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SHINY APPLICATION FOR VISUALISATION OF MOVEMENTS OF ELECTRONIC TAGS DEPLOYED WITHIN ICCAT GBYP

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SUMMARY

An interactive web application for visualisation of electronic tags movements was developed using Shiny by RStudio. It reads data from the relational database, which has previously been created in PostgreSQL for incorporating structured data provided by ICCAT GBYP electronic tags. This Shiny application allows visualisation of maximum probable geolocations and tracks and provides options for tags data filtering and grouping according to several criteria.

RÉSUMÉ

Une application web interactive permettant de visualiser les déplacements des marques électroniques a été développée au moyen de Shiny par RStudio. Elle permet de lire les données de la base de données relationnelle, préalablement créée dans PostgreSQL pour incorporer des données structurées fournies par les marques électroniques du GBYP de l'ICCAT. Cette application Shiny permet de visualiser les géolocalisations et les trajectoires les plus probables et permet de filtrer et de regrouper les données de marquage selon plusieurs critères.

RESUMEN

Se ha desarrollado, utilizando Shiny de RStudio, una aplicación web interactiva para la visualización de los movimientos de las marcas electrónicas. Lee los datos de la base de datos relacional, que había sido previamente creada en PostgreSQL para incorporar datos estructurados proporcionados por las marcas electrónicas del ICCAT-GBYP. Esta aplicación Shiny permite la visualización de las geolocalizaciones y trayectorias más probables y aporta opciones para el filtrado de los datos de las marcas y para su agrupación de acuerdo con diversos criterios.

KEYWORDS

Tagging, Bluefin tuna, Electronic tags, Data collections

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1. Introduction

The Atlantic-Wide Research Programme for Bluefin Tuna (GBYP) is a special research programme of ICCAT whose main goals are to reduce uncertainty in stock assessment and to provide robust management advice, which requires improved knowledge of key biological processes and parameters. Since the majority of the data used in the stock assessments are obtained from the fisheries-dependent data, it is important to obtain data from alternative sources, such as tagging studies, in order to verify the assumptions made when conducting the assessments.

One of the major research tasks under the ICCAT GBYP is to carry out the large, wide and intensive scientific tagging program to address several important biological and ecological topics regarding Atlantic bluefin tuna (*Thunnus thynnus*). According to the general programme, in Phase 1 (2010-2011) the Tagging Design and the Tagging Manual were adopted and from Phase 2 (2011-2012) onwards, it was proceeded with the tagging activities. At the beginning, the priority was given to the deployment of the conventional tags, but due to low recovery rates, in Phase 4 the Steering Committee decided to focus on the deployment of electronic tags instead, keeping the conventional tagging only as a complementary activity. Tagging activities of the ICCAT GBYP have been reported by Di Natale *et al.* (2015), Di Natale *et al.* (2016), Di Natale *et al.* (2017) and Tensek *et al.* (2017).

GBYP started with electronic tag activities in 2011 when the first few pop-up satellite tags were deployed. Over the course of 8 years, up to 2018, within the framework of this Program, or in joint actions with other institutions, more than 340 electronic pop-up tags were deployed, although the number of useful datasets is smaller. The basic analysis of the electronic tag data up to Phase 6 has already been performed by Tensek *et al.* (2017). The complex analysis of the data has not been performed yet. All available electronic tag datasets are currently used by operating model for bluefin tuna MSE purposes.

The data obtained by electronic tags comprise a set of unstructured and semi-structured data of different type which are received in different formats and follow a different folder hierarchy. Without performing the significant additional effort, the data cannot be easily accessed or searched through and it is difficult to do any type of comparison between two or more tags. In 2017 the first attempt was made for organizing electronic tag data and in this way facilitate their extraction for any further analysis. With that aim, a relational database was created in PostgreSQL which allowed gathering all relevant data provided by electronic tags in a structured manner and the code was developed in R for automatic cleaning, formatting and writing the data into the database (Tensek, in press).

