Improving the evidence base for scallop diving fisheries management

King scallops (*Pecten maximus*) are the second most valuable shellfish landed in Scotland. Ladings into Scotland have fluctuated between 7,500 and 11,800 tonnes over the last five years with an average value of around £20 million per year (Scottish Government, 2016). While most landings come from dredge fisheries, there are some areas where commercial diving is very important, accounting for 40% of the landings in the coastal waters of the west of Scotland and Orkney (Dobby et al, 2012). The commercial diving fleet consists of about 40 – 50 fulltime divers which usually operate closer to the shore than dredgers.

Landings data for these fishing activities is currently collated at the level of assessment areas which are defined on the basis of ICES statistical rectangles. These rectangles are approximately 30 by 30 nautical miles. The coarse resolution of this assessment strategy does not match the actual scale of resource exploitation by divers and thus has implications both for marine spatial planning and for stock assessments. Within the context of marine spatial planning, establishing the location of inshore fishing activities is important because they have considerable socio-economic importance and contribute significantly to food security. Increased use of marine areas in the next decade makes it increasingly important to map fishing activities to inform marine planning and meet policy commitments. Additionally, assessing the spatio-temporal distribution of fishing activities can inform fisheries managers of interactions with other fishing activities (e.g. scallop dredging and scallop diving). This is particularly relevant at present, as the scallop dredgers have expressed concerns regarding new measures set to be introduced on June 1st 2017 (key of which is an increased minimum landing size) which may lead to fishing area changes for scallop dredges into inter-reef areas in inshore waters which are currently considered 'scallop divers domain'. In terms of stock assessments, current analytical assessments may not be at the appropriate spatial scale to inform local management (Miethe et al, 2016), and catch per unit effort indicators may provide a better indication of the state of the inshore scallop beds.

The objectives of this project are 1) test different methods to obtain information on the fine scale spatial location of scallop diving activities; 2) test methods to capture effort data at a trip level (number of divers per boat and dive time per diver).

Methods

Seven field trips were conducted (4 in the West Coast of Scotland and 3 in Orkney) onboard commercial diving vessels. For each trip, Global Navigation Satellite System (GNSS) data were collected using a handheld Garmin Etrex 20 where GNSS positions were recorded at 1 minute intervals. Time of departure, times when divers went in and out of the water, and time when the vessel reached port at the end of a trip were recorded. Activities recorded on-board were matched with the GNSS tracking data using the time in which each activity occurred.

Random Forests (RF, Breiman 2001) were used to infer when vessels were engaged in diving activities based on positional data. RFs are a machine learning classification technique that combines multiple decision trees for more accurate classification (Cutler et al. 2007). Each tree assigns the most likely class by recursive binary partitioning (tree branch-like structures) that increases the homogeneity within groups based on a range of observations about that item. The distance between observations, relative angle between positions, and the time of the day were used as predictors of diving activities. The Random Forest model was fitted using the R package randomForest (Liaw & Wiener 2002). We used information from the 7 observer trips to assess the performance of the model's output to observer's ground-truthed data on diving activities. We randomly divided the 7 trips into two sets, one of four, for training and of 3 for prediction, to test for out of sample accuracy of the model. Accuracy was defined as the number of correctly classified instances (for both diving and not diving) with respect to their total number of locations.

Results and discussion

Seven field trips were conducted (Fig. 1) to understand how this fishery operates and to record positional data of the vessels and the activities taking place. The mean trip duration was 8 hours, ranging from 6.1 – 10.1 hours. Four main types of vessel behaviours occurred during a diving trip: (1) steaming to, from and in between fishing grounds; (2) deploying divers; (3) repositioning vessel close to divers and (4) recovering divers.

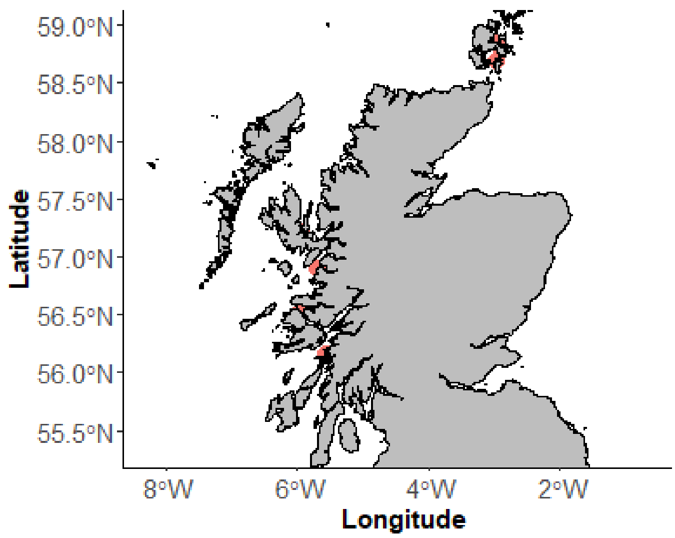

Fig. 1 left) Map of Scotland, showing the location of diving trips conducted in the West Coast of Scotland and Orkney islands. Right) Diver showing scallops collected during a dive.

Exploratory data analysis of the distribution of vessel speeds (in knots) during each behaviour, suggested that speeds during diving activities overlapped speeds during steaming (Fig. 2). It was therefore challenging to detect from spatial data only, when a diver had been deployed or recovered. This is an area of the project that will require further research and collection of more data to improve the detection of divers either going into or out of the water.

