SSS: seabed interpretation in a fishing area (100m sea depth)

Ancient Trawl Marks and Milli-Sandwaves

Rev. 1.0

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18.06.2023

Contents

Thanks to everyone who spent their personal time on this text.

Thanks Giuliana D, for the advice on oceanology.

Thanks Fradana K, for the discussion and argumentation.

Thanks Joshua D, who made the text more understandable and stricter.

Ivan D.

Introduction

In June of 2023, the P1962 Celtic Connector Survey of the Celtic Sea Basin was carried out. This area in active fishing has been using "bottom trawling" fishing methods. The geophysical survey was being conducted on board of the *OSV Relume* via a subsea WROV (HD 064) that flew at altitude above the seabed of about 7 meters using SSS and SBP (Combined SSS/SBP Edgetech 2205 Series, c/w SSS 230-850 kHz + SBP 2-16 kHz). An DH R2Sonic MBES system was also utilized for this geophysical survey. The average depth of the Celtic Bason was roughly 100m.

Throughout this survey and when target interpretation and seabed classification started, it became necessary to create a system of classes (domains) to describe the "features" of the seabed and to explain the origin of these features. Based on the SSS data, the following features were identified as:

1) Trawl Marks (Figure 1),

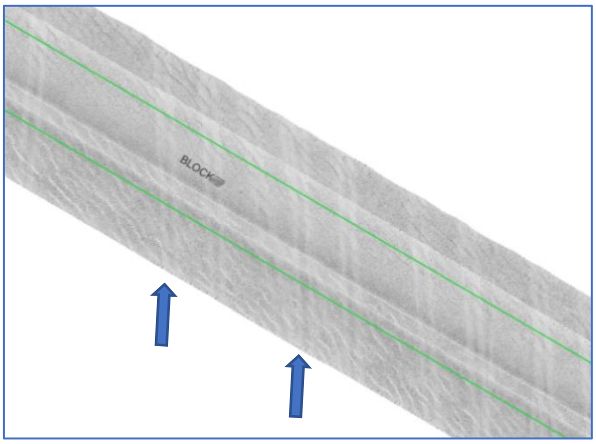

Figure 1

2) Long Ridges of Unknown Origin Filled with Megaripples (***unknown genesis,*** Figure 2),

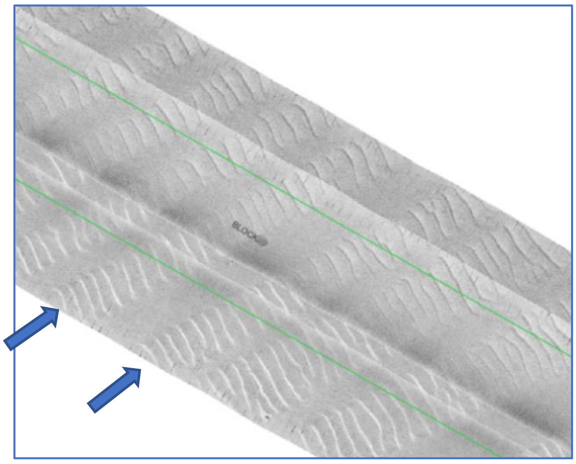

Figure 2

3) Other, "localized" seabed features (scars, boulder fields, rock outcrops).

The following classes have been distinguished "historically" to describe the seabed:

-- Area of Trawl Scars – areas including traces of trawling,

-- Low Parallel Ridges with Megaripples – zones for mapping long strips with Megaripples infill,

-- Megaripples,

-- Numerous Boulders,

-- Occasional Boulder.

1 Trawl marks

The figure below shows the structure of the trawl schematically. Two weights move along the bottom, a net with smaller weights is stretched between them (Figure 3).

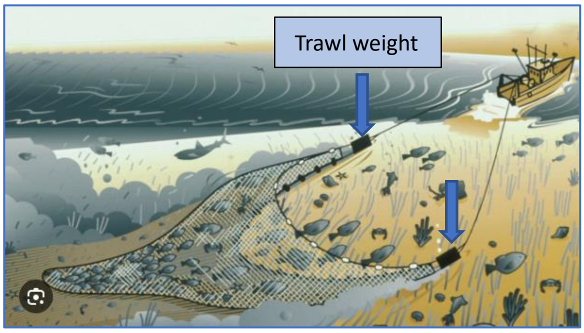

Figure 3 (Picture from Mar Sem Fim site)

The structure of the trawl corresponds to the trawl marks on the bottom, which are visible on the SSS data (Figure 4).

