MONITORING THE OCCURRENCE OF PORPOISES AND BOTTLENOSE DOLPHINS IN THE COASTAL WATERS OF ROMANIA BY LOGGING THEIR ECHO-LOCATION ACTIVITY

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Abstract. Dolphins and porpoises are aquatic mammals, which spend most of their life underwater, surfacing just to breathe air. This behaviour is the very first reason why scientists find it quite challenging to study these charismatic animals. But cetaceans possess one of the most interesting and helpful ability known for the animal world, they are able to echolocate. They exchange information and coordinate their behaviour by echolocation using clicks, for example. In this way, we do not need to see the animals but to hear them. The technological development in the past decades brought several devices for this specific reason. Between 2020 and 2022, four F-PODs were used to collect information on cetaceans within the Romanian coastal waters by means of click detection. A total of 11672 hours of data, covering the 4 seasons, were collected, and analysed by the team as a first study of its kind in Romanian Black Sea waters. These results confirm that F-PODs provide an effective method for monitoring the occurrence of bottlenose dolphins and harbour porpoises, in coastal waters despite the different habitats, and create the possibility of delineating short- or long-term patterns of use of the habitat or evaluating long term trends in support of species conservation.

Keywords: Black Sea, click detectors, F-POD, marine mammals, dolphins, porpoises, presence/absence.

Rezumat. Monitorizarea apariției marsuinilor și afalinilor în apele costiere românești prin înregistrarea activității lor de ecolocație. Delfinii și marsuinii sunt mamifere acvatice, care își petrec cea mai mare parte din viață sub apă, ieșind la suprafață doar pentru a respira. Acest comportament reprezintă principalul motiv pentru care, pentru oamenii de știință este destul de dificil să studieze acest grup de animale carismatice. Cetaceele posedă una dintre cele mai interesante și utile abilități cunoscute pentru lumea animală, ele fiind capabile să ecolocheze. Acestea fac schimb de informații și își coordonează mișcările prin ecolocație folosind, spre exemplu, click-urile. În acest fel, nu trebuie să vedem animalele pentru a le studia, ci să le auzim. Dezvoltarea tehnologică din ultimele decenii a adus mai multe dispozitive exact pentru acest motiv specific. În perioada 2020 – 2022, patru dispozitive de tip F-POD au fost utilizate pentru colectarea de informații de la cetacee în apele costiere românești prin detecția click-urilor. 11672 de ore, acoperind toate cele 4 sezoane, au fost colectate și analizate de echipa de autori ca un prim studiu de acest gen în apele românești ale Mării Negre. Rezultatele confirmă faptul că F-POD-urile reprezintă o metodă eficientă de monitorizare a apariției afalinilor și marsuinilor în apele costiere în ciuda habitatelor diferite și creează posibilitatea de a delimita modelele de utilizare pe termen scurt sau lung ale habitatului sau de a evalua tendințele pe termen lung în sprijinul conservării speciilor.

Cuvinte cheie: Marea Neagră, detector de click-uri, F-POD, mamifere marine, delfini, marsuini, prezență/absență.

INTRODUCTION

The Black Sea is home to three species of cetaceans: the Black Sea bottlenose dolphin (*Tursiops truncatus* ssp. *ponticus,* Barabash-Nikiforov, 1940), the Black Sea common dolphin (*Delphinus delphis* ssp. *ponticus,* Barabash-Nikiforov, 1935), and the Black Sea harbour porpoise (*Phocoena phocoena relicta*, Abel, 1905) (ACCOBAMS, 2021; BIRKUN, 2008, 2012; CENOBS, 2021; DI SCIARA, 2002; MURARIU, 2004, 2005; PAIU et al., 2019; RADU et al. 2013; TOMILIN, 1957; VIAUD-MARTINEZ et al., 2007), which are also the object of our study. In the coastal waters of Romania, the most recorded visual sightings have been those of the Black Sea harbour porpoise and the Black Sea bottlenose dolphin, known for their coastal distribution (PAIU et al., 2019b; GOL`DIN and GLADILINA, 2015; BIRKUN et al., 2014; MURARIU, 2012).

In comparison with the visual observation, which typically gives good spatial coverage, is expensive and is biased towards good environmental conditions, static acoustic monitoring gives good temporal coverage of a single area, is cost efficient, but requires interpretation of the resulting data. During the past years, research and innovation in technology have made available different sound capture devices. The prototype version of the F-POD was designed in 1996 with the aim of studying porpoise behaviour around fishing nets. This version was known as Proto-Pod (HARLAND, 2006). It had several limitations due to the technology available at that time. These were associated with the use of analogue filtering and the comparatively high current consumption of microelectronics. Later, the T-POD and C-POD were released and tested (MEDING et al., 2005; ÖZTÜRK et al., 2019; THOMSEN & PIPER, 2004, 2006; THOMSEN et al., 2005; VERFUß et al., 2005, 2006, 2007). These devices sample marine sound at 1 million samples per second and process this data stream in real time to select acoustic events that are either tonal, as is the case for porpoise clicks, or are loud transient sounds such a *Tursiops* clicks. (CHELONIA LTD, 2022). Each 'event' is stored in a 16-byte record giving a very compact record such that 1 year of data can generally be stored on a single 32GB SD card which is the standard memory. It can record continuously for 4 months with alkaline batteries and 7 months on primary lithium cells.

