possible to identify the intended target species of each trip more accurately, allowing trips to be characterised into métiers more accurately.
- By comparing the distribution of all effort with that of the fishing trips that are sampled for discards or landings, it will be possible to check for spatial bias in the sampling.

The ecosystem approach to fisheries management increasingly requires spatially resolved fisheries data, through the use of VMS many of these requirements can now be met.

Landing and Processing Fishers' Knowledge in the Galway and Aran Fishery

(How fishermen's experience could be used for co-management.)

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Despite a strong Irish biological science programme, it is not always possible for fisheries managers to make stock assessments for various Irish fisheries. However, there is a perception developing amongst Irish fisheries managers that fishers have a great amount of knowledge about the environment they work in. It is believed this knowledge could meet shortcomings where scientific approaches do not produce the required results.

The Irish Fishers Knowledge Project (IFKP), working with the Irish Sea Fisheries Research Partnership (IFSRP) has deployed mainly qualitative methods to ascertain whether fishers based in the Galway and Aran region have this specialised knowledge of their working environment. The results clearly show fishers do have a knowledge that can be used as data where science cannot provide results, but they also show something equally or even more significant. It is likely that fishers can also provide information outside the current scope of biological fisheries science. This additional information is partially ecological, but is also social, economic and political. The preliminary results of the IFKP potentially suggest that fishers should not be limited to the role of information providers. Fishers have a vast array of ideas for managing the fishery that they operate in and it could be argued that there should be a more direct role for fishers in fisheries management. The geographically distinct fishery of Galway and Aran could be an excellent place to test this hypothesis.

Linking Industry-Science Co-Operation and Co-Management: the Celtic Sea Herring Experience.

(Collaboration between scientists and fishermen to develop and propose new management measures for Celtic Sea herring.)

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[3.] Chairman, Celtic Sea Herring Management Advisory Committee.

The development of co-management arrangements has been flagged as a potential tool for incentivising more sustainable fisheries management by the European Commission in their 2009 Green Paper on Reform of the Common Fisheries Policy. Additionally the principles of an ecosystem approach to fisheries management stress the beneficial outcomes of strengthening both industry participation in management and enhancing links between industry and science.

In an Irish fisheries management context science-industry research links are being strengthened through a number of initiatives but functional examples of formal co-management, i.e. the sharing of responsibility and accountability for resource management between stakeholders, scientists and government administrations, are few.

In this paper we present an account of the Celtic Sea Herring Management Advisory Committee (CSHMAC), which although formally only an advisory body has developed into an informal management network incorporating a strong industry-science partnership. We discuss the history behind the formation of the Committee, its role as a problem solving forum in response to a resource crisis and the development of learning processes which were required to build management capacity and which culminated in a jointly developed Recovery Plan from 2007 onwards and subsequent TAC increase of 70% in 2010.

We also discuss how the Committee attempts to use innovative solutions to deal with classic fisheries management problems such as focusing on longer term approaches, ensuring equitable resource distribution within the inshore fisheries sector, embracing stakeholder responsibilities, the maintenance of incentives for sustainable actions in a relatively open access context and the incorporation of ideas such as closed areas which would be compatible with the ecosystem approach.

The paper concludes with a discussion of whether or not the CSHMAC model can be usefully applied to other fisheries in Irish waters particularly those with more complex governance profiles.

Capturing Fishers' Knowledge – the Celtic Sea Cod Fishery

(Findings from interviews with Celtic Sea fishermen.)

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The acknowledgement that fishers' often have substantial knowledge of the systems in which they work, and that this could and should be used in management, has been growing as a number of studies have shown the benefits of such an approach. The Irish Fishers' Knowledge Project (IFKP) is the first of its kind in Ireland, in its objective to investigate ways in which fishers' knowledge can be systematically captured and usefully integrated into the assessment and management process.

A number of issues surrounding the Celtic Sea cod fishery make it a particularly appropriate case study. A lack of data of sufficient quality has meant that fisheries scientists have been unable to make an assessment of the cod stocks; fishers' knowledge then may be able to contribute to filling in the gaps in scientific knowledge. In addition, fishers and fisheries scientists hold quite divergent views on the status of the cod stocks. On the one hand scientific advice has consistently recommended reductions in fishing mortality; on the other fishers maintain that the stocks are healthier than previous assessments have estimated. Both these narratives need to be explored with the objective of gaining clarification on the cod stocks. The scientific viewpoint is well documented; the IFKP provides the opportunity to explore fishers' knowledge to a depth that has not been attempted before. Arguably, a second objective should also be to facilitate a better understanding between the two if any success in effective management of the stocks is to be achieved.