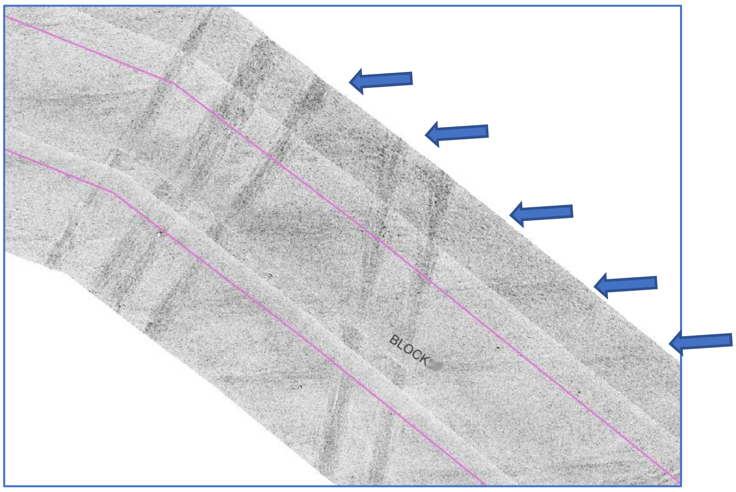

Figure 4

The width of the strip created by the trawl-weight at the seabed is approximately 7 meters. The most common average distance between the centres of weights (centres of parallel lines of trawling weights) observed was 23 meters. Less common distances observed were measured as 32 meters and 53 meters (Figure 5).

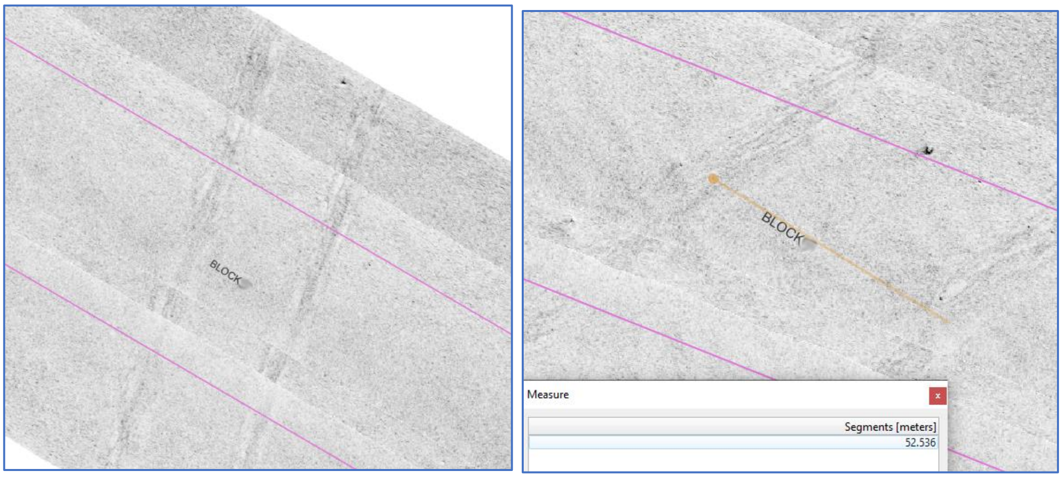

Figure 5

Sometimes trawling is carried out with a system of weights (more than two) and leaves a sequence of parallel trails. An example of such a sequence is shown by the five blue arrows in the Figure 5 above. It is a drawing of 12 trawl-marks below, which were likely created in one pass (Figure 6). The distance between the extreme lines is 380 meters. It is possible that trawling was carried out by two vessels at the same time. It is possible that trawling is carried out by multiple passes of one vessel in parallel courses, however, the uniform distance between the trawl-marks is maintained very clearly, which is unlike for parallel passes.

