Anti-Submarine Warfare In the Black Sea

Written by Aaron Amick USN Retired

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INTRODUCTION

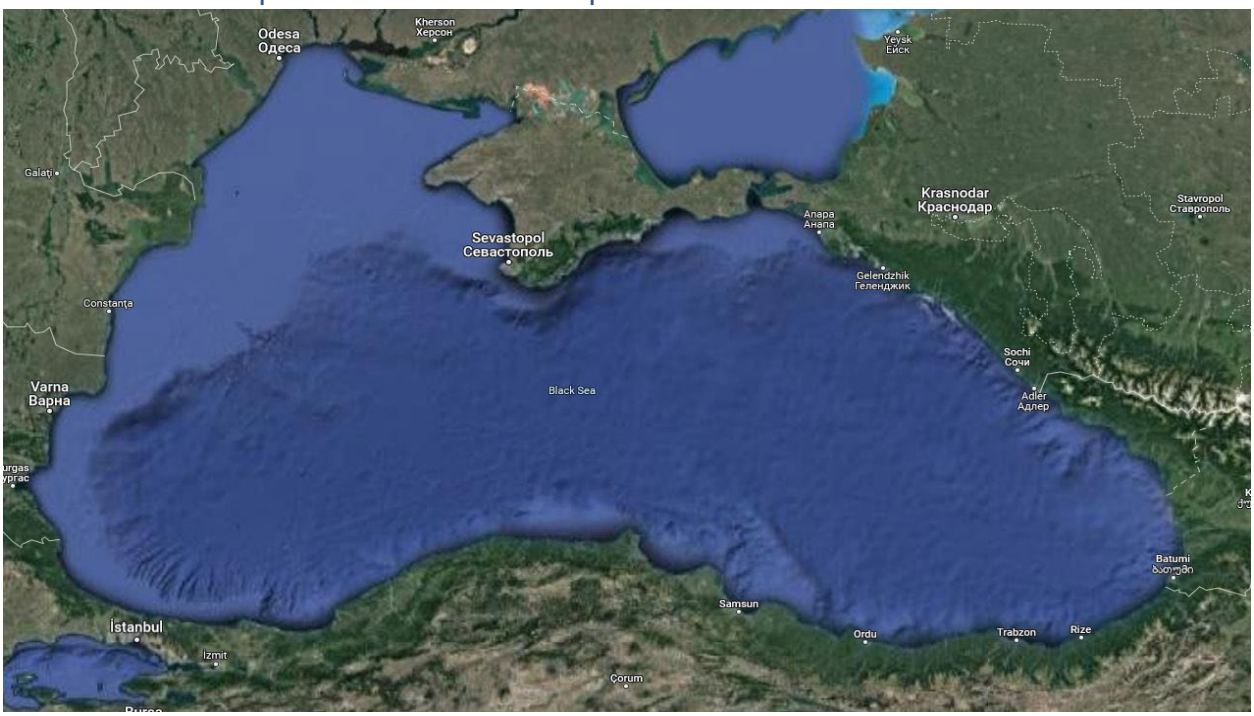
The Black Sea is a unique water body for Anti-Submarine Warfare. Its undersea environment poses many challenges and few opportunities for exploitation. This paper discusses how to find submarines in this difficult domain.

PURPOSE OF THIS PAPER

The purpose of this product is to highlight conditions that affect sonar performance. The focus is a sonar search for quiet diesel-electric submarines like the Project 636.3 Kilo class, but the lessons here may apply to all submarines. All information in this paper is from publicly available sources.