In addition to the electronic tags database, in 2017 the first Shiny application was also created, for visualisation of electronic tags tracks, temperature and depth series, time at temperature, time at depth, minimum and maximum depths in relation to the sea bottom and the Argos post-release tracks. Although the application permitted visual insight into the most relevant data of each tag, it did not provide the option of simultaneous visualisation of more than one datasets nor did it allow filtering tags by criteria other than tag ID.

For this reason, additional Shiny application was developed for visualisation of tracks of various tags at the same time. The application allows selection of particular tags by directly choosing their ID or filtering of entire dataset according to month, deployment area, deployment year or presumed maturity of tagged individual. Moreover, in order to enhance the possibility of visual identification of possible patterns, the application provides the option of colour coding by grouping tags by month, deployment area or deployment year.

2. Materials and methods

The electronic tags deployed by the ICCAT GBYP include pop-up satellite tags made by Wildlife Computers. Since all the tags have been produced by the same manufacturers, the individual datasets have similar format and are comparable. The datasets of one tag consist of various tables that store information on tag sensor reading (so called raw data) – light, temperature and depth and the positions of the tag once it has released/popped off (Argos). In addition to the raw data, a set of each tag normally includes the table with estimated geolocations (so called processed data), which were calculated by some algorithm using the raw data.

The electronic tags datasets are currently stored in a dedicated repository on the GBYP server within the ICCAT Secretariat. These datasets consist of semi-structured data that come in different formats and include several different files for each tag. In 2017 the electronic tag database has been developed for compiling all of these datasets in an organized manner. For that purpose, a code was created in R, which automatically reads the multiple datasets, cleans and formats the data and finally writes the structured data into the appropriate table within the database. The relational database was created in PostgreSQL, which is currently stored only locally on a personal computer.

In order to visualise geolocations of multiple tags on the same map and to be able to interactively filter the whole dataset according to some pre-defined criteria, an application was developed, using Shiny (web application framework for R). This Shiny application connects automatically to the PostgreSQL database and reads the appropriate table that stores data on geolocation. The dataset is filtered according to values defined by user and the interactive map is plotted. There are several control widgets incorporated within the user interface that allow filtering of data and different type of visualisation or colour coding (**Figure 1**). The most significant R packages that were used for developing the application were, apart from “shiny”, “tidyverse” (basic operations), “RPostgreSQL” (database connection), “leaflet” (interactive map) and “sp” (spatial data structures - tracks). Likewise the database, the Shiny application is currently hosted in the local server and the Shiny application only runs locally on the same engine (PC).

3. Results

The Shiny application allows visualising of multiple electronic tags geolocations and tracks on the map. The application is interactive in a way that the user can choose the data subset to be mapped. The dataset can be filtered by tag number, month, and presumed maturity of the fish (juvenile/adult – according to biological parameters for E-BFT), in addition to deployment area and deployment year. User can also choose the type of visualisation – the geolocations can be represented as individual points or as a track, where points are connected by line in consecutive order (**Figure 2**). In both cases, to distinguish geolocations, each point displays the tag number when hovered over with a mouse. In addition, in order to distinguish special movement patterns, user can choose a type of colour coding, weather it is by tag number, month, deployment area or deployment month. When tags are grouped, a legend is also displayed to show the color-coding (**Figure 3**).

4. Discussion

The Shiny application proves to be very handy, allowing instant visualisations of tag movements, comparison or data visual search. It can also contribute to identifying season-related and maturity related-migration patterns.

Currently the GBYP electronic tag database is kept on the personal computer and it cannot be remotely connected. The Shiny application is also only locally run. The possibility of the integration of the electronic tag database within the ICCAT Secretariat has already been discussed, but no decisions or further steps have been taken. The possibility of publishing the database and the Shiny application online and available to the external users has not been discussed yet. Nevertheless, from a technical point of view, it can be rather easily achieved, if it is so decided.

