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Use of mAUVs in the monitoring of benthic habitats and marine litter

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DOMI Development P.C

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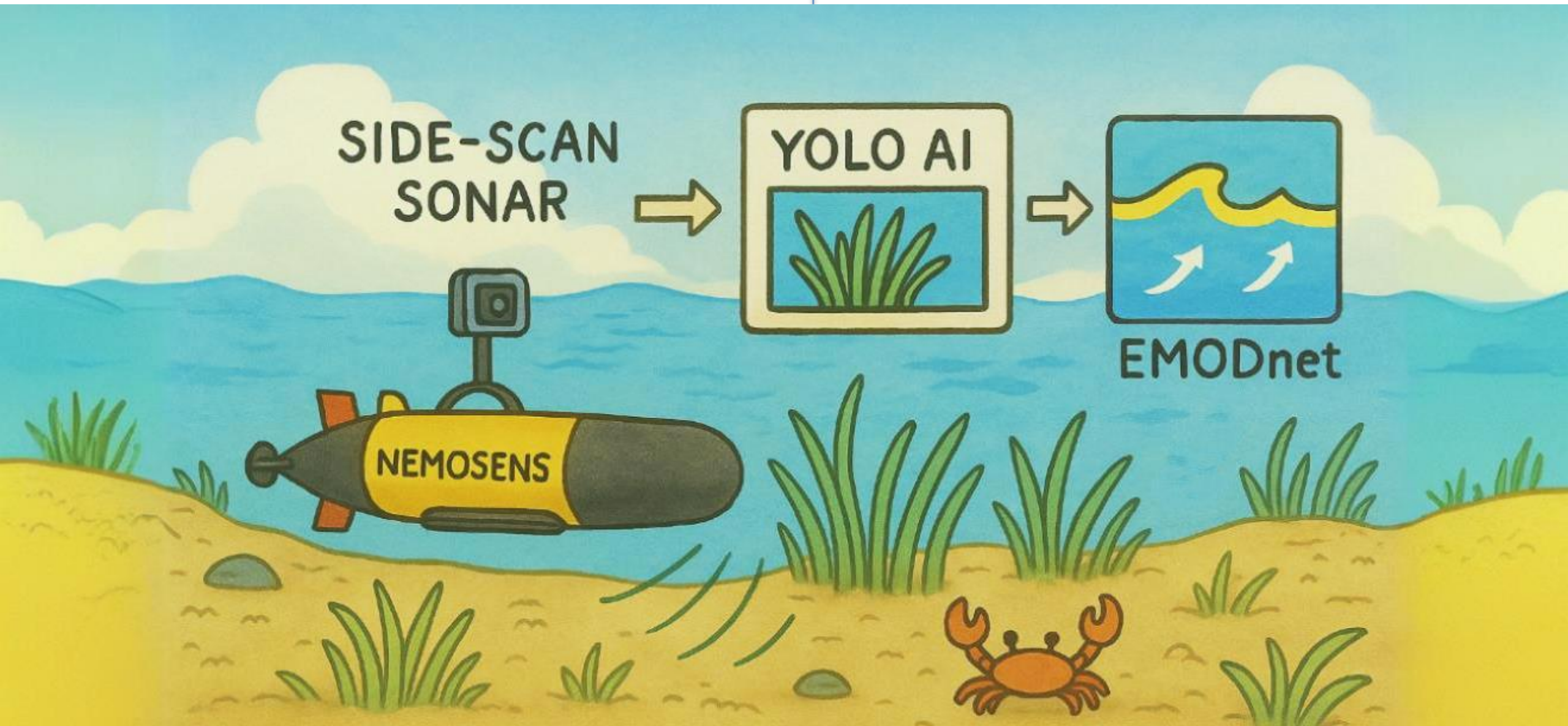


micro-AUVs – What are they?

Autonomous Underwater Vehicles (AUVs)

are self-propelled, untethered robots that navigate underwater without real-time human control.

micro-AUVs (mAUVs) are a compact sub-class — typically **< 1 m in length and < 10 kg** — designed for shallow-water and coastal operations where larger AUVs cannot access.

They carry integrated sensor payloads and follow pre-programmed mission plans, enabling **repeatable, high-resolution surveys** with minimal ship time.

Small & Lightweight

< 1 m long, < 10 kg — deployable by hand from a small boat or shore

Fully Autonomous

Pre-programmed waypoint missions; no tether or constant operator input

Modular Payload Bay

Swappable sensors: side-scan sonar, camera, CTD, water sampler

Cost-Effective

10–50× cheaper to operate than crewed survey vessels

micro-AUVs – Key Advantages for Marine Monitoring

Access to Shallow & Complex Areas

Operate in water depths of 1–300 m, including rocky reefs, seagrass beds and confined areas inaccessible to survey vessels or towfish.

Proximity to the Seabed

Flying at 1–3 m altitude above the bottom, mAUVs dramatically improve the resolution of sonar imagery and optical data compared to surface-towed systems.

Repeatable Missions

Pre-programmed waypoint plans allow identical transects to be re-run across surveys, enabling robust temporal change detection of habitats and litter accumulation.

Multi-Sensor Integration

A single dive can simultaneously collect side-scan sonar, stereo video, USBL positioning and water quality data — reducing the number of field operations required.

Minimal Environmental Impact

Electric propulsion and small hydrodynamic profile reduce noise and physical disturbance to sensitive benthic communities compared to vessels or divers.

Reduced Cost & Crew

A two-person team can operate an mAUV from an inflatable boat, replacing crewed research vessels and significantly cutting survey costs and carbon footprint.

Technology platform and data collection

RTSYS NEMOSENS mAUV equipped with:

- **RBRlegato CTD**: salinity and temperature data
- **GoPro Camera**: RGB videos and images
- **StarFish 454 Side Scan Sonar**: acoustic images

Side-scan sonars

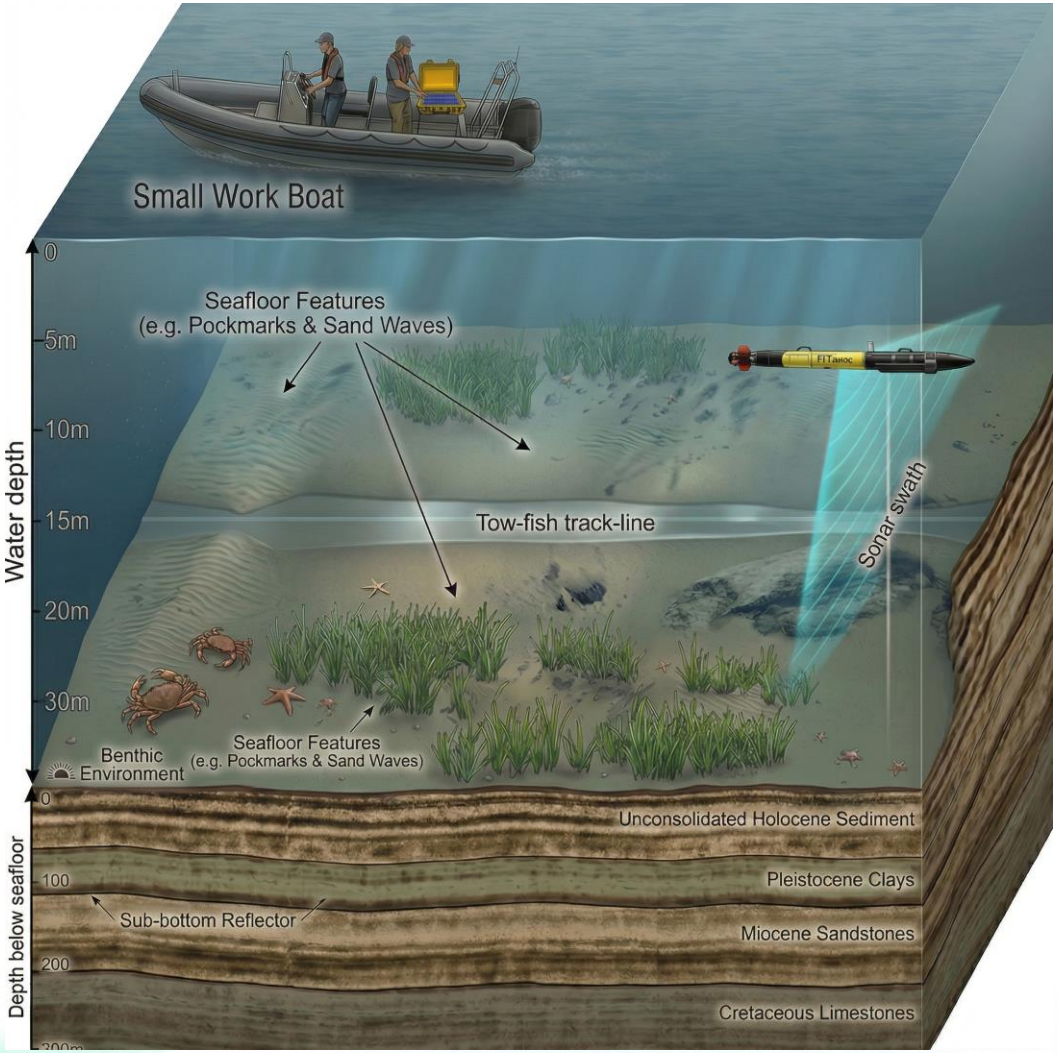
The Side Scan Sonar (SSS) is an acoustic reflection technology. **Basically, they use a swath of sound** to survey the seafloor.

Side-scan sonars **emit conical or fan-shaped pulses across a wide angle** perpendicular to the path of their towed sensors ('towfish' or 'rail') and record the echoes.

The received signals (echoes) create a detailed image of the **seafloor's reflectivity and its anomalies** ('sonograph') within the beam's swath (coverage range). The travel time and intensity of the returned pulse are recorded.

The **reflectivity** of the seafloor **depends on its roughness** and the nature of the topmost material:

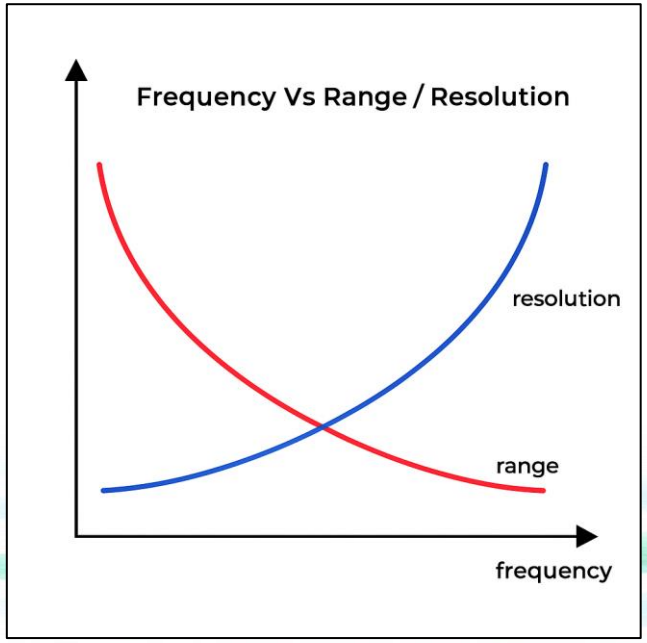
- coarse-grain sediments display higher reflectivity than fine-grain deposits,
- rocky outcrops reflect higher than sediments, etc.

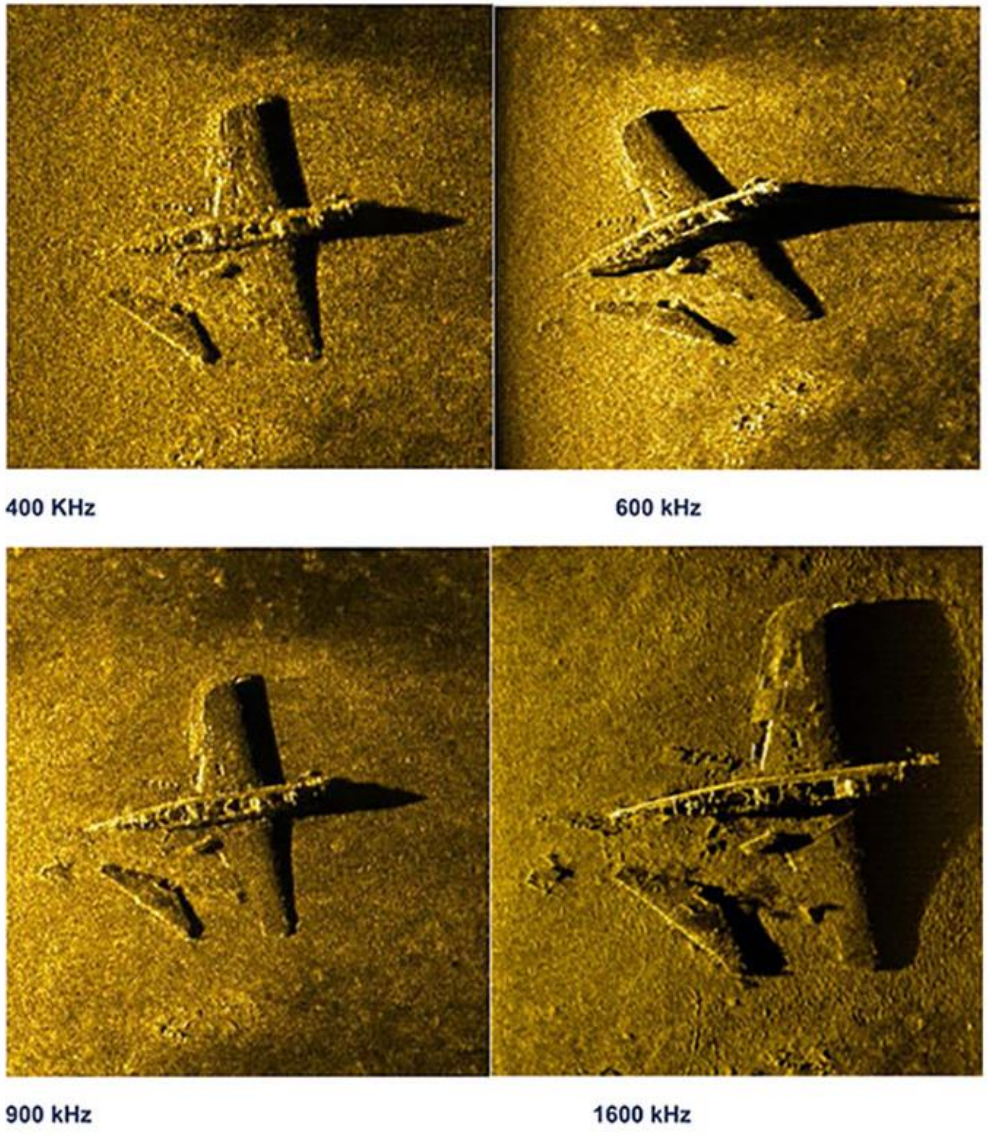


Side-scan sonars – Range of detection

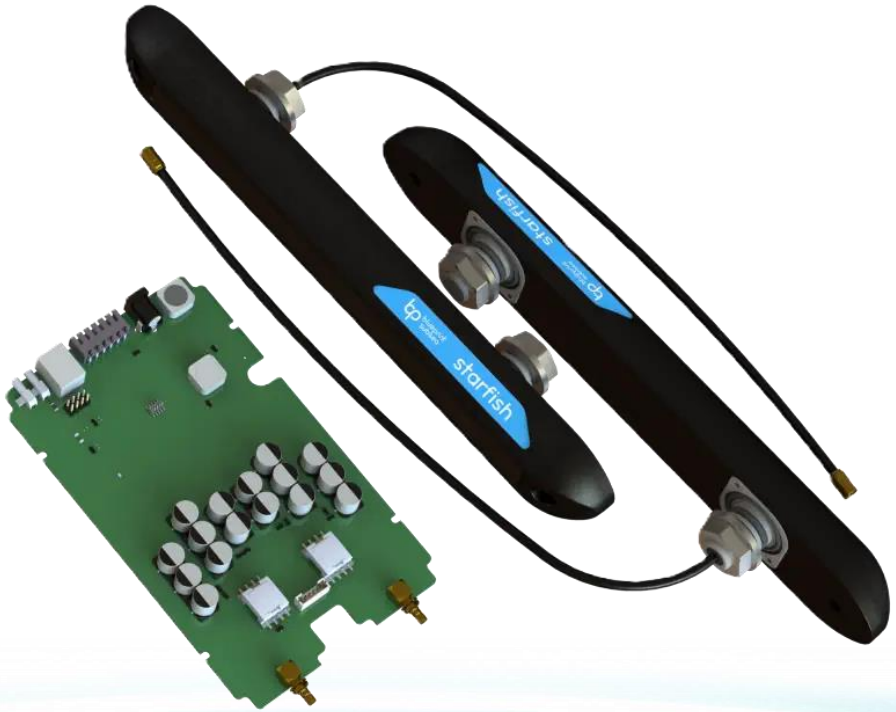
The **lower 200 kHz** frequency side scan sonar is capable of detecting large targets at **ranges of 150 meters**.

The **higher 455 kHz** frequency side scan sonar **has a narrow beam** and **shorter (100m) range** for **more detailed** images of closer targets.