This is the first study using F-POD in the Black Sea, as previous passive acoustic monitoring was performed with A-tags and C-PODs in Turkish Strait System starting with 2010 (DEDE et al., 2011, 2014, 2017, 2018;

KAMEYAMA et al., 2012, 2014) and similar testing devices for noise monitoring purposes by MIHAILOV (2020) in the north-western Black Sea.

The data is stored in a custom, open-source, format and can be processed using the freeware FPOD app that embodies the ‘KERNO-F’ classifier which identifies click trains in the data and ascribes a species group to each train. These species groups are: (1) ‘NBHF’, narrow-band high frequency, which includes all porpoise species and a few dolphin species, (2) other cetaceans, which includes all the other dolphin species and toothed cetaceans, excluding the Sperm Whale, (3) boat sonars which produce long tonal pulses, and (4) an ‘unclassified’ category which holds all those click trains that cannot be confidently allocated to one of the preceding 3 classes.

The resulting F-POD data includes inter-click intervals, which encodes some behavioural information. In general, only brief segments of the clicks emitted from a porpoise are registered by the F-POD due to the scanning movements of the animal’s head and the directionality of the sound beam. The full click train made may then appear as several successive click trains in the F-POD data (CHELONIA LTD, 2022). These are frequently used to monitor the behaviour and habitat use of harbour porpoises and bottlenose dolphins. Interesting patterns in visit length and frequency are emerging for both species.

PHILPOTT and colleagues (2006) used visual methods to show that porpoise detections are within 500 m from the C-POD, a predecessor of the F-POD, and the farthest distance that dolphins were observed, corresponding with acoustic data, was 3,355 m.

Our study focuses on identifying the seasonal presence of harbour porpoises and bottlenose dolphins along the Romanian coastal area and on the detection of trends at the four stations: Mangalia (F-POD no. 6275), Agigea (F-POD no. 6276), Constanta (F-POD no. 6272) and Mamaia (F-POD no. 6274) (Table 1).

MATERIAL AND METHODS

This represents the first application of these devices for static acoustic monitoring in the Black Sea. The devices were set to record continuously. A total of 11672 hours of data, covering the 4 seasons, were collected, and is presented in Table 1. The F-POD also records the temperature and the angle of the instrument to the vertical.

Table 1. Deployment information and overall data collection effort and stations.

F-POD No.	GPS Location	Deployment period November 2020 – June 2021					Total no of hours
		Depth (m)	**P1**	**P2**	**P3**	**P4**	
6272	44.16733°N 28.66397°E	9.8	23.11- 08.12	18.12 - 02.01	19.01 - 27.03	11.05- 06.06	2979
6274	43.8132°N 28.59886°E	11	23.11- 17.12	17.12 - 02.01	14.01 - 8.02	01.05- 06.06	2435
6275	44.27327°N 28.64087°E	8.8	23.11- 18.12	18.12 - 02.01	19.01 - 27.03	28.05- 06.06	2800
6276	44.07956°N 28.64832°E	11	23.11- 17.12	17.12 - 28.12	14.01 - 27.03	01.05- 06.06	3458

The monitoring plan included four sampling areas in proximity of 4 cities: Mamaia, Constanța, Agigea and Mangalia (Fig. 1), which further on will also name the station, on depths between 8-11 m. The devices were fixed at 1 m above the sea bottom. These were moored with 25 kg concrete anchors, and properly signalled with buoys. A deployment and recovering procedure was developed, with no divers involved, so as to be able to deploy and recover them from the safety of a boat (Fig. 2).

Each train was used for analysis (e.g. in accordance with other studies, only trains belonging to the ‘Cet Hi’ and specie KERNO/F classifier, NBHF (porpoises) and OTHER CET for bottlenose dolphins were used for the analysis. For a detailed description of the analytical procedure, see www.chelonia.co.uk. We chose the proportion of ‘Detection Positive Hours’ (DPH) as an indicator for acoustic activity/presence of harbour porpoises and bottlenose dolphins. The DPH-values for each recording were compared among software versions with a paired t-test (‘before and after control’, ZAR 1984). The proportion of hours with porpoise registrations (DPH) and bottlenose registrations (DBH) from the number of monitored hours (% DPH) per monitoring period of the study are shown from the fall of 2020 until the summer of 2021 for each measuring station. Then, to overcome the saturation, we have obtained a density of hourly detections over the hall period (by months).

For determining the diel cycle, the analysis took in account the hall clicks detected, for each of the two species, by month. For a better visualisation, the DPH and DBH were plotted against time within specific areas. Therefore, data from measuring stations were pooled from the following areas (from north to south) (Fig. 1): the Mamaia station; Constanta station, Agigea station; and Mangalia station.