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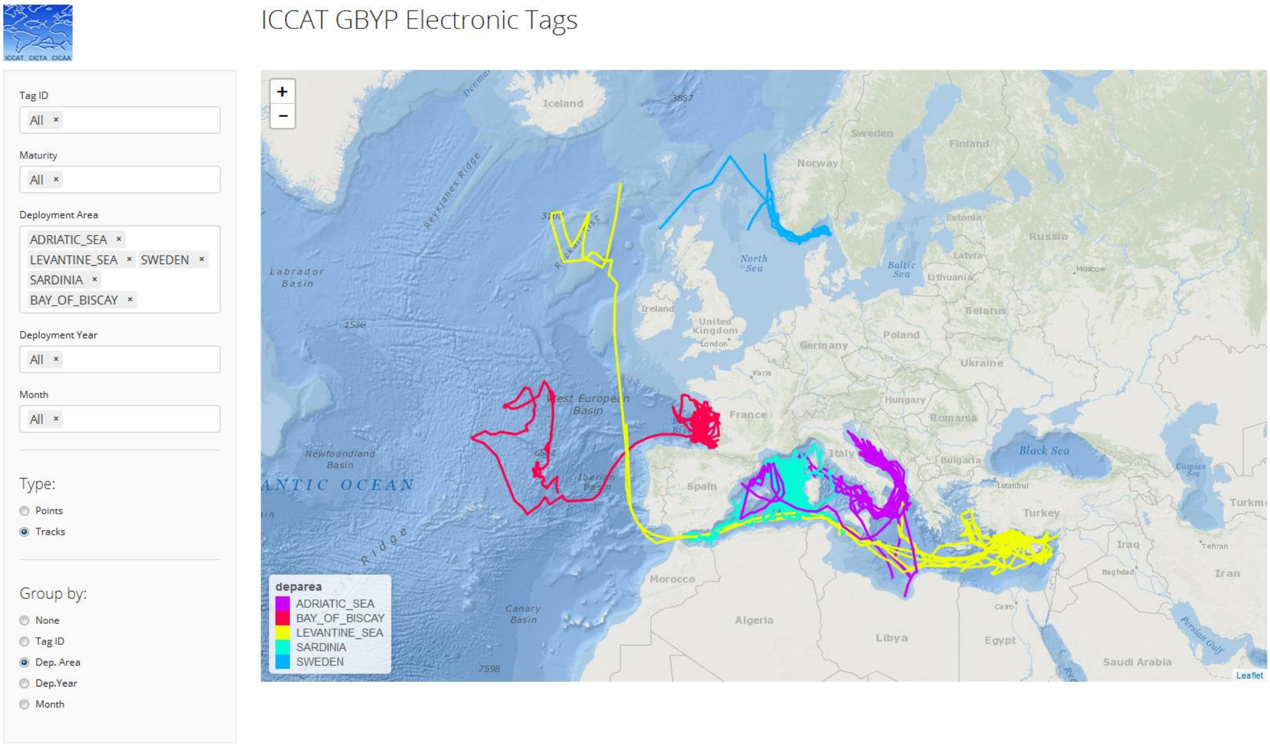


Figure 1. The interface of the ICCAT GBYP Electronic Tags Shiny Application. User interface with control widgets is on the left side and the interactive map on the right side.