Side-scan sonars – StarFish 454 OEM



	StarFish 454 OEM
Frequency	450kHz CHIRP
Operating Range	Up to 100m per channel
Horizontal Beam Width	0.5°
Vertical Beam Width	60°
Transducer Angle	Variable (OEM Specified)
Dimensions	390mm x 22.5mm x 40mm
Weight (In Air)	0.8kg
Construction	Polyurethane Rubber (PA6 Housing)
Colour	Black

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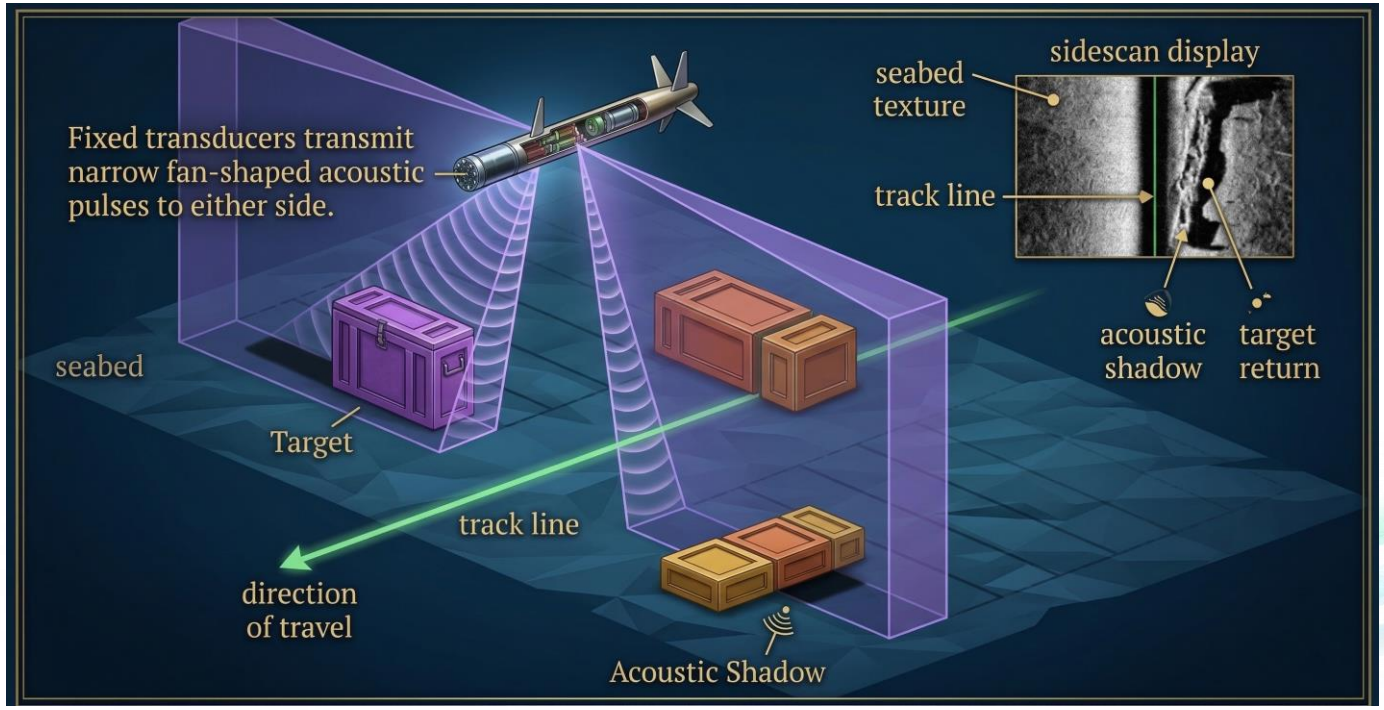
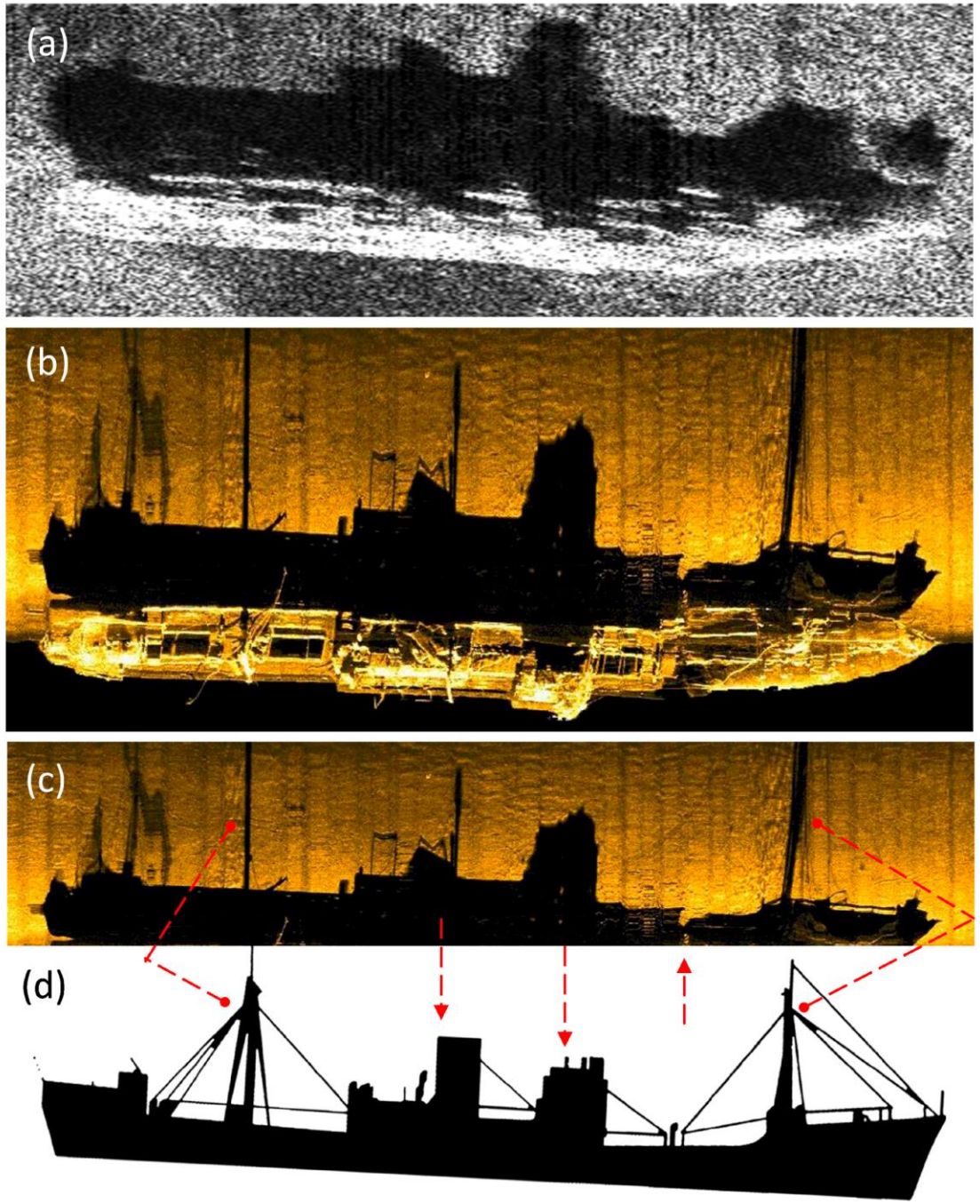
Side-scan sonars – Acoustic shadow

Using a side scan sonar is rather like **looking at a world made of shiny black plastic, in the dark, with only a narrow torch beam** for illumination.

It can be the most important sonar imagery feature as **it provides a three-dimensional quality** to a two-dimensional survey.



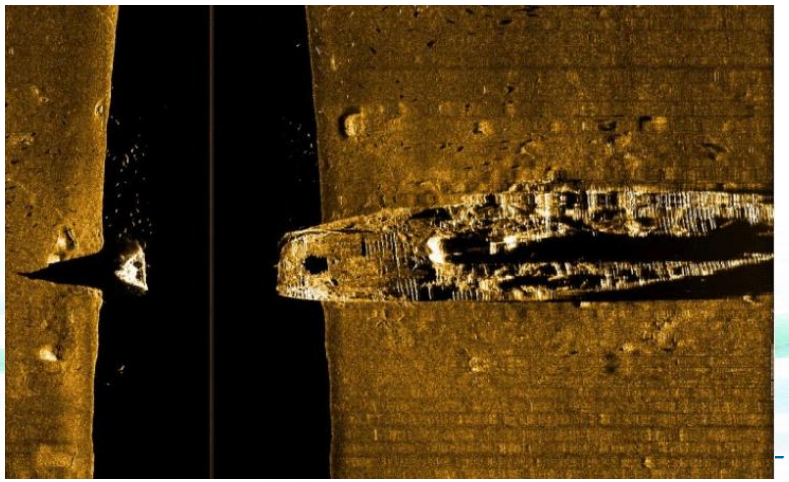


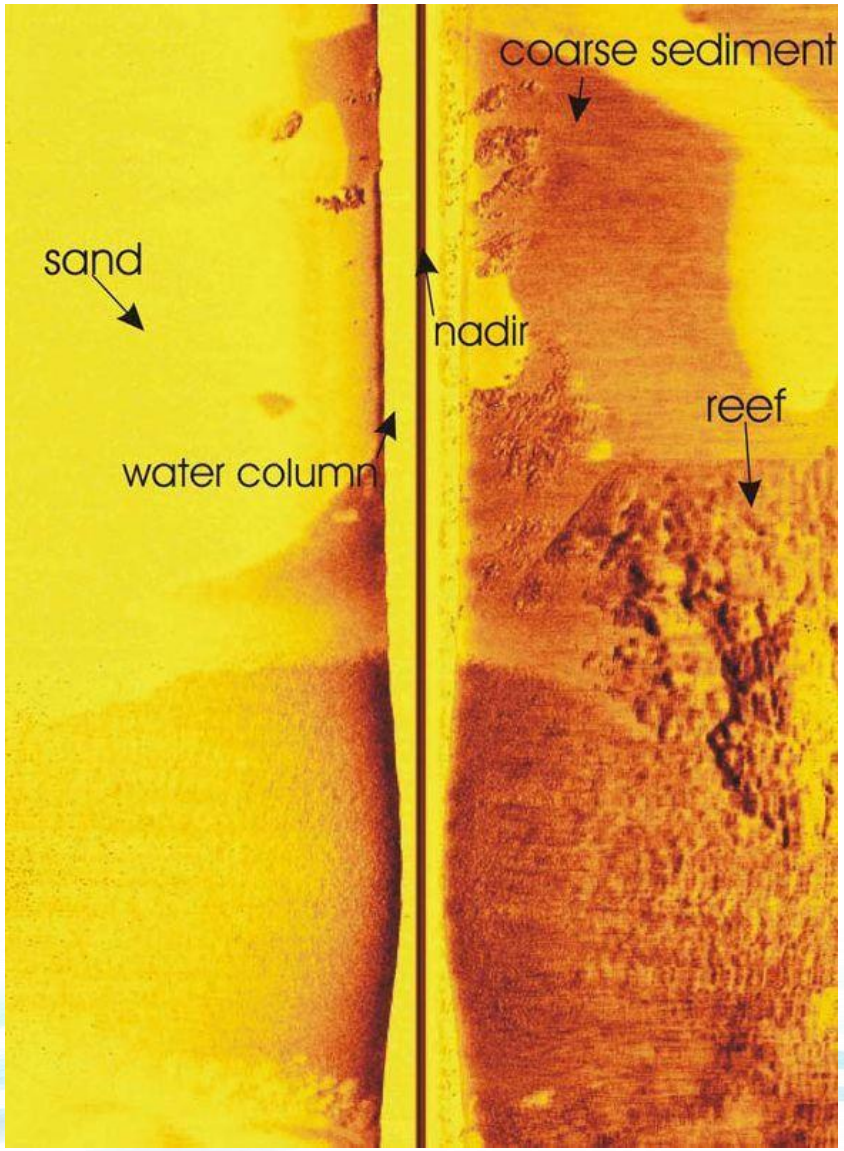
Side-scan sonars – Nadir line

Side-scan sonars **measure the time of each return to calculate the location of targets** on the seabed.

The **nadir zone** is the area on the seabed directly beneath the towfish where the beam hits at near-vertical incidence. It appears as a **bright line** in the sonar record because the strong vertical return creates ambiguity.

The **water column** is the area appearing to the left and to the right of the center line, making up approximately 5% of the range scale.





eXtented Triton Format (XTF) files

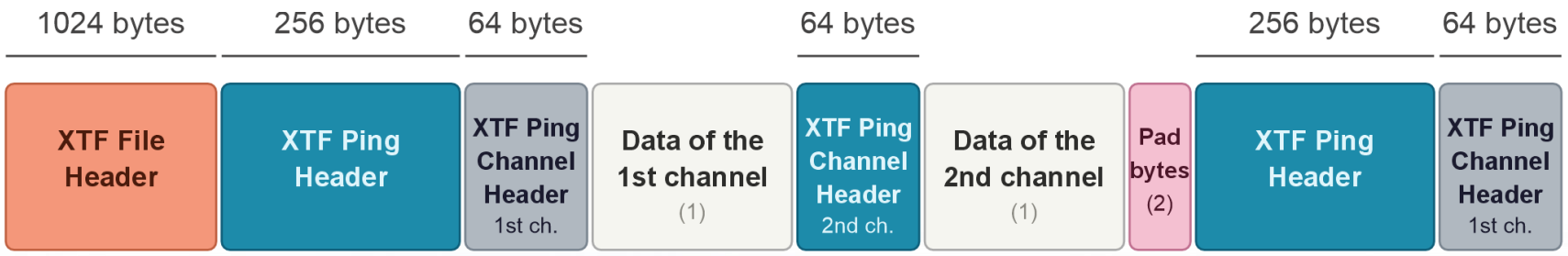
Triton Imaging, Inc (1988)

An XTF file can be thought of as a "**pool**" of data.
If you use XTF to collect data during a survey, you **can add data to the file at any time without needing to synchronize** your data packets.
For example:

- bathymetry data may be logged five times per second
- sonar data is being logged at 10 times per second.

No storage space is wasted and no "holes" are created in the saved data stream.

XTF file structure



(1) Variable length — depends on samples per ping and bit depth.
(2) Pad bytes align the next ping block to a 512-byte boundary.

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SONARWIZ

Developed by **Chesapeake Technology**, is an all-in-one software solution for geophysical, hydrographic, pipeline, and archaeological marine surveys.

- real-time data acquisition
- post-processing
  - sidescan,
  - sub-bottom,
  - bathymetry, and
  - magnetometry data

OpenSideScan

CIDCO

Developed by **CIDCO**. Open-source software for:

- processing and
- visualizing sidescan sonar data

ReefMaster

Developed by **ReefMaster Software**, is a Windows-based software.

- Track and depth log import
- Real-time mapping
- Sidescan mosaic creation
- Waypoint and route management
- Export to GPS

pyxtf

Developed by Oystein Sture (oysstu), is a Python library for reading and writing eXtended Triton Format (XTF) files.

- Read and parse XTF files (file headers & sonar/sub-bottom/bathymetry packets)
- Write or generate XTF files
- Support for reading multiple data packet types (navigation, ping, attitude, etc.)

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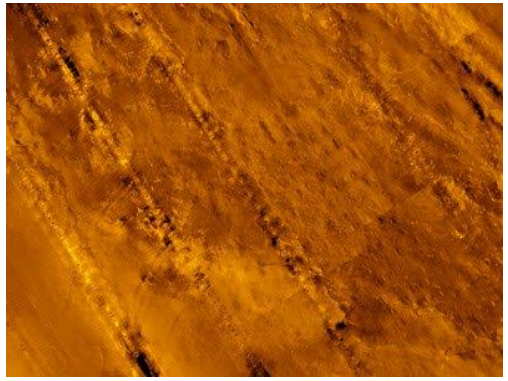
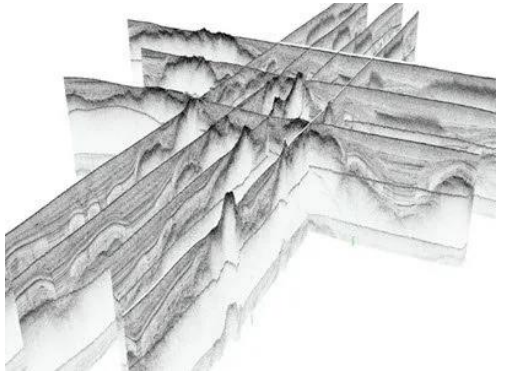
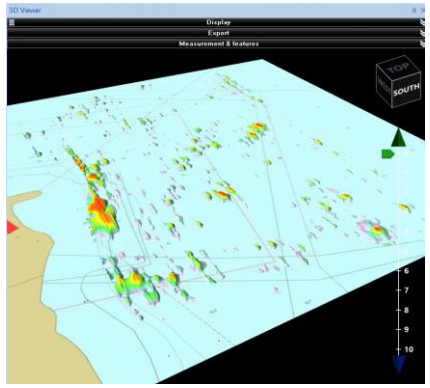
Sidescan



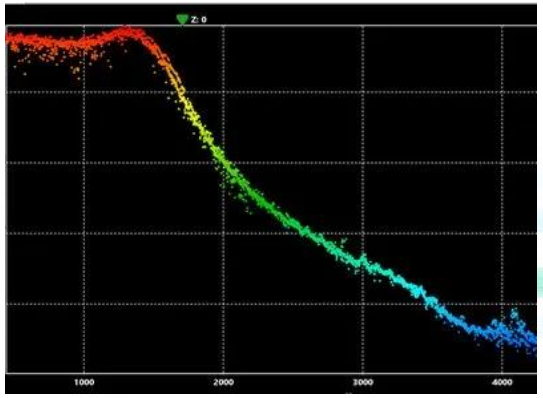
Sub-Bottom



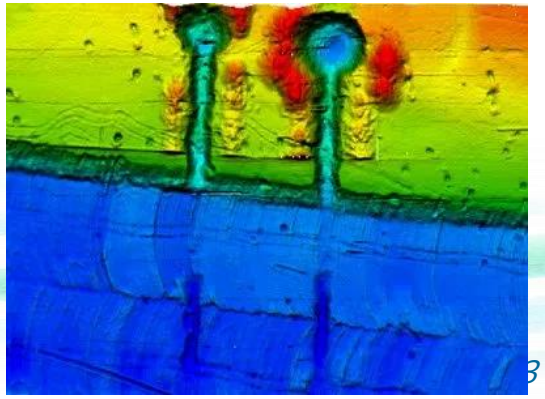
Magnetometry



Single beam



Multi-beam



https://chesapeaketech.com/products/sonarwiz-sidescan/

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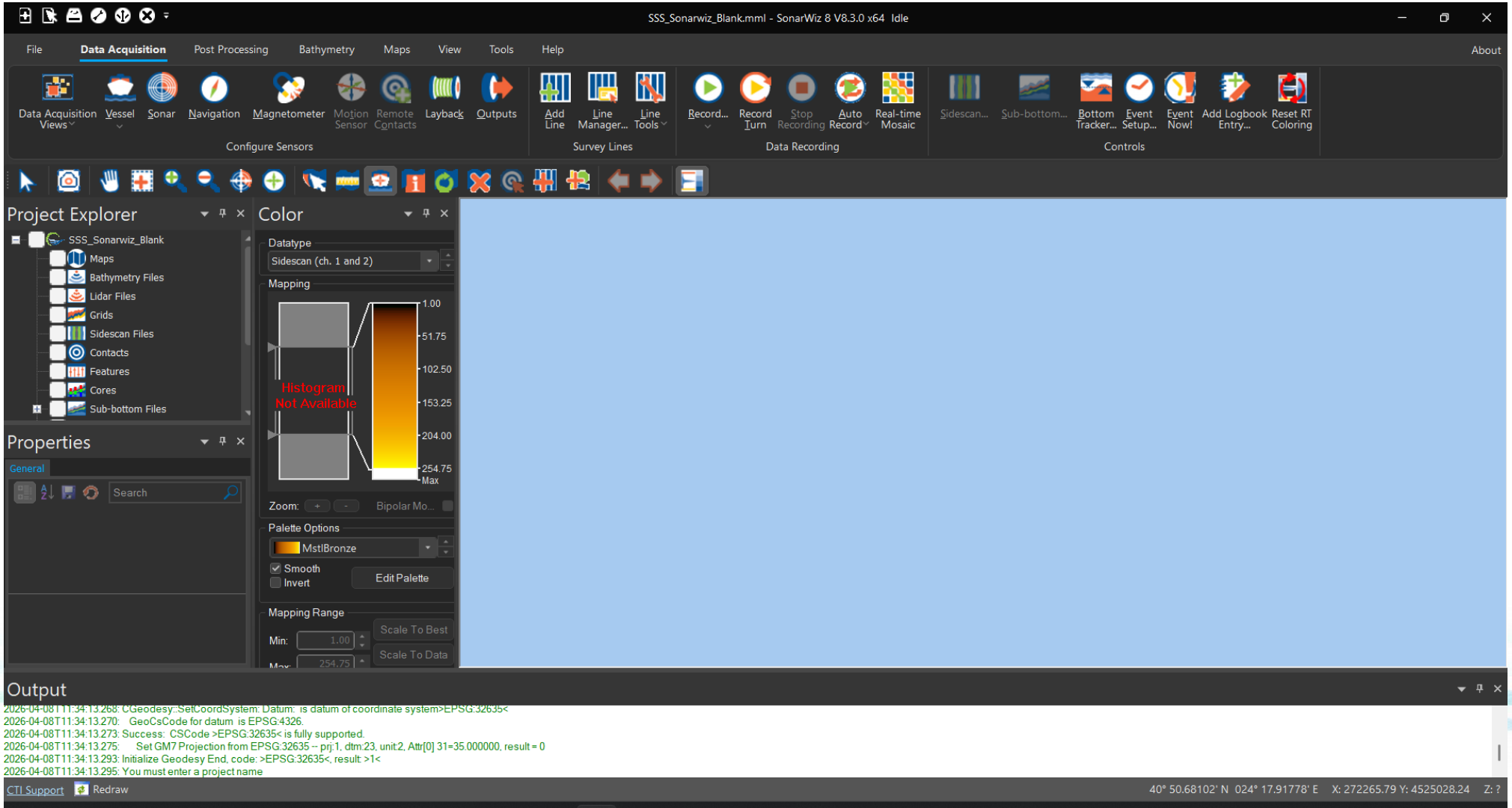
Main view



