DELIVERABLE D4.3.2

Report on model simulations results

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Project acronym	Adri.SmArtFish
Project full title	Valorisation of SMall-scale ARTisanal FISHery of the Adriatic coasts, in a context of sustainability
WP4	Valorisation of Small-Scale Fishing and diversification of opportunities
Activity 4.3	Joint development and piloting of eco-innovative approaches
Partner in charge	PP1
Partners involved	
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As part of Activity 4.3 of the Adri.SmArtFish Project, Deliverable 4.3.2 derives from the monitoring of nektonic populations within the pilot areas of the Veneto region. The monitoring activities have been performed using active bioacoustic techniques, which involved the use of instrumentation equipped with technology suitable for the discrimination of individual targets. Subsequent statistical analyses of the data collected allowed the quantitative determination of target sizes and their bathymetric distribution. Therefore, these surveys will serve to assess the presence and the size distribution of potential target species for the SSF. Data were acquired using a combined transducer, with frequencies of 38 kHz and 200 kHz. A Simrad EK80 wide-band scientific echosounder equipped with split-beam technology and frequency modulation was used for sampling. The area explored are shown in figure 1.

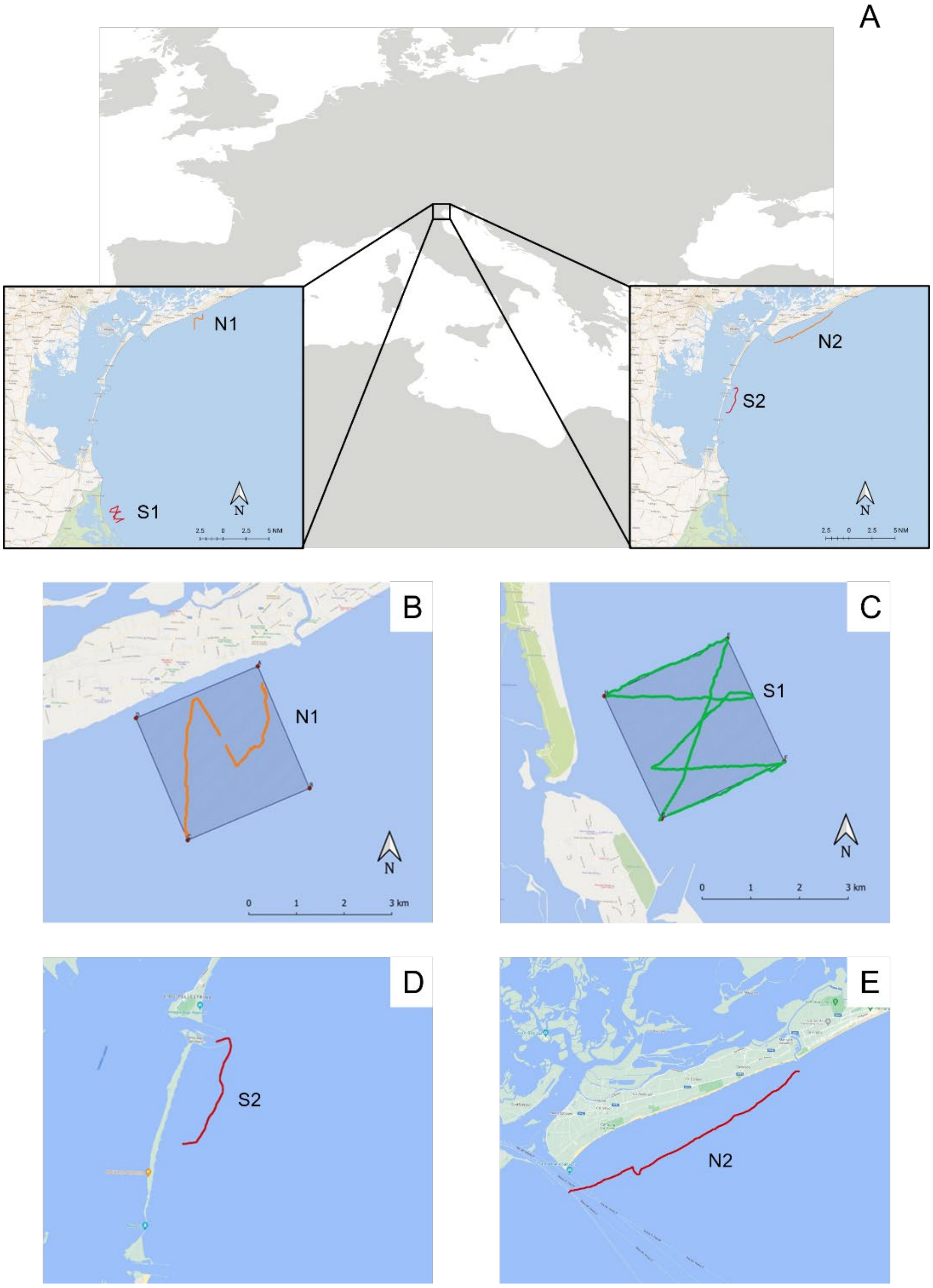

Figure 1. Sampling area monitored with using active bioacoustic techniques (A) and survey transect tracks in the pilot area, sampled on B: N1 - June 23rd 2020; C: S1 - November, 27th 2020; D: S2 - July, 7th 2021; E: N2 - July, 11th 2021.

Acoustic method

The scientific echosounder functions in the same way as a conventional echosounder, which is frequently used by both professional and recreational fishermen. The transducer (Figure 2a) emits a pulse at a specific frequency when immersed in the water; the resulting pressure wave propagates down the water column until it encounters a reflecting obstacle. Some or all the reflected echo is recorded. The response is recorded via the transceiver (Figure 2b) and represented as an echogram (Figure 2c). The pulse pressure frequency (ping) and the transducer beamwidth determine the resolution of the data that can be obtained. All the data collected are recorded on special computer media for further processing and analysis.