The Multiple Métiers Fished by the Irish Industry

(Description of Irish fisheries using gear, vessel and landings data.)

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This investigation presents Irish métiers ("homogeneous subdivisions of a fishery by vessel type"; ICES, 2003) defined through the application of factorial and clustering methods to 2003 fishing trip data. The analysis incorporated six trip characteristics, fishing gear, mesh size, vessel length, landings based species composition, area, and month. Of these, the analysis showed gear, mesh size and species assemblage as dominant factors in defining Irish otter trawl métiers.

Métier definitions were applied to 2003-2006 fishing trip data to assess recent dynamics and stability. During this period, overall proportions within many of the defined métiers have fluctuated around similar levels, implying some relative overall stability. It also indicates the métier definitions are appropriate, having remained relevant over time. Where changes have occurred it has been possible to associate some shifts in metier behaviour to changing management and stock abundance.

A total of 52 métiers were identified and defined for Irish fishing activities. Effort and vessel numbers was dominated by demersal towed gear metiers including those directed towards megrim and monkfish on the continental shelf slope, and *Nephrops* in the Irish Sea and Small grounds. Pelagic species directed metiers however dominated landings.

Defining appropriate métiers can be used as a tool to improve fisheries assessment and management. It also allows for improved sampling stratification, increased precision for stock parameters and better scientific advice through the consideration of exploitation patterns and métiers dynamics.

Key Words: Irish fleet; Métiers; Multivariate analysis; Dynamics; Mixed fisheries

Theme Session 5 – Understanding Biological Interactions

Chair: Aengus Parsons

Unravelling Population Connectivity in The Deep-Sea – Towards Sustainable Fisheries

(Understanding deep-sea stocks and a suggested fishing approach.)

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The stock structure and life history of two commercial deep sea fish; the Roundnose grenadier (*Coryphaenoides rupestris*) and Black scabbardfish (*Aphanopus carbo*) in the North Atlantic is investigated using a multidisciplinary approach of otolith microchemistry, isotope and shape analysis.

Results to date indicate that the Roundnose grenadier is highly structured within the North Atlantic, with target populations becoming more distinct with age. Analyses indicate early life is spent in shallower waters migrating progressively deeper with age.

Results of the Black scabbardfish suggest this species is highly migratory, conforming to a single, cyclic migrant stock hypothesis within the North Atlantic, with a spawning ground in Madeiran waters and feeding ground around the Rockall region.

Current lack of information on the biology, ecology and stock structure of these deep-sea species coupled with increasing fishing pressure has led to overexploitation of these vulnerable species.

In light of the findings of this study (and those produced the deep-sea research group DEECON), it is suggested that fishing efforts towards these species be tailored to reflect both their individual stock structure and highly different lifecycles. Two commercial deep-sea species, one fishing industry and scientists working towards sustainable fisheries in the deep sea.

Keywords: Roundnose grenadier, Black scabbardfish, ICP-MS, stock structure, Trace elements, Isotopes, Elliptical fourier analysis, North Atlantic

Preliminary findings on the biology of Black Scabbardfish (*Aphanopus carbo* Lowe, 1839) in the North East Atlantic – implications for management

(Indentifying areas of mature and immature black scabbard in the North East Atlantic.)

