INVESTIGATING OF DOLPHIN'S STRANDING USING MOTHY MODEL AND ADVANCED GIS ANALYSIS

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Abstract
In August 2015 more than 300 dolphin calves were stranding on the Bulgarian seacoast. Data were collected from witnesses, organized by us in a network, using IT online services and other communications. Further these data were formatted in GIS context. Using the numerical model MOTHY and the estimated exact hour of death of dolphin carcasses, were chosen 28 specific cases were chosen. We simulated 252 possible trajectories for 25 days, with more than 50 000 coordinate points. These raw data from the model were organized in a specific geodatabase. Then, advanced GIS analysis were used to locate the place and exact time of death of dolphin's calves, back in time. The results point a place in Black sea, 35 km north of Snake Island that was the most probable place where the dolphin's calves died around 25 July 2015. Suspected reason of death, determined by different ways, was the usage of illegal gillnets for turbot. Further, historical data of ship's traffic were analyzed (with active AIS) to determine possible offender/s. As only small percent of carcasses reach the coast in the investigated area due to specific currents in the Western Black Sea, it is suspected that the incident concern thousands of dead dolphin calves. The significance in its investigation is apparent for preventing new similar incidents. The applied new advanced methods and workflow can be used to investigate different types of past time accidents in the sea.

Keywords*: Dolphins, Stranding, Bycatch, Gillnet, Turbot, IUU, MOTHY, GIS*

PREFACE

A wildlife disaster unfolded on the Bulgarian Black Sea coast in the summer of 2015. Hundreds of dead baby dolphins (*Phocoena phocoena*) have been discovered on beaches along the 378 km long coastline. In July and especially in August carcasses of baby dolphins were found at the seashore on almost all Bulgarian beaches, in particular after strong winds. Due to specific sea currents in the Black Sea at that time of the year, only a small percentage (5-10%) of carcasses reached the mainland. As the number of registered cases was more than 300, it was suspected to be a very large wildlife disaster with probably thousands of dolphin victims. The incidents were found to be periodic in time, which gave us a clue about the possible cause. At the neighboring coastlines of Romania and Turkey there were no similar cases, but it was evident that most of the carcasses had been in the water for more than 20 days. Due to the complexity of the case it was important to obtain as much data as possible and structure and analyse them using different approaches in order to identify the potential cause of death.

COLLECTING DATA

Most of the signals and data on the deaths came in from citizens and tourists. The state institutions were lacking data because there was no procedure in place beforehand covering such incidents. However, the non-governmental organization "Save Koral Beach" immediately invented a workflow for collecting valuable data and created an emergency network of supporters, colleagues, concessionaires, beach tenants, lifeguards, divers, surfers, spear fishermen, fishermen and tourists. Social networks, in particular the Facebook group "Save the Dolphins", were used to record signals and for communication, collecting information details and exchanging photos and information. Information about this activity was promoted in the News of several national TV media. Missing network for monitoring of dolphins (stranding) in Bulgaria, prove that this approach was very successful in time of emergency. The response was huge and soon revealed that the number of dead dolphins was far worse than was expected initially (Figure 1).

Figure 1. Two of more than 40 dead dolphin calves found at Koral Beach, 400 km away from the suggested place of incident

The collected data consisted of detailed information including location, time and photos. Because of different quality of received data, they further were sorted, checked and filtered. All data that was received was directly published online via a public web map GIS application (http://dolphins.koralbeach.com), so that every person could check his own signal and give further detailed descriptions if needed. The largest number of cases occurred between 1 and 12 August 2015 (Figure 2).

