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Using of the Geophysical Methods to Detect Submerged Targets and their Impact on the Sedimentary and Morphological Situation in Shatt Al-Arab River/ Basrah, Southern Iraq

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Abstract - Shatt Al-Arab River in Basrah Governorate is one of the most important rivers and waterways in southern Iraq. It consists of the confluence of the Tigris and Euphrates rivers in Qurna city, north of Basrah Governorate. The river has been subjected to environmental degradation due to many human effects. The most important of these effects is the presence of many wrecks and debris visible and completely submerged. The present study used Side Scan Sonar (SSS) and Sub Bottom Profiler (SBP) techniques to identify the submerged wrecks and detect the impact of these wrecks on the sedimentary situation of the river.

The SSS and SBP surveys revealed the presence of 66 distinctive sites for these targets, in addition to different targets have been recorded mostly represented debris and a lot of tires. Some sites contained more than wrecks, as some sites recorded the presence of more than 5 wrecks. The targets identified include medium and small boats, tankers, pontoons, bridge structures, tugs, and unknown debris. Many completely submerged debris and shipwrecks have been discovered in the river. The SBP sections and satellite images explained that the presence of many wrecks, especially the large sizes, significantly changed the shape of the river banks over many years through their trapping of sediments.

استخدام الطرق الجيوفيزيائية في تحديد الأهداف المغمورة وأثرها على الوضع الرسوبي والمورفولوجي في مجرى شط العرب/ البصرة، جنوبي العراق

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3- الجامعة الوطنية للعلوم والتكنولوجيا، البصرة - العراق

المستخلص – يعد نهر شط العرب في محافظة البصرة من أهم الأنهار والممرات المائية في جنوب العراق ، ويتكون من التقاء نهري دجلة والفرات في مدينة القرنة شمال محافظة البصرة ، وقد تعرض النهر للتدهور البيئي بسبب العديد من الآثار البشرية. من أهم هذه الآثار وجود العديد من الغوارق والحطام البحري والمغمور جزئياً وكلياً. استخدمت الدراسة الحالية المسوحات الجيوفيزيائية البحرية متمثلة بتقنيات السونار (SSS) ورسم المقاطع العرضية للقيعان (SBP) لتحديد هذه الاهداف والكشف عن تأثيرها على الوضع الرسوبي والمورفولوجي للنهر.
كشفت المسوحات الجيوفيزيائية عن وجود 66 موقعا مميزا لهذه الأهداف ، بالإضافة إلى تحديد أهداف مختلفة معظمها تمثل غوارق وحطام ، احتوت بعض المواقع على أكثر من هدف، حيث سجلت بعض المواقع وجود أكثر من 5 اهداف. تشمل الأهداف التي تم تحديدها القوارب المتوسطة والصغيرة ، والناقلات ، والطوافات ، وهياكل الجسور، والحطام غير المعروف ، وقد تم اكتشاف العديد من حطام السفن المغمورة بالكامل في النهر. كشفت المقاطع العرضية للقيعان (SBP) وصور الأقمار الصناعية أن وجود العديد من الغوارق وخاصة ذات الأحجام الكبيرة ، أحدث تغييرا ملموساً في شكل قاع النهر خلال سنوات عديدة من خلال صدها للرواسب.

كلمات مفتاحية: مجرى شط العرب; الغوارق; تقنية السونار البحري; تقنية المقاطع العرضية للقيعان

Introduction

Shatt Al-Arab River is formed in Qurna city north of Basrah governorate, where the Tigris and Euphrates Rivers are meet, then it flows southeastward and empties into the Arabian Gulf south of Al-Faw city. Throughout its history, Shatt Al-Arab River has played a crucial role in the economic, social, and political development in the region, over the past 40 years, it has experienced various types of changes, both natural and man-made. The construction of modern hydraulic systems has resulted in a significant decrease in water discharges, leading to an increase in salinity due to heightened tidal effects. Additionally, there has been an increase in sediment deposition in the rivers, leading to the formation of different geomorphologic features such as islands, bars, and point bars (Al-Mosawi, 2020). Moreover, the region surrounding Shatt Al-Arab has been subjected by conflicts and wars, including the first Gulf War (1980-1988), the second Gulf War (1991), and the third war (2003). These conflicts have resulted in sunken ships, wrecks, and debris which led to the deterioration of the river's condition.