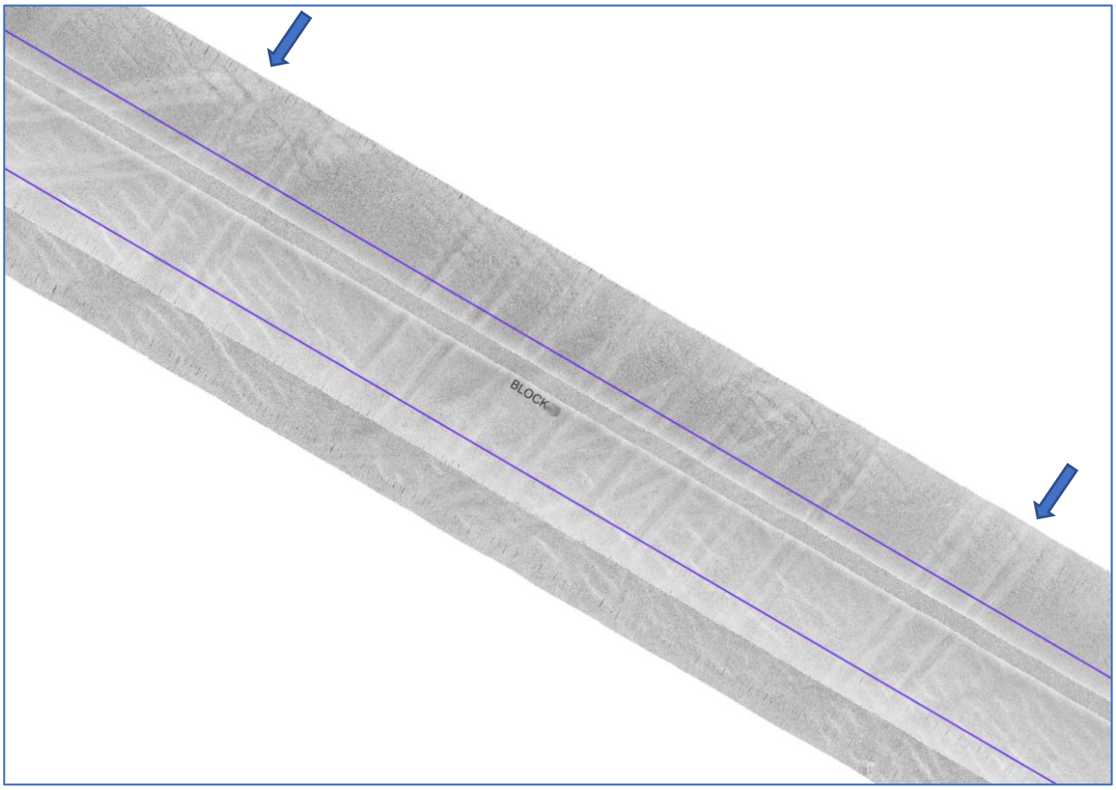

Figure 6

2 Ancient Trawlmarks (previously "Low Parallel Ridges with Megaripples")

The structures named "Low Parallel Ridges with Megaripples" (Figure 7) are characterized by the following features:

-- The width of the marks in which there are no sand waves is mainly from 6 to 11 meters;

-- The distance between the centres of the marks (in which there are no Megaripples) is often 24 or 32 meters.

This geometry allows us to assume that these "structures" are also trawling results.

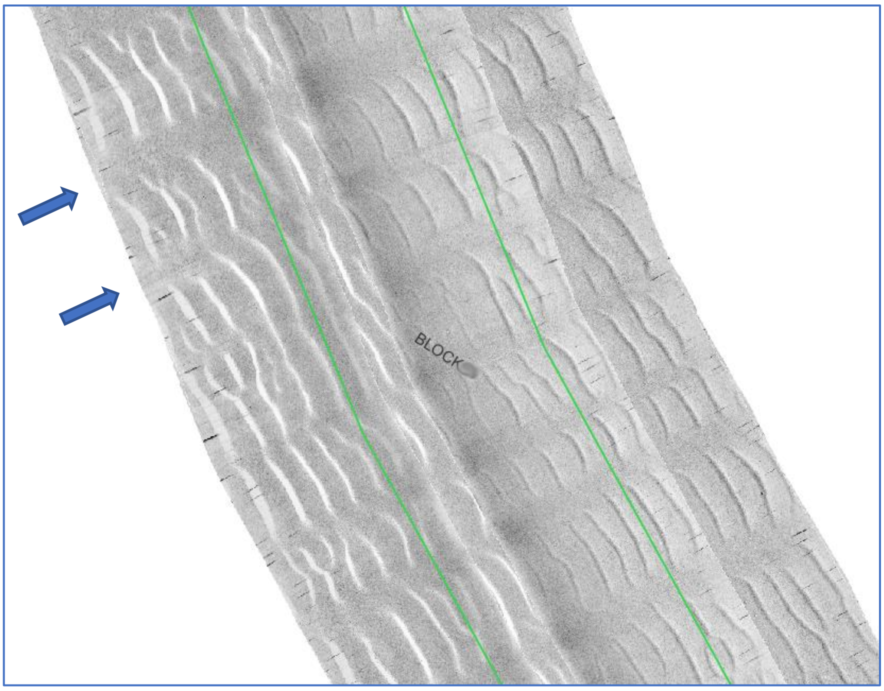

Figure 7

An argument in favour of this interpretation is that Megaripples can be extended from one "Parallel Ridges with Megaripples" to another. There is also a "bending" of sand waves (Figure 8), probably in the direction of movement of the trawl-weights.