KEY FINDINGS

Shallow and Deep-Water Columns Require Different Search Methods



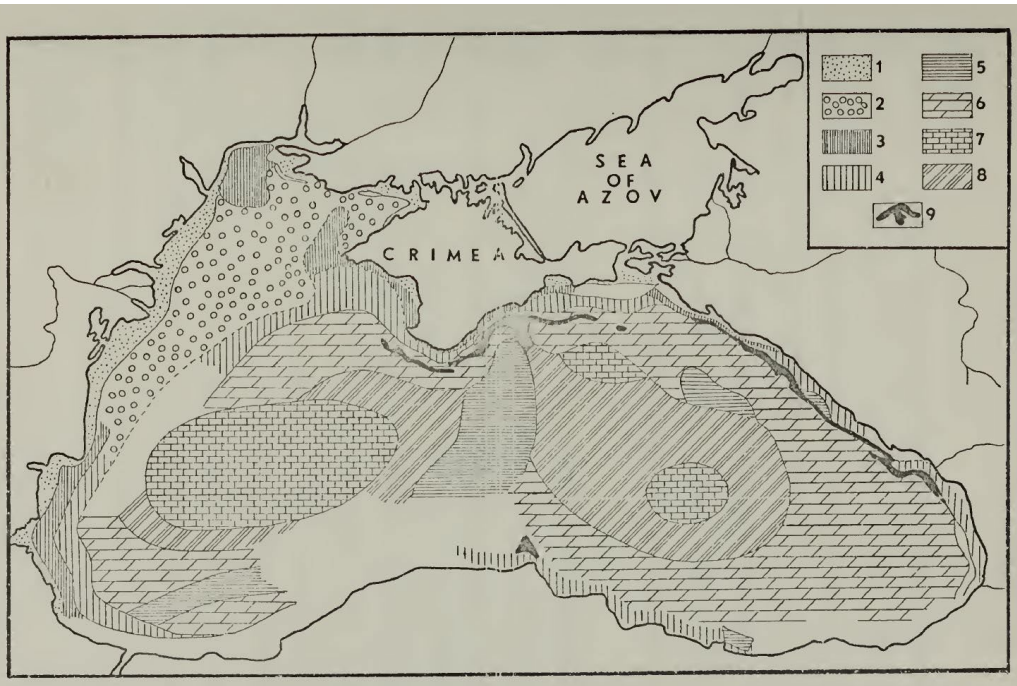
The Black Sea is a complex underwater environment that changes significantly from summer to winter. It also has two very different depth stratums. Continental shelf in the North-west and very deep water everywhere else.

Shallow areas have a higher ambient noise level due to shipping, a hard bottom and uneven salinity level due to freshwater runoff from two of Europe's largest rivers, the Danube and Dnieper. These rivers also carry farmland fertilizers and power plant discharge into the Black Sea. These contaminants create a water body dense with Hydrogen Sulfide, low in oxygen and few biologics. This dense fluid moves to the deep waters of the Black Sea where it builds up over time.

High noise levels, complex salinity mixing, erratic shell bottom create a multi-path water column. Continental shelf waters are insonified with broadband noise from multiple sources, scattered by uneven shell seafloor, and bent by freshwater river runoffs. Expect poor performance year-round on the continental shelf.

Deep regions are highly dense with hydrogen sulfide because of the anoxic nature of the Black Sea. This results in a lower-than-average biologic activity. Due to less shipping and low biologic activity, the entire deep-water column has a low ambient noise level. This improves sonar performance resulting in long detection ranges especially during the colder months of the year, peaking in February.

Bottom Types of the Black Sea



1. Sand
2. Shells
3. Mytilus mud
4. Phaseolina mud
5. A series of clay with calcareous clay interlayers.
6. Transitional mud with gray clay interlayers.
7. Calcareous mud
8. Calcarous mud with gray clay interlayers.
9. Areas devoid of recent sediments.

Figure 30. Bottom Sediment Distribution in the Black Sea [Arkhangel'skiy 17].

Shell bottoms in shallow areas absorb less energy. This has the effect of allowing shipping noise to dominate the total background noise equation resulting in degradation of passive sonar performance.

Some deep-water regions enjoy a good bottom bounce benefit with hard, compacted clay. Other muddy regions degrade ASW sonar performance. Combined with lower ambient noise it is possible to greatly increase sonar ranges both active and passive in the clay bottom areas.