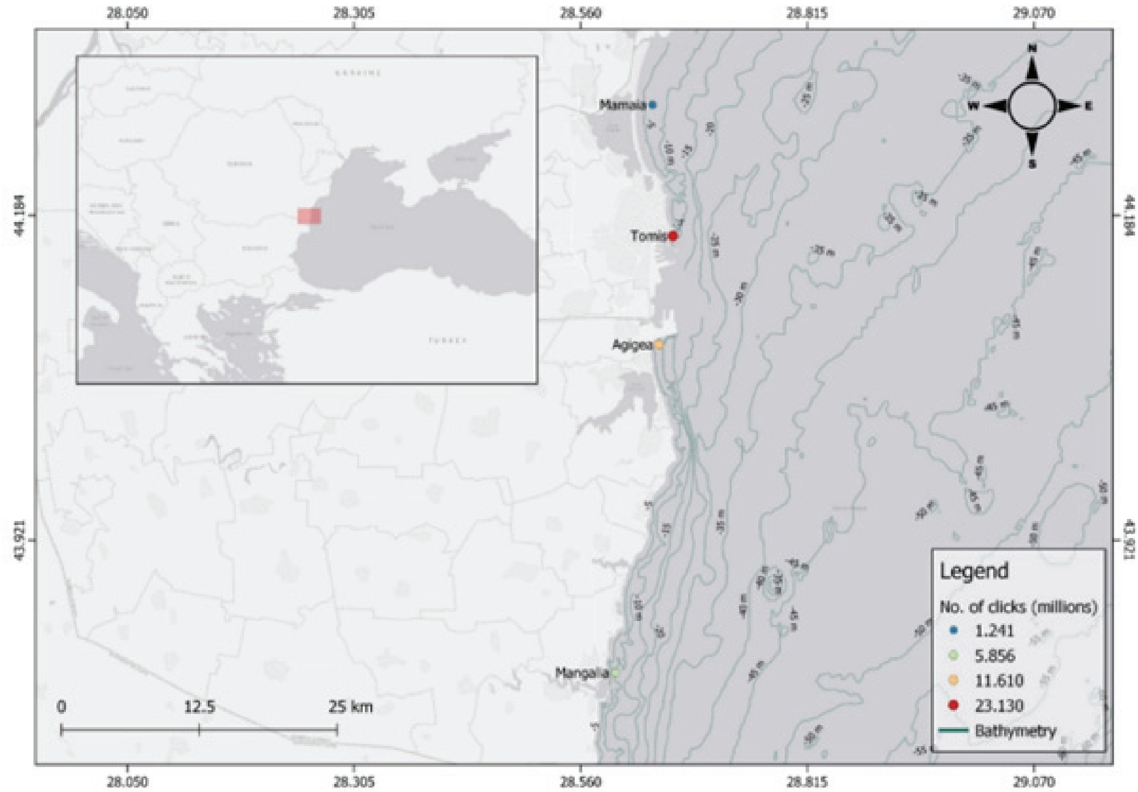

Figure 1. The 4 F-POD monitoring stations along the coastal waters of Romania (coloured dots), and the abundance of clicks recorded in each station during the research. The map was produced in QGIS software (QGIS Development Team, 2020) (original).

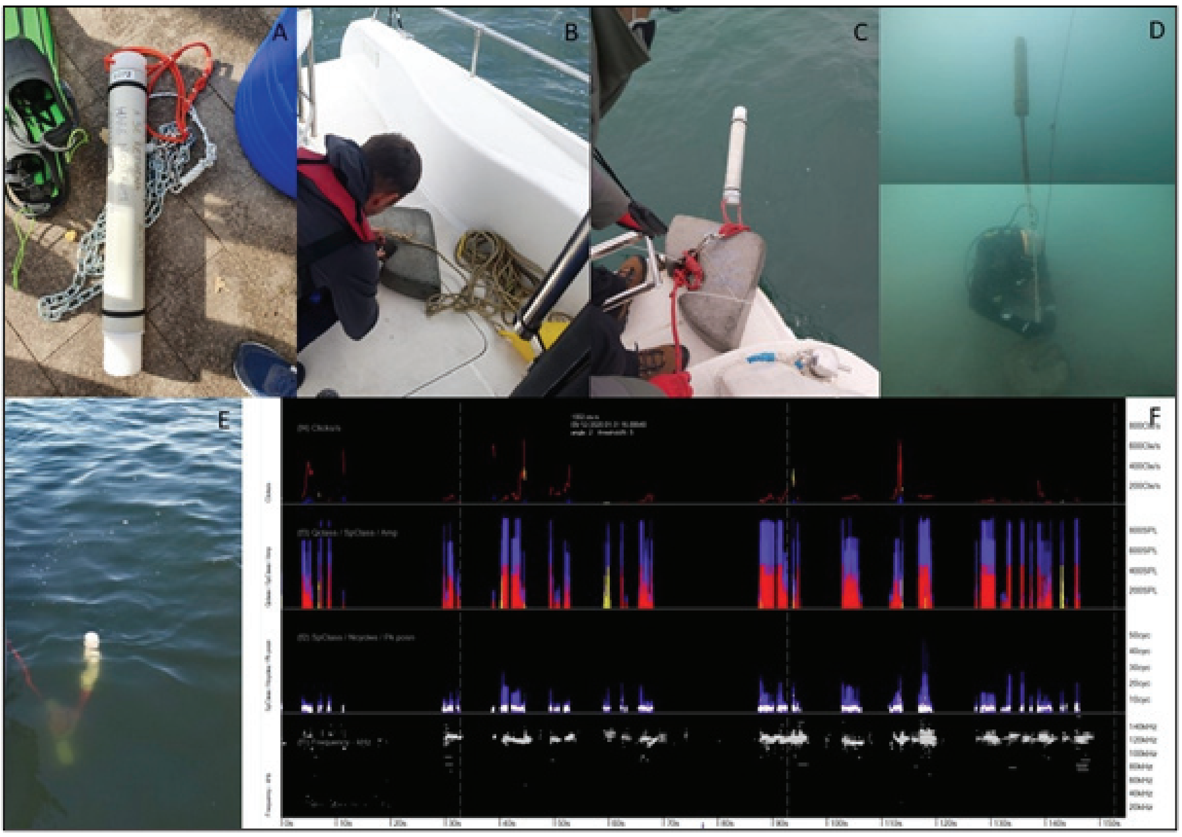

Figure 2. The mooring scheme for anchoring the F-POD devices. A. Fixing the FPOD to the Anchor; B. Fixing the buoy to the anchor; C. Deployment of the assembly; D. Underwater position of the device; E. Recovery of the device; F. Data display using F-POD.exe (original).