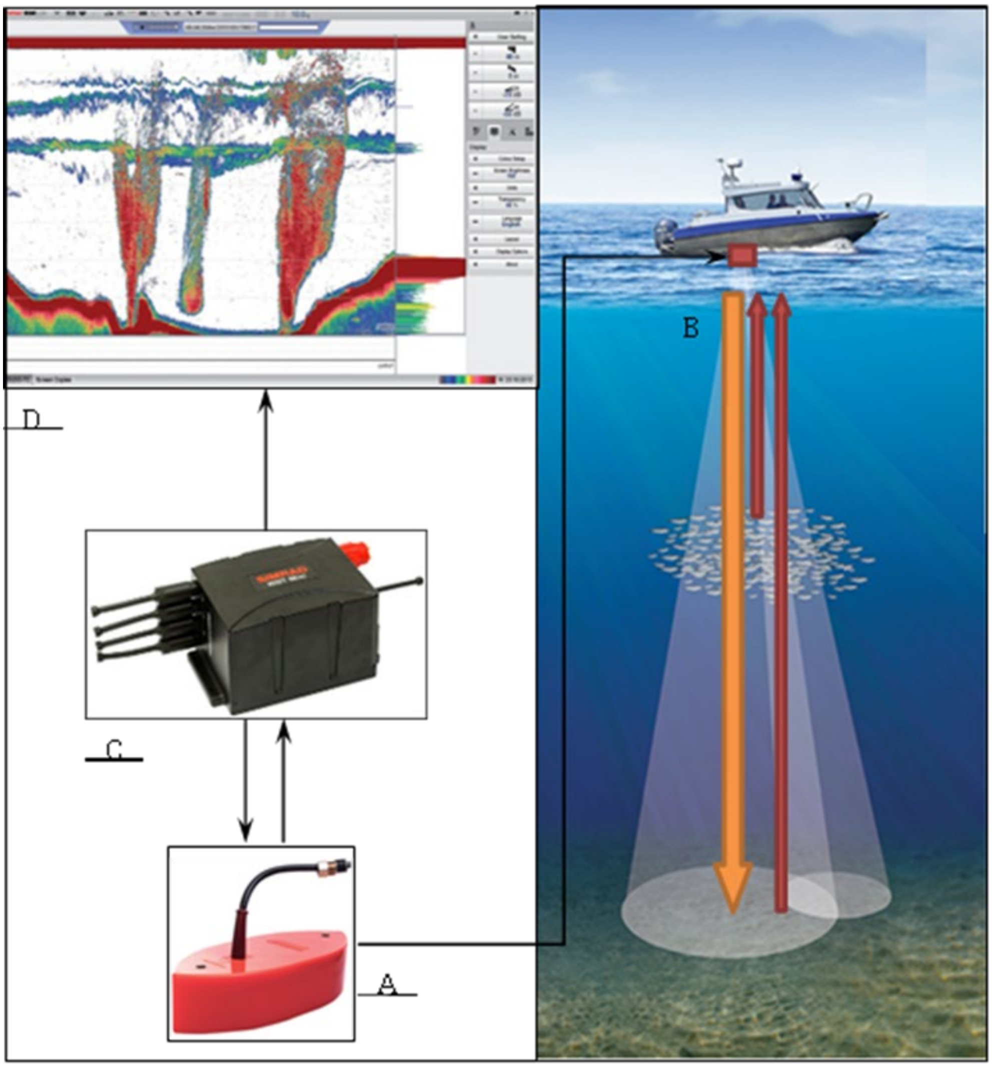

Figure 2: General operation diagram of a scientific echosounder system. The transducer (A) emits sound pulses and records return echoes (B); the transceiver (C) controls the pulse emission, receives the echoes from the transducer, and generates an echogram (D).

Acoustic reflectivity, also known as Target Strength (TS), is the fraction of echo reflected by the target and picked up by the transducer. It is proportional to the size of the target and is measured in decibels (dB) (Simmonds and MacLennan 2005). The TS values can then be used to determine the length of the organisms present within the emission beam and thus to estimate the biomass (Frouzova et al., 2005). When individual targets are relatively small and dense within the sampled volume of water, their echoes combine, and it is no longer possible to determine the individual contributions in terms of reflected energy (Foote, 1987). In this case, the quantity measured is the backscattering volume (Sv or MVBS). This quantity is commonly used in studies of planktonic aggregations. In the present study, the analyses conducted refer to measurements of TS.