Depositional and erosional features from the obstacles on the seafloor are widely reported in all offshore environments (Whitehouse 1998). The anthropogenic and rock obstacle features such as (breakwaters, pilings, and shipwrecks) give rise to sediments and scour features in their bottoms (Astley *et al.,* 2014). An understanding of the processes that affect erosion and sedimentation features caused by shipwrecks is critical because they can control the long-term stability and safety of submerged anthropogenic structures. In shipwreck investigations, scouring is reported widely, from submerged wreck sites near shore in shallow water (Baeye *et al.,* 2016; Caston 1979; McNinch *et al.,* 2001; Quinn *et al.,* 1997; Wheeler 2002) to deep-water sites on the continental shelf (Ballard *et al.,* 2000, 2002; McCann and Oleson 2004). Scour is reported from intact and scattered wreck sites (Arnold *et al.,* 1999; McNinch *et al.,* 2001; Quinn *et al.,* 2002; Wheeler 2002).

The presence of a large number of shipwrecks and debris is a rare case in a waterway as Shatt Al-Arab river, which is described as a freshwater stream and a source of human and agricultural use for Basrah Governorate. It passes through numerous ports, cities and villages towards the head of the Arabian Gulf. This study aims to use marine geophysical surveys Side Scan Sonar (SSS) and Sub Bottom Profiler (SBP) as well as satellite images (Google Earth) to identify sunken debris and shipwrecks in Shatt Al-Arab River and to assess their morphological and sedimentary impacts.

The study area is located between Latitude (30° 34´50" N- 31° 15´ 00" N) and Longitude (47° 46´ 20" E- 48° 45´ 00" E). It lies in Basrah Governorate south east of Iraq, the study area includes the section of Shatt Al-Arab river that extends from Al-Sindbad Island north of Basrah city to Al-Faw city, the length of the section is 120 km, where 36 km in the Iraqi border, and the political boundaries between Iraq and Iran extend to 84 Km (Fig. 1).