RESULTS

Along the research monitoring activity performed between November 2020 - June 2021, from fall to summer, 486 days and 3 hours of continuous recording were collected. The four datasets, associated to the four stations, mentioned before, were analysed, and for them we describe the following results.

In terms of cetacean detection, using the F-POD devices, the presence/absence of the animals was underlined for each of the stations in figure 1. On monthly bases, an hourly average of click detections was calculated for each of the species for each station (Figs. 3 and 4). The analysis revealed a common presence in the area, of both species but with a clear more increased number of clicks from harbour porpoise. This is normal, also since porpoises are proved to click most of the time, in comparison with dolphins which have long periods of totally silence (AMUNDIN, 1991; VERFUß et al., 2005).

When we move our analysis on each station, it revealed the fact that the harbour porpoise is having a decline in presence/clicks during the winter months (January-February), an increase during the spring, then followed by a decrease in June (Fig. 3), most probably due to the human activity in the area. On the other hand, the bottlenose dolphins' detections follow the same pattern, but increase later, in May, again with a slow decline in June in 3 of the 4 stations. In the Agigea station, the recorded presence was increasing (Fig. 4). For a better visualization of the figure 4, for bottlenose dolphins' detections, in station 6272, the number of detections was cut to 1803 from the total of 4803.

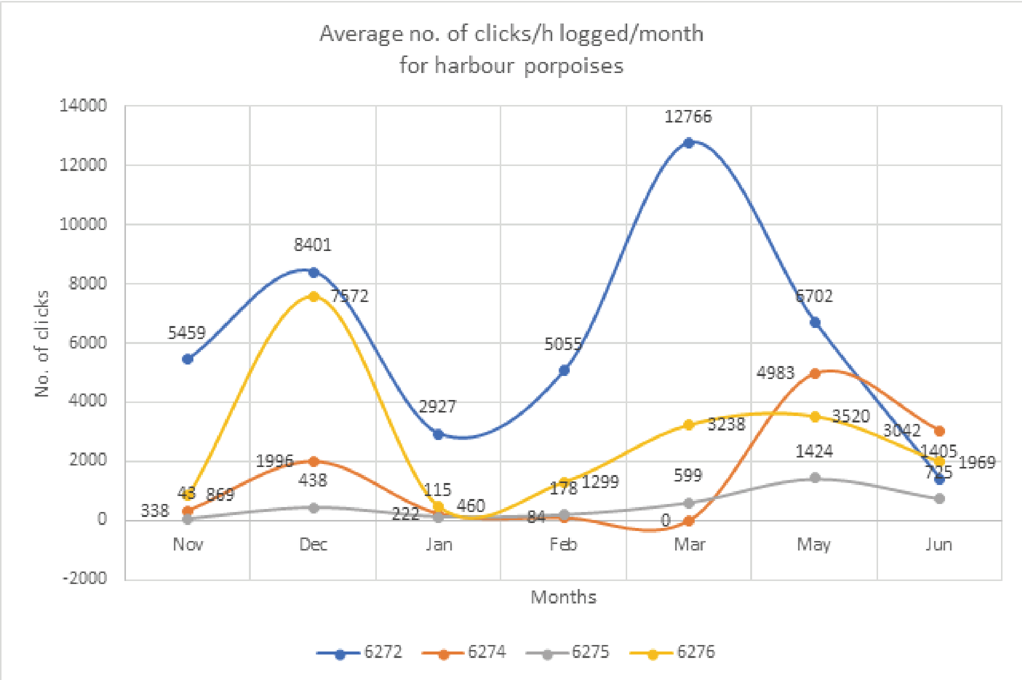

Figure 3. Monthly average number of clicks detection/hour in the four stations, for harbour porpoises in each station.

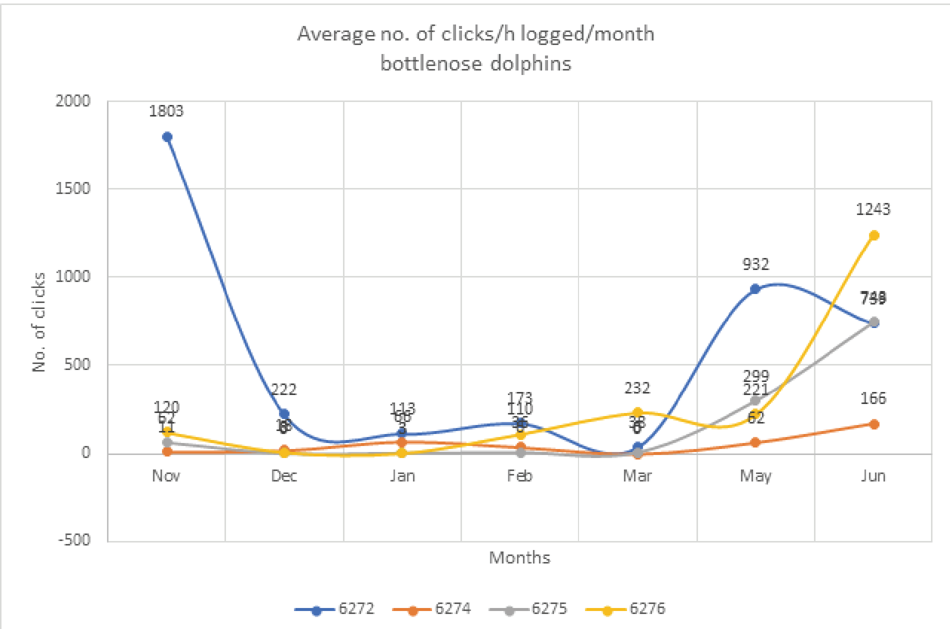

Figure 4. Monthly average number of clicks detection/hour in the four stations, for bottlenose dolphins in each station.