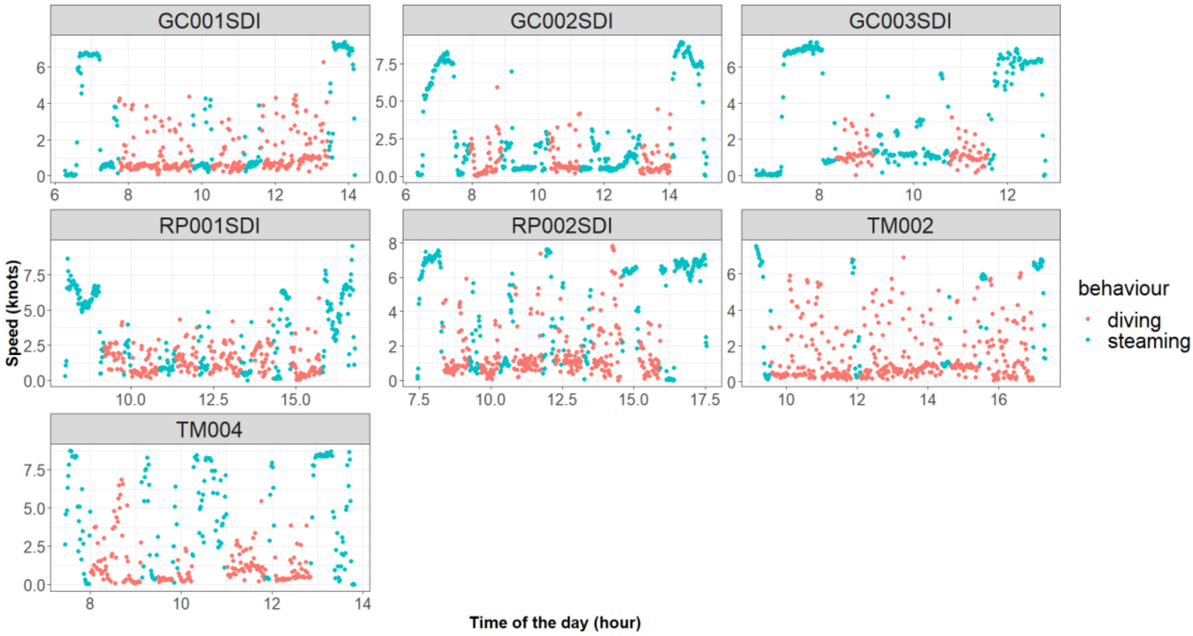

Fig. 2. Speed in knots for each vessel during a diving trip throughout the day, showing when diving activities were occurring (red) and when not (blue).

The Random forest model predicted diving activities with a 70% accuracy. While this accuracy might seem low, the actual fishing areas were identified rather well (Fig. 3). These results are encouraging, as it sets a precedent for a process that could lead in the automatization of inference of diving activities for the scallop diving fleet. If applied at fleet level, the main areas where the fleet operates would be easy to identify and map at very fine spatial scales.

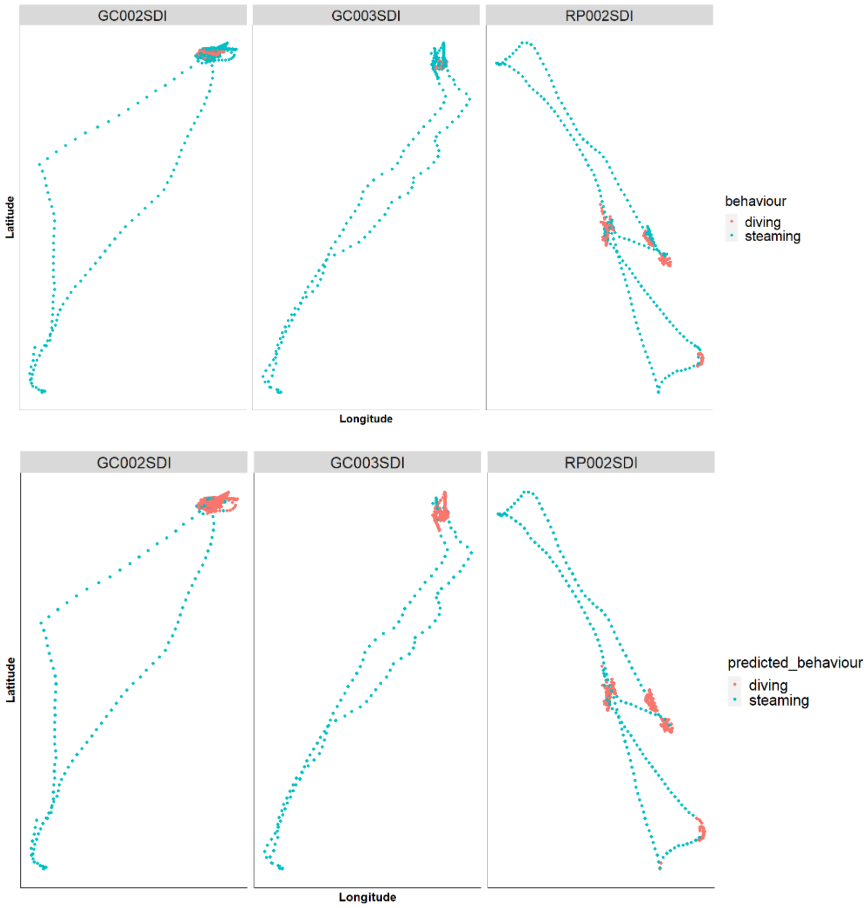

Fig. 3. A) Individual fishing trips showing where diving or steaming was occurring according to on-board annotations. B) Same individual trips as above but showing classification results from Random Forest model. Note areas where diving is occurring are well represented with the model.

References

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3. Miethe, T., Dobby, H., and McLay, A. 2016. The use of indicators for shellfish stocks and fisheries: a literature review. Scottish Marine and Freshwater Science Vol 7 No 16