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Mapping fishing effort: Combining fishermen's knowledge with satellite monitoring data in English waters

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ABSTRACT

We describe and analyse data on fishing effort collected by interviewing 1914 fishermen between 2007 and 2010. Combining socio-spatial data collected through a voluntary mapping project called "FisherMap" with UK and European vessel satellite monitoring data provides high resolution, national-scale maps of distribution and relative intensity of fishing for six gear types. The effort maps show, for the first time, a large scale and holistic approach to mapping fishing effort by including the under-reported, yet significant, inshore fishing fleet (85% of registered vessels,<15 m). The data from this study have been used to facilitate the planning, management advice and subsequent designation of 38 inshore Marine Conservation Zones. The authors conclude that, effective management of the inshore marine environment requires up-to-date, high resolution and holistic maps of fishing effort that can be obtained only through validated interpretation of inshore vessel monitoring system data.

1. Introduction

Fishing activities are complex and vary greatly across different ports, seasons and gear types. Vessel Monitoring Systems (VMS) are required in the UK only on vessels ≥12 m long (EC No. 1224/2009), which represent 15% of the UK fleet size (MMO, 2014). Prior to 2002, VMS were limited to vessels ≥15 m (10% of UK fleet size). As most fishing vessels are not required to carry VMS there is a paucity of data describing the spatial distribution and intensity of effort by smaller, generally "inshore" fishing vessels at the resolution required for setting Marine Protected Area (MPA) conservation objectives (Hinz et al., 2013).

Effective conservation and management of the marine environment requires knowledge of the spatial distribution of commercial fishing effort (FAO, 2003; Sinclair and Valdimarsson, 2003; Jennings, 2007). High resolution spatial data on fisheries are needed for future MPA designations, and for the effective management of existing sites (Aswani and Lauer, 2006; Witt and Godley, 2007). Marine spatial planners and other industries using the marine environment also need detailed fisheries activity data to assess the potential impacts of proposals on fishing livelihoods, such as assessing potential displacement effects or looking for co-location potential between different uses (Douvere, 2008; Eastwood et al., 2007; Stelzenmüller et al., 2008; Ventin, 2014).

Whether an MPA can deliver its ecological and social benefits depends on effective management of human activities. Without appropriate management, English MPAs cannot contribute to the wider, international protected areas network to which the UK Government is committed (The Conservative Party, 2015). Such activities may damage or disturb the protected habitats and species (herein referred to as features) for which the site was designated (Jennings and Kaiser, 1998). Understanding the spatial distribution of activities relative to site features is therefore fundamental in setting MPA conservation objectives for the site.

As of 2016, 240 (87%) of the UK's 275 MPAs lie within 6 nm of the UK coastline. Of these, 47 (17%) are less than 10 km^2. In order for MPA management advice (e.g. adaptive management or restricted access) to be effective, the resolution of reporting fishing activity needs to reflect the scale of the sites and of the

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mapped features within them. National-scale data on fishing effort are currently compiled from information provided by skippers, who are required to report their fishing locations in large rectangles (~56 km × 69 km). Such data are spatially too coarse for high resolution analyses (Hinz et al., 2013; Lee et al., 2010). Also, the absence of data for the smaller inshore fleets presents a considerable challenge to MPA managers who are required to deliver MPAs in favourable condition whilst facilitating practicable, feature-based management for the UK fishing industry.

While VMS technologies are not used on a large proportion (85%) of the UK fishing fleet, other methods of describing the distribution and intensity of fishing activities are needed. Previous efforts to describe fishing activity have been based on log book data (e.g. Kaiser et al., 2000), aerial surveys (e.g. De Juan and Demestre, 2012), 'distance from port' rules, seabed maps as proxies for possible fishing grounds, and interviews with fishers (Breen et al., 2015).

Until recently, UK fishing effort studies have focussed on individual gear types, regions or vessel size. The current study uses data from a voluntary mapping project, called "FisherMap" comprising 1914 interviews with fishermen between 2007 and 2010, combined with UK and European VMS data to provide high resolution, national scale maps of fishing distribution and intensity for six gear types.

2. Materials and methods

2.1. Mapping fishing effort for vessels <15 m

2.1.1. FisherMap

The FisherMap study aimed to map the extent and intensity of fishing activities around the coast of England to inform the new Marine Conservation Zone recommendations under the UK's Marine and Coastal Access Act (MCAA, 2009; des Clers et al., 2008). Data were collected by four regional project teams across England ("Net Gain", "Balanced Seas", "Finding Sanctuary" and "Irish Sea Conservation Zone's") (Fig. 1).