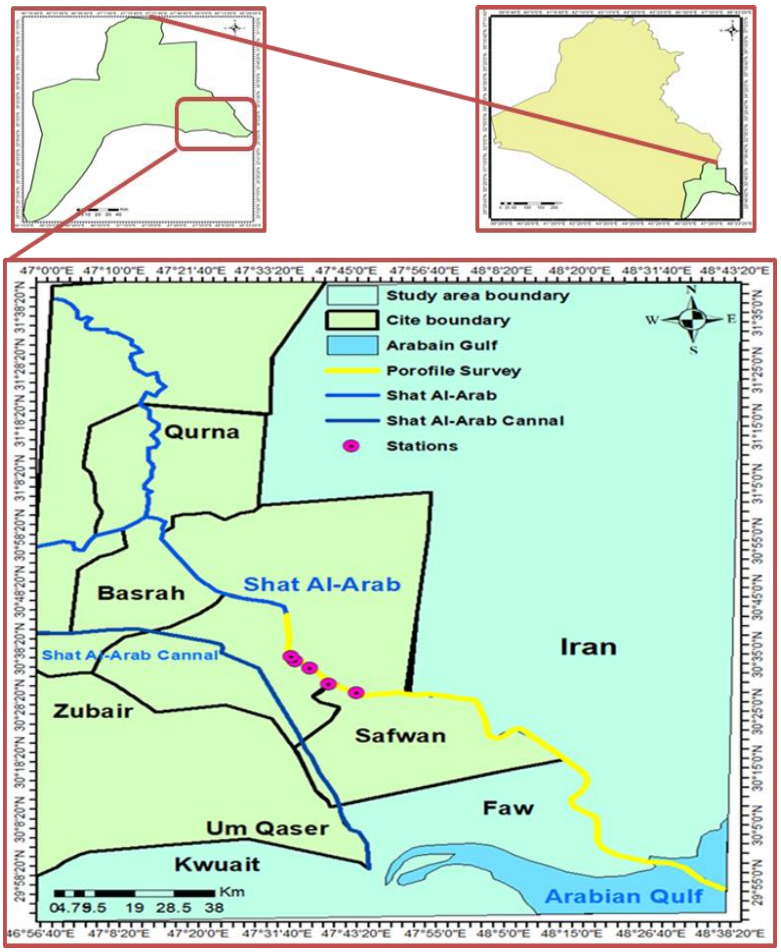


Figure 1. The study area location map (yellow line).

Materials and Methods

Two marine geophysical acoustic techniques were utilized in this study: SSS and SBP. These technologies provide detailed information about sedimentary structures, and processes, and identify sunken objects at a small scale, with high levels of accuracy in both temporal and spatial resolution (Davis *et al.*, 2002). SBP allows for measurement of features beneath the vessel, while SSS is used to create maps of the seafloor or river-bottom and classify its characteristics. Data obtained from satellite images (Google Earth) have also been used for many years to display the condition of these shipwrecks and the extent of their impact on the morpho-sedimentary condition of the river.

The SSS system is an active technology that utilizes a long acoustic array to emit a wide beam perpendicular to the array and a narrow beam parallel to the array's long axis (Urick, 1983; Mazel, 1985). This type of sonar system is widely used to efficiently generate images of large areas of the water floor. It is employed in various applications such as maritime archaeology surveys and determining shipwrecks, providing valuable information on seabed material types and textures when combined with water floor samples. Sonographs, which are recordings of SSS images, capture the vertical coverage of the beams at an angle of approximately 40 degrees, with a 10-degree aim below the horizontal (Fig 2). The energy in the vertical side of the beam provides continuous coverage for a 180-degree zone, extending from the surface to the bottom directly beneath the equipment.

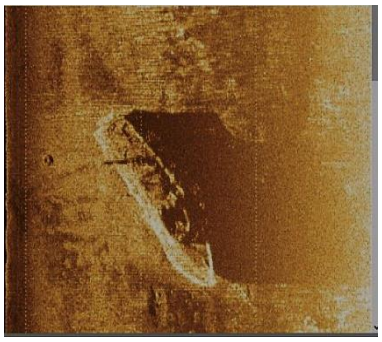


Figure 2. An example of SSS image (sonograph) in Shatt Al-Arab River.

During the measurements, The Starfish 990F SSS systems were mounted in this survey, at the side of the vessel, 1 m below the water surface. The acquisition parameters included of 260 kHz with a swath width of 100 m (40 m on each side of the source). The horizontal beam width of the used transducer is 2.2° and the vertical beam width is 75°.

The SBP is an acoustic investigation method used to map sub-bottom features by conducting multiple surveys across a river cross-section. The SBP pinger system emits sound waves through a transducer (or an array of transducers) at a specific frequency. When these waves encounter the water-sediment and sediment-rock interfaces, they generate reflected waves that return to the transducer. The survey is conducted using the Strata Box™ marine geophysical instrument (manufactured by SyQwest, Inc., USA), which functions at a frequency of 10 kHz. The output from the Strata Box provides subsurface imagery in the form of a cross-section, scaled horizontally in a spatial domain (in feet or meters) and vertically in a temporal domain (in milliseconds) or depth (in feet or meters), as illustrated in Fig. 3.