Data show a clear seasonal variation within the stations north of the Constanta harbour and Mangalia in comparison with Agigea station, where although a decrease in detections was recorded during wintertime, differing from the other stations, the number of detections in December overcame the peak recorded in May in the other three stations for harbour porpoises. In comparison, bottlenose dolphins' recordings show a similar steady trend for the period November – April, with a positive trend in March and May, and a peak in June.

Overall, when we analyse the diel pattern of the species, along the entire period, there are no significant time frames in which porpoises are more active. This is changing when we study the dynamic of occurrence on monthly basis, when the presence was recorded mainly during night hours, in the cold season and all-day round for the summer. A high number of clicks was seen in 6272 (Fig. 5), 6274 (Fig. 7) and 6275 (Fig. 9), while in 6276 (Fig. 11) a lower activity was recorded.

As for bottlenose dolphins, the dynamic of occurrence is covering the entire 24 hours, along the study period, only in station 6272 (Fig. 6); for the other three stations, there are "silent hours" either early in the morning (6275) (Fig. 10), or in the afternoon (6274) (Fig. 8), or even midday (6276) (Fig. 12).

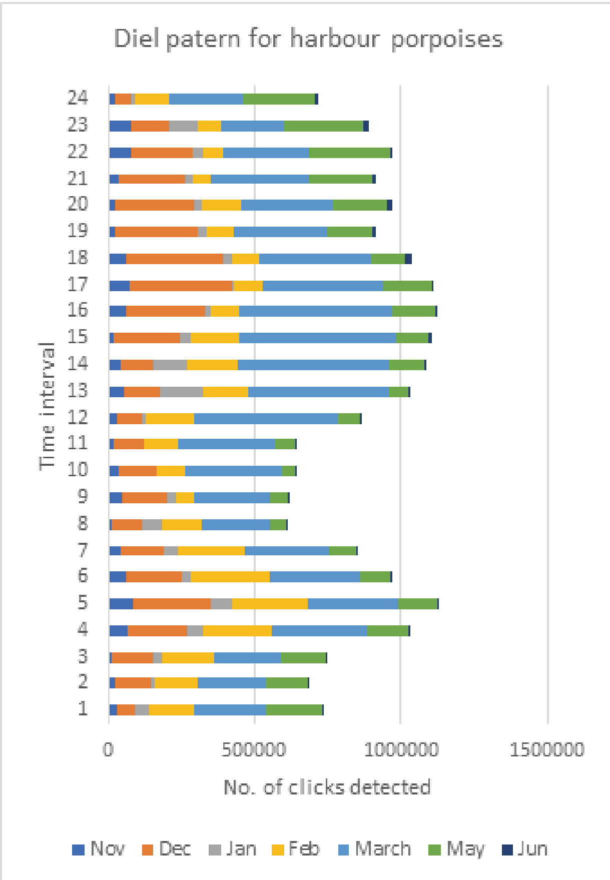

Figure 5. Diel patterns of harbour porpoises in station 6272.

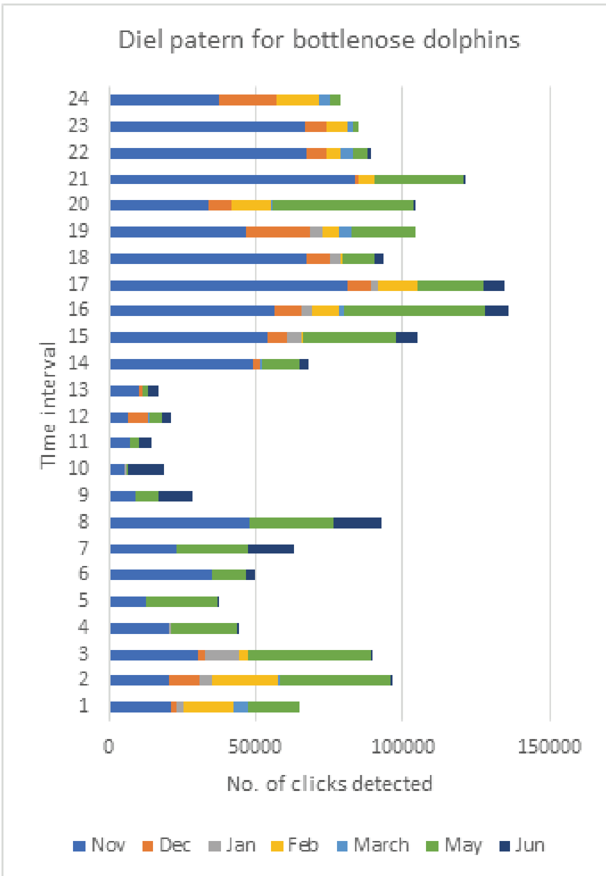

Figure. 6. Diel patterns of bottlenose dolphins in station 6272.