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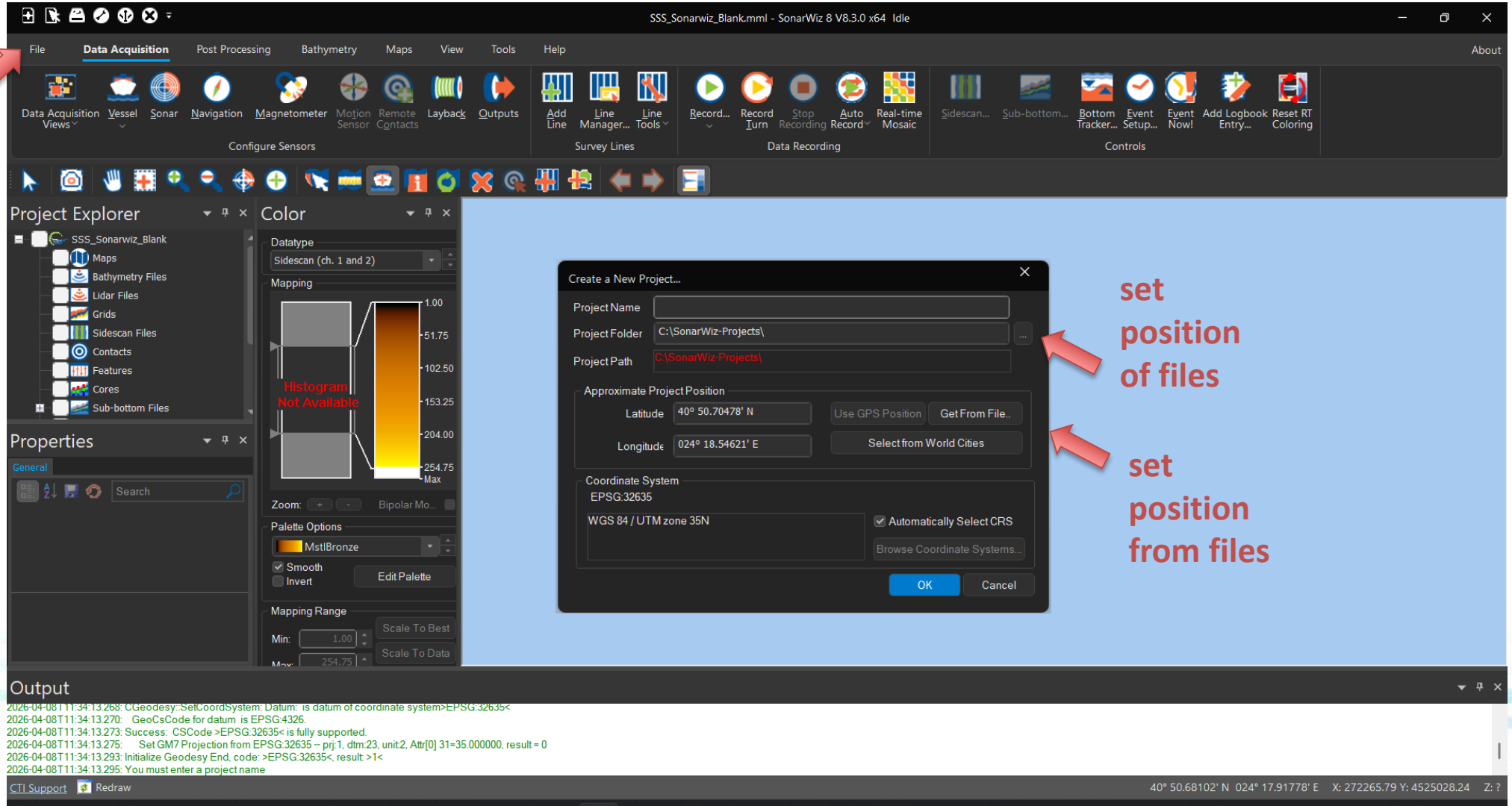
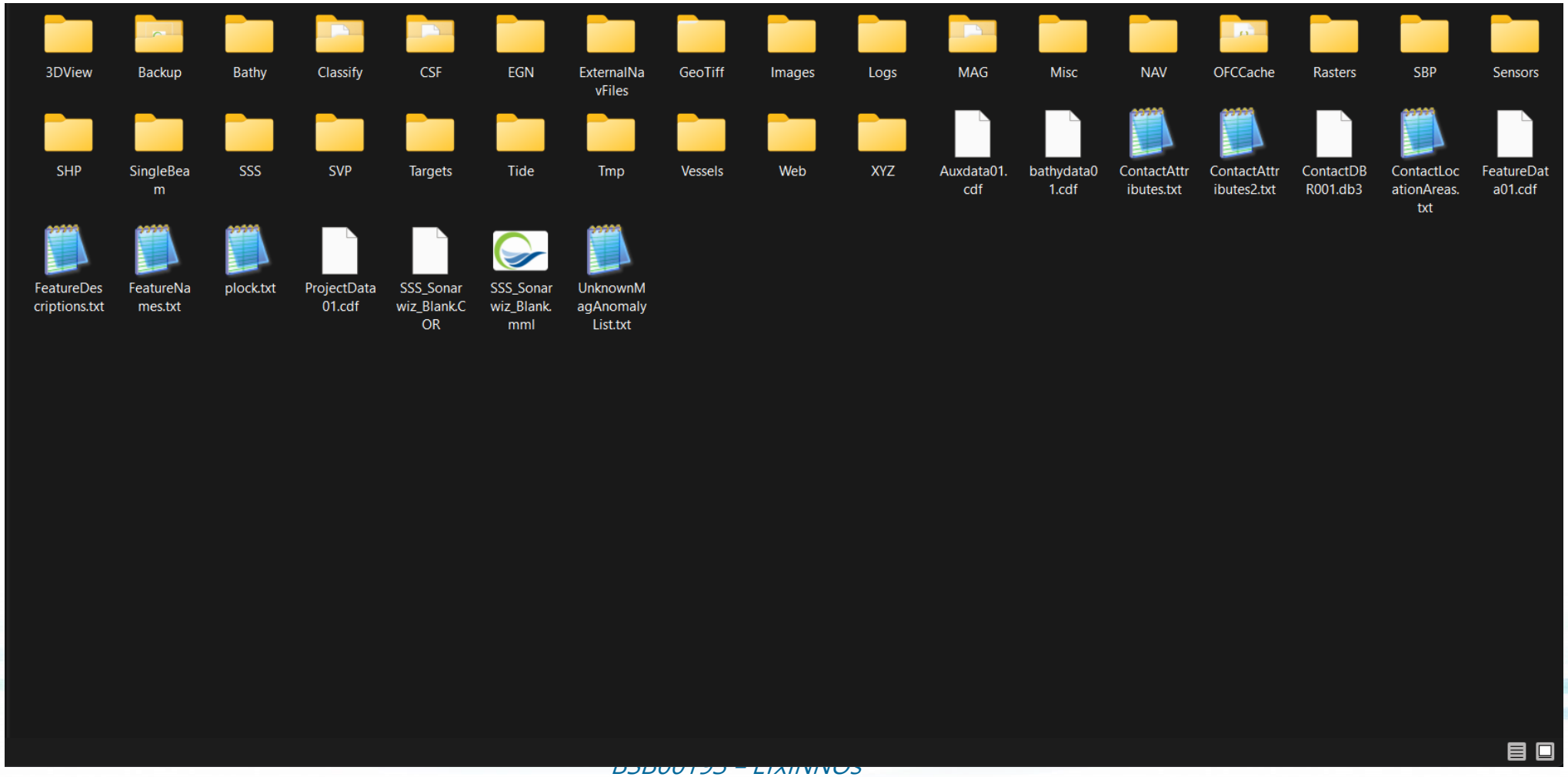
Project creation

Create a new project



Project folder



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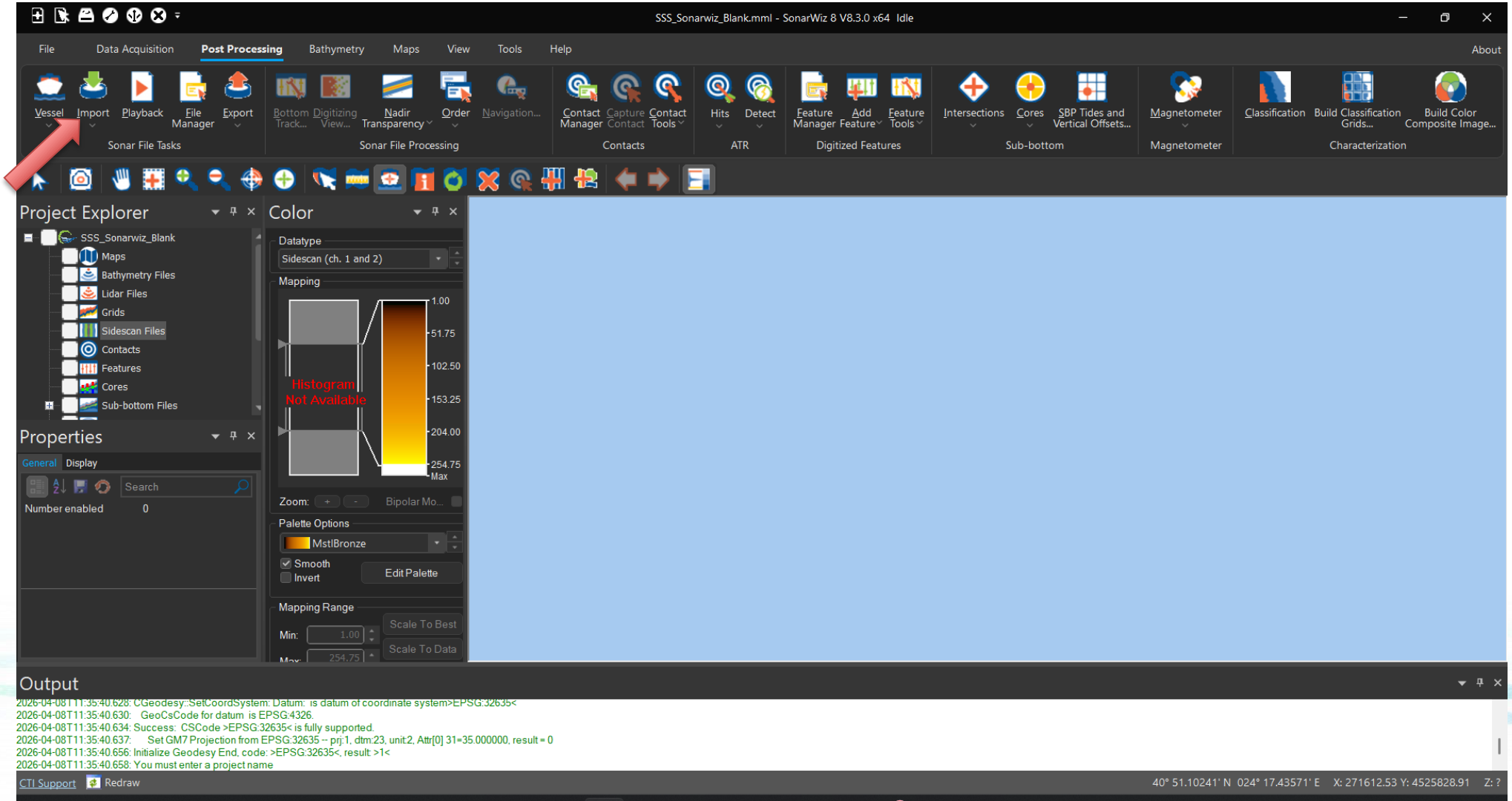
Import files

import SSS files



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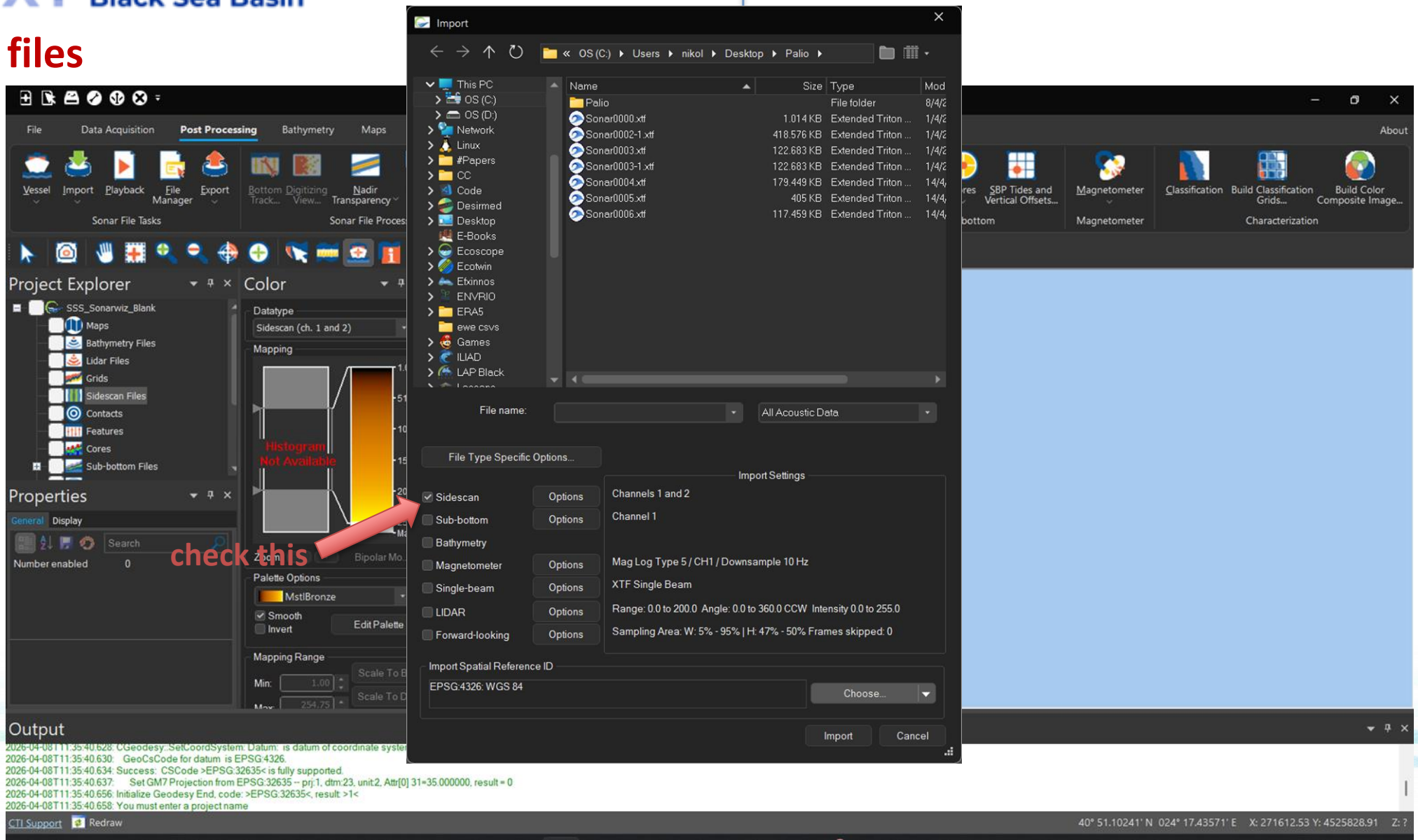
Import files



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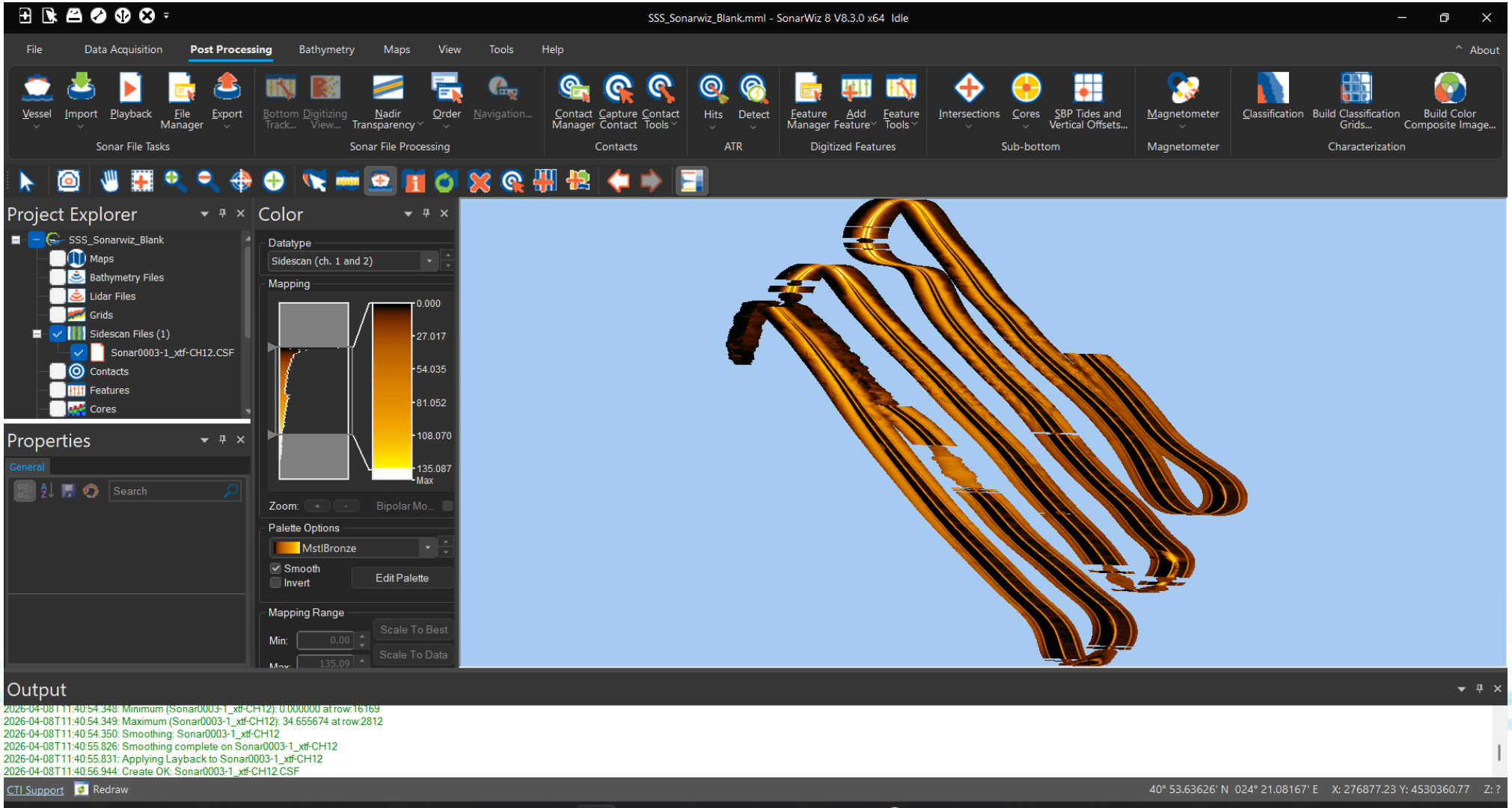
Import files