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The black scabbardfish (*A. carbo*) is widely distributed in the deep water ecosystem of the north east Atlantic. In 2008, the commercial fisheries yielded landings of 7,053 tonnes. It is mainly captured in a multi species trawl fishery to the west of the UK and Ireland and by longliners in the waters off Portugal and Madeira. The species is managed under the EU Common Fisheries Policy and two management areas are subjected to annual Total Allowable Catches. Between September 2008 and May 2010, 2,360 specimens were collected from these two different areas: NW Scotland (French trawlers) and Madeira (Potuguese longliners). Additional data were obtained from four scientific deep water surveys. Preliminary analyses show that the two areas are very different in terms of the biology of black scabbard. The length frequency distributions were significantly different, with fish from Madeira (max. size 142 cm) significantly larger than those from UK, Scotland (Max size 129 cm). The overall, the sex ratio was 1:1.30 and 1:1.01 (M:F) for NW Scotland and Madeira, respectively. In the northern area, all the specimens were immature throughout the year, while in Madeira all maturity stages were observed. In Madeira, spawning occurred during the fourth quarter, with peak maturity in October (males) and in November (females). The gonadosomatic index (GSI) for males and females in Madeira reached a maximum in October and November, while it remained constant in the northern area. These preliminary results may support the view that black scabbard undertake a north south spawning migration and that the current management areas may not be appropriate.

Fisheries Discards in the Irish Sea (Division VIIa) Exhibit Temporal Oscillations and Trends Reflecting Underlying Processes at an Annual Scale

(Annual trends of discards in the Irish Sea.)

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There are concerns of non-inclusion of discards data in fisheries assessment as it can lead to underestimation of biomass and fishing mortality, particularly if there have been changes in discards practices over time. Although the high variability in space and time is a well documented feature of discards, the temporal dynamic of this practice has received little detailed attention. The present study aims to characterise the temporal patterns of discarding practices in the Irish Sea (ICES division VIIa) from 1994 to 2008. Trend and seasonality were explored in discards per unit effort (DPUE) of haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*) and cod (*Gadus morhua*) through Bayesian autoregressive models (AR) and harmonic regressions (HREG). DPUE of whiting and cod appear to have remained constant throughout the observed period but haddock DPUE have slightly increased. The HREG models illustrate that discarding of all three species occur in annual cycles perhaps reflecting fish biology and fishers' behaviour.

The EU FP7 'CoralFISH' project: a unique science-fisheries research partnership

(Involving stakeholders in deep-sea fisheries management.)

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Fisheries management success stories usually have a common ingredient: A good working relationship between the fishing industry, scientists and policymakers. In Europe, this has not historically been the case, although several initiatives are underway to strengthen fisheries-science-policy linkages. Oceanic and deep-sea fisheries are coming under scrutiny due to claims of over-fishing and seafloor habitat destruction. The future viability of oceanic and deep-sea fisheries will need the adoption of an ecosystem approach to management (EAM) with the full cooperation of all stakeholders.

The large integrating EU 7th Framework project 'CoralFISH' (http://www.eu-fp7-CoralFISH.net) is addressing issues relating to the sustainability of deep-sea fisheries and the conservation of vulnerable marine ecosystems such as deep-water corals. The project consortium is drawn from 10 countries and includes a fisheries SME as a full consortium partner. The latter is collecting fisheries data for the project as well as providing feedback on the relevance of our science and industry targeted outreach programme.

Theme Session 6 – Management Coordination

Chair: Sean O'Donoghue

Forgotten Signals in Fisheries Management

(Looking at fish stock status with a new technique.)

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In recent years, there have been increasing calls for the use of indicators and reference points in fisheries management system. This is particularly true in situations where data are limited or of poor quality for traditional stock assessment. Here we present a new monitoring tool based on Statistical Process Control (SPC), an extension of the traditional indicator-traffic-light based approach, implemented within a statistical framework. The SPC technique is widely used in disciplines such as psychology, electronics and manufacturing technology. We illustrate how SPC tools can be used for evaluating past managerial events and real time qualitative assessment using three key fisheries: - Irish Sea Cod, Megrim and North East Atlantic Mackerel.

Potential age-based catch indicators were identified and used with Cumulative Sum control charts (CUSUM), an SPC tool to detect persistent changes in a system. The CUSUM was designed based on ICES precautionary spawning stock biomass reference limits. The performance of CUSUM was consistent with the traditional traffic-light approach and was able to produce early warning signals for certain fisheries. However, CUSUM might have limitations for species where recruitment to the fishery occurs before maturity, resulting in delayed signals. The performance of CUSUM with species having different life histories and the role of CUSUM in a fisheries management framework with Harvest Control Rules is suggested for future research.

A Possible Management Tool Allowing Flexible Choices in the Celtic Sea Mixed Fisheries

(An idea for giving fishermen more flexibility in mixed fisheries.)