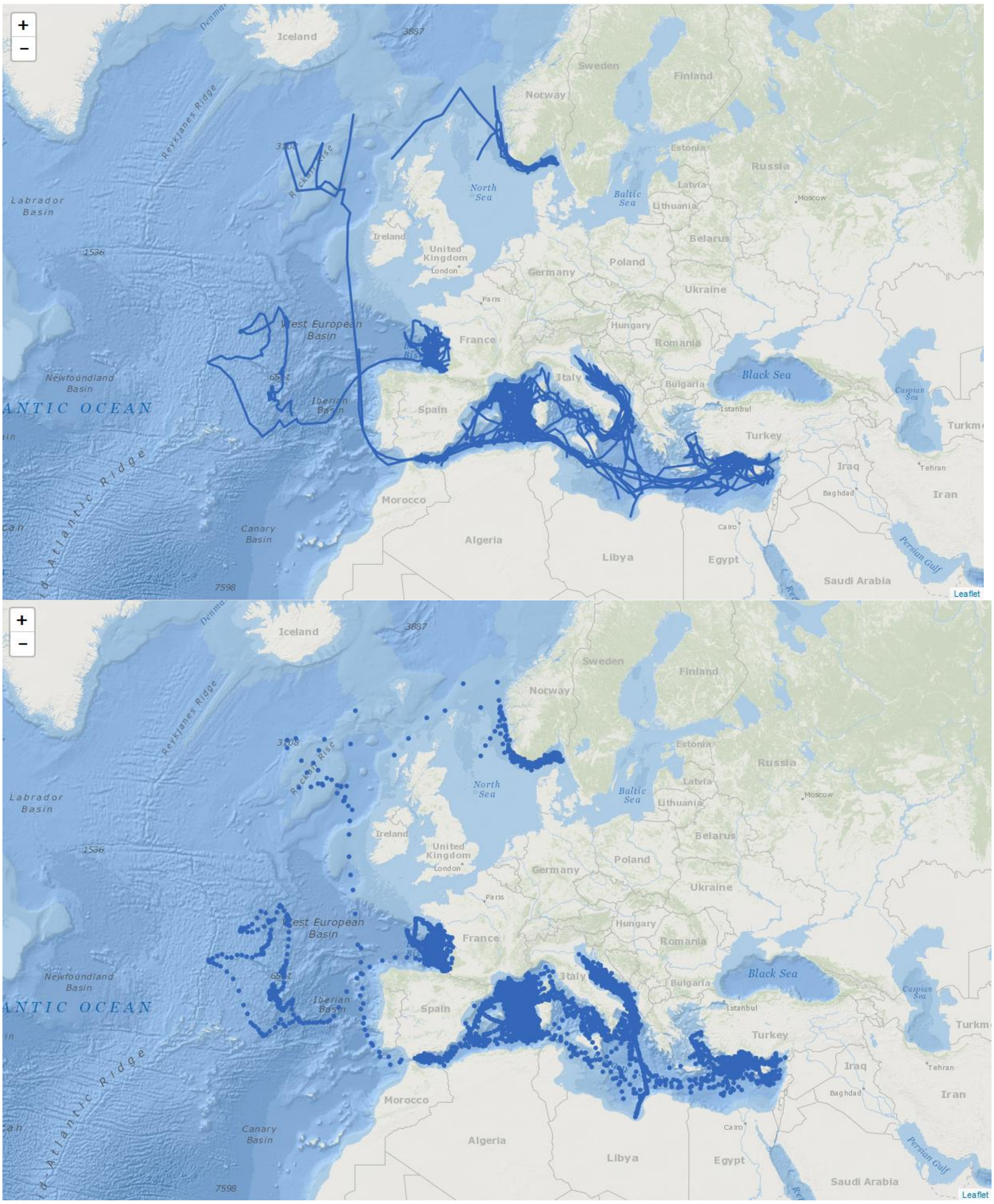
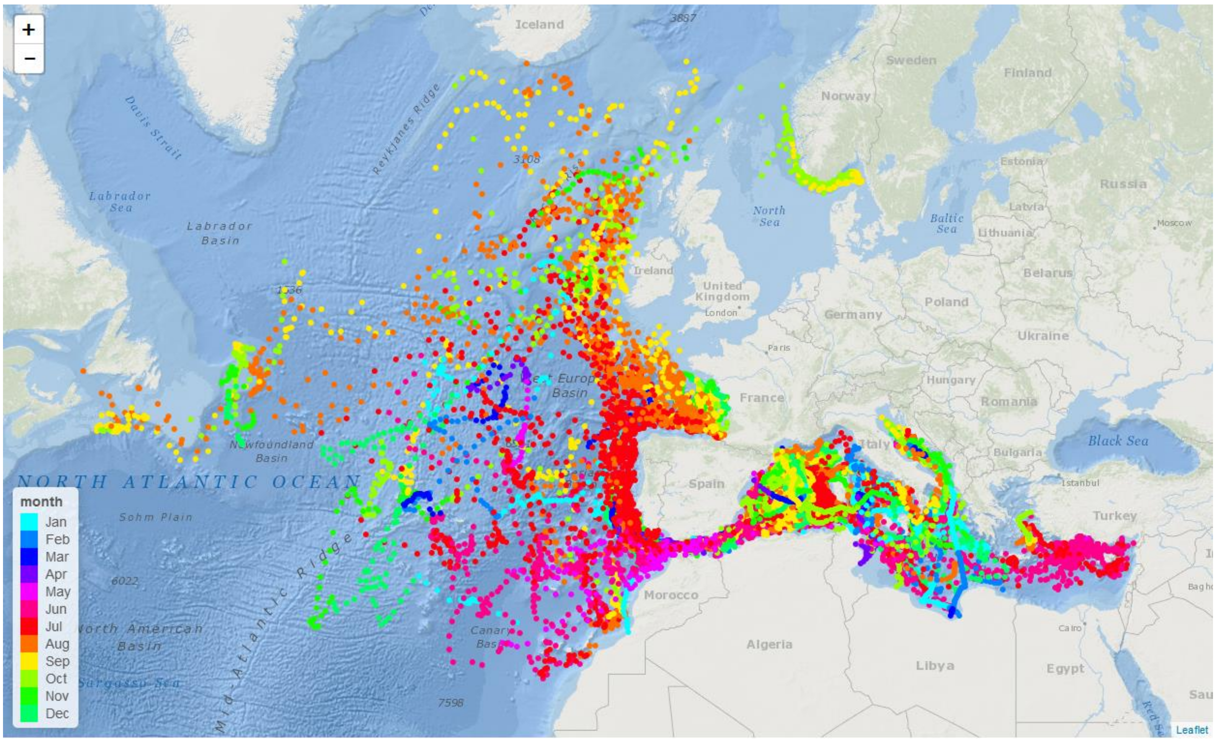