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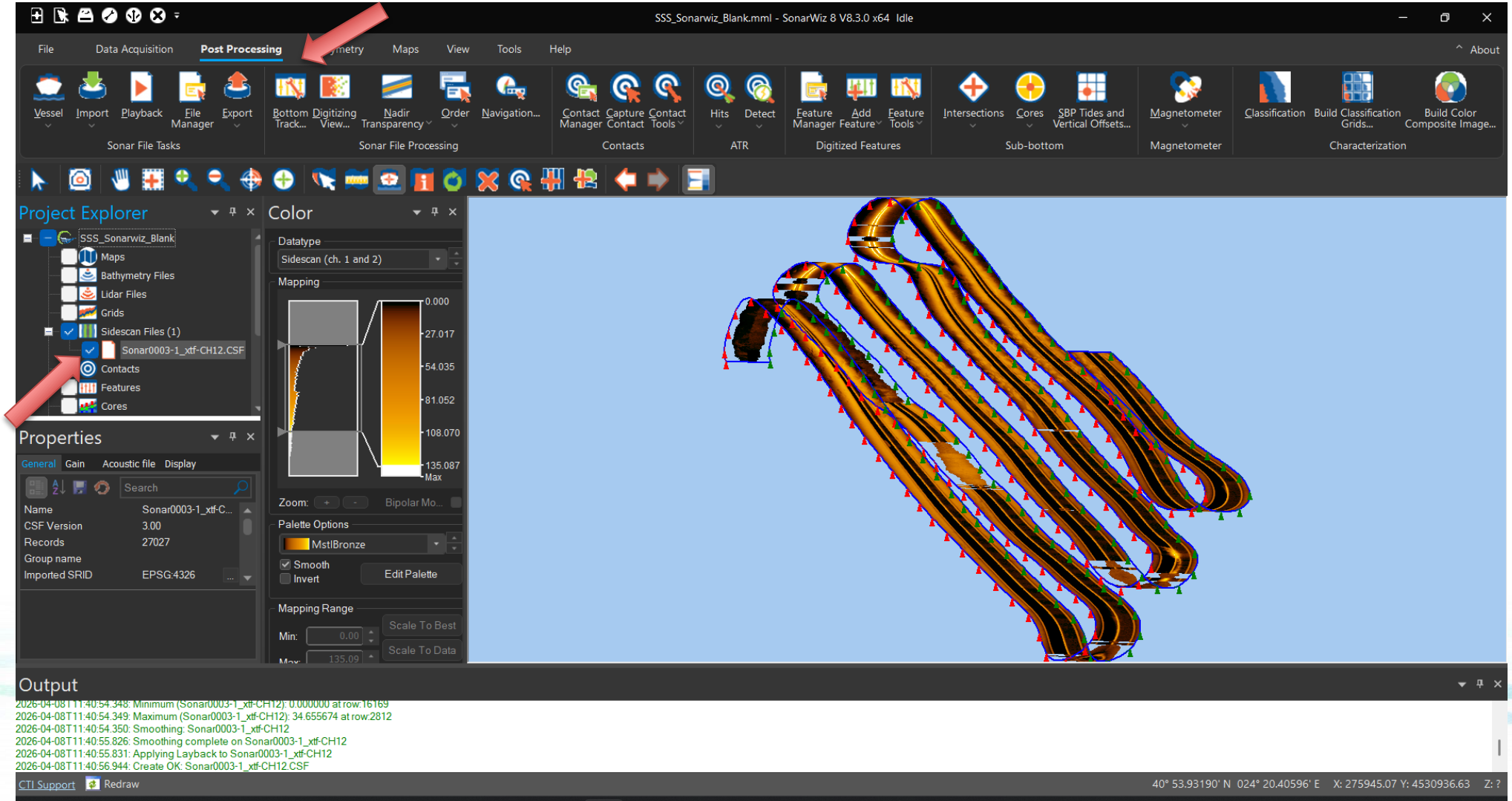
Bottom Track

Bottom track processing

select SSS file



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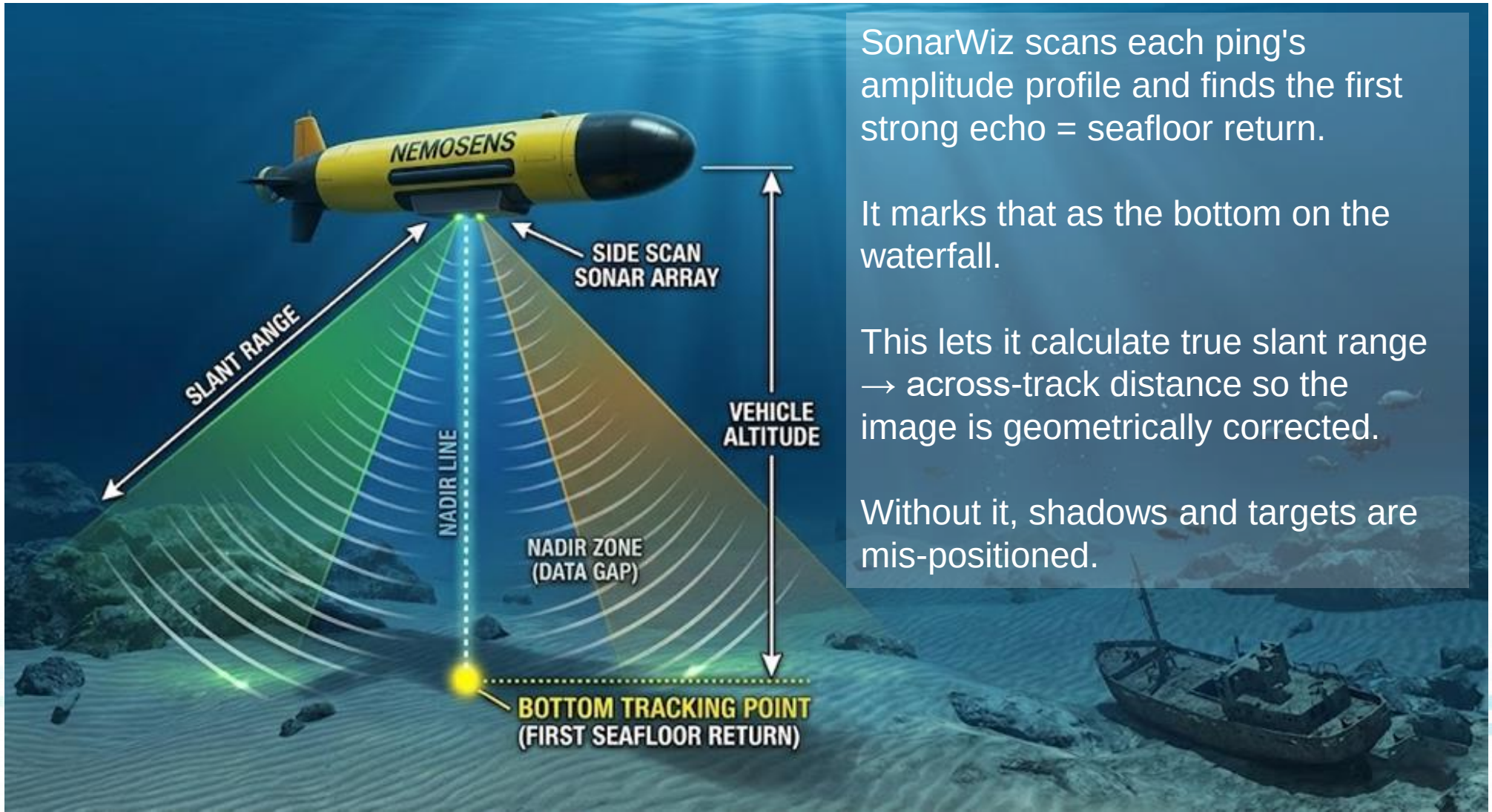
Bottom Track



SonarWiz scans each ping's amplitude profile and finds the first strong echo = seafloor return.

It marks that as the bottom on the waterfall.

This lets it calculate true slant range → across-track distance so the image is geometrically corrected.

Without it, shadows and targets are mis-positioned.

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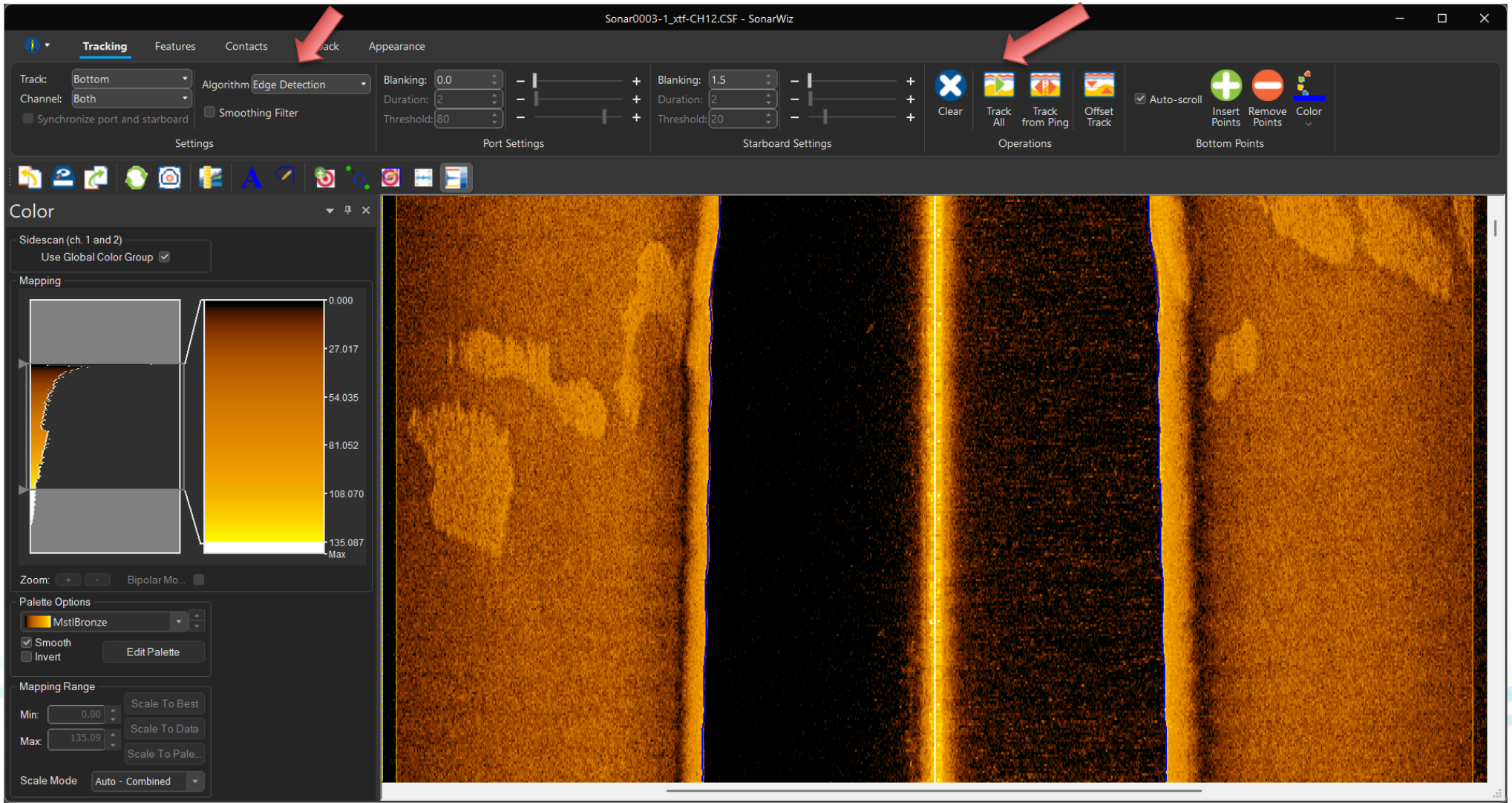
Bottom Track

select algorithm

Track processing



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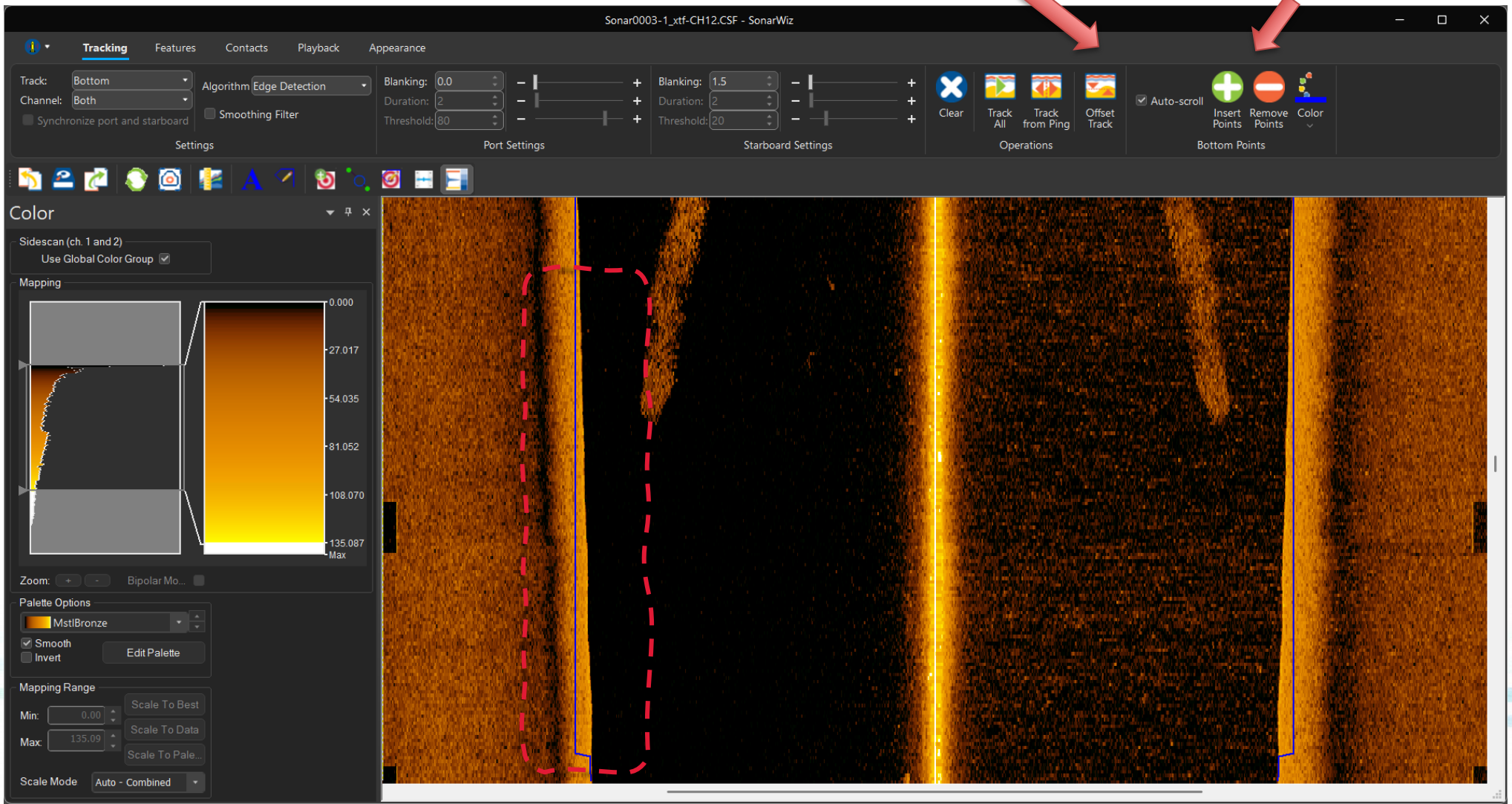
Bottom Track

add offset

remove/add points



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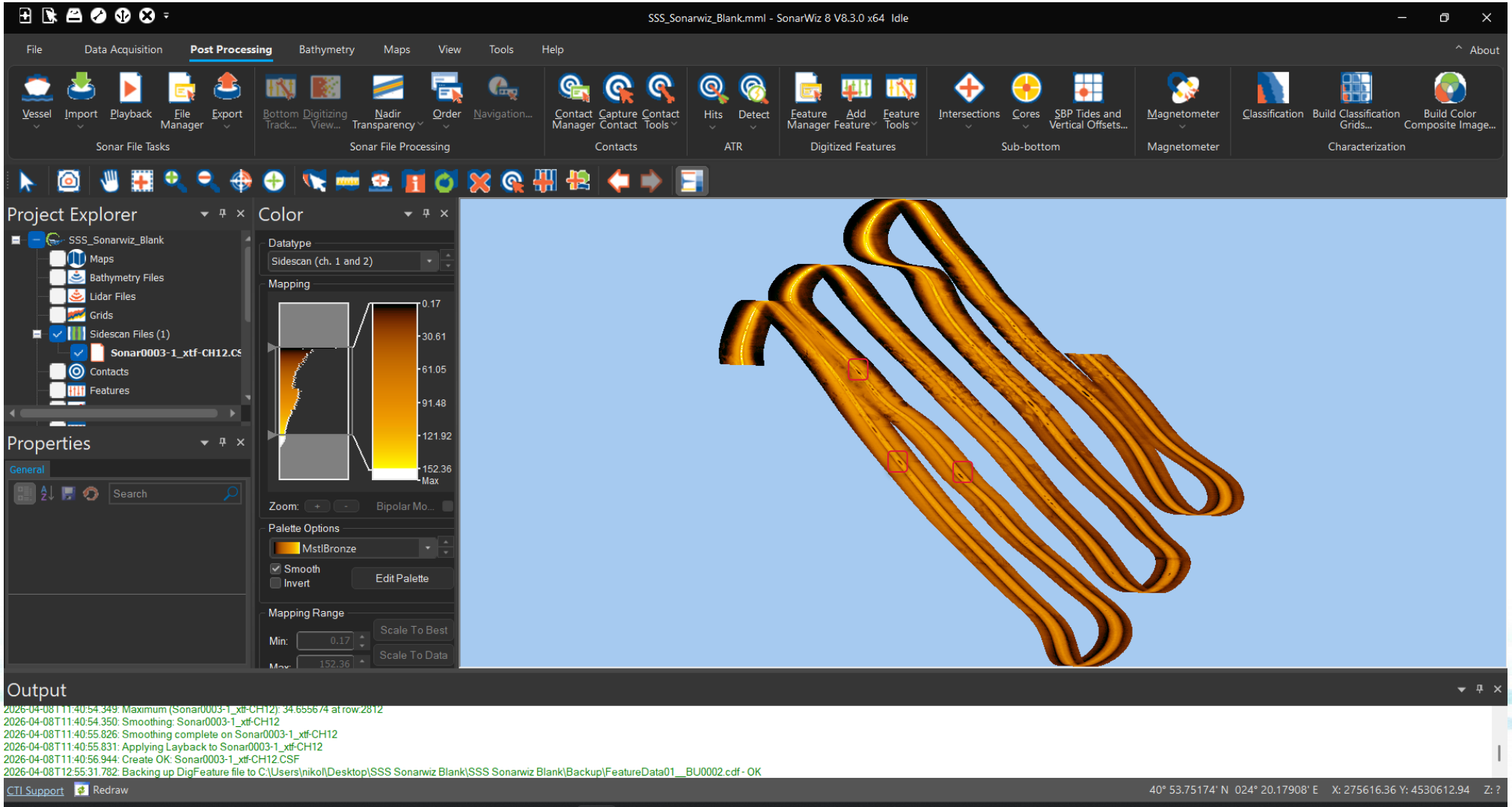
Bottom Track

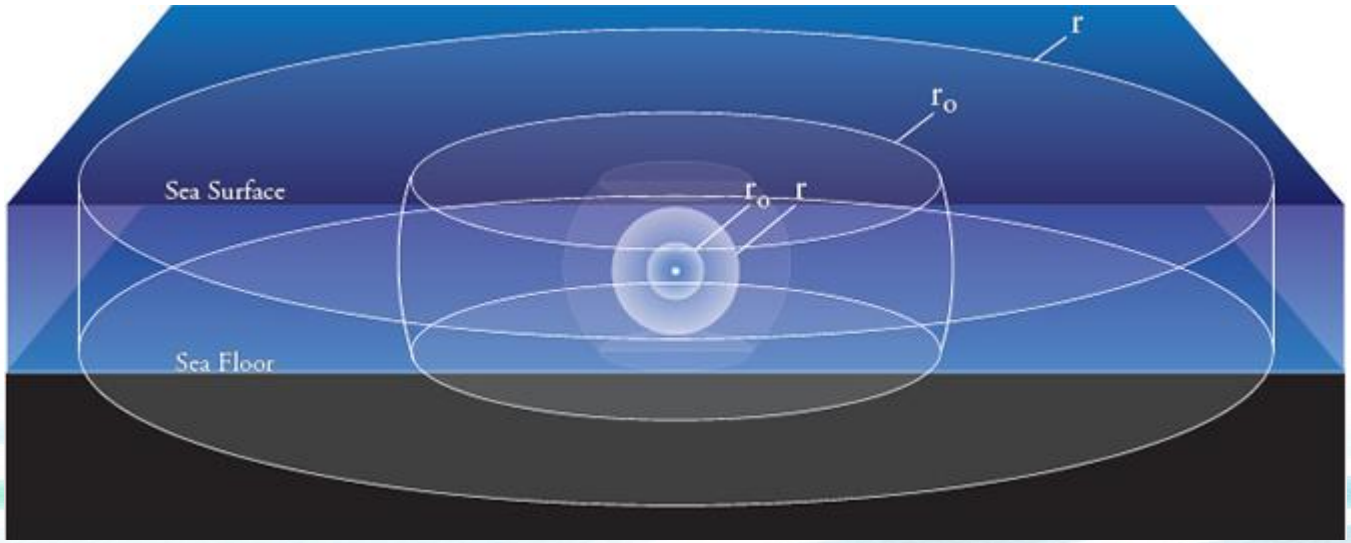


Sidescan Gain and Signal Processing

Sound **cannot propagate uniformly in all directions** from a source in the ocean forever.