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Demersal mixed fisheries in the Celtic Sea mainly land cod, haddock, whiting, *Nephrops*, and anglerfish. Cod is taken by bottom trawls and less so by beam trawls. Although the cod recovery plan does not currently cover the Celtic Sea, a management plan including effort restrictions is expected. The problem of mixed fisheries is that while stringent catch and effort restrictions must protect depleted stocks, healthier stocks allow more liberal fishing. A dilemma results between underexploiting some stocks and discarding and overexploiting others. We explore a possible solution, enabling flexible effort allocation, based on the idea that one unit of effort exerts a larger pressure on a stock in some seasons/regions than in others, and that moreover this differs by species. Fishing can be regulated by fleet, by giving fishers a number of 'tokens' per species, equivalent to the overall allowable fishing pressure implied by the respective TAC. The number of tokens for each species that fishers 'pay' for one unit of effort in a particular season/region is equal to the ratio of the historical catchability of that season/region to the overall historical catchability. Fishers can freely choose how often and when/where to fish, only restricted by their tokens, directing activity to those seasons/regions where fishing pressure per unit effort is high for a healthy stock and low for a depleted stock.

The Large Fish Indicator – an intuitive index of fish community state.

(How the proportion of large fish in the sea can be used to describe the effects of fishing.)

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Exploitation is known to curtail the size and age structure of fish populations. This structural change can reduce reproductive potential and enhance non-linearity in recruitment dynamics. Fisheries independent surveys of the Celtic Sea suggest that biomass of large (> 40 cm) demersal fish diminished by more than 80% from 1986 – 2004. The effect of this decline in biomass on community size structure was investigated using two size-based ecosystem indicators: the large fish indicator (LFI) and mean length of fish in the community. The LFI showed a significant negative trend over the time series, declining from 0.6 to almost 0.1, but mean length did not show any sustained trend. Calculation of interannual fluctuations showed that both indices remained rather stable until around 1998, when marked instability was established. This change in dynamics corresponded to a sustained minimum in large fish biomass. Instability may reflect enhanced leverage on community size-structure exerted by small changes in large fish biomass when this component becomes critically depleted, while increased survey variance at low biomass likely acts as a compounding factor. Where size-spectra in highly perturbed fish communities become unstable, size-based ecosystem indicators are likely to exhibit reduced management utility.

Geostatistical Analysis of *Nephrops Norvegicus* Density Around Ireland

(Distribution of prawns around Ireland.)

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The purpose of this geostatistics analysis is to investigate the spatial pattern of *Nephrops norvegicus* for the main *Nephrops* fisheries grounds: Celtic Sea, Aran grounds and Irish Sea. Norway lobster populations show complex aggregated patterns of spatial distribution (often named clusters or stocklets) and biological characteristics seem to be strongly related to sediment seabed type. In this presentation, the spatial distribution and abundance of *Nephrops* is considered, in relation to key population parameters and fishing patterns in order to improve management advice. Data collected from research surveys including Underwater TV and commercial fisheries are considered in this geostatistical analysis framework using available R statistical tools.

An Industry/Science Approach To Not Catching Cod

(Irish response to cod avoidance measures.)

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The EU Fisheries Councils in November and December 2008 adopted a new Cod Recovery Plan, which restricts fishing effort in certain areas and with certain gear types. Under this regulation, Member States can apply for groups of vessels to be exempt from days at sea provided they can demonstrate they consistently catch less than 1.5% cod by trip. In 2009 BIM began testing a variety of gear options that would allow *Nephrops* fishermen to continue to fish with reduced cod catches meeting the 1.5% threshold. The trials were carried out in March/April 2009 with several different gear modifications tested but the overall conclusion from these trials was that a rigid sorting grid was the most efficient gear and gave consistent reductions in cod catches. Following on from the technical trials three vessels opted to use the rigid sorting grid in Area VIIa and were allocated additional effort on the basis that they fished solely with the modified gear. The three vessels initially tested the grid on a voluntary basis during several trips between July and October 2009 to assess the practicalities of using the grids. These engineering trials were conducted under full commercial conditions and carried scientific staff from BIM/MI to evaluate the impact of grids on catches. Following on from the engineering an enhanced observer programme of these three vessels has been carried out by BIM/ MI and the data collected has confirmed that cod catches are consistently low and well below the 1.5% threshold. Cod catches aggregated across all observed trips were 0.06%. All of this work has formed the basis for a case for exemption for these three vessels, which has been submitted by DAFF to the EU.