Depending on the purpose of use, scientific echosounders can operate at different frequencies, generally between 1 kHz and 5 MHz. The choice of frequency is always a compromise, as low frequencies allow larger portions of the water column to be explored than high-frequency sound waves, but at the expense of the resolution of the data obtained. High frequencies, above 200 kHz, allow very small targets to be identified, under a millimetre in size, but in turbid waters such as those of the upper Adriatic it is only possible to explore a few metres below the transducer due to signal attenuation. The most commonly used transducers for fish detection usually operate between 30 kHz and 200 kHz. The various factors that need to be taken into account when selecting the appropriate frequency for the monitoring task are shown in Figure 3.

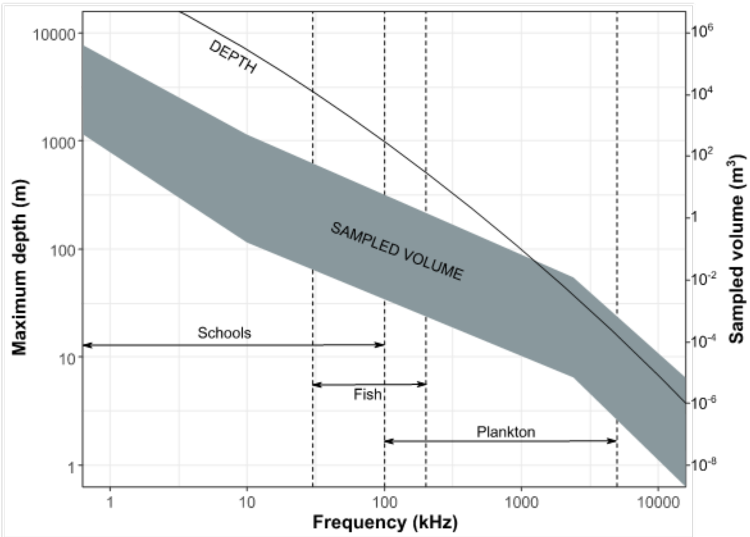

Figure 3: The ability of sonars to detect targets depends on the frequency of the sound waves emitted. The vertical range indicates the maximum distance at which targets can be identified and isolated from background noise. The abscissa shows the frequencies typically used for sampling schools, individual targets and plankton.