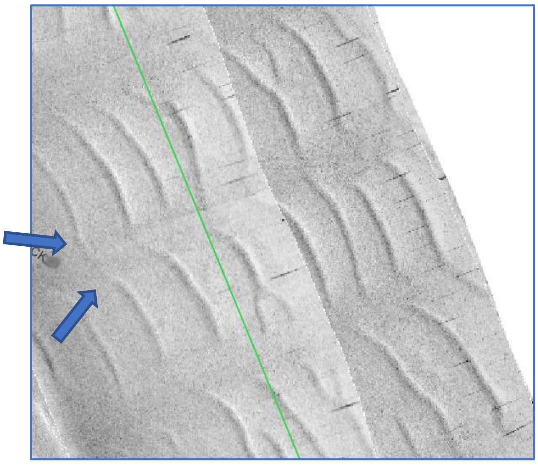

Figure 8

Another feature is the perpendicular of the belts, in which there are no Megaripples, to the crests of sand mega ripples (Figure 9).

Perhaps the following mechanism of the formation of "Parallel Ridges with Megaripples" takes place:

-- The direction perpendicular to the crests of sand megaripples coincides with the direction of the bottom current (Figure 9), as a result of which these sand megaripples are formed;

-- At depths of 100 meters, sedimentation processes proceeds quite slowly (surface storms do not reach these depths, and a sub-horizontal bottom with small slope angles does not contribute to gravitational transfer processes);

-- When the trawl-weight leaves a mark in the direction tangential to the direction of the current, two mechanisms are activated (1) the weight "passes" over the waves, breaking their structure, but not completely destroying it, (2) the transfer of sand by the current "heals" the marks of trawling;

-- When the trawl-weight creates a mark along the direction of the sea current (1) the weight "destroys" sand megaripples (especially when moving towards megaripples) and at the same time "pushes" the mass of sand to the sides. Thus, there is no "extra" mass of sand, in the direction of the current, which could be transferred by it in order to "heal" the mark of trawling.

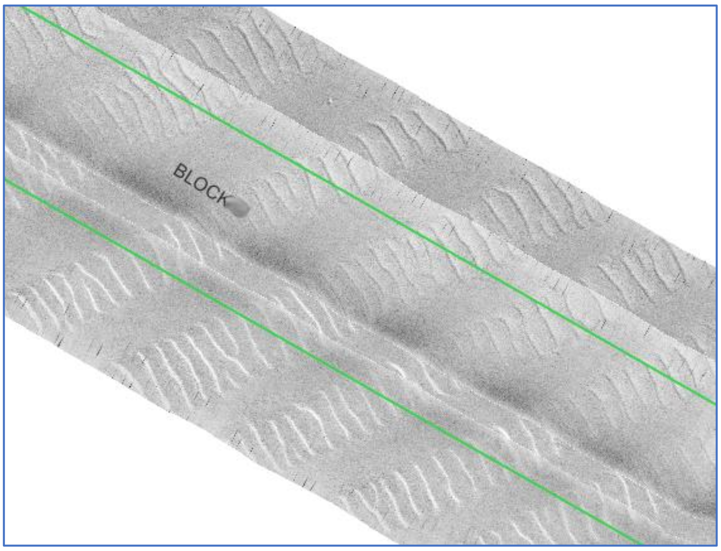

Figure 9

As a result of this mechanism, marks of trawling carried out along the direction of the sea current exist for a long time and can "overlaying" be forming wider strips without sand megaripples. That is, such marks can be named as "ancient trawl marks".

3 Milli-sandwaves (previously "Megaripples")

In a strict sense, the structures we have in the route (with "ancient trawl marks") are not "Megaripples" – if by "Megaripples" we understand the big ripples of sand formed by the current on the surface of the sand layer. Let us consider the structure of sand megaripples that are broken by trawl marks in more detail. At Figure 10 below is an overlay of MBES data on SSS mosaic with varying degrees of transparency of the MBES layer.