Analysing the dial pattern by species/month, a clear difference was recorded for bottlenose dolphins in station 6272, for January, February, and March when the species is missing from the area between 4:00 UTC (Coordinated Universal Time) and 14:00 UTC. For December, the situation is similar, but no clicks are recorded between 4:00 UTC to 10:00 UTC.

In station 6274 (Figs. 7; 8), harbour porpoises again show a uniform distribution on the overall period and just for December, between 8:00-13:00 UTC are missing, and February, between 10:00-13:00 UTC. For bottlenose dolphins, no presence is recorded between November and February between 7:00-14:00 UTC. Sure, there are some other hours with no presence recorded, like, for June, between 7:00-10:00 and 20:00 – 24:00 UTC.

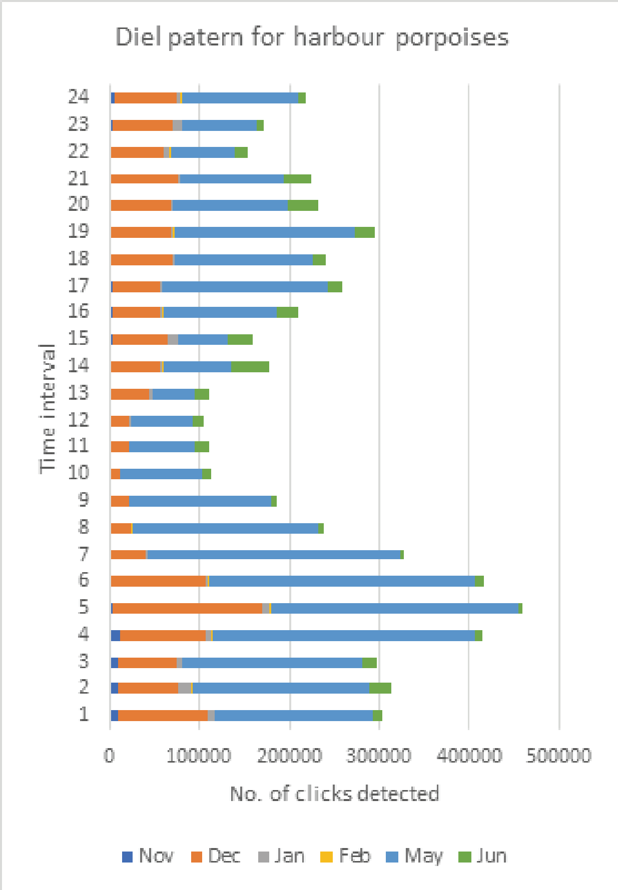

Figure 7. Diel patterns of harbour porpoises in station 6274.

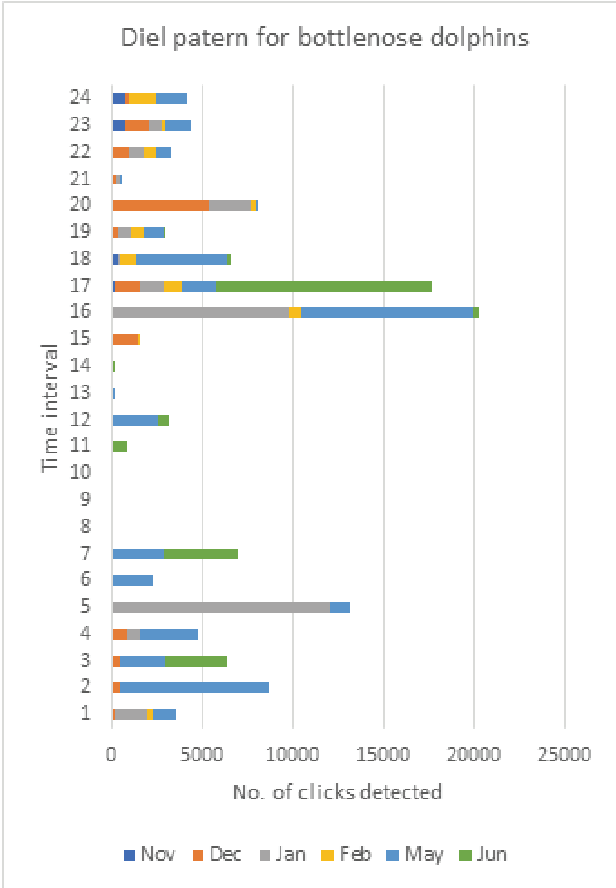

Figure 8. Diel patterns of bottlenose dolphins in station 6274.

The monthly analysis of data from station 6275 (Figs. 9; 10) shows a continuous presence in the area for harbour porpoises, except for November when they were missing between 12:00-13:00 UTC and 17:00-19:00 UTC and then 21:00-22:00 UTC and January at 4:00, 8:00 to 9:00 and 12:00 UTC.

A different situation was recorded for bottlenose dolphins which were not so present in the area, with reduced presence from November to February and an increase in March when they were lacking only during 24:00-6:00 UTC. In May, the same situation was recorded but extending from 19:00-6:00 UTC. June has the highest recorded presence, with animals missing just between 22:00 and 1:00 UTC.

In the last station 6276 (Figs. 11; 12), harbour porpoises were present all the time with just 4 exceptions of one hour in November (13:00 UTC) and 3 in January (5:00, 9:00, 11:00 and 14:00 UTC).

In the case of bottlenose dolphins, the situation was similar to the other stations with representativity on the hall period but a diel cycle per month presenting a low activity between November and January, with no animals between 2:00-6:00 UTC, 10:00-15:00 UTC primarily, and a February with only 3-hour intervals of recorded animals (10:00, 1700-18:00 UTC) and no presence in the rest of the time. From March to June, the silence intervals were primarily during the night 2:00 – 6:00 UTC.