The instrumentation used in this activity is characterised by high values of precision and accuracy of the measurements, since the components have been assembled trying to minimise as much as possible the electrical noises that can in turn cause background noises (high signal/noise ratio). Moreover, the conical emission beam of the sound waves has been designed to minimise undesired effects, such as the presence of side lobes, accessory emission regions that can interfere with the central region and give rise to untrue measurements. In addition, a tungsten calibration sphere was used to calibrate the echosounder to have a specific response intensity for the water medium being explored, as the transmission of sound waves in water also depends on the salinity and temperature of the water.

The split-beam technology, used at 38 kHz, also allowed target directionality to be defined; this is made possible by the fact that the transducer is ideally divided into 4 quadrants (channels - Figure 4a) which each differentially record the intensity of the echo response. By integrating the 4 intensities for each ping it is possible to estimate the position of the target within the emission cone; by summing the positions belonging to a single fish for several consecutive pings it is possible to identify the direction of the target's movement (Figure 4b).

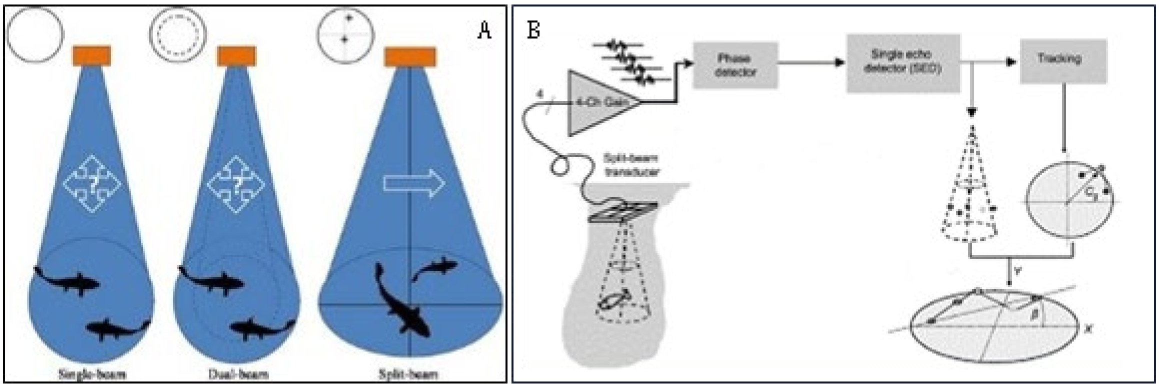

Figure 4: A - Single-beam technology is able to discriminate targets only along the vertical axis, dual-beam technology uses a narrow central emission cone and a wider adjacent one to improve target identification. With the introduction of split-beam technology it is possible to record the direction and speed of movement of individual fish. B - By integrating several successive surveys of the same target (fish), its movements can be reconstructed.

Setup

The configuration adopted during all sampling campaigns is schematically shown in Figure 5. It consists of a PC equipped with Simrad EK80 software and a GPS receiver for recording the speed of movement of the vessel and the latitude and longitude position of the pings. The WBT-Mini transceiver is connected to the personal computer via a LAN connection, which in turn is connected to a 12V power source and the transducer, which is immersed in the water via an external 'pole' support and attached to one of the boat's sides.