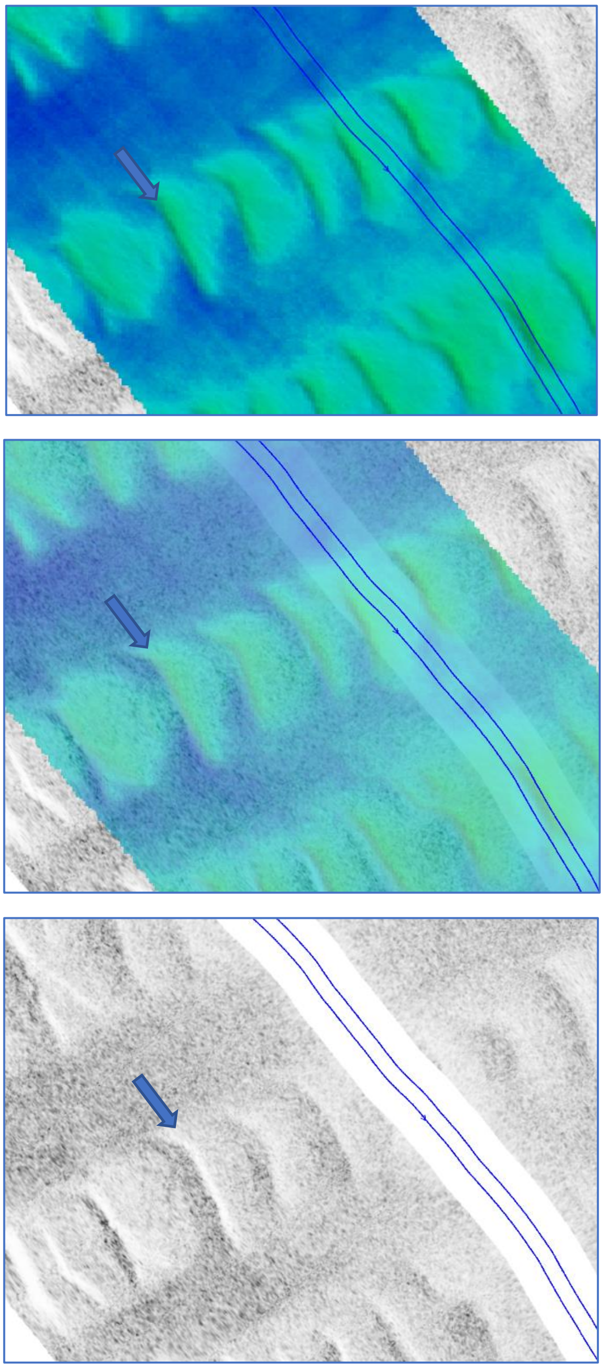

Figure 10

SSS "rays" are incident on sand waves from a gentle slope side. In this case, due to the small changes of the sand wave surface angle, the reflection coefficient practically does not change. After the emitted signal passes the sand wave crest, a shadow (white zone, Figure 10) is drawn on the sonogram. After the shadow there follows a zone with a high coefficient of reflection (black zone, Figure 10). Moreover, this reflection coefficient is close to the reflection coefficient of marks left by the trawl weight. If there was sand described in place, then the reflection coefficient would have to be lower, since the "rays" of the SSS fall more "tangentially" at the foot of the sand wave.

Such an effect with the reflection coefficient can be explained by the fact that we are dealing not with "waves-disturbances on the thickness of the sand", but with separate sandy "milli-sandwaves". To illustrate the difference between "megaripples" and "sandwaves", the Figure 11 is shown (but sandwaves have another scale than our structures).