Summertime Effects on the Deep-Water Column

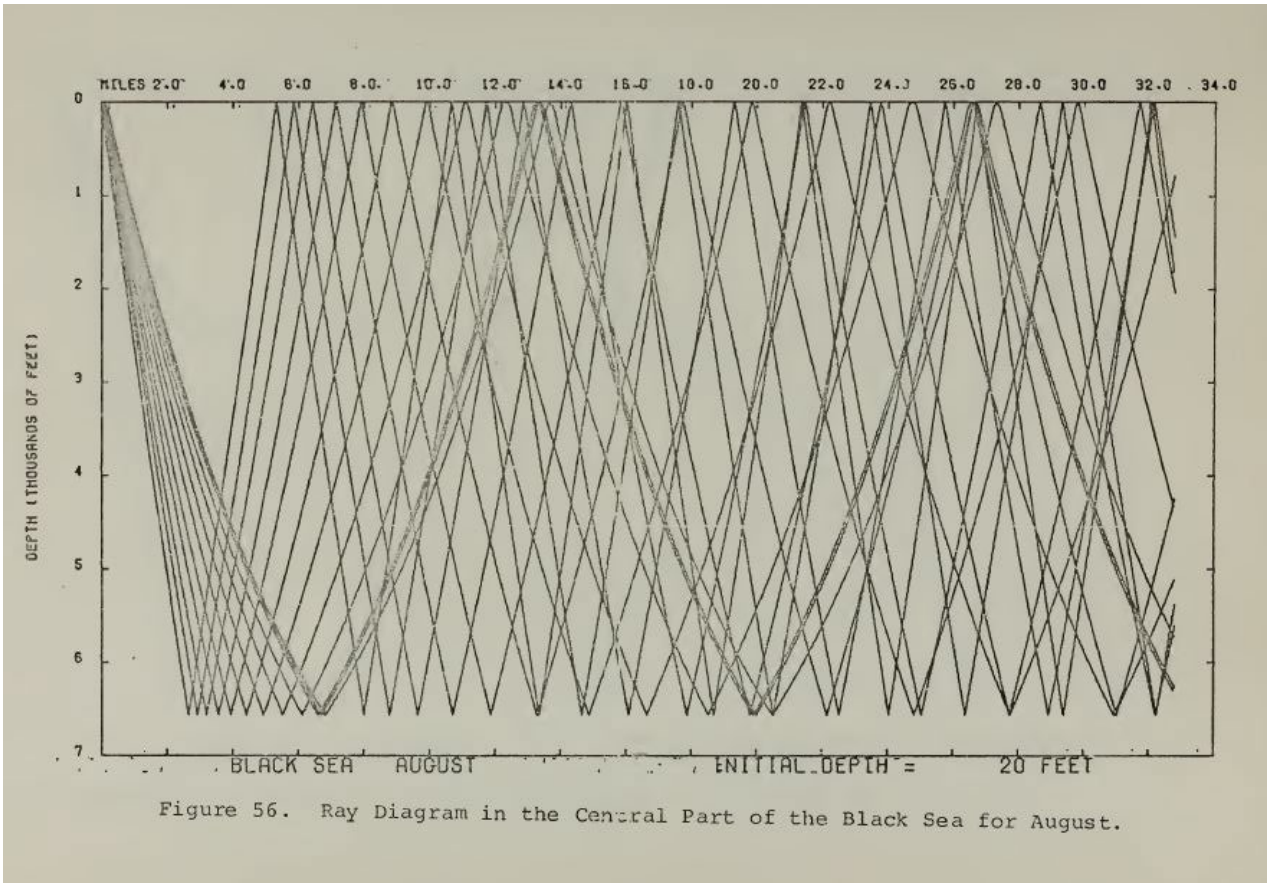


Figure 56. Ray Diagram in the Central Part of the Black Sea for August.

During summertime, peaking in August, Bottom Bounce propagation paths dominate the deep-water regions. Being aware of the bottom type is critical to understanding sonar performance. Performing regular ray trace models can reveal blind areas in the transition from bottom bounce to direct path. It is likely to have very short direct path sonar detection. Sonar operators may observe loss of contact as it closes to CPA (Closest Point of Approach).

These conditions are conducive for bi-static ranging and attack. Keeping a second MPA passively localizing a detection while an active sonar maintains track will produce best results. It is likely a submerged sonar sensor will not be aware of an overhead MPA due to short direct path propagation.