Beyond some range the **sound will hit the sea surface or sea floor**.

Once the **sound is trapped between the top and bottom of the ocean it gradually begins to spread cylindrically**.

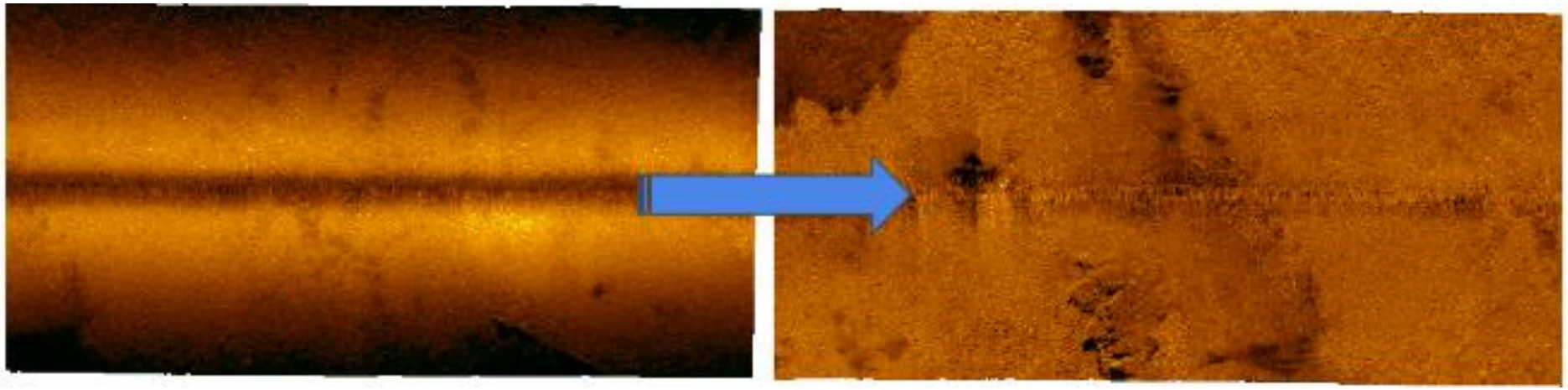


As acoustic waves propagate through the water, **they lose intensity** because of **geometric spreading** and **absorption**.

The result is an **across-track change in signal brightness** in the **waterfall** display.

Sidescan Gain and Signal Processing

SonarWiz provides algorithms for **leveling the brightness across track.**



Automatic Gain Control

Auto TVG

Beam Angle Correction

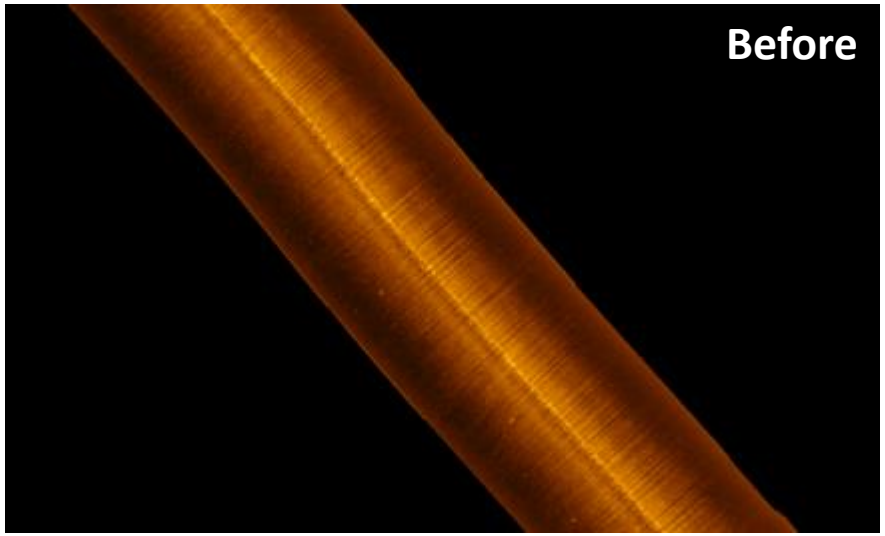
Empirical Gain Normalization

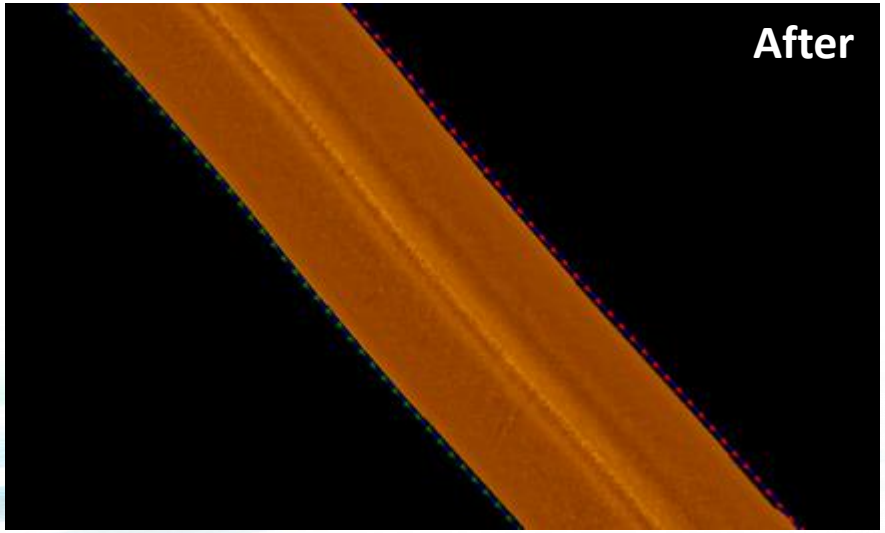
Automatic Gain Control

The AGC Algorithm:

1. **measures a local average signal strength**, and then
2. **rescales all the data** so that the local average is shifted to some **chosen global average** that determines on the large-scale how quiet or loud the data will be after rescaling.

More specifically, the local average at a given ordinate is computed by averaging some number of samples to the left and right of this ordinate.

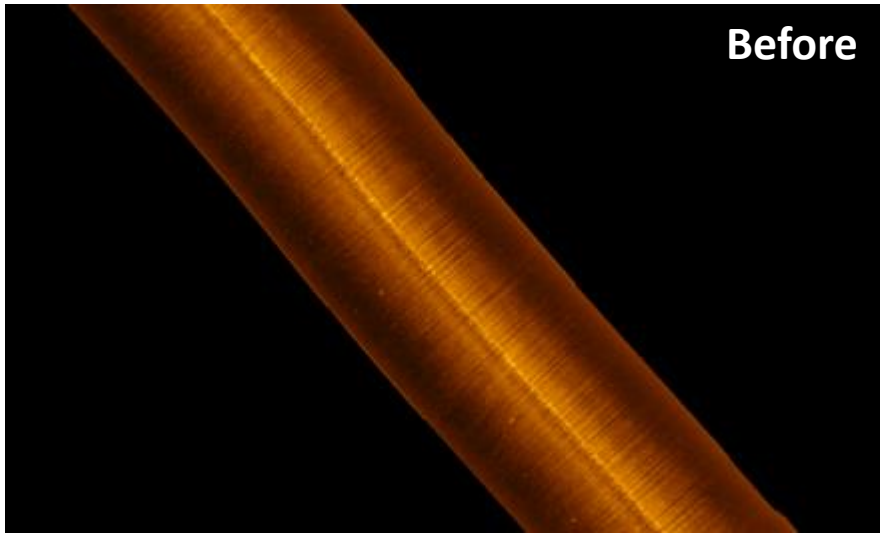


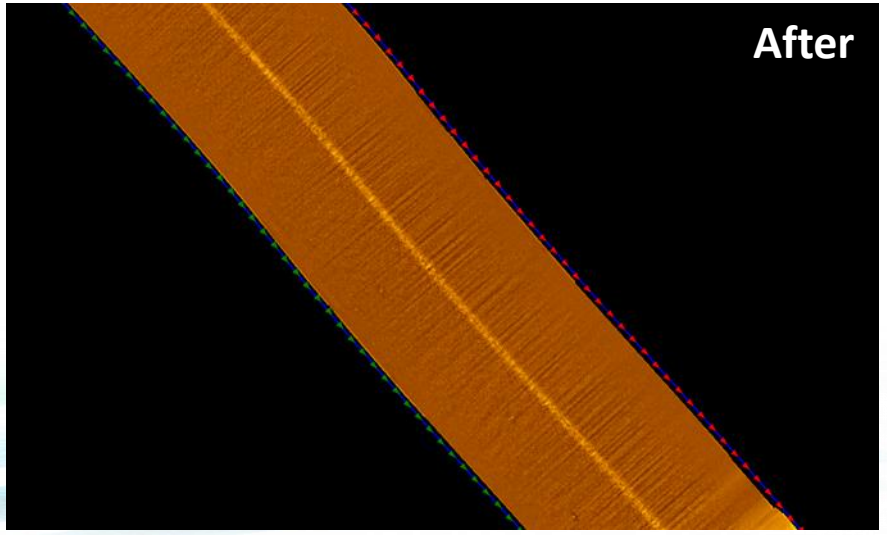


Beam Angle Correction

The Beam Angle Correction function (BAC):

attempts to compensate for non-linear response characteristics of the sonar transducers.

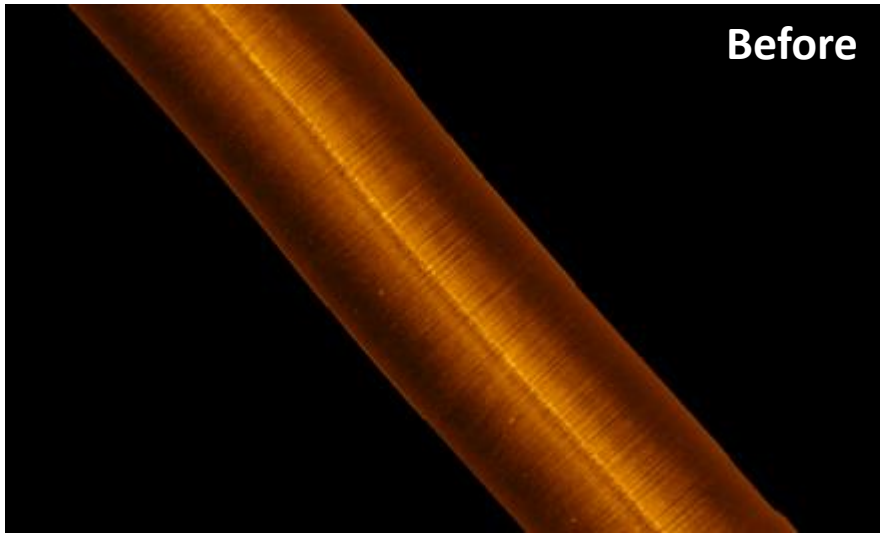


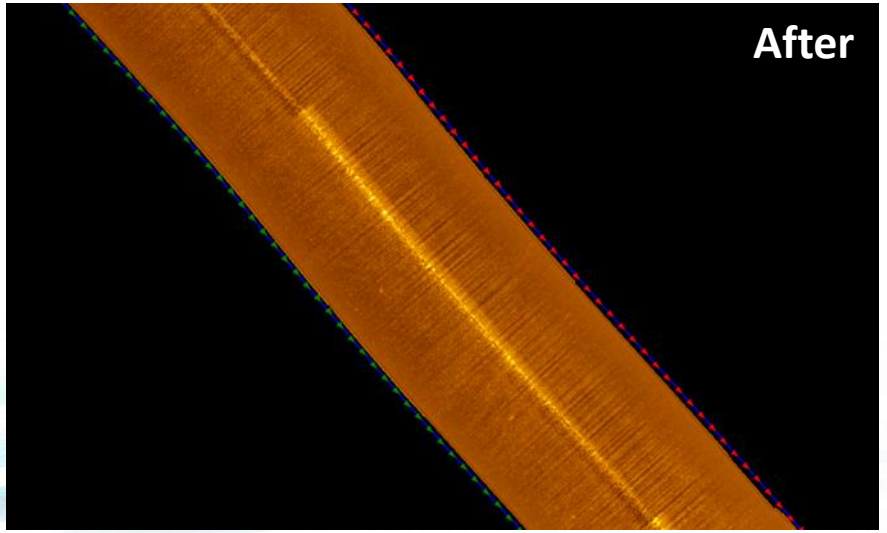


Auto TVG (Time Varying Gain)

The Auto TVG function:

1. **dividing** the data into many **parallel swaths**,
2. attempting to **equalize the backscatter** of each swath.
3. The **Root Mean Square** (RMS) power of each **swath is compared** to a desired power level.
4. **The error signal is fed back to an infinite impulse response (IIR) filter** and
5. the **gain for that swath** is adjusted in the **opposite direction**.



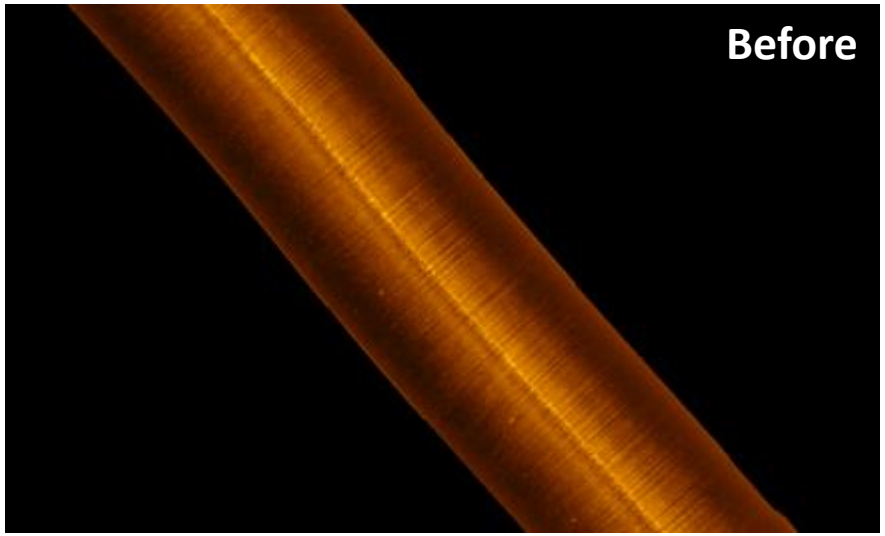


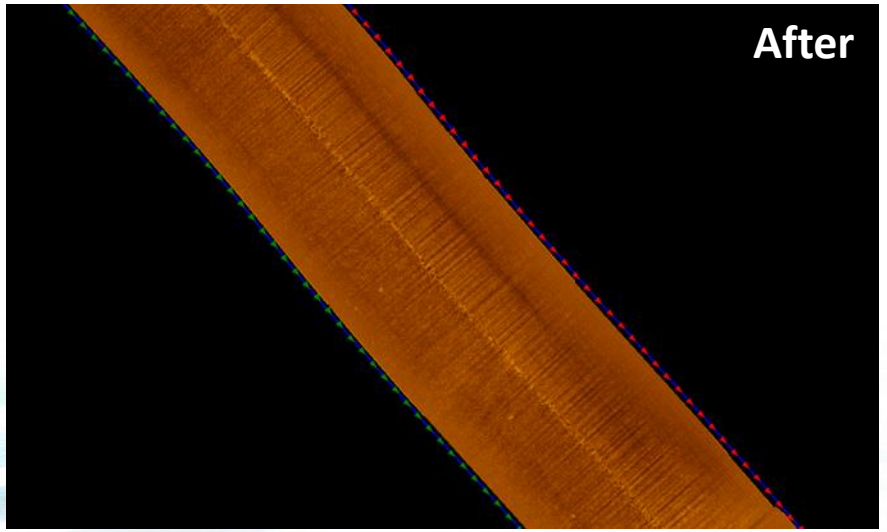
Empirical Gain Normalization

works extremely well in most situations and can be considered a replacement for BAC.

The Empirical Gain Normalization (EGN) function:

1. **sums and averages up all** of the **sonar amplitudes** in all pings in a set of sonar files **by altitude and range**.
2. **The amplitude values are summed and averaged by transducer** (port and starboard) so there are actually two tables.
3. The resulting table is used to work out the beam pattern of a sonar by **empirically looking at millions of samples of data**.





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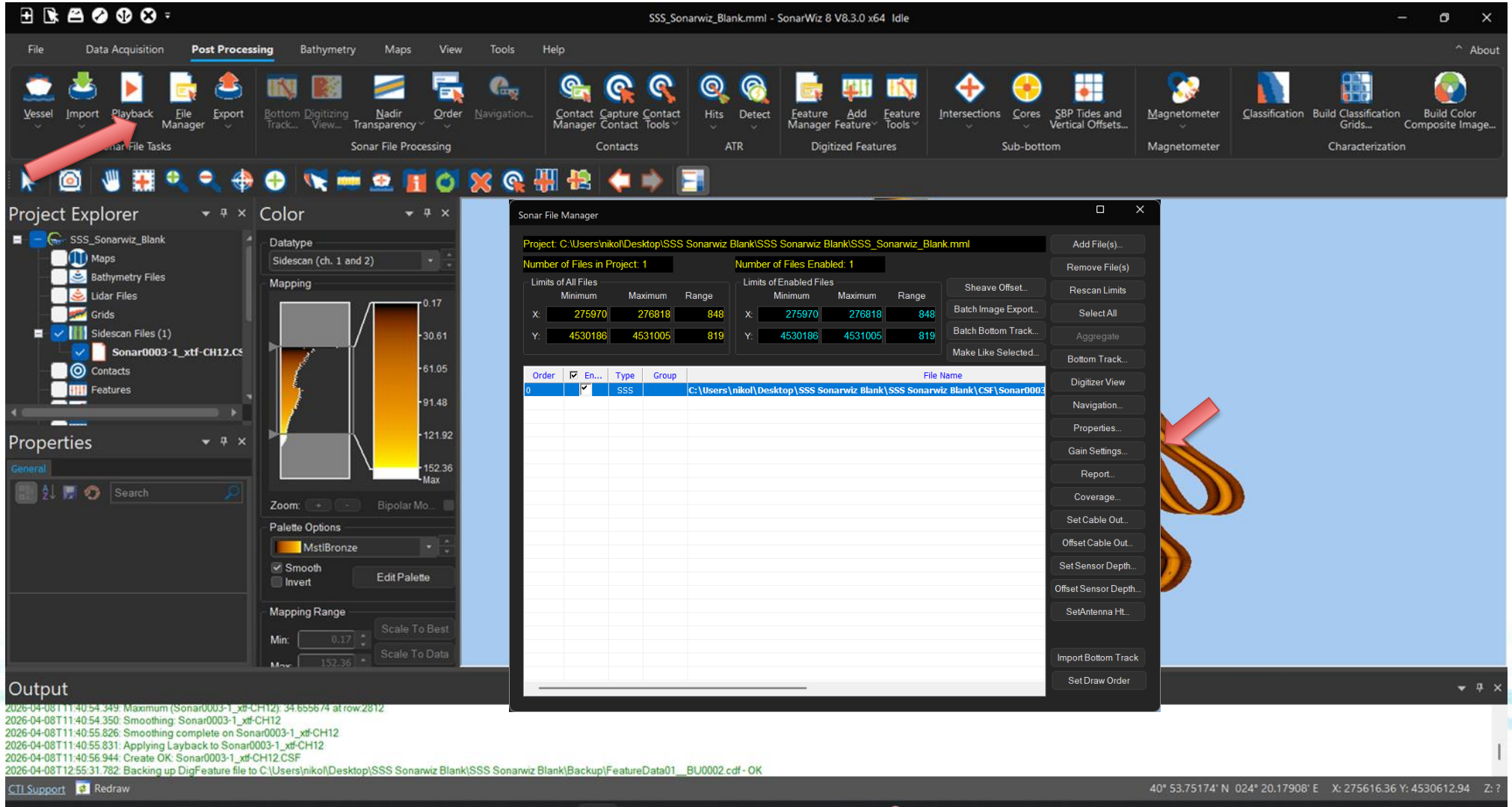
Sidescan Gain and Signal Processing