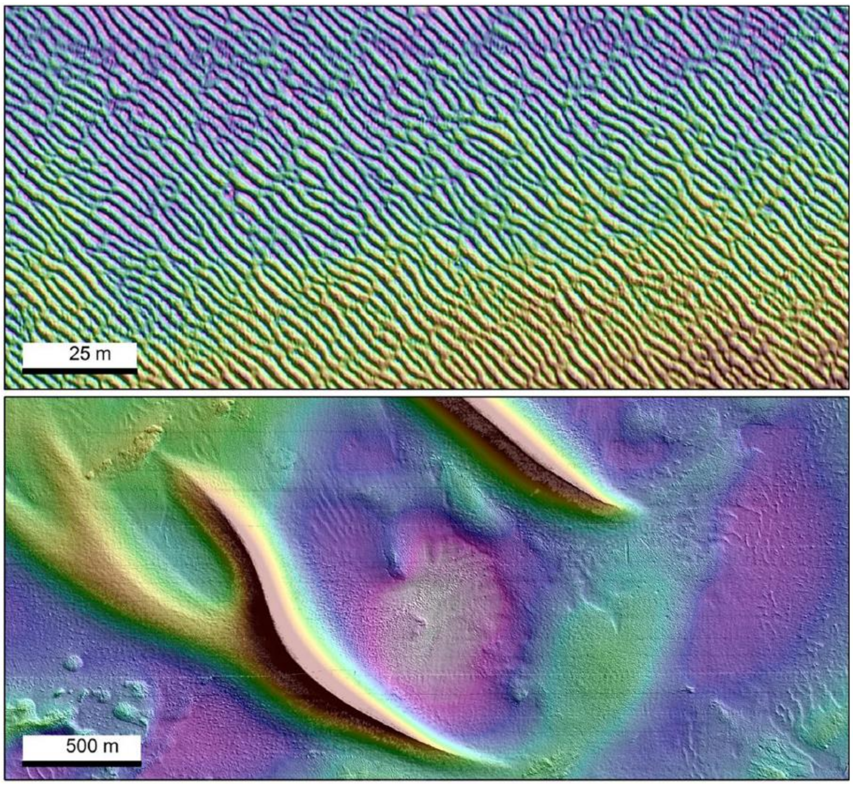

Figure 11 (Pictures from article Valérie K. Bellec, et all. "Sandbanks, sandwaves and megaripples on Spitsbergenbanken, Barents Sea" // Marine GeologyVolume 416, October 2019, 105998)

What we define as the "Low Parallel Ridges with Megaripples" and "Megaripples" zones are isolated "milli-sandwaves" resulting from a lack of sandy material.

In the presence of a relatively large amount of sandy material, ancient trawl marks directed along the current would have probably been "healed".

4 Ancient trawling marks in areas without milli-sandwaves

There are no sand waves in the western part of the route section. However, at the bottom, in the direction of the current, structures look like "Low Parallel Ridges with Megaripples" stand out (Figure 12). They are probably also associated with traces of "ancient trawling".

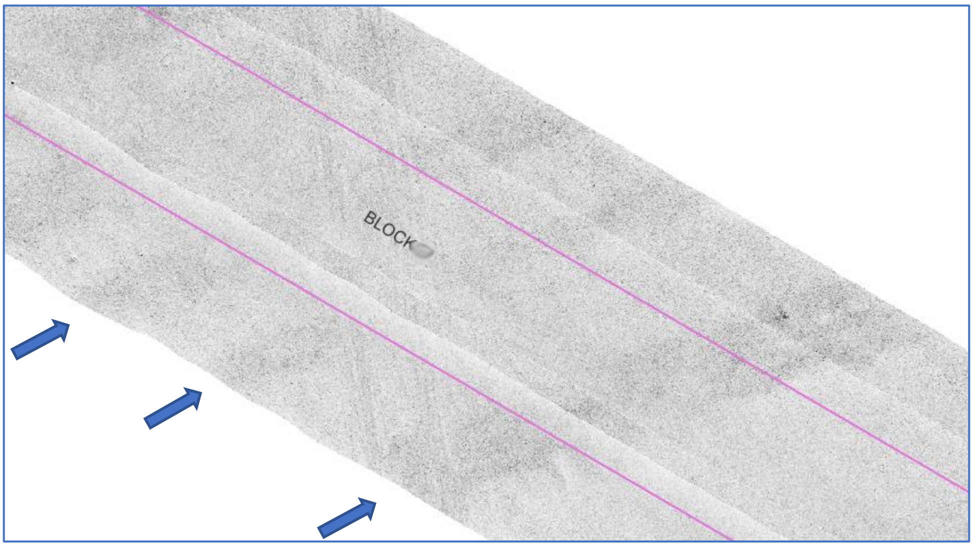

Figure 12

It is likely that a thin layer of finer sand fraction is common in this area, which cannot form sand waves. Below the sand fraction is gravel material, which has a high reflectivity (black color on the sonograms).

This composition of sediments leads to two consequences:

1) The trawl weight periodically leaves "small plough marks" (Figure 13) on the seabed, which were rarely observed in the area of " milli-sandwaves".