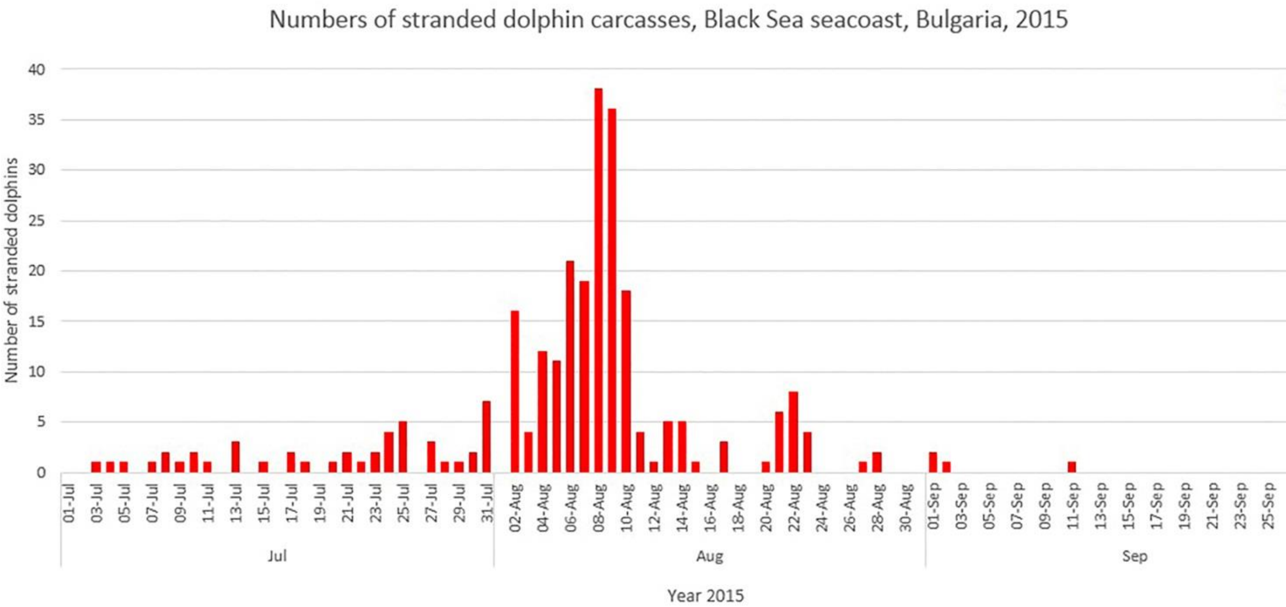

Figure 2. Number of dead dolphin calves in the summer of 2015

Therefore, this period was chosen for detailed analysis and investigation. From the photos for each case, experts determined the approximate time of death of each dolphin. Then, 28 representative cases were chosen in that time period, spread out all over the Bulgarian Sea coast. Data was structured in a geo database with coordinates and time of appearance of each of the carcasses, time of death, photos, and other attribute information.

MODEL MOTHY

The next step was to find out the place of origin of this wildlife disaster. Simulations of the backward movement of dolphin carcasses were performed with the numerical model MOTHY. This model was developed about 20 years ago by the French national weather service METEO FRANCE (Pierre Daniel, 1996). It was initially developed to simulate the drift of containers at the sea surface and the movements of oil spills, but was later expanded with other functionality to support search and rescue operations (Pierre Daniel, 2002). The model MOTHY can also predict the movements (or simulate backward trajectories) of animal carcasses, as was required in this study (H. Peltier et al., 2012). The numerical model needs bathymetric data, information about the location of the stranded dolphin carcasses and an estimate of the time period of their drift in days. It also needs meteorological information, such as data about the winds at 10 meter altitude above the sea surface and the atmospheric pressure data for the entire period of the simulation. The weather data in this study is from the regional atmospheric model ALADIN (R. Bubnova et al., 1995) which is used at the Bulgarian national weather service, the National Institute of Meteorology and Hydrology (NIMH). Data on sea currents fields at the mixed-level depth of the Black Sea obtained from the American ocean model HYCOM (Eric P. Chassignet et al., 2007) was used as input as well. With all these input data the MOTHY model first simulates surface currents and subsequently the movements of the floating objects taking into account currents, winds, buoyancy and turbulence. The output of the model is a set of backward trajectories for different levels of immersions of the carcasses (H. Peltier et al., 2012).

TRAJECTORIES

For the 28 selected cases 252 trajectories (9 per case) were computed with varying level of immersion. About 50,000 possible coordinate points were obtained from these trajectories: one point for every 3 hours during 25 days (or less, depending on the time of death) back in time per case (Figure 3).