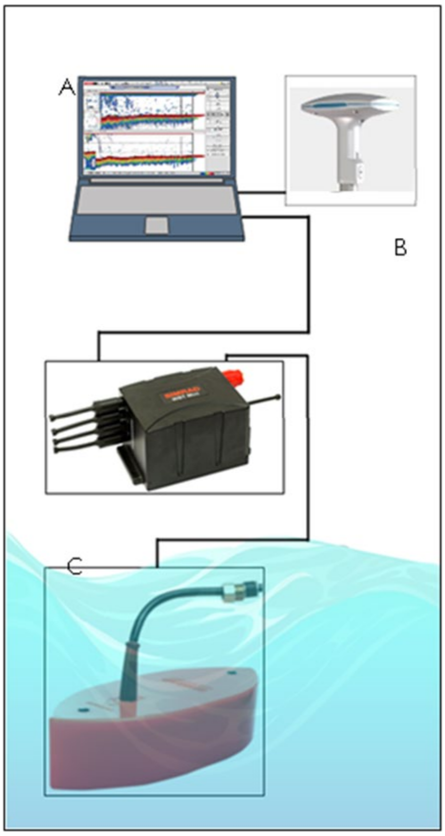

Figure 5: instrumentation setup diagram – Laptop with acquisition software (A); MRU with compass, motion sensor and GPS receiver (B); Simrad WBT- MINI transceiver (C); 38-200kHz split-beam transducer (D).

Analysis of acoustic data

Data collected with the 38-kHz frequency were used in this study. The echograms obtained during the acoustic survey were analysed with the aim of isolating biological targets present in the water column. Most fish have TS between -65 and -20 dB, but this varies greatly with fish anatomy and orientation (Simmonds and MacLennan 2005), for this reason we adopted a minimum (conservative) threshold of -70 dB. Target strength can be defined as the quotient between the value of the reflected intensity of the target and the sound intensity hit the target in logarithmic function and can be related to target length and then to the biomass (Johanesson and Mitson, 1983).

Within these aspects, the analysis procedure involved the following steps:

1. Visual examination of the RAW data.
2. Exclusion of bad data parts (if any).
3. Exclusion of the near field area located in the upper portion of the water column.
4. Detection of the bottom line.
5. Implementation of single target detection algorithm to isolate pings corresponding to living organisms.
6. Implementation of fish track detection algorithm to aggregate and localize fishes.
7. Visual examination of tracks to exclude bad implemented data.
8. Export of data in tab form.
9. Analysis of exported data into R and GIS environment.

Results

Figure 6a shows a relative homogeneity in signal intensity. As could be expected, in general the majority of targets shows very low values of TS, corresponding to meso- or macroplankton and small nekton size ranges, with the exception of N1, where the median is shifted towards significantly higher TS values. In Figure 6b the same data have been presented considering the bathymetric distribution of target TS in the water column: the study area was ideally divided into three layers: from the water surface to 6 m depth, between 6 and 12 m depth, and between 12 m and the seafloor. Analysing the bathymetric distribution shows that, in general, the size of organisms increases as one moves from the surface towards the bottom. S1 is an exception, as the trend is opposite, although a number of organisms with high TS are observed near the bottom.