file manager



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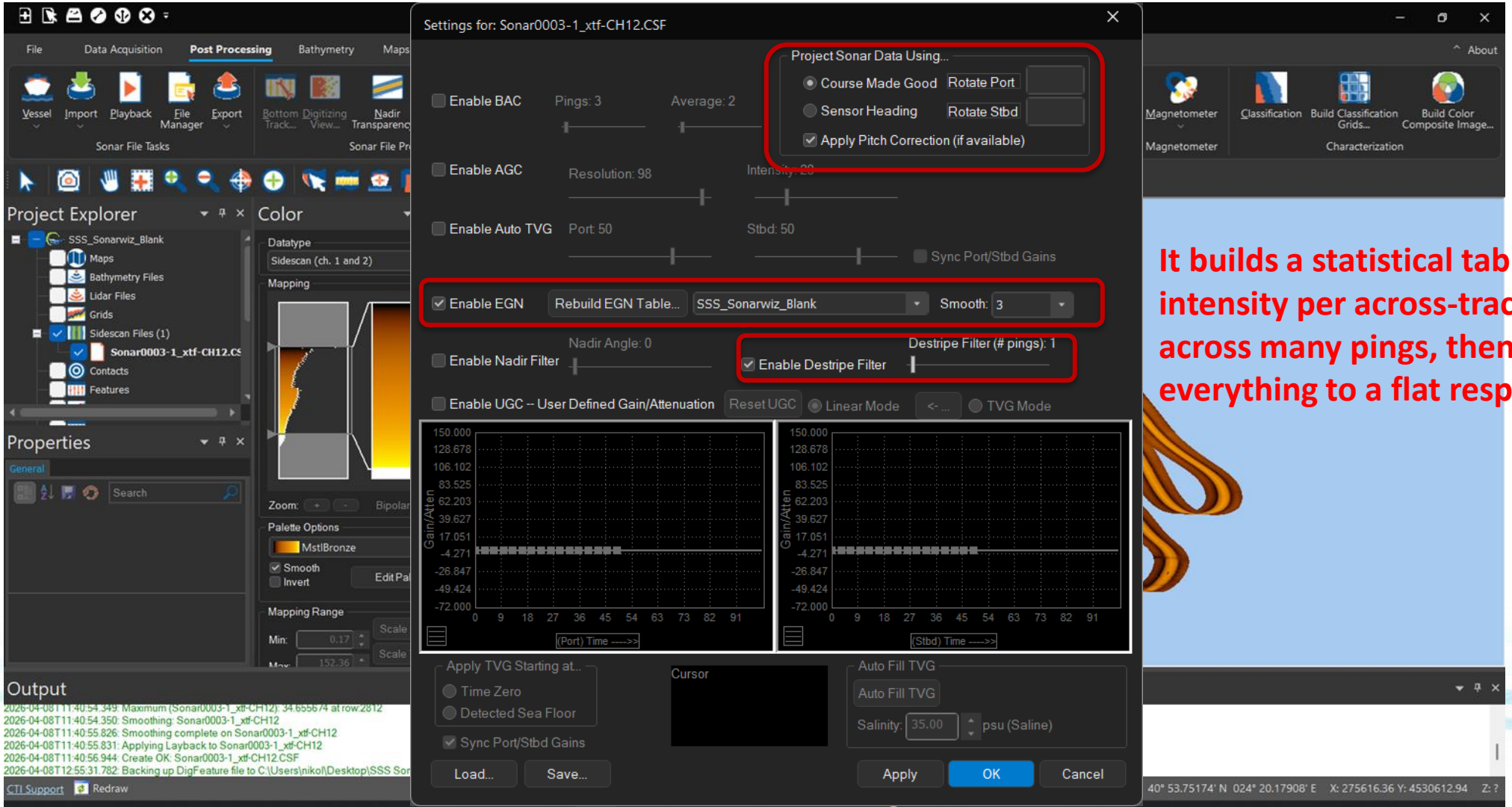
Sidescan Gain and Signal Processing



It builds a statistical table of average intensity per across-track position across many pings, then normalizes everything to a flat response.

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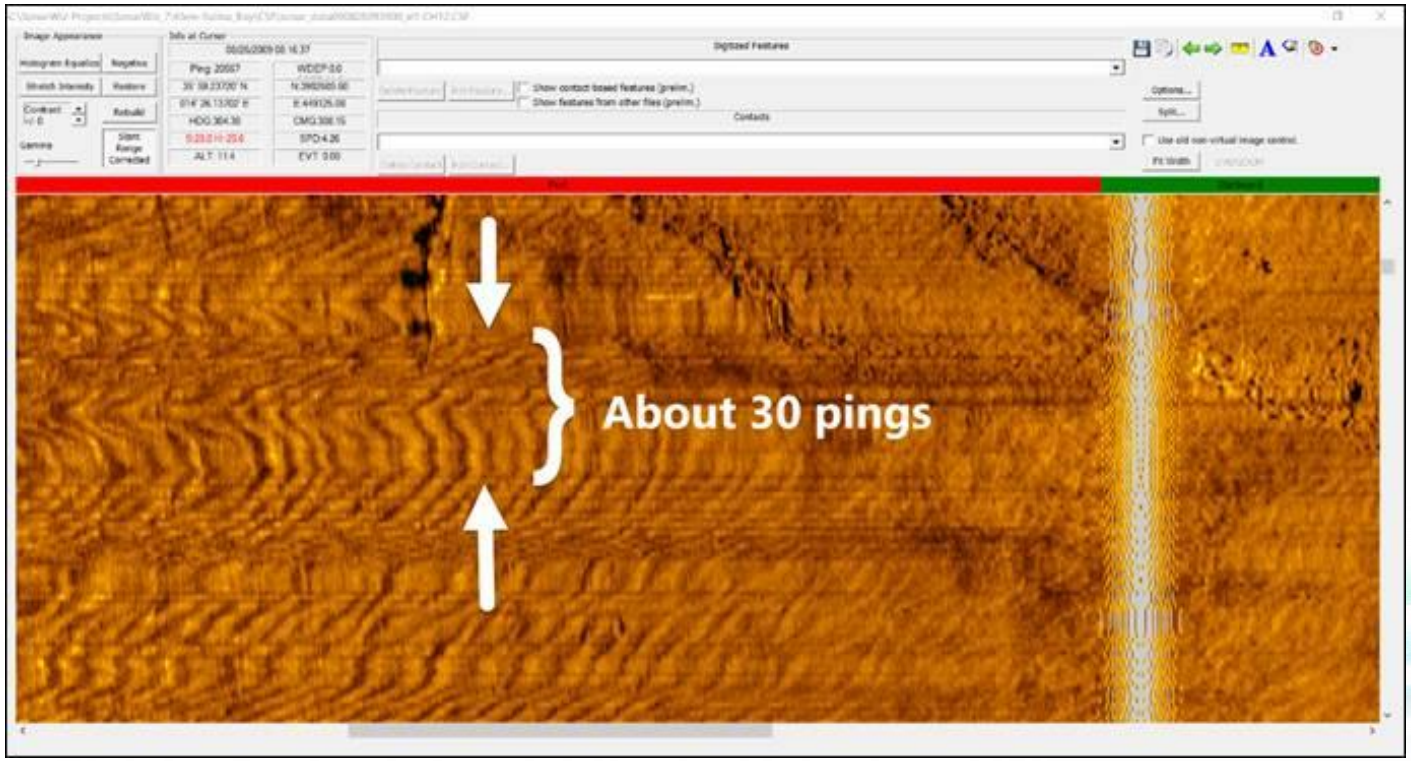
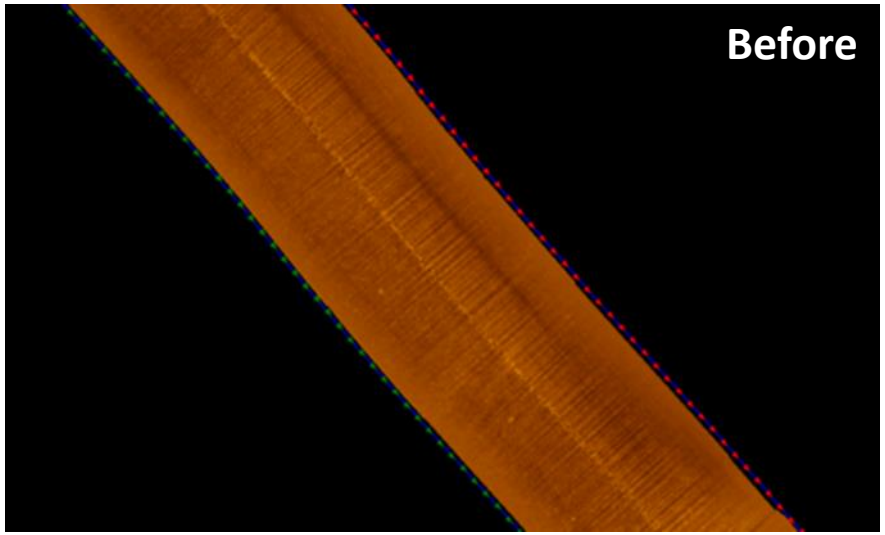
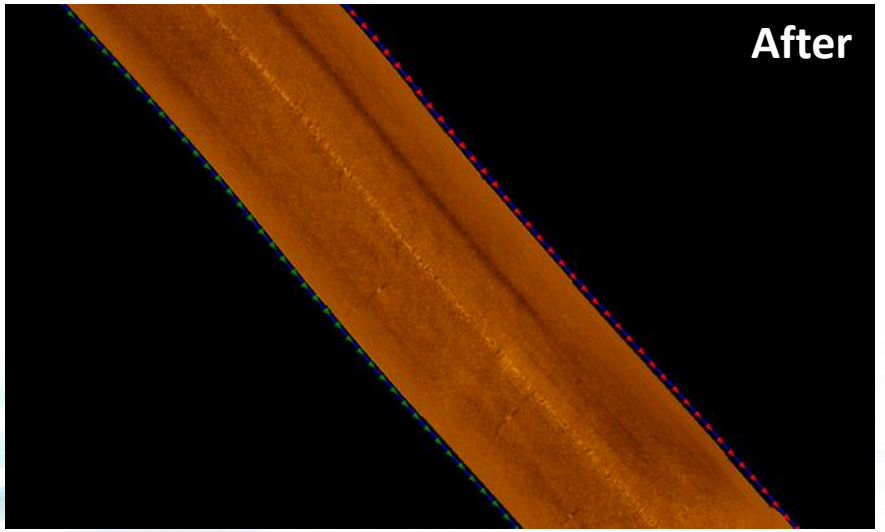
De-Striping

The De-Striping function:
Is used to reduce the effects of a '**pitching**' sonar that is characterized by a pattern perpendicular to the direction of travel.







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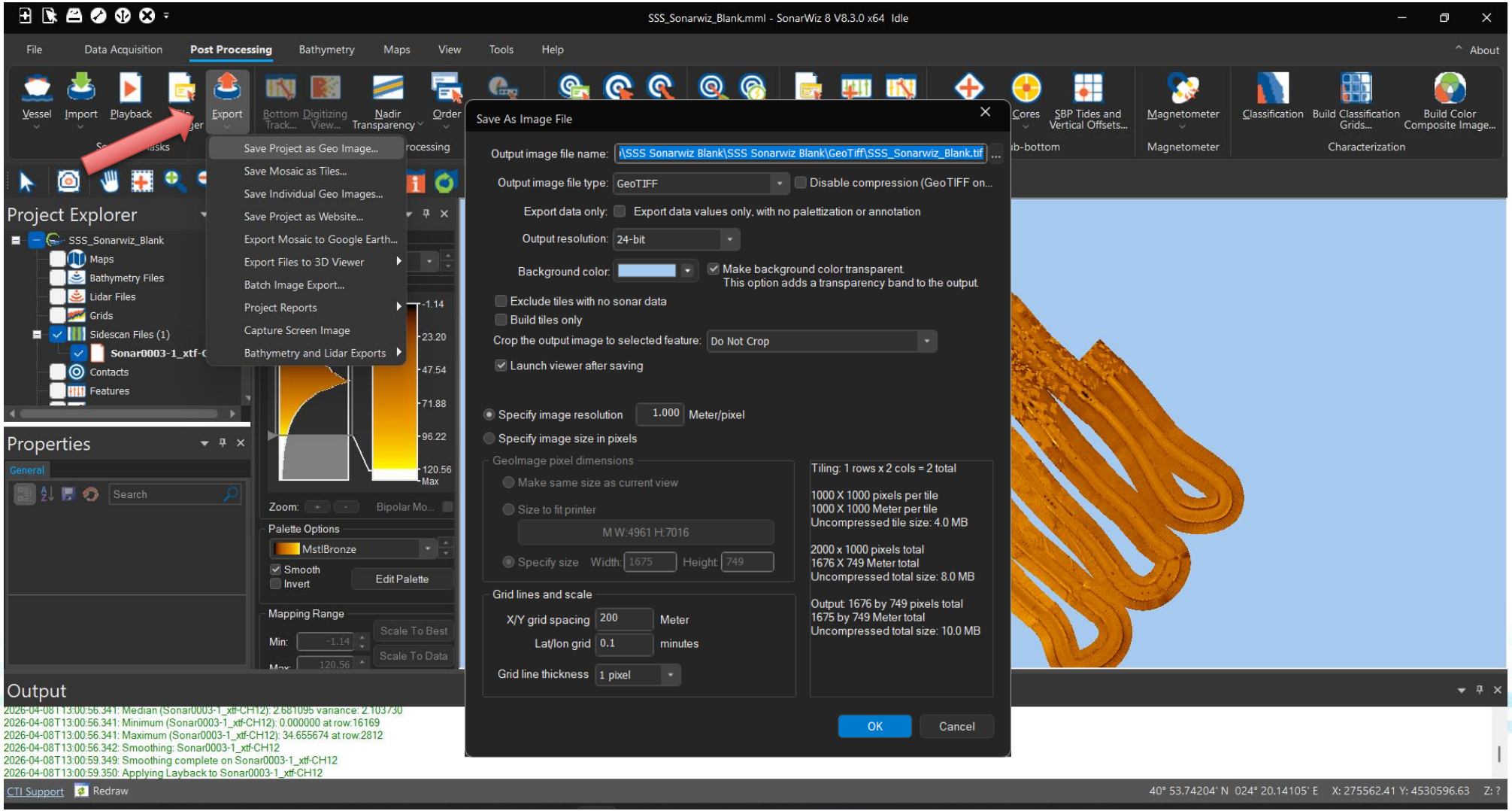
Export track



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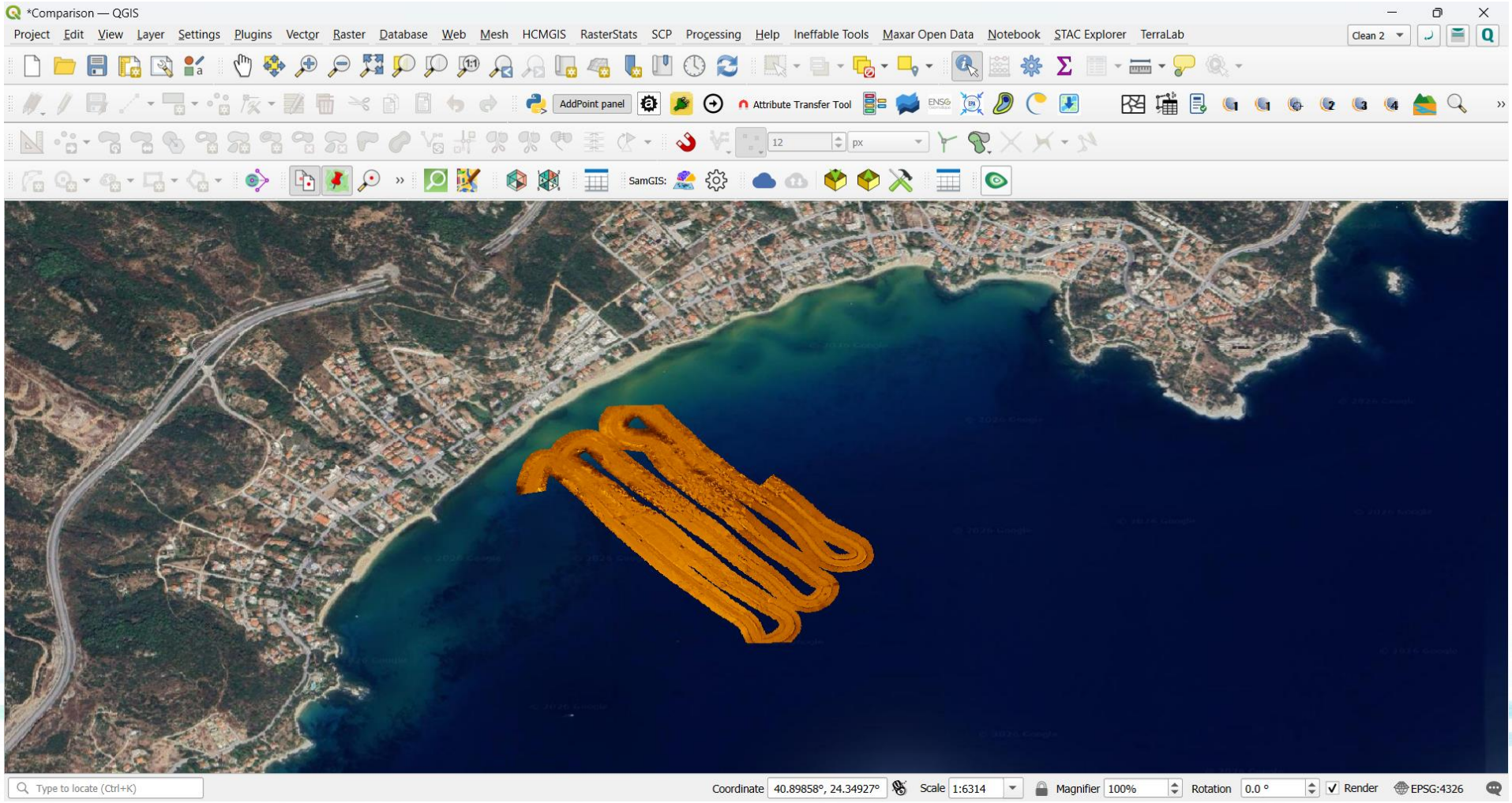
Export track