Figure 2. Mapping geolocations as tracks (above) or points (below), according to user preference.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Morocco
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Libya
Egypt
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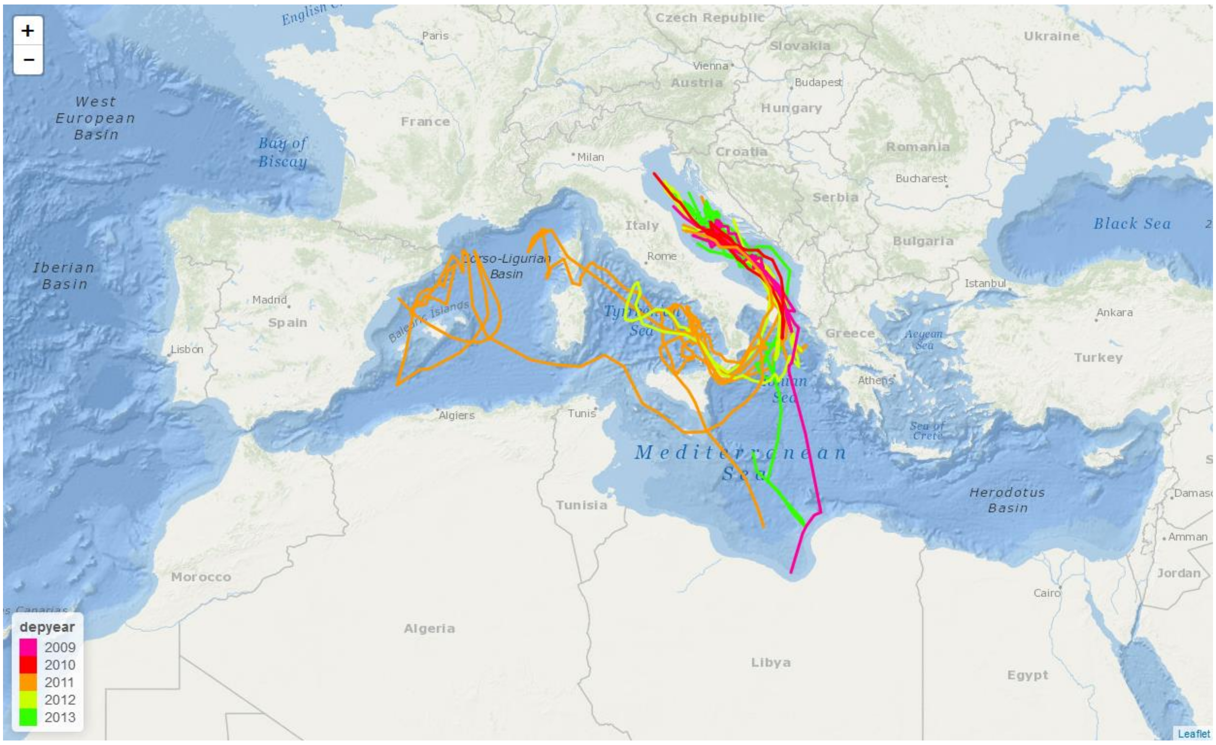
Sohm Plain
North American Basin
Sargasso Sea
Mid-Atlantic Ridge
Leaflet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Bucharest
Serbia
Black Sea
Iberian Basin
Italy
Bulgaria
Rome
Istanbul
Madrid
Spain
Ankara
Lisbon
Greece
Turkey
Athens
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Leaflet