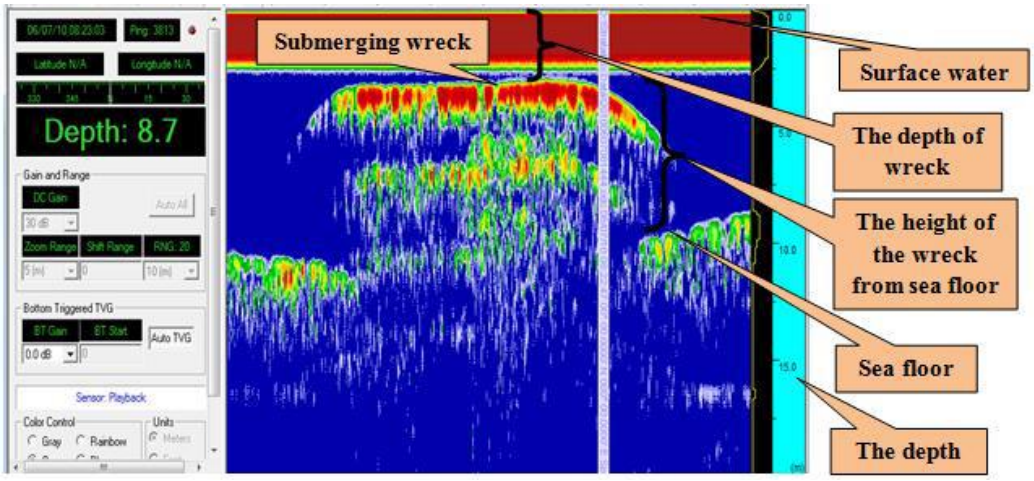


Figure 3. An example of the SBP section carried out in the Shatt Al-Arab (Al-Mosawi, 2020)

Geophysical field work was performed as parallel tracks were surveyed on both sides of Shatt Al Arab River and perpendicular tracks were surveyed to the river to search for specific targets. The survey faced significant difficulties due to the large shipwrecks located at shallow depths. Also, fishing activities in the river were one of the challenges of the field survey. There were highly high difficulties in field survey operations near and within the shared river borders between Iraq and Iran.

In Shatt Al-Arab River, the SSS and SBP surveys revealed the presence of 66 distinctive sites for these targets or wrecks, in addition to different targets that have been recorded mostly

represented debris and a lot of tires. Some sites contained more than wrecks, as some sites recorded the presence of more than 5 wrecks. Many of the targets were not identifiable by SBP sections, because the water depth was too shallow, and it is difficult to perform the SBP survey in water that has a depth of less than 2 m. The identified targets include medium and small boats, tankers, pontoons, bridge structures, tugs, and unknown debris.

Many completely submerged debris and shipwrecks have been discovered in the river. The highest number of recorded wrecks were in the section between Al-Maaqal Port and Abu Floos Port due to the presence of ports and high human activity in this part of the river's course (Figs. 4 and 5).