This paper discusses the progression from the experimental phase to the voluntary adoption of the grid by fishermen in return of additional effort and ultimately exemption from the days at sea regime. It demonstrates a high degree of cooperation between industry and science in developing a technical gear solution to a specific fishery problem and also that fishermen will make changes to their operational practices if real incentives to do so exist.

Keywords: Cod Recovery; Days at sea; Irish Sea; Rigid Grid; Industry Science; incentives

Theme Session 7 – Fisheries and Marine Ecosystems

Chair: Michael Gillooly

Models Connecting Science and Fisheries Management

(Assessing the impact of fisheries management using ecological models.)

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The implications of new marine management measures and policy directives are some-times just as hard to predict as those of un-managed and/or unsustainable exploitation. Simulation models integrating our current understanding of ecological communities help identify likely system responses, and allow us to test the utility of indicators for monitoring and managing such responses.

Our modelling work concentrates on two aspects of community structure at the centre of the Ecosystem Approach for which scientific uncertainty is still high. Biodiversity in marine communities, covering exploited and unexploited populations at all trophic levels and for species of all sizes, is at the focus of the Population-Dynamical Matching Model (PDMM). We give examples of numerical experiments investigating the effects of different fishing regimes and mesh-size constraints on a suite of biodiversity indicators, as well as on the community size structure, characterized by a Large Fish Indicator. The focus of the Fish Community Size-Resolved Model is the representation of ecosystem interactions between and within size-structured populations. This model is used to investigate the effect of size-selective fishing on stock biomass and structure.

Results demonstrate how models can provide a vehicle for the formulation of enhanced scientific advice that incorporates the needs and questions of the fishing industry.

Modeling the Ecosystem Role of Top Predators (Cetaceans and Seals) in Irish Waters

(What do seals and cetaceans eat, and what is the importance of that in the broader ecosystem, particularly in relation to commercial fisheries?)

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The strategic situation of Ireland in the North East Atlantic, with high biodiversity and productive waters, make this area important for apex predators. A total of 24 species of cetaceans and 2 species of seals have been recorded within the EEZ. The occurrence of a number of small dolphin species in the pelagic ecosystem suggests the importance of these marine mammals within the Celtic Seas, especially the Irish Sea. Although, several studies on feeding ecology on marine mammals have been carried out around the world, very little information is available on the diet of small cetaceans in Irish waters. Furthermore, these predators are usually included within trophic models as a single category, due to lack of diet information. We present information on the diet of harbour porpoise and bottlenose dolphin in Irish waters. We will develop ecological trophic models using Ecopath with Ecosim (EwE) software to investigate the role of these predators in the Irish Sea in order to understand the food-web dynamics in the area, and in particular the fishery interactions.

Integration of VMS and Telemetry Technologies to Assess Niche Overlap and Competition Between Marine Mammals and Commercial Fisheries in Southwest Ireland

(Overlap or avoidance: the distribution of seals and fishing vessels at sea.)

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Competition between marine mammals and commercial fisheries for prey/catch has recently been brought into sharp focus with general declines in many fish stocks, coupled with increased attention to environmentally sustainable fishing. The competition between seals and fisheries is one of most important and urgent of these interactions. Seal predation on commercial fish species, particularly cod, have been cited as a contributory factor in overfished stocks failing to recover, on both sides of the Atlantic. However, if this is the case, then the corollary would have to be that these species are also important for the sustainability of seal populations. This perceived problem is particularly acute in southwest Ireland where seals have been illegally culled in recent years. We will report on a study to investigate this interaction and quantify the overlap between commercial fisheries and seals in southwest Ireland. We will use spatially explicit maps of seals movements and foraging ranges derived from telemetry data from tagged seals. These will be combined with gear specific VMS information on the activity of the fishing fleets to understand the spatial and temporal overlap of any competition. The resulting information will allow us to identify 'hotspots' of overlap betweens seals and fisheries and contribute to mitigation measures to minimize the impacts on both seals and commercial fisheries.