The FisherMap methodology was adapted from two participatory mapping projects piloted with commercial fishermen in the Thames Estuary (des Clers et al., 2001; des Clers, 2004a,b), and from the Pacific Marine Analysis and Research Association (Ardron et al., 2005) methods on marine planning. The FisherMap interviews were carried out by a team of 15 full time liaison officers who asked individual fishermen to draw the areas where they had fished that year on maps (Plate 1) and complete a questionnaire describing their activity, i.e. fishing methods, gear type, species targeted, and months of the year of operations (des Clers et al., 2008). Interviews typically lasted between one and two hours.

Liaison officers generally had a background as experienced commercial fishermen which enhanced credibility for the project and gave better mutual understanding of the technical information. The pattern of engagement varied with the port, season, weather and state of the tide. Initial meetings were held with local or sectoral association leaders and vessel owners to explain the nature of the project and the interview process. Once a general agreement had been reached within a port, individual fishermen were approached on the quayside and an interview organised.

Each interview involved a questionnaire and large format maps. The questionnaire gathered basic data about the size and power of vessel used and the home port. Each gear type was described by the months of the year that it was operated and the species targeted, and linked to one or more polygons drawn on clear acetate overlays to indicate the areas. The acetates were A2 size taped to a background chart. Background charts were produced using commercial maritime data using similar colour schemes and symbology to mimic nautical charts. They were printed in large format at four different scales for the region, so the fishermen could select the most appropriate for the scale of use (Plate 1). Each chart had a unique reference printed at the top of the sheet, and four reference points repeated on each acetate to ensure accurate geo-referencing, and linkage to the correct interview. The acetates were digitised and linked to the other data within the database.

2.1.2. Interview sampling strategy

The FisherMap survey categorised fishing gear into 6 broad types (demersal gears, dredging gears, pelagic gears, nets, lines, and pots & traps). FisherMap interviews were stratified by gear type, home port and vessel size so as to ensure representation across the fleets. The current study used only interviews for <15 m vessels as effort for vessels ≥15 m is captured from VMS data. Data from Cornwall were collected separately by the Cornish Fish Producers Organisation (CFPO) whose methodology had a broader gear classification, did not identify individual vessels, and used lower spatial resolution for vessel presence (1 km^2).

2.1.3. Data validation

When regional scale maps had been produced, fishermen and representative bodies were invited to validate them to confirm the data collection methods adequately captured their fleet's activities and that no errors had been made during the digitisation process. Validation was undertaken part way through the data collection period, so that sampling could be adjusted to cover areas or fleets which, in the views of stakeholders, were poorly represented. Holding group data validation meetings with all participants provided an important opportunity for combined outputs to be discussed, verified and corrected.

2.1.4. Raising sampled interview data to fleet level

Interview data as samples have limited use, so multipliers were used to raise the data to fleet level in order to provide more meaningful management information that was comparable between the four regional projects. Distribution data for sampled vessels were raised to fleet level using landing records between 2007 and 2010, extracted from the Defra iFISH database. This gave estimates, by regional project and gear type, of fleet activity.

Vessels <15 m were identified uniquely using a combination of Registry of Shipping and Seamen (RSS), Port Letter and Number (PLN), length, nationality and Administration Port data. The vessel's administration port was then used to assign a record to the appropriate regional project's fishing fleet. Mean annual vessel numbers taken during the study period, for each gear type, were divided by the interview sample size to generate the fleet raising factors (Table 1).

iFISH data for pair trawlers were carefully treated to prevent double counting and the 84 vessels with unique RSS numbers and 'Unknown' administration port were excluded from estimates of fleet size. Furthermore, the Marine Management Organisation's (MMO) landings records have an unknown number of vessels assigned to group categories for unidentified boats <10 m and between 10 m and 15 m. These records were also excluded from the estimate of fleet size. All <15 m vessels whose administrative port was registered outside of England were also excluded from the estimations of fleet size on the basis that interview data from FisherMap for such registered vessels was negligible and thus not a significant component of the English fishing fleets.

2.2. Mapping fishing effort for vessels ≥15 m

Numbers of vessels ≥15 m actively fishing were derived from VMS data between 2007 and 2010 using standardised methods described by Lee et al. (2010). Unprocessed VMS point data were filtered using a simple rule that a speed between 1 and 6 knots