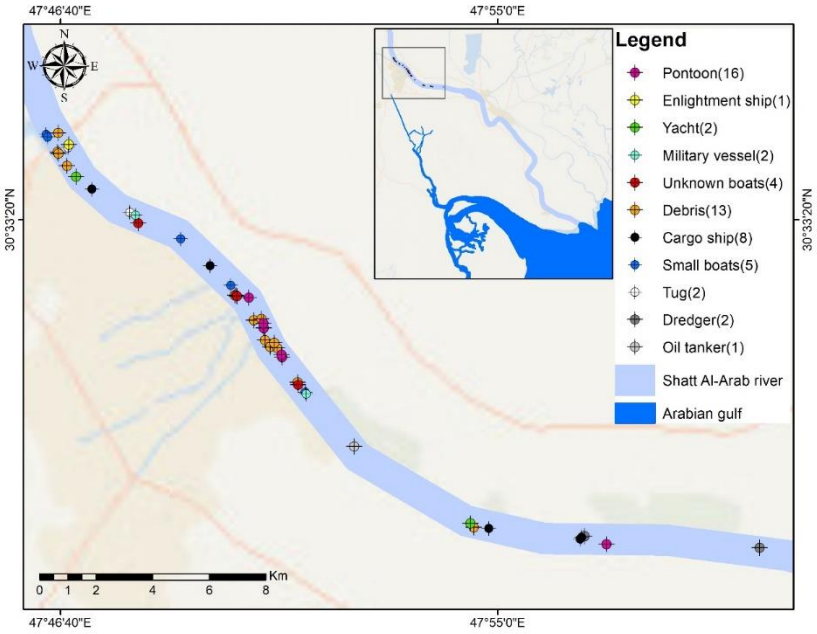


Figure 4. Distribution of shipwrecks and their types in Shatt Al-Arab River between Al-Maaqal Port and Abu-Floos Port.

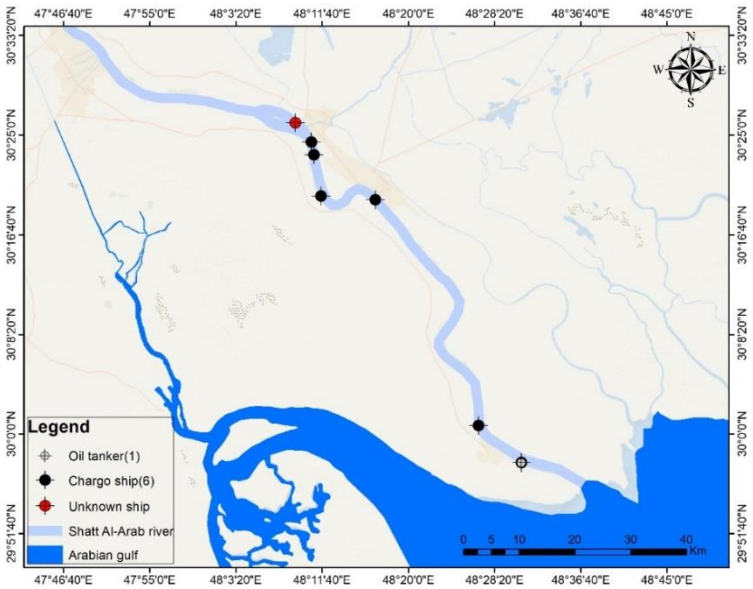


Figure 5. Distribution of shipwrecks and their types in Shatt Al-Arab River between Abu-Floos Port and the estuary of the river.

The recorded wrecks can be classified into commercial and military wrecks, as the wrecks resulted from military events during the last 44 years, during which Shatt Al-Arab River was a stage for these events, not only in Shatt Al-Arab course, but also in the internal waters, branch rivers, and Iraqi territorial water (Al-Mosawi, 2020; Audai, 2022) where there are many submerged shipwrecks with large sizes in the Khor Al-Zubair course and near Hajam island(Al-Mosawi *et al.*, 2022), which were not registered with the interested and responsible authorities represented by the General Company for Iraqi Ports

Images of the some different types of objectives identified from these surveys (in addition to some data available at the General Company for Iraqi Ports, especially with regard to the weight of some shipwrecks) are as follows:

-Military vessel with coordinates: N (30° 33' 24.52"), E (47° 48' 9.51") fig. 6 submerged, with a length of 30 meters, a width of 6 meters, a height above the bottom of 3 meters, and a weight of 350 tons. It is located at Al-Maaqal Port, quay (12).

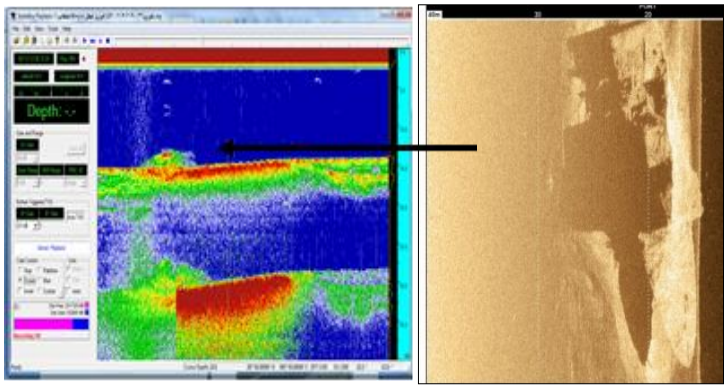


Figure 6. A military vessel at Al-Maaqal Port, quay 12, (lift) the SBP section, and (right) the SSS section.