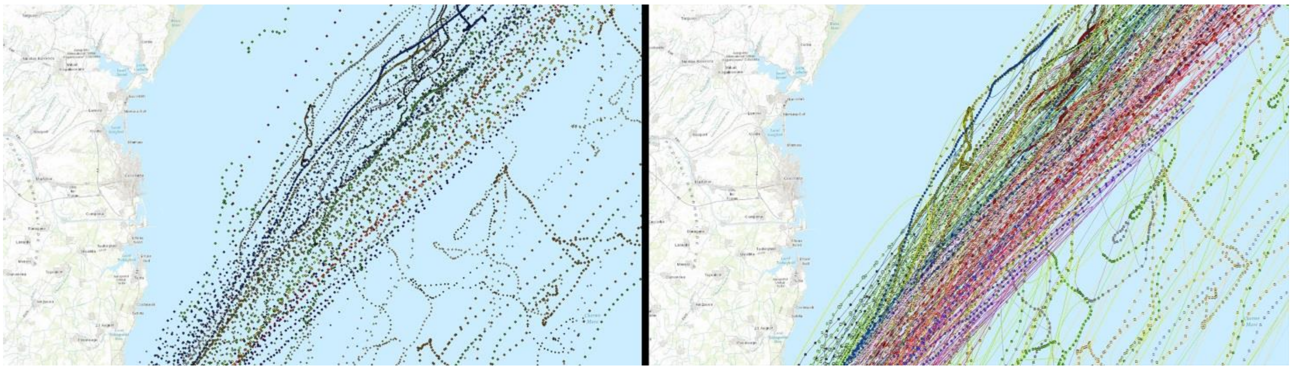

Figure 3. Points and trajectories after MOTHY model simulations

The raw data received from the model were reformatted for advanced time analysis with ESRI’s Tracking Analyst, an extension for ArcGIS for Desktop. A time window for 1 day and 3 days for every trajectory was used, compensating in some degree for the potential time errors in the data. All 252 trajectories were investigated back in time in search of a concentrated cloud of trajectory points somewhere in the sea. Eventually such a concentration was indeed found in any used analysis, located 35 km northeast of Snake Island in the Exclusive Economic Zone of Ukraine in the Black Sea (Figure 4).