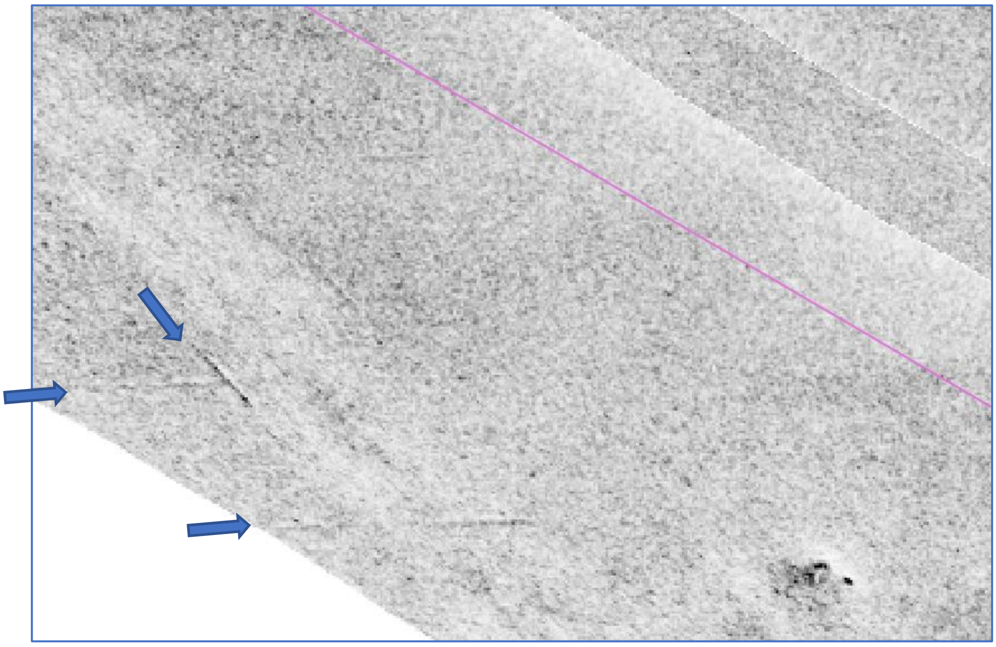

Figure 13

2) The central part of the trawl "dragged" the upper part of the sand, periodically creating/losing isometric "sand heaps" (Figure 14) with a diameter of 5-10 meters at the bottom (in the middle part of trawl).