LIST OF ABSTRACTS & AUTHORS

	Title	Details
1	Pros and Cons of Using Commercial Fishing Vessels as Acoustic Platforms for Monitoring Herring off the West Coast of Ireland	Saunders, R.A., O'Donnell, C., Clarke, M.W. and Reid, D. Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
2	Measuring and mitigating uncertainty in Nephrops Underwater Television surveys	Doyle, J. and Lordan, C. Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
3	Spatio-Temporal Dynamics of Atlantic Cod (Gadus Morhua) in the Irish and Celtic Seas: Results from a Collaborative Tagging Programme.	Bendall, V.[1], Ó Cuaig, M.[2], Schön, P.J.[3], Hetherington, S.[1], Armstrong, M.[1], Graham, N.[2] and Righton, D.[1] [1.] Centre for Environment, Fisheries and Aquaculture Science, Pakefield Road, Lowestoft, NR33 0HT, UK. [2.] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland. [3.] Fisheries Division, Department of Agriculture and Rural Development, 4th Floor North Dundonald House, Upper Newtownards Road, Belfast, BT4 3SB, Northern Ireland.
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5	Temporal Trends in Stock Composition of Celtic Sea Herring	Harma, C.I,[2] , Brophy, D.[1] and Clarke, M.W.[2] [1.] Commercial Fisheries Research Group, Galway-Mayo Institute of Technology (GMIT), Dublin road, Co. Galway, Ireland. [2.] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
6	Long-term Changes in the Biological Parameters of Herring in the Celtic Sea and Southwest of Ireland	Lynch, D.[1], Wilson, J.G.[2], and Clarke, M.W.[1] [1.] Marine Institute, Rinville, Oranmore, Co, Galway, Ireland. [2.] Zoology Department, Trinity College, Dublin 2, Ireland.
7	The Rebuilding Plan for Celtic Sea Herring and Steps Towards Developing a Long Term Management Plan	Egan, A. and Clarke, M.W. Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland
8	Long Term Trends of Mackerel Spawning Locations and Associated Environmental Conditions	Hughes, K.M.[1], Johnson, M.P.[1] and Dransfeld, L.[2] [1.] Marine Environment, Martin Ryan Institute, National University of Ireland Galway (NUIG), Ireland. [2.] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
9	Managing for Sustainable Exploitation of Dredging in Intertidal Mudflats	Clarke, S. and Tully, O. Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
10	Estimating Exploitation Rates on Shrimp Using Standardised Catch Rate Depletion Methods	Kelly, E. and Tully, O. Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.

	Title	Details
11	Designing Technical Conservation Measures to Optimise Egg Production in Lobster Stocks	Tully, O.[1] and O'Donovan, V.[2] [1.] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway. [2.] An Bord Iascaigh Mhara, An Cuilin, Dingle, Co. Kerry, Ireland.
12	Unlocking the Power of VMS Data to Inform Fisheries Assessments and Advice	Gerritsen, H.D. and Lordan, C. Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
13	Landing and Processing Fishers' Knowledge in the Galway and Aran Fishery	Hind, E.J. Department of Political Science and Sociology, National University of Ireland Galway (NUIG), Ireland.
14	Linking Industry-Science Co-Operation and Co-Management: the Celtic Sea Herring Experience.	Fitzpatrick, M.[1], Reid, D.G.[2], Clarke, M.W.[2] and Power, G.[3]. [1.] Coastal and Marine Resources Centre, University College Cork (UCC), Co. Cork, Ireland. [2.] Marine Institute, Rinville, Oranmore, Co. Galway, Ireland. [3.] Chairman, Celtic Sea Herring Management Advisory Committee.
15	Capturing Fishers' Knowledge – the Celtic Sea Cod Fishery	Martin, E.M. Department of Political Science and Sociology, National University of Ireland Galway (NUIG), Ireland.
16	The Multiple Métiers Fished by the Irish Industry	Davie, S. and Lordan, C. Fisheries Science Services, Marine Institute, Rinville, Oranmore, Galway, Ireland.
17	Unravelling Population Connectivity in The Deep-Sea – Towards Sustainable Fisheries	Longmore, C., Fogarty, K., Neat, F., Brophy, D., Trueman, C., Milton, A. and Mariani, S. MarBEE, UCD School of Biology and Environmental Science, University College Dublin (UCD), Belfield, Dublin 4, Ireland.
18	Preliminary findings on the biology of Black Scabbard fish (Aphanopus carbo Lowe, 1839) in the North East Atlantic – implications for management	Ribeiro Santos, A.[1], Connolly, P.[2] and Rogan, E.[1] [1.] Department of Zoology, Ecology and Plant Science, University College Cork (UCC), Co. Cork, Ireland. [2.] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
19	Fisheries Discards in the Irish Sea (Division VIIa) Exhibit Temporal Oscillations and Trends Reflecting Underlying Processes at an Annual Scale	Viana, M.[1], Graham, N.[2], Wilson, J. G.[1] and Jackson, A.L.[1] [1.] School of Natural Sciences, Department of Zoology, Trinity College Dublin, Dublin 2, Ireland. [2.] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
20	The EU FP7 'CoralFISH' project: a unique science-fisheries research partnership	Grehan, A.J. Earth and Ocean Sciences, National University of Ireland Galway (NUIG), Ireland.
21	Forgotten Signals in Fisheries Management	Pazhayamadom, D.G.[1], Rogan, E.[1], Kelly, C.[2] and Codling, E. [3] [1.] University College Cork (UCC), Co. Cork, Ireland. [2.] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland. [3.] University of Essex, UK.