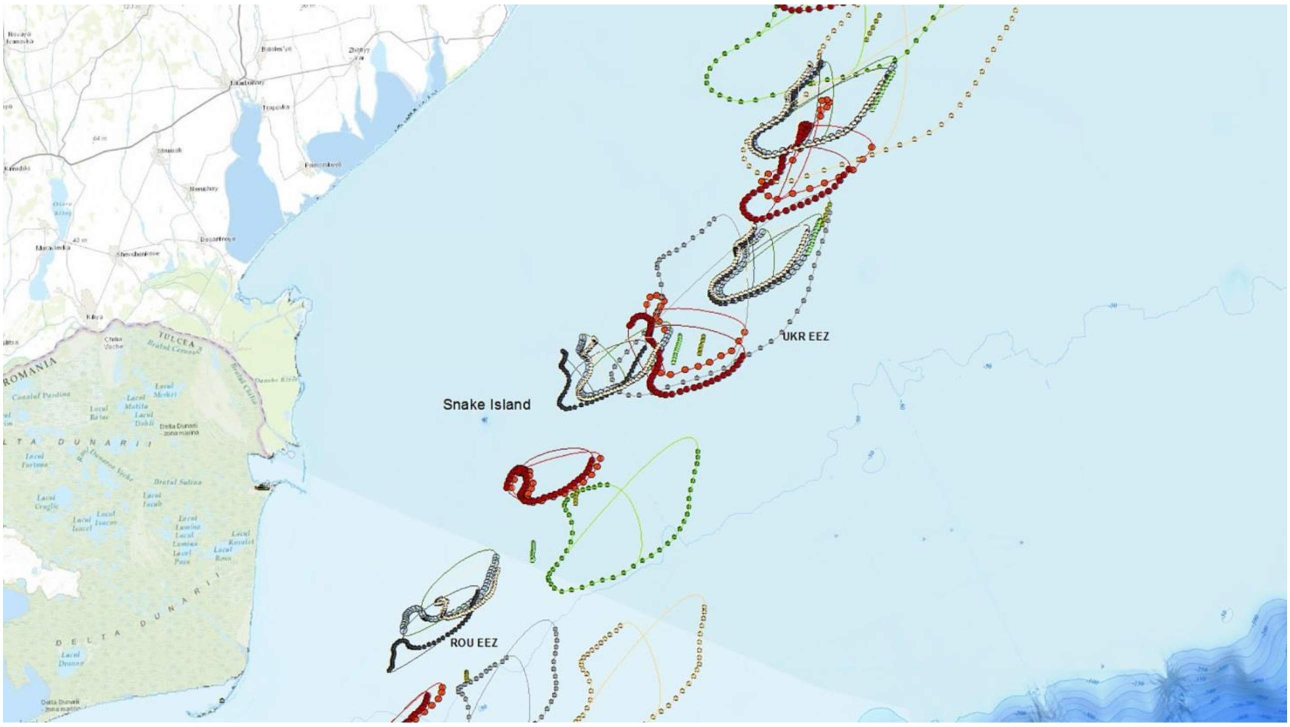

Figure 4. Cloud of trajectory points shows the place of incident, 35 km NE from Snake Island

Most of the carcasses were found hundreds of kilometers away from that place after more than 20 days of floating in the sea. So the possibility of getting this result by chance is minimal.

TURBOT ILLEGAL FISHING

The time of the incident of the selected cases was determined as well and was found to be between 25 and 26 July 2015. Knowing the place and time of the incident were the first steps in discovering the cause. During a deeper investigation of the other available data it was found that some of the dolphin calves also died around 1 August 2015 in the same place, so there was some cyclic event taking place. All of dead calves, more than 300 registered cases, were equal in size, neonates from *Phocoena Phocoena* species. For most cases the exact cause of death was not possible to determine by necropsy because of the long time the carcasses had spent in the sea already. However, necropsy could prove in some cases that drowning was the cause of death (Kuiken T., 1996). Drowning of dolphin calves most often happens when they are caught in fishing nets as bycatch. Happening all over the world, Illegal, Unreported and Unregulated (IUU) fishing is one of the most devastating activities in the seas. The Black Sea is notorious for such activities, especially illegal turbot fishing by gillnets (Bayram Öztürk, 2013). The place around Snake Island is one of wildlife's richest places in the Black Sea, including turbot population. The unspecific time of the illegal turbot fishing at the place in question was also explained as well as historical data point maximum of bycatch dead dolphins especially in that time window of the year in that area. The illegal turbot gillnets are often hundreds of kilometers long and are the main cause of death globally especially for *Phocoena phocoena* due to the specific anatomy and behavior of this species (Randall R. et al., 2013), (Kastelein et al. 1995), (Kastelein et al., 2000). Knowing the place, time and cause, the challenge still is to find the offender. Historical data of marine traffic (marinetraffic.com) based on the automatic identification system (AIS) was obtained and analysed, but there were no results due to the fact that illegal fishing boats never activate their AIS. Also, we had no public access to VMS data for the region and not analyse them. Completing the crime scene investigation, a thorough analysis of the data of all cases in the summer of 2015 made it possible to mark several places in the Black Sea where illegal fishing of turbot might be happening.

FUTURE PREVENTION

The approach explained in this article can be used for a wide range of applications, investigations or rescue missions at sea, without the actual need for satellite and sensor data, border police or military information. Many people contributed to the investigation with their expertise, which has also helped in the wide-spread communication about this topic. The authors hope that publicity of this severe wildlife disaster in the summer of 2015, concerning the death of probably thousands of dolphin calves, can prevent further extermination of the small population of *Phocoena phocoena* and other marine wildlife in the Black Sea. The population of turbot is also on its critical minimum in Black Sea, as well as many other species of marine life, and in the same time the lack of adequate control is evident. Black Sea is arena of Illegal, Unreported and Unregulated (IUU) fishing, gas and oil investigation and production, military activities, pollution. The extermination of marine sea life continues.

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BIOGRAPHY

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