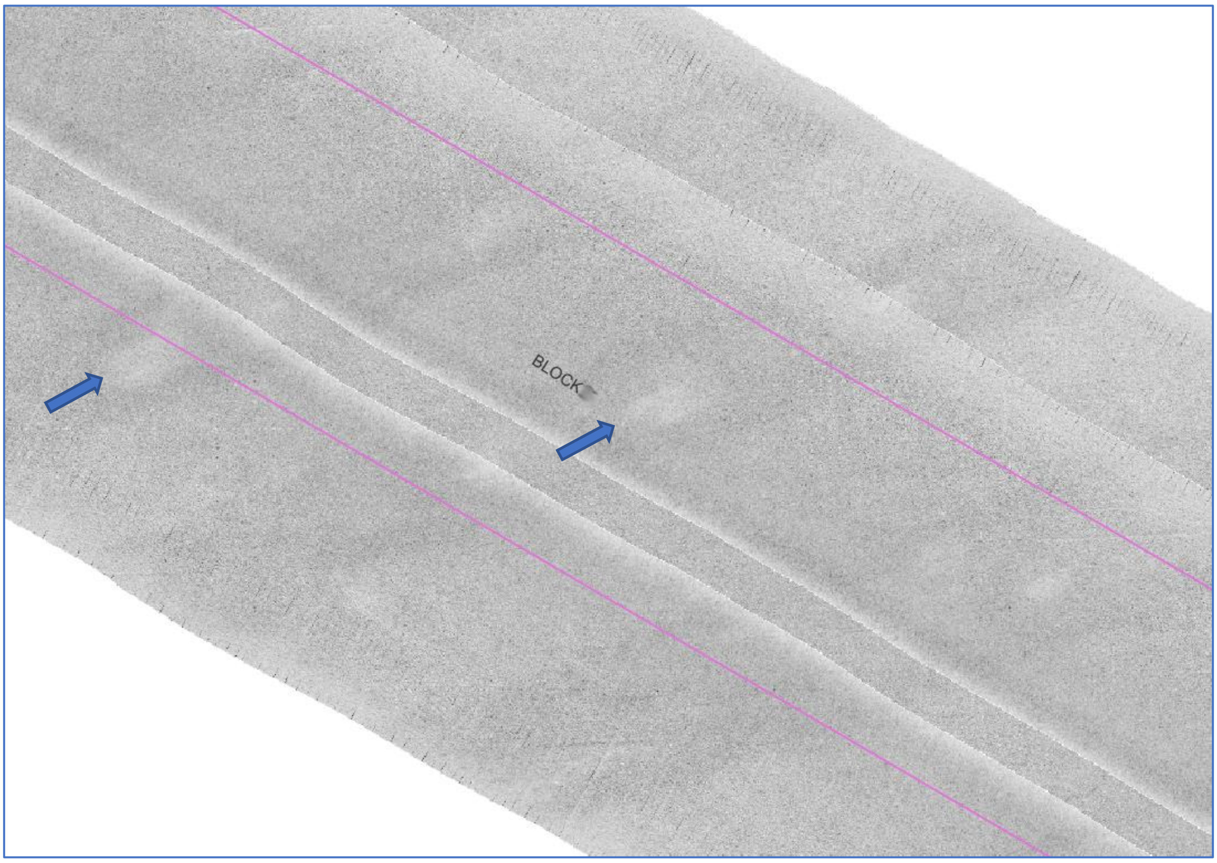

Figure 14

Conclusions

Based on the description given above, the following classes of "Seabed features" can be distinguished:

-- **Trawl marks** are relatively recent trawl marks, usually at an angle to the direction of the current. In the future, these traces will be "healed";

-- **Ancient Trawl marks** – traces of a relatively old trawl, going in the direction of the sea current. These marks are characterized by a long existence, they divide the "milli-sandwaves" into separate ridges, they also leave wide belts/marks on the sandy bottom where the "milli-sandwaves" are absent. Such features can only take place with a lack of "moving" material;

-- **Megaripples** – sand megaripples, that are disturbed surface of the sand thickness;

-- **Milli-sandwaves** – isolated "milli-sandwaves" (can be determined by sonogram colours and by the presence of Ancient Trawl marks). Such features can only take place with a lack of "moving" material;

-- **Grabbed sand hills** – isometric sand "heaps" formed as a result of trawling;

-- **Boulder Field** – field with density about 5 boulders per 10x10 meters;

-- **Occasional Boulders**.

It is a screenshot of the interpretation performed according to these rules at Figure 15.

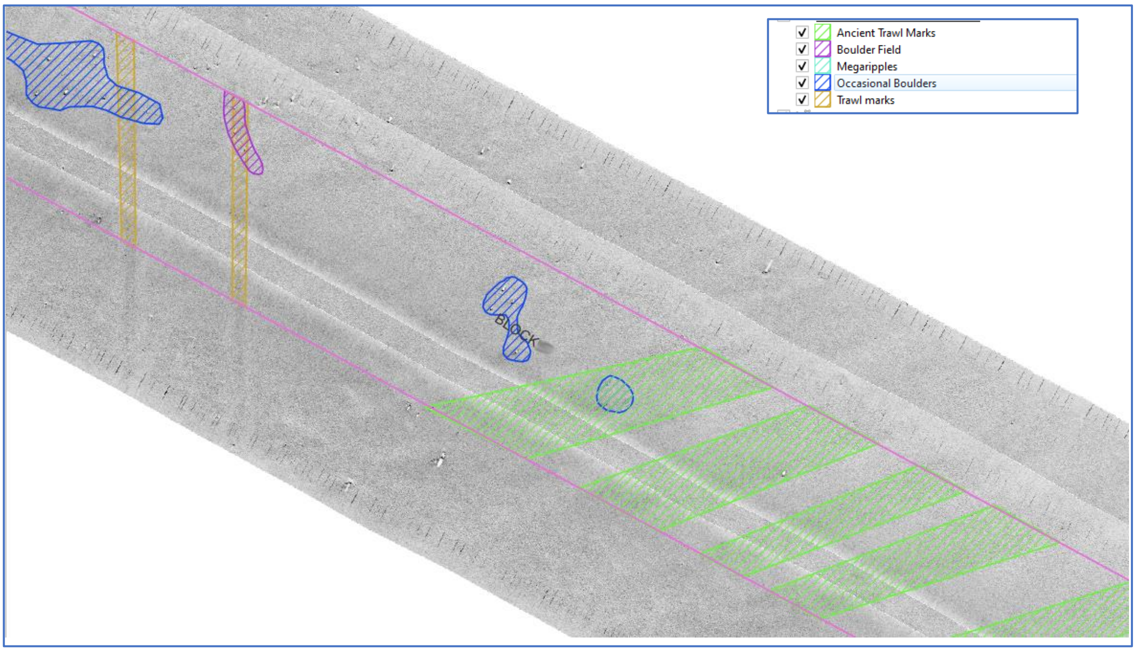

Figure 15

In deep water conditions, with slow sedimentation processes and slow changes in the surface of the seabed, human activity (in our case, trawling) can create "tracks" that live for a long time and are visually look like the result of geological processes.