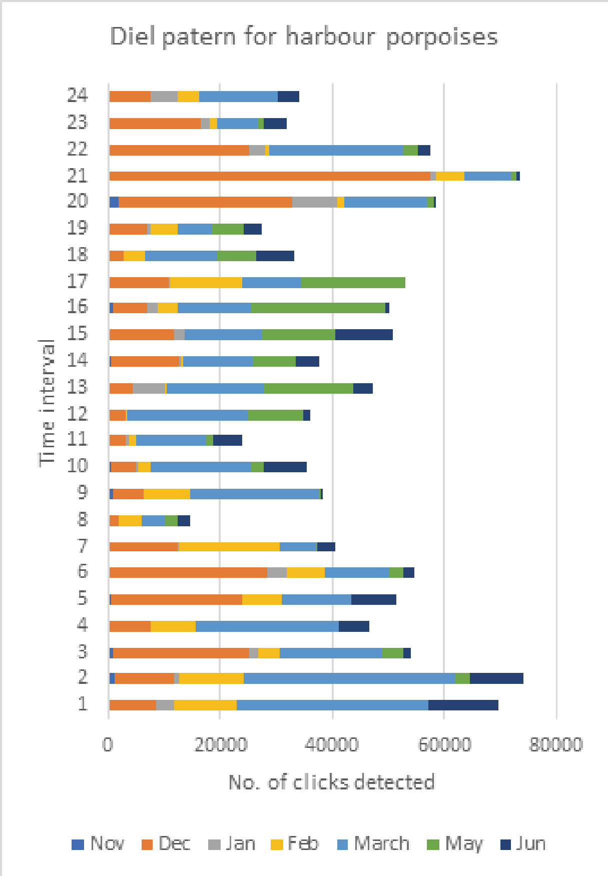

Figure 9. Diel patterns of harbour porpoises in station 6275.

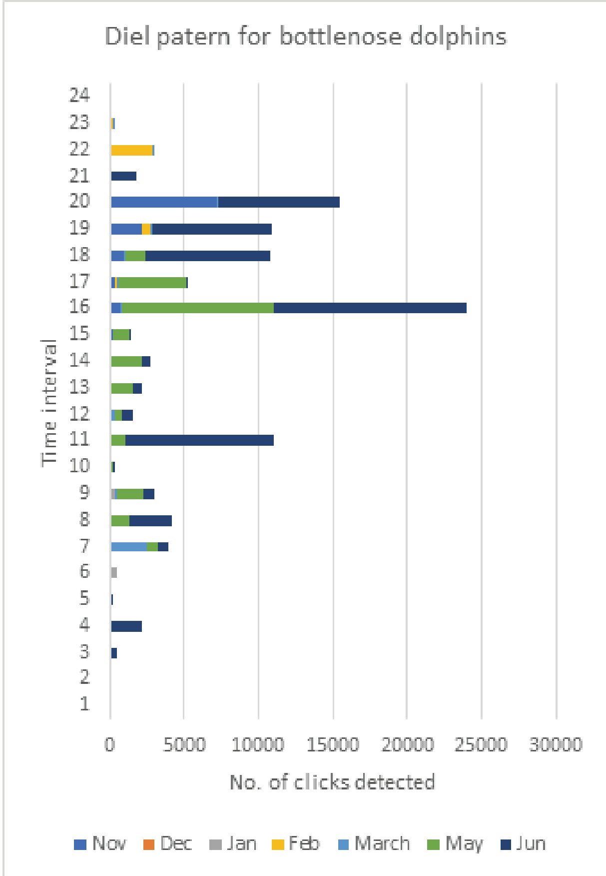

Figure 10. Diel patterns of bottlenose dolphins in station 6275.

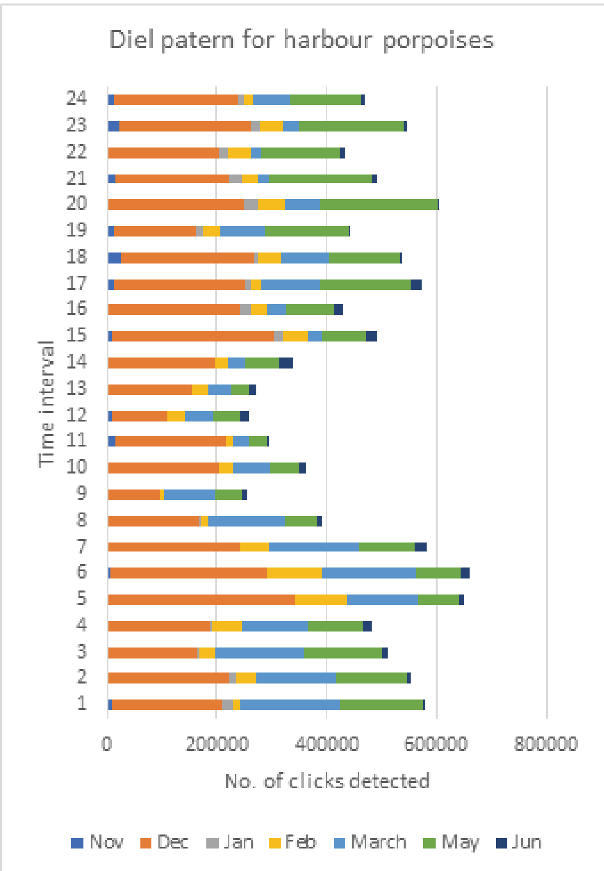

Figure 11. Diel patterns of harbour porpoises in station 6276.