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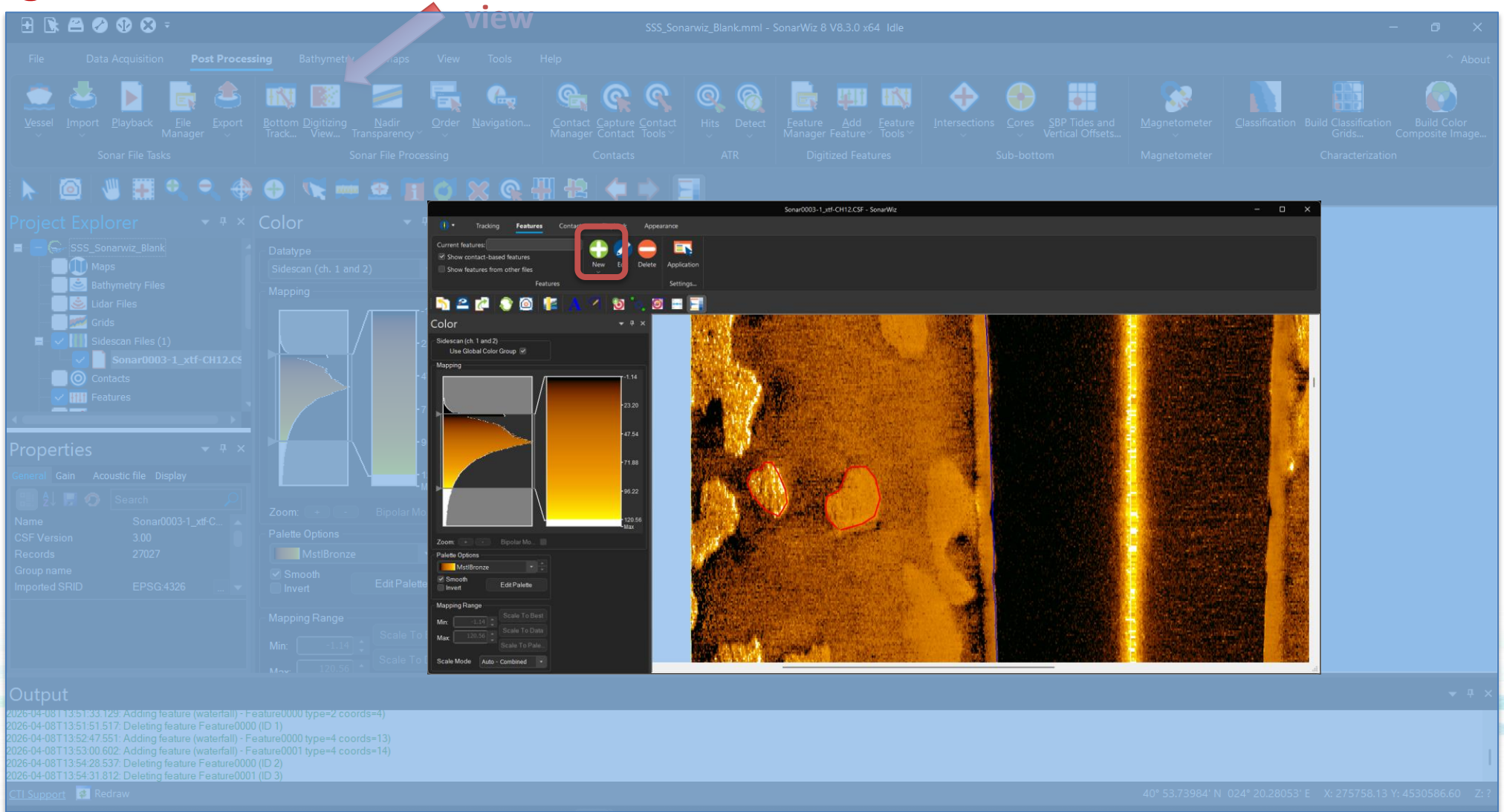
Digitizing features

digitizing view



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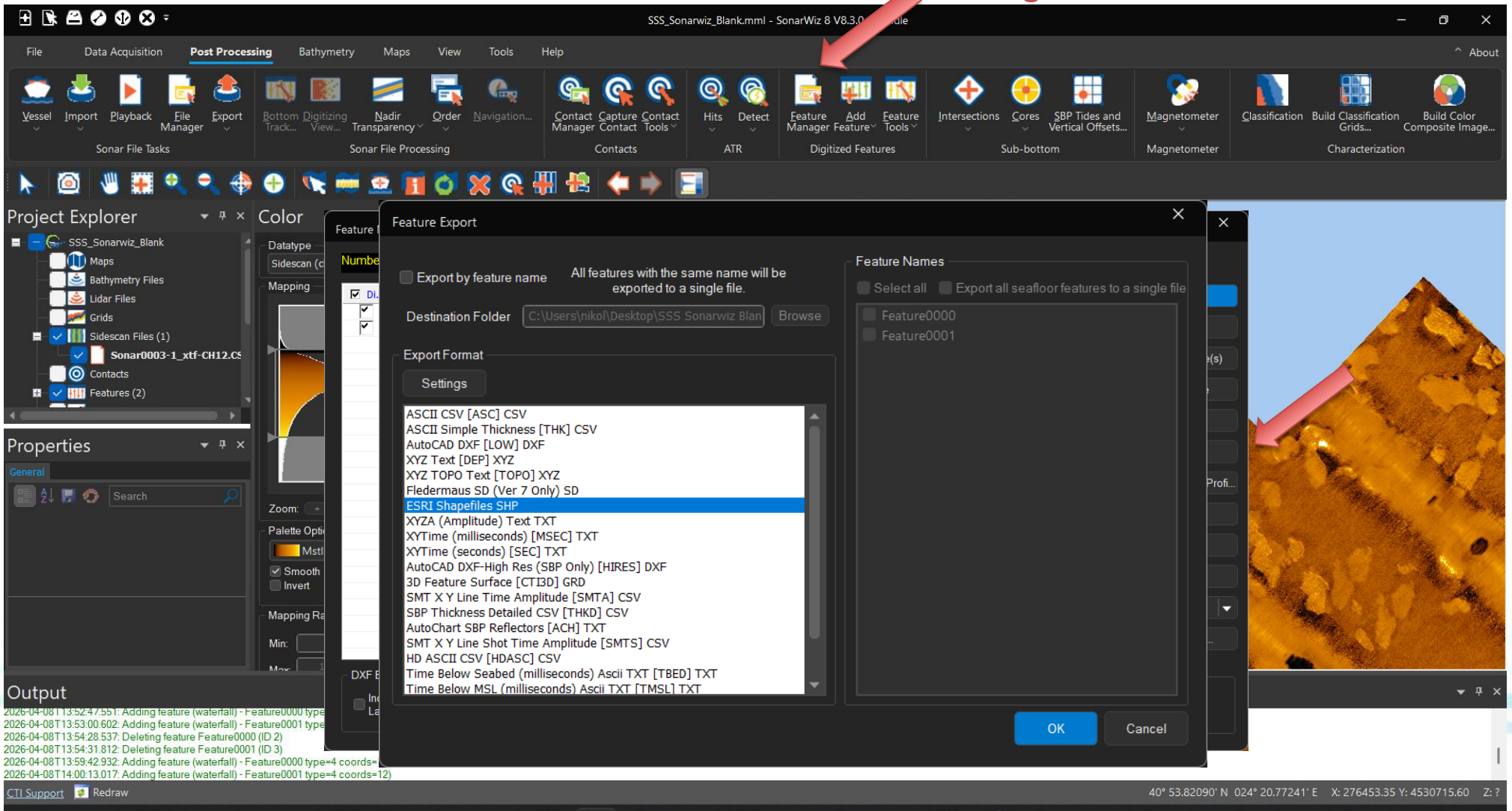
Digitizing features

Feature manager



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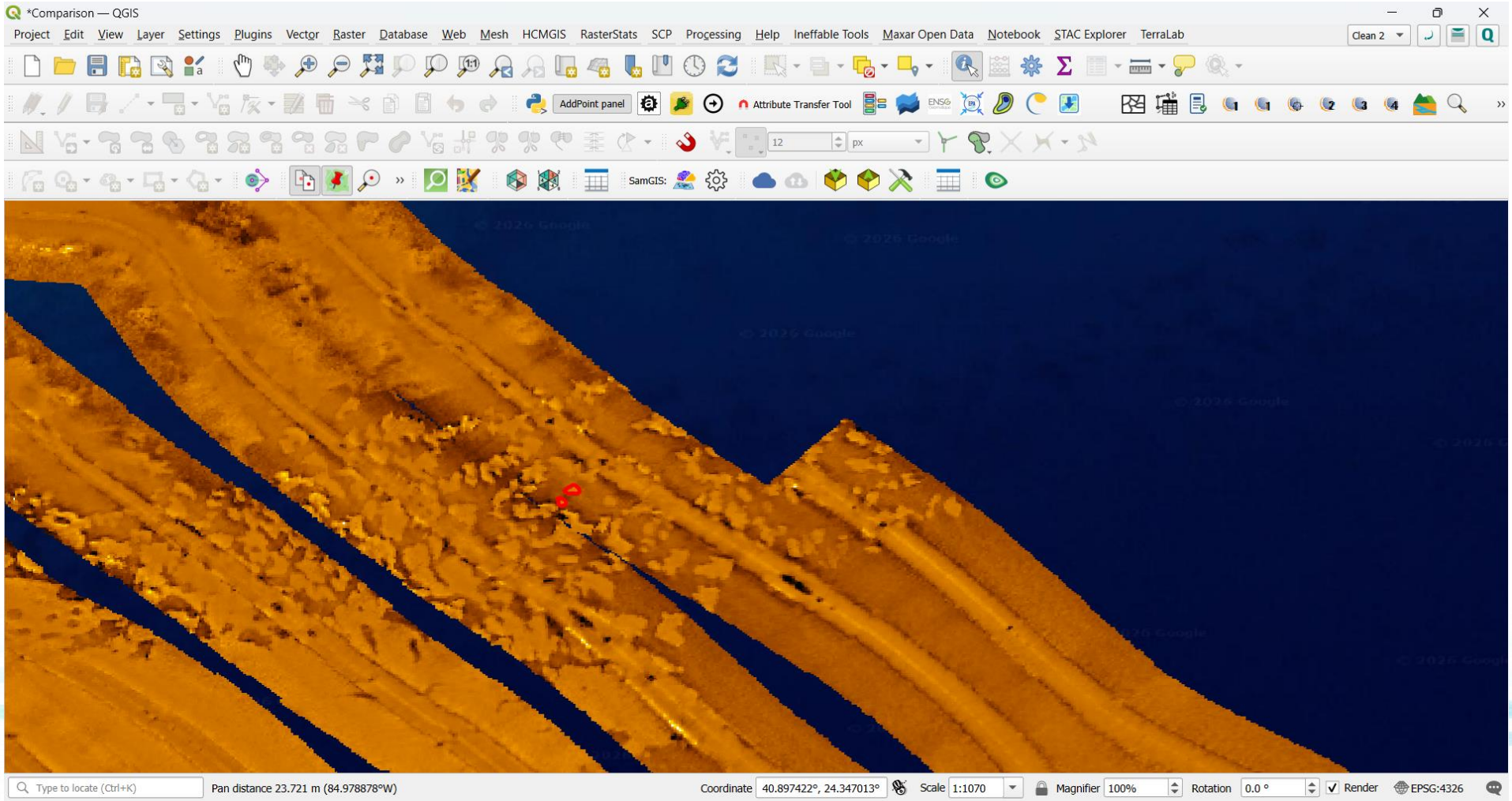

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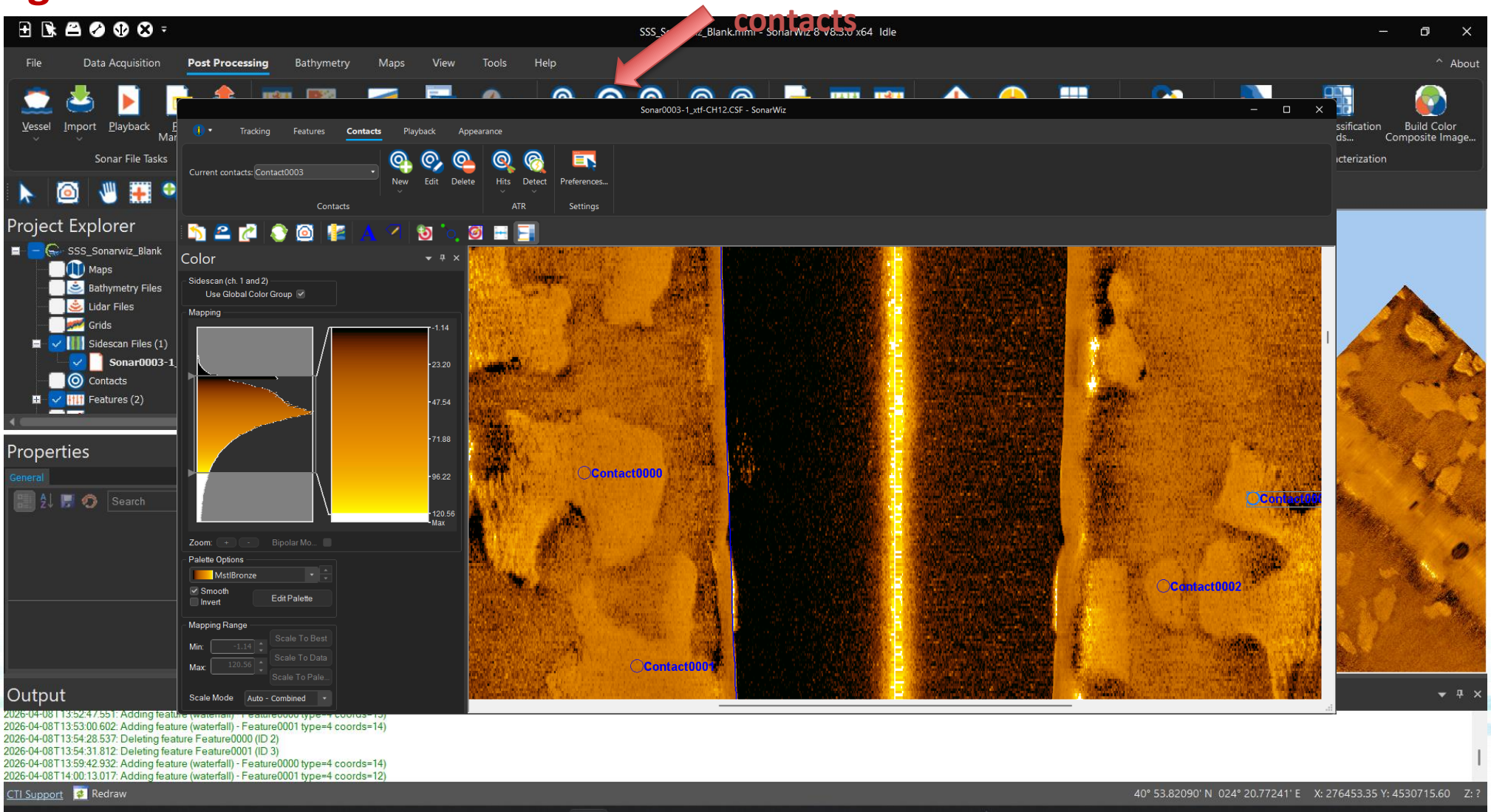
Capturing Contacts



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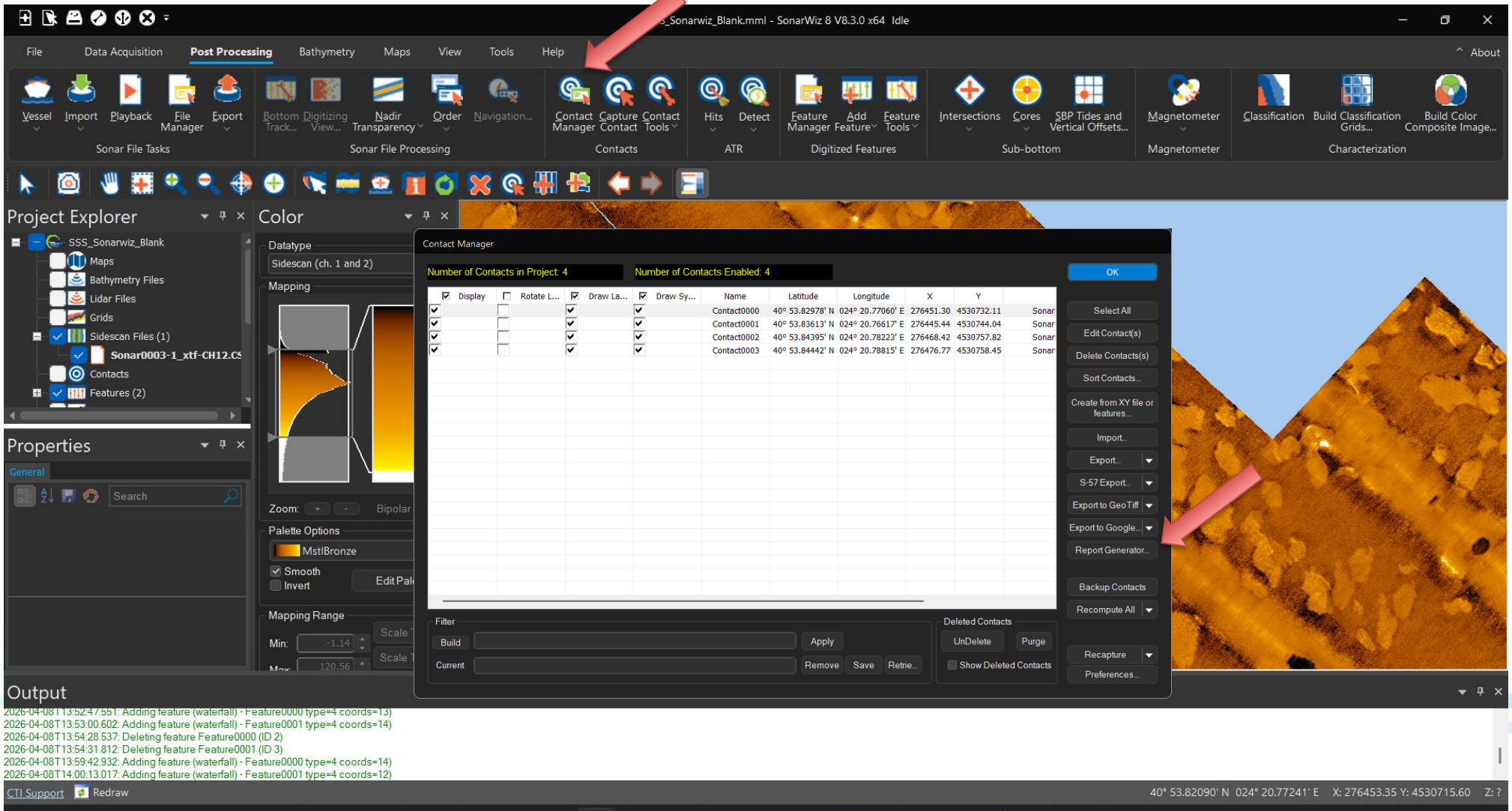
Capturing Contacts

Contacts manager



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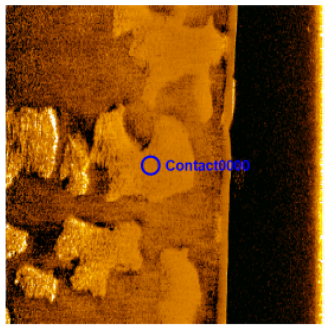
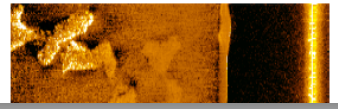
Capturing Contacts

Report PDF Small English

Generated on 8/4/2026 5:16:46 μμ

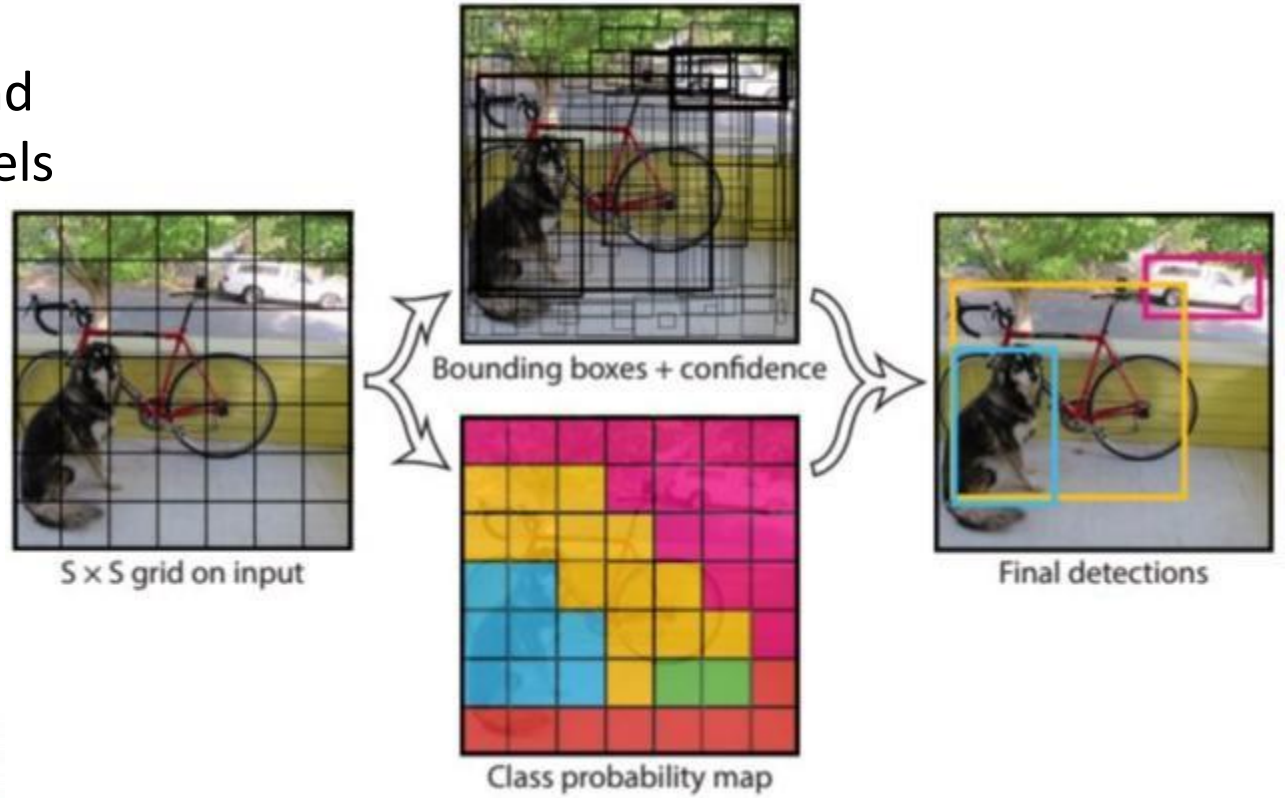
Target Image	Target Info	User Entered Info
	Contact0000 • Sonar Time at Target: 1/4/2016 3:34:40 μμ • Click Position 40.8971631525 24.3461766962 (WGS84) (X) 276451.30 (Y) 4530732.11 (Projected) • Map Projection: EPSG:32635 • Acoustic Source File: Sonar0003-1.xtf • Ping Number: 4457 • Range to target: 16.50 Meters • Fish Height: 10.48 Meters • Heading: 0.000 Degrees • Course Made Good: 314.614 Degrees • Event Number: (-1) • Line Name: Sonar0003-1 • Target depth: 10.48 Meters	Dimensions and attributes • Target Width: 0.00 Meters • Target Height: 0.00 Meters • Target Length: 0.00 Meters • Target Shadow: 0.00 Meters • Mag Anomaly: • Avoidance Area: • Classification1: • Classification2: • Area: • Block: • Description: • Water Depth: 10.50 Meters
	Contact0001 • Sonar Time at Target: 1/4/2016 3:34:48 μμ • Click Position 40.8972688649 24.3461029093 (WGS84) (X) 276445.44 (Y) 4530744.04 (Projected) • Map Projection: EPSG:32635 • Acoustic Source File: Sonar0003-1.xtf • Ping Number: 4534	Dimensions and attributes • Target Width: 0.00 Meters • Target Height: 0.00 Meters • Target Length: 0.00 Meters • Target Shadow: 0.00 Meters • Mag Anomaly: • Avoidance Area: • Classification1:

What is YOLO (You Only Look Once)?