-Ten different-sized pontoons submerged with coordinates N (30° 31′ 33.21″) E (47° 50′ 35.76″) Fig. 7, each on the right side of the river.

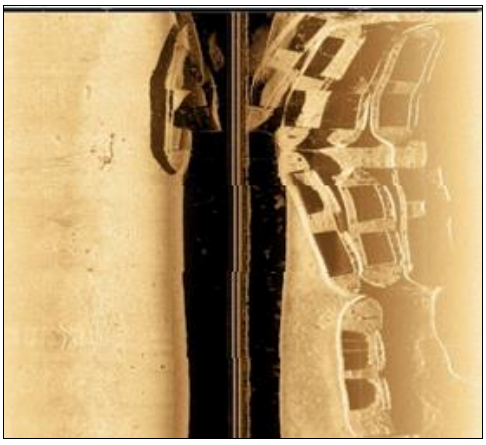


Figure 7. Ten pontoons submerged at the Al-Ashar area on the right side of the river

-A submerged boat on one of its sides with coordinates N (30° 31′37.01"), E (47° 50′ 32.87") Fig. 8, unknown, length of 40 meters, height above the bottom 3.5 meters and a submerged pontoon with a length of 22 meters and a width of 10 meters, on the right side.

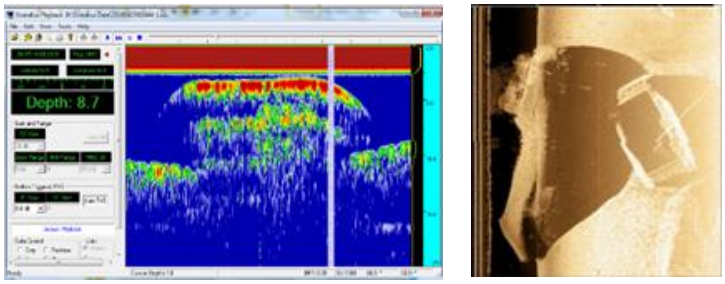


Figure 8. Unknown boat at Al-Ashar area on the right side of the river.

-Debris with coordinate N 30° 34´ 12.95" E 47° 46´ 48" fig. 9 represents the remaining part of an old bridge connecting Sindbad Island to the Najibiya area The length of this bridge is 25 meters a width of 9 meters and a height of 10 meters.

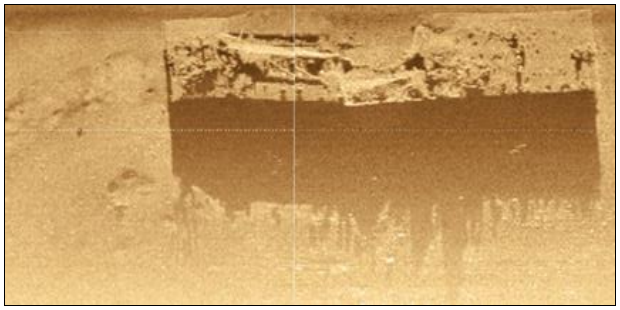


Figure 9. Debris to the old bridge between north of Sindbad Island.

-Marine debris representing the remains of the Rose Wood Cargo Ship with coordinate N 30° 28´ 16.90" E 47° 54´ 33.01" fig. 10. The length of this boat is 50 meters a width of 9 meters and a height of 6 meters both of them stable on the base.