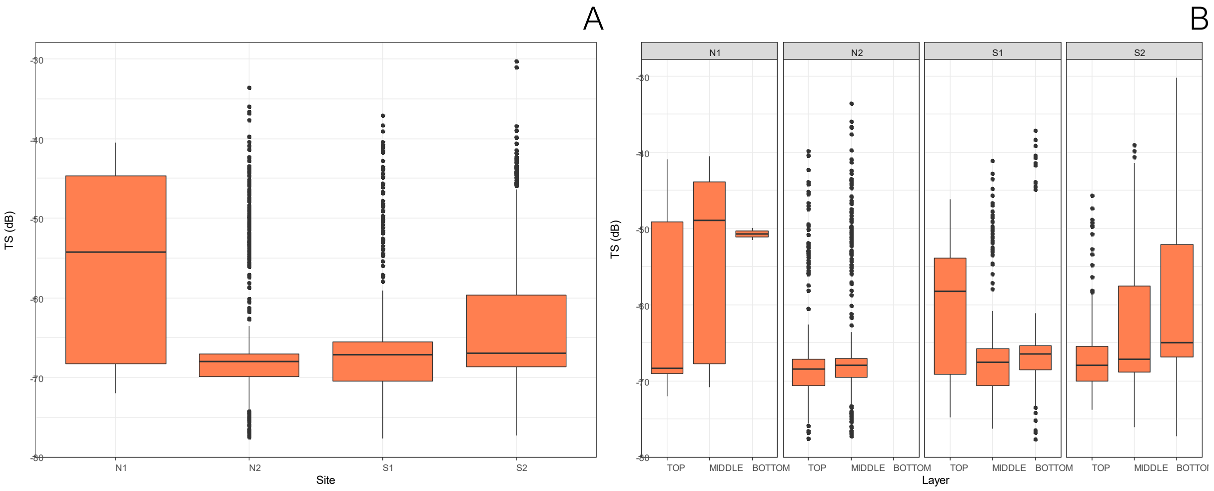

Figure 6. TS distribution of targets in the four surveys. A: entire water column; B: the same TS distribution of targets splitted into the top (0-6m), middle (6-12m) and bottom (>12m) layers.

The TS frequency (Figure 7) distribution confirms the above. With the exception of N1, it is evident that most of the targets consist of small organisms, concentrated around TS values around 70 dB. Subdividing the targets according to depth (figure 7B), it can be seen that in the area to the north the targets are predominantly distributed in the central-upper portion of the water column, while to the south most organisms occupy the central-lower portion of the water column.

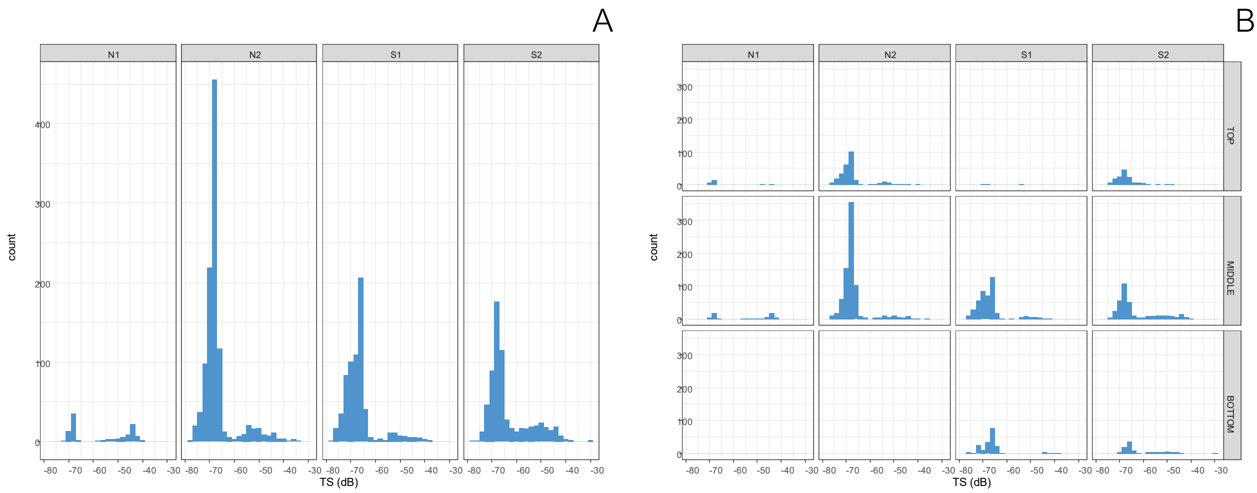

Figure 7. Size classes of targets (as TS) in the four surveys. A: entire water column; B: same data splitted into the top (0-6m), middle (6-12m) and bottom (>12m) layers.

The abundances of the tracked organisms were spatialised in figure 8, where the recorded Target Strength of each organism in the water column were superimposed on the tracks shown in figure 1.