- A real-time object detection algorithm
- Detects what objects are present in an image and where they are using bounding boxes and class labels

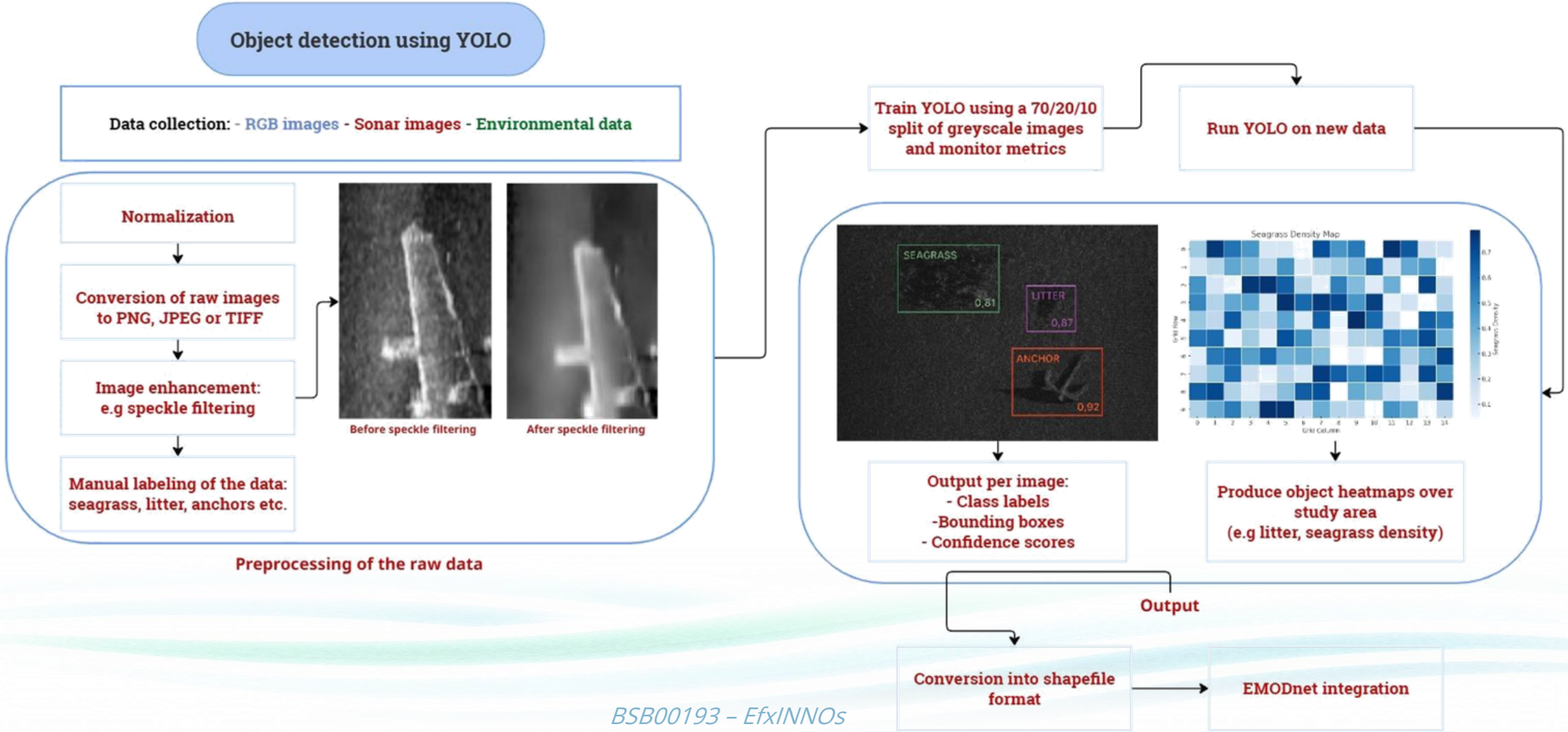
How does it work?

- Input image is divided into an S x S grid
- Each grid cell predicts:
  - Bounding boxes
  - Confidence score
  - Class probabilities
- All predictions are made in one forward pass through the network



Rahman, Zillur & Ami, Amit & Ullah, Muhammad. (2022). A Real-Time Wrong-Way Vehicle Detection Based on YOLO and Centroid Tracking. 10.48550/arXiv.2210.10226.

Object detection workflow



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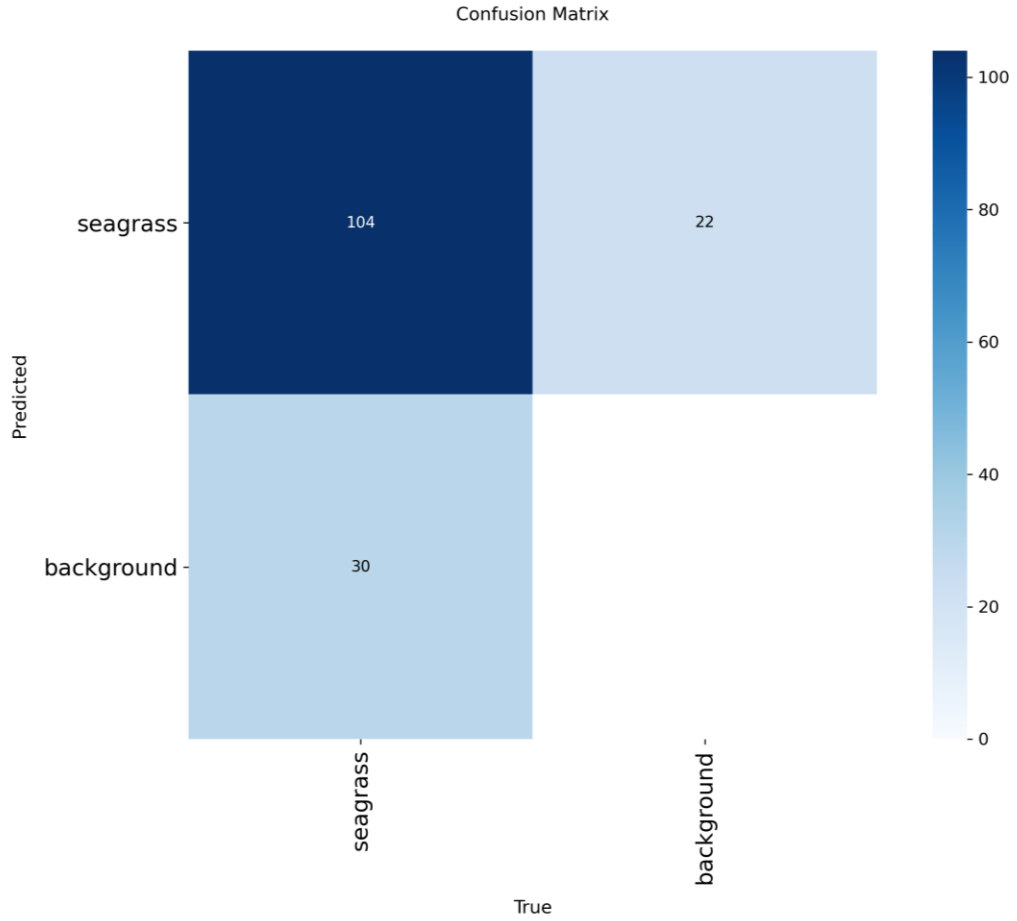
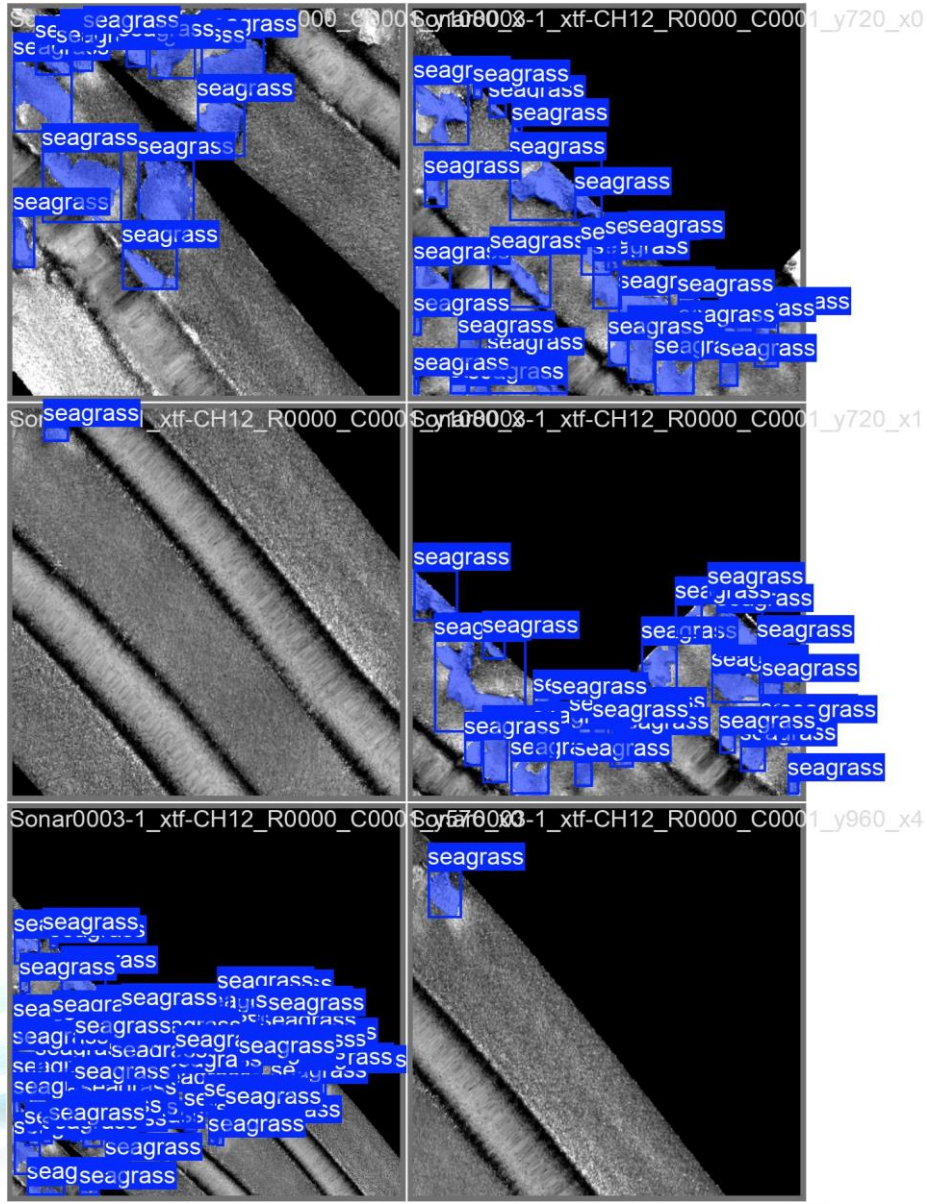
Object detection preliminary results

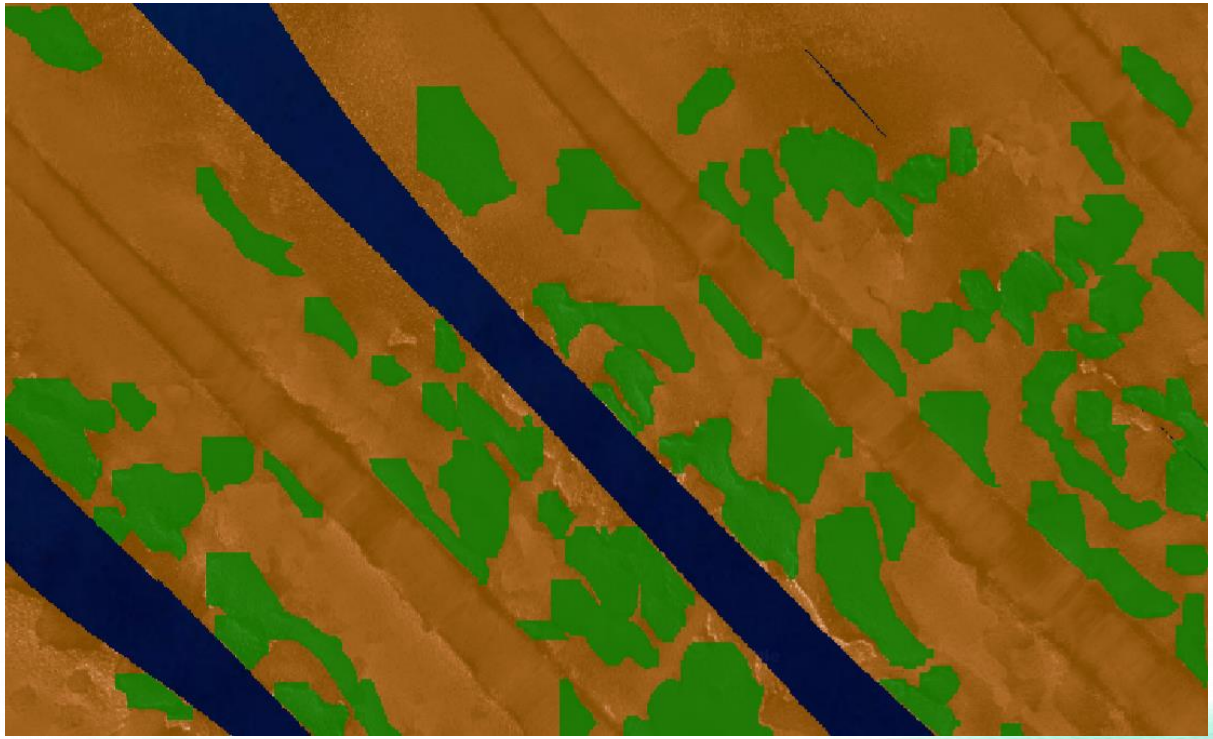
YOLO-8n model



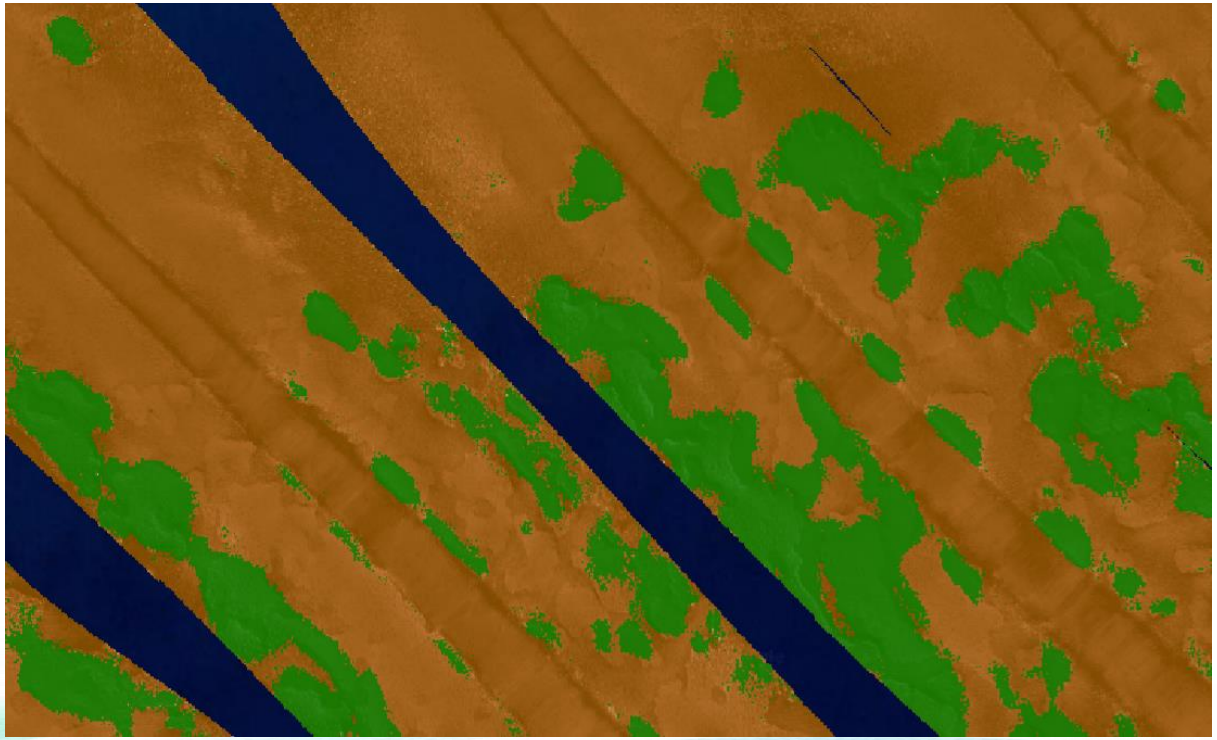


Object detection preliminary results

YOLO-8n model



U-Net model



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EMODnet

European Marine Observation and Data Network

EMODnet Submitter's Dashboard

| DASHBOARD

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Submitter's Data Submission List

Add

Show 10 entries

Submission identifier (UUID)	Title of dataset	Status	Last Update	Controls
Enter Submission identifie	Enter Title of dataset...	Select...		
1dd3a10a-695e-40fc-9e20-89dd9864d23b	Efxinnos - Seagrass - North Aegean	Drafting form part 1 by Data Submitter	2025-06-20 19:23:57.522252	View Edit
37c2a56b-9f34-403a-baa7-f6da8a4500db	Fishing weir areas on the territory of the Black Sea basin management region	Drafting form part 1 by Data Submitter	2025-05-22 13:54:12.431628	View Edit

Showing 2 entries of 2

1

emodnet.ec.europa.eu/ingestion

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Thank you!