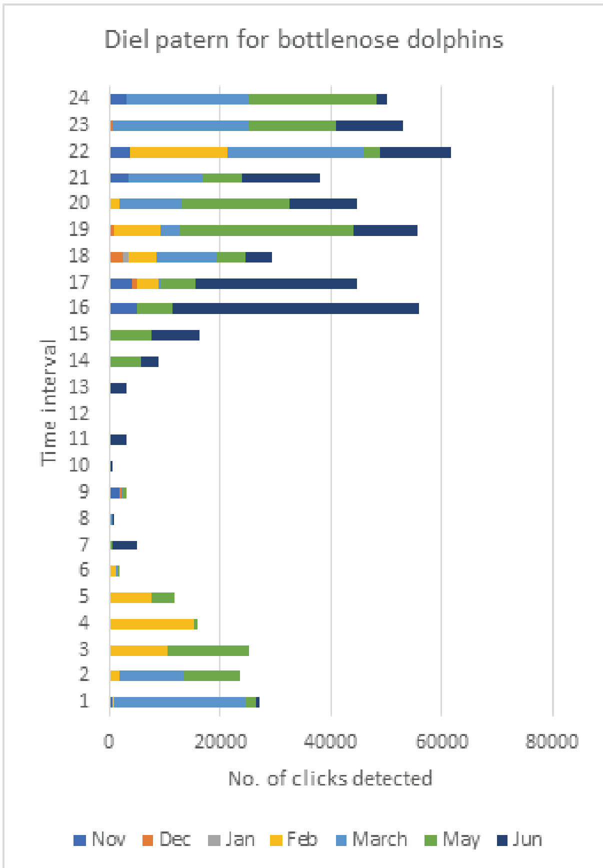

Figure 12. Diel patterns of bottlenose dolphins in station 6276.

DISCUSSIONS

Knowing the site fidelity and usage by marine species, as well as abundance estimates, is critically important to conservation, to the point that obtaining such estimates is something viewed as a prerequisite for management (JAMES, 2014). The lack of such data, as is the case of Romanian Black Sea waters, produces a delay in management of the stocks.

Not few times it was proven that, besides visual observation, acoustic methods should be used when studying cetaceans, due to their capacity of spending quite a huge amount of time under the water, travelling at high speeds, and remaining undetected by visual means. Also, during night-time, visual observations are hard to implement even with optical systems e.g., night vision. This is where devices able to capture the echolocation come into help. Several aspects of echolocation 'behaviour' can be quantified. The distribution of interclick intervals (ICI) (or the reciprocal, Pulse Repetition Frequency PRF), rates of change of ICI, click durations, and spatial and temporal patterns in overall use of echolocation, all provide us with information on how a cetacean is using its echolocation in a behavioural context (THOMSEN 2004, 2006). Behaviour is of interest within the scope of acoustic monitoring for two reasons. Firstly, because it may affect detection probabilities in much the same way that factors such as environmental conditions, and indeed behaviour can affect abundance estimates made, using visual techniques. For example, cetaceans may perhaps be silent more often when travelling and resting than when feeding or socialising. Additionally, the level in the water column at which the animals are active may differ between sites, with prey distribution or with temporal factors such as tidal state or time of day, so the position of an acoustic monitoring device in the water column may affect detection probability. Secondly, acoustic monitoring provides a means of investigating vocalisation behaviours which cannot be detected by visual methods (LEENEY & TREGENZA, 2006).

In our case, it is important to study the habitat use of a species, most common in relation to already established marine protected areas (MPA) or in process of designating such new areas is necessary to be able to collect 24h data towards establishing the presence and absence in the area of the targeted species, to find the trend in terms of use on daily, monthly, yearly bases and continue to the way the animals use the area, or for what reason (VERFUß et al., 2005, 2007).

From our data sets, there are some interesting findings, which will need further attention, when it comes to clicks detection for harbour porpoise which in 3 of the 4 stations was clearly fitting the literature of being more abundant in spring and summer. But the data collected show for station 6276 (Agigea) a peak of detections in December as none of the other station, and greater than the one in summer. Looking more closely to the recorded data, we assume by the number and frequency of the click bursts that there was most probably a feeding aggregation/behaviour.

Recordings from other, more quiet locations with lots of porpoises sometimes show a rise in detection rates. Results also vary depending on the target species.

CONCLUSIONS

The seasonal/monthly distribution of sampling performed within the study revealed a seasonal variation in the presence/density of dolphins and porpoises in the Romanian Black Sea territorial waters, with lower presence (detection rates) in winter than in spring-summer, and autumn for the two targeted species.

The passive static acoustic monitoring proved to be a very valuable research method that can reveal seasonal and geographical differences in the presence and density of harbour porpoises and determining trends. Going further, these are useful tools to understand the use of the area (habitat) by the species and the dynamic of the species within that space.

As the device is able not only to collect clicks, but it also has incorporated temperature and influence of currents as parameters, a correlation may be possible between the mentioned parameters and the presence of cetaceans in the area. This will be looked at in a future article.

In comparison with the visual observations which typically give a good spatial coverage, are expensive and are biased towards good environmental conditions, static acoustic monitoring, on the other hand, gives good temporal coverage of a single area, is cost efficient but requires indirect interpretation of the resulting data.

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