Winter Effects on the Deep-Water Column

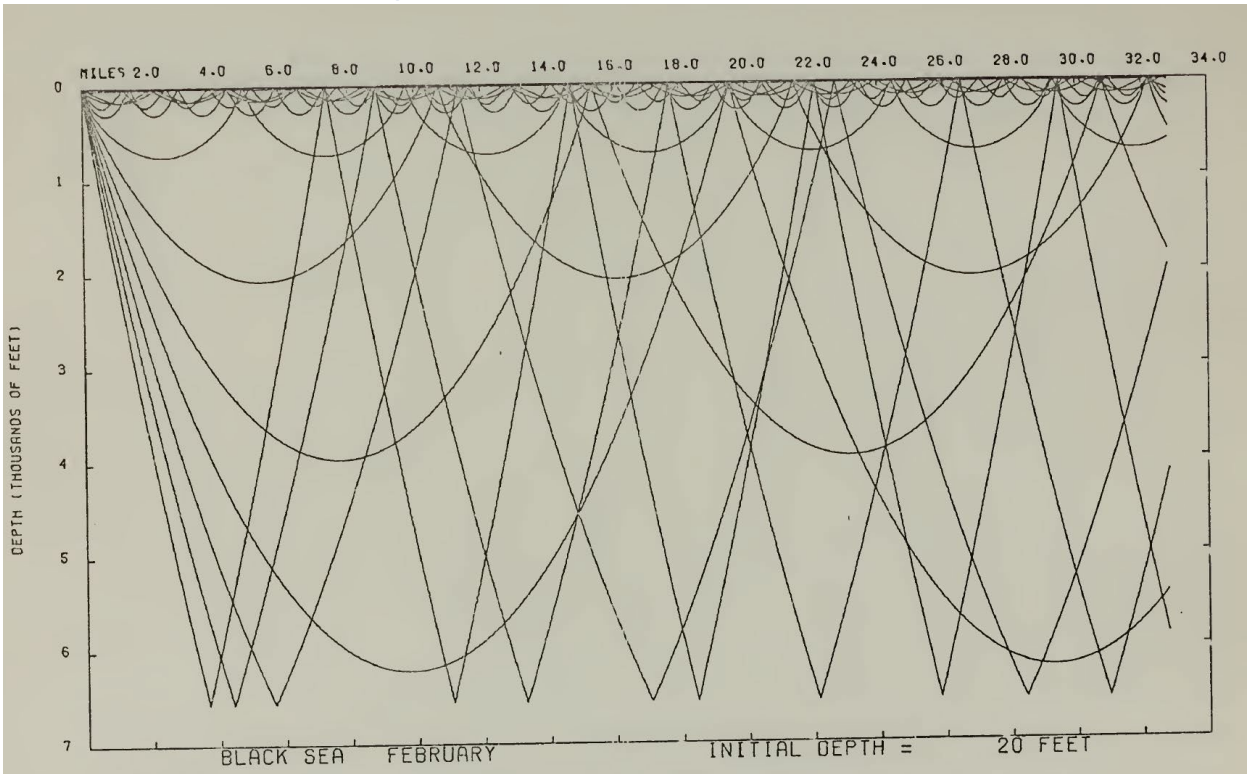


Figure 51. Ray Diagram in the Central Part of the Black Sea for February.

Through the Fall, Winter and Spring Convergence Zones begin to appear. These have a range as short at 12kyds and 40kyds at their extreme. Colder months give the sonar performance its best chance at detection in deep water.

A surface duct is created by a weak layer that averages between 250 and 400 ft depth. This focused area of noise can be exploited against submarines operating launch or periscope depth. Moving the acoustic array below this layer is critical for long range detections. Bringing the acoustic array above the layer or switching to a hull mounted sensor is ideal for short direct path tracking.

Other Key Factors

Anti-Submarine Warfare is conducted in a multi domain environment. This means factors outside the sub surface domain must be accounted for. In the Black Sea theater, Russian long-range Surface to Air radar and missile coverage is widespread and poses a significant lethal threat to maritime patrol aircraft.