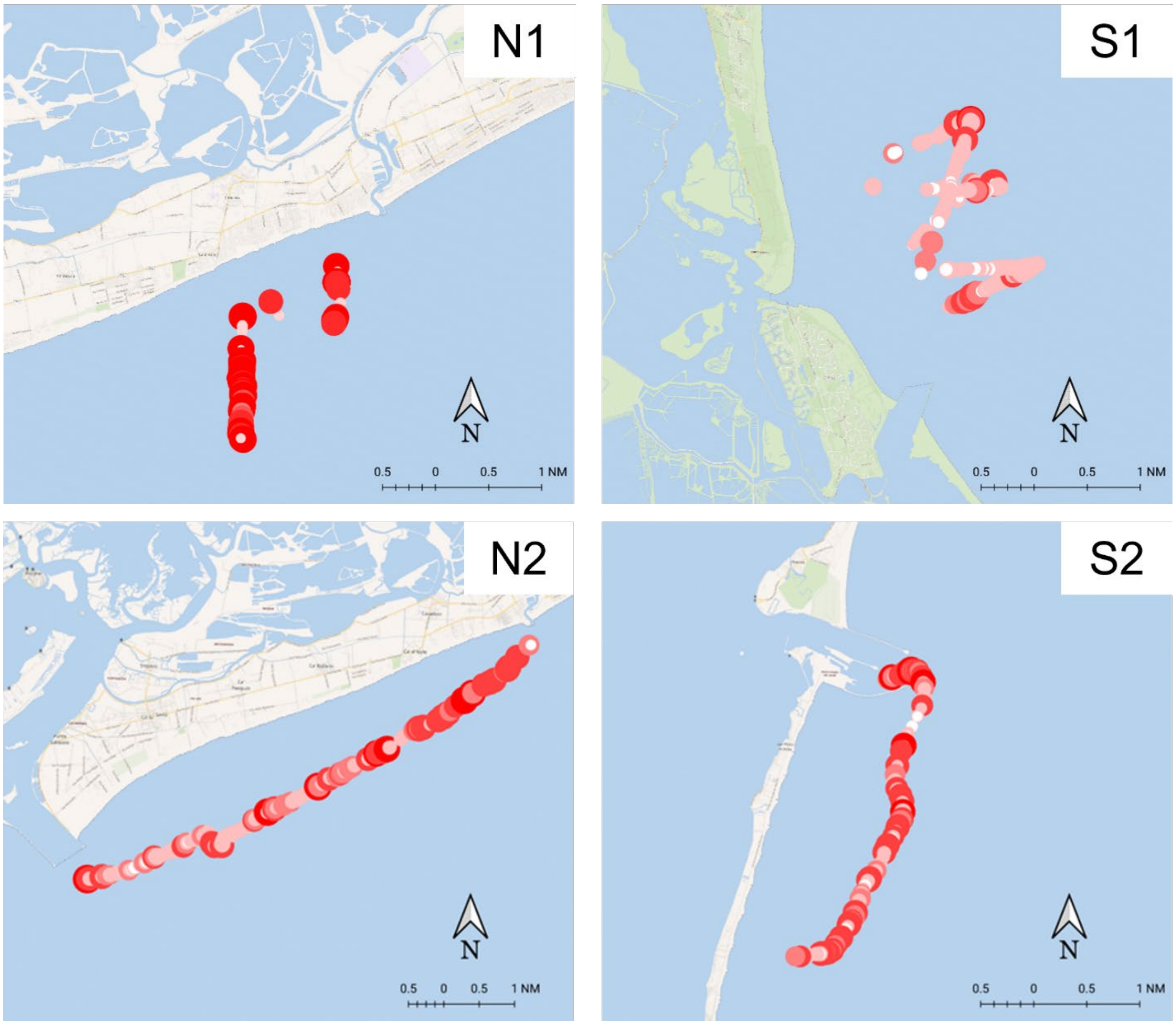

Figure 8. Survey transect tracks in the pilot areas with superimposed the targeted organisms: each dot represents a single target, the intensity of the colour and the size of the dot are proportional to the Target Strength and thus to the size of the organism

Beyond the normal and expected spatial differences between the areas, the analyses carried out on the collected data show the presence within the pilot areas of a large number of potential targets, even of large size, confirming the suitability of the chosen areas for the SSF.

References

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