	Title	Details
22	A Possible Management Tool Allowing Flexible Choices in the Celtic Sea Mixed Fisheries	Kraak, S.B.M.[1,2], Davie, S.[2], Kelly, C.J.[2], Codling, E.A.[3] and Rogan, E.[1] [1.] University College Cork (UCC), Co. Cork, Ireland. [2.] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland. [3.] University of Essex, UK
23	Unstable Size-Structure in a Highly Perturbed Marine Fish Community	Shephard, S.[1] and Reid, D.G.[2] [1.] Commercial Fisheries Research Group, Department of Life Sciences, Galway-Mayo Institute of Technology (GMIT), Dublin Road, Co. Galway, Ireland. [2.] Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
24	Geostatistical Analysis of Nephrops Norvegicus Density Around Ireland	Benchikh, H.A.[1], Lordan, C.[2], Codling, E.[3] and Rogan, E.[1] [1.] Department of Zoology, Ecology and Plant Science, University College Cork (UCC), Co. Cork, Ireland. [2.] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland. [3.] Department of Mathematical Sciences, University of Essex, Colchester, CO4 3SQ, UK.
25	An Industry/Science Approach To Not Catching Cod	Rihan, D.J.[1], McDonald, D.[2] and Graham, N.[3] [1.] An Bord Iascaigh Mhara, PO Box 12, Crofton Road, Dun Laogahire, Co. Dublin, Ireland. [2.] An Bord Iascaigh Mhara, BIM National Fisheries College, Greencastle, Co. Donegal, Ireland. [3.] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
26	Models Connecting Science and Fisheries Management	Farnsworth, K.F.[1] , Fung, T.[1], Houle, J.E.[1] , Reid, D.G.[2] and Rossberg, A.G.[1] [1.] Queen's University Belfast, School of Biological Sciences, Medical Biology Centre, 97 Lisburn Road, Belfast, UK BT9 7BL. [2.] The Marine Institute, Rinville, Oranmore, Co. Galway, Ireland
27	Modeling the Ecosystem Role of Top Predators (Cetaceans and Seals) in Irish Waters	Hernandez-Milian, G.[1], Rogan, E.[1], Reid, D.G.[2] [1.] Department of Zoology, Ecology and Plant Sciences, University College Cork (UCC), Distillery Fields, North Mall, Co. Cork, Ireland. [2.] Marine Institute, Rinville, Oranmore, Co. Galway, Ireland.
28	Integration of VMS and Telemetry Technologies to Assess Niche Overlap and Competition Between Marine Mammals and Commercial Fisheries in Southwest Ireland	Cronin, M. [1], Gerritsen, H. [2] and Reid, D. G.[2] [1.] Coastal and Marine Resources Centre, University College Cork (UCC), Naval Base, Haulbowline, Cobh, Co. Cork, Ireland. [2.] Marine Institute, Rinville, Oranmore, Co. Galway. Ireland.