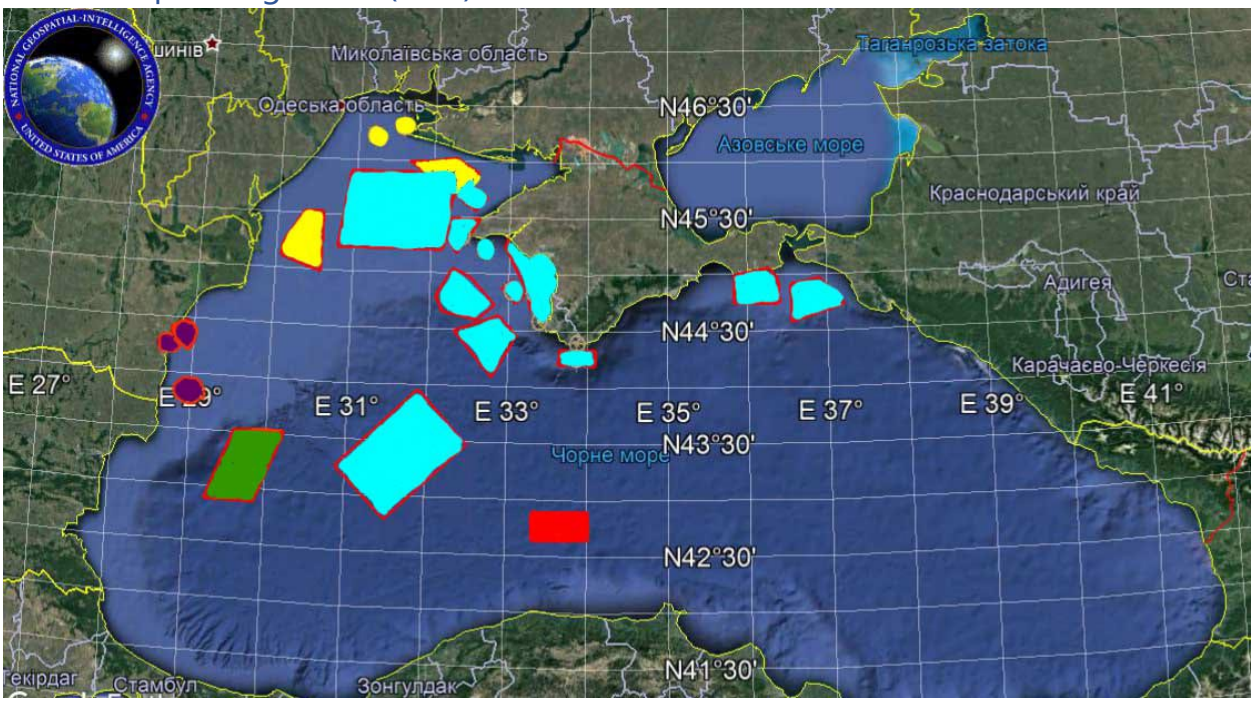
Russian peace time operating areas may not indicate war time deployment locations and movements but should not be ignored.

Russia's surface fleet is still active, mobile and a threat despite recent losses.

Russia's Black Sea submarine fleet has been very successful in employing the Kalibr cruise missile against Ukraine. Tracking these launch baskets may establish a pattern of operation that can be exploited.

Estimated Russian Air Search Radar Range Along the Black Sea Coast

Russian Operating Areas (blue) since 2014



Conclusion

Understanding why the Black Sea is different than any other ASW environment is key to success. Over a century of fertilizer and power plant runoff into this constricted body of water has led to an anoxic soup of high-density Hydrogen Sulfide saturated water.

This greatly increases the density of water, raising the speed of sound thus limiting propagation. But there are areas and times of year when sonar performance is maximized.

The layer, if it exists, will be weak. The cutoff frequency will be near 6khz. This means, in winter, when the surface duct exists, High Frequency, hull mounted sonars may experience greater than expected performance.

Use Bottom Bounce and Convergence Zone for long range detection. Move aggressively to prosecute contacts with air assets that may not be detected until overhead the submarine.

Combining information and assets from all domains is key to a successful ASW operation in the Black Sea. The Black Sea is a contested air space. Maritime Patrol Aircraft must be evasive and protected.

Key Takeaways

- Deep water sonar searches during the winter months over a hard bottom are ideal for very long-range sonar performance
- Shallow water ASW operations will be difficult year-round due to the chaotic nature of the environment. While this is an advantage to the submarine, it is extremely high risk. Evasion after counter-detection is limited to speed and endurance; both are in limited supply to the Diesel-Electric submarine.
- Anti-Submarine Warfare is a team function. Successful employment requires assets across all domains to protect prosecuting units.