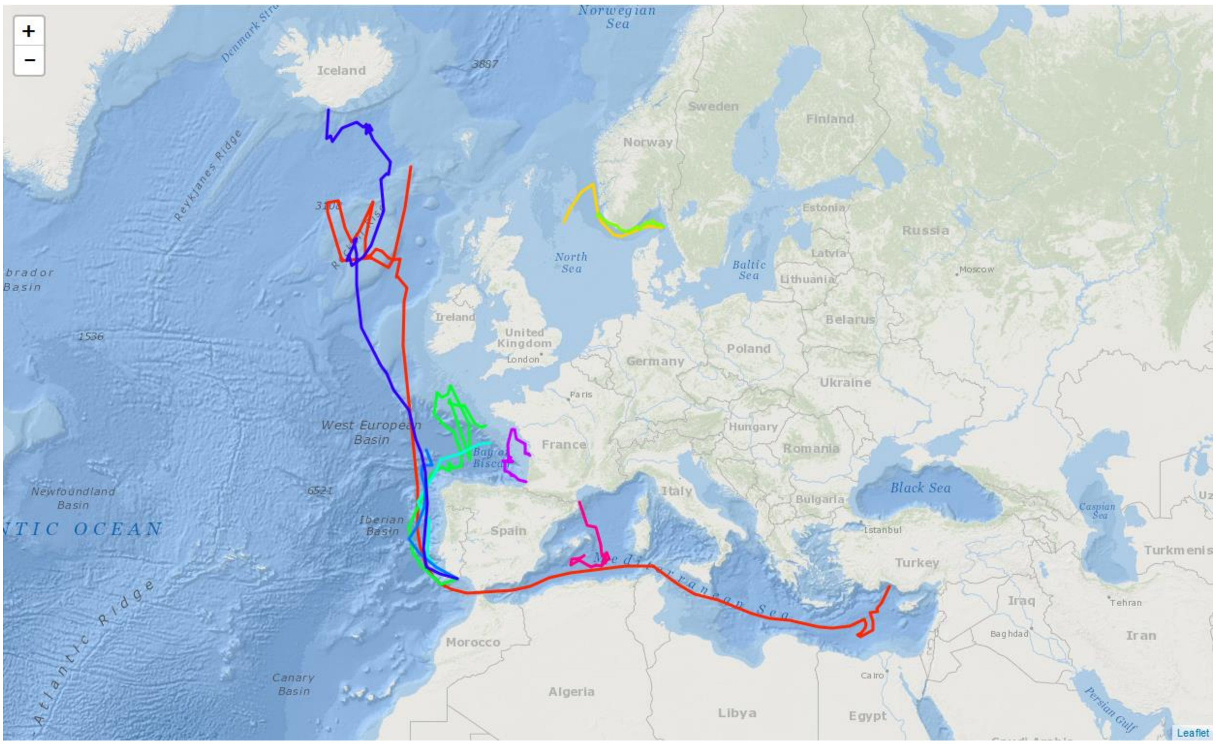

Figure 3. Differential colouring, according to the user preference: by month (above), deployment year (in the middle) or individual tag number (below). When tags are grouped, a legend is also displayed to show the color-coding.