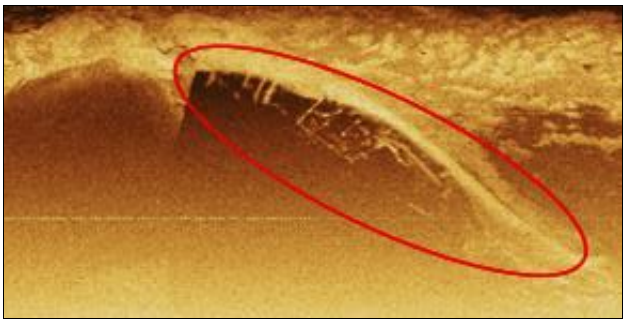


Figure 10. Marine debris representing the remains of the Rose Wood Cargo

-Boat partially buried in the sediments with coordinate N 30° 30´ 37.22" E 47° 51´ 12.35" fig. 11. The length of this boat is 20 meters a width of 3.5 meters and a height of 1.5 meters stable on the base.

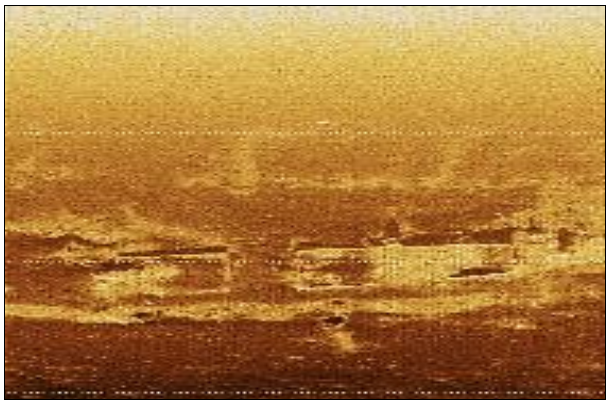


Figure 11. The boat was partially buried in the sediments

- The wreckage with coordinate N 30° 31´ 18.65" E 47° 50´ 44.97" fig. 12 represents the remains of the old Tanuma Bridge.

Figure 12. The wreckage represents the remains of the old Tanuma Bridge

-Al-Thawra Yacht wrecks (Iraqi yacht) with coordinate N 30° 34´ 2.34" E 47° 46´ 58.3" fig. 13. The length of this boat is 60 meters a width of 8 meters and a height of 4 meters with a weight 600 tons and it is stable on the right side. It was sunken in 2003.

Figure 13. Al-Thawra Yacht wrecks

- Al-Sehaila (Iraqi oil tanker) with coordinates N 30° 29´ 36.71" E 47° 52´ 16.29"fig. 14. The length of this boat is 102 meters a width of 16 meters and it is stable on its base. It was sunken in 2003.

Figure 15. Gulf Hero (Panama Cargo ship) wrecks.

Figure 14. Al-Sehaila (oil tanker) recks

- Gulf Hero (Panama Cargo ship) with coordinates N 30° 33´ 50.3" E 47° 47´ 16.44" fig. 15. The length of this boat is 150.63 meters a width of 18.86 meters and a height of 8.6 meters with a weight of 4877 tons it is stable on the right side. It was sunken in 1980

The Morpho-sedimentary effect of the shipwrecks

In some countries of the world, the study of shipwrecks is a passion, especially for shipwreck sites of historical or archaeological significance, and in some places, shipwrecks are included in tour programs. Conversely, these sites can create serious risks to coastal and river infrastructure, shipways, and even shore users. In the case of Shatt Al-Arab River, the SBP sections at many shipwreck sites were accomplished to identify these shipwrecks' effect on the riverbed's sedimentary status (Figs. 16, 17, and 18).

The sections showed beyond doubt that these wrecks have an impact on the morphological and sedimentlogical situations of the river bed represented by sedimentation processes, which represent sites of the low river current, and scoring sites of the high river current is due to the wreck impact. In addition to SBP sections, satellite images were used for many years to monitor the impact of some shipwreck sites on the morphological status of the river near the bank sites (Fig. 19), the figure explained that the presence of these wrecks, especially the large sizes, made a significant change in the shape of the river banks during many years through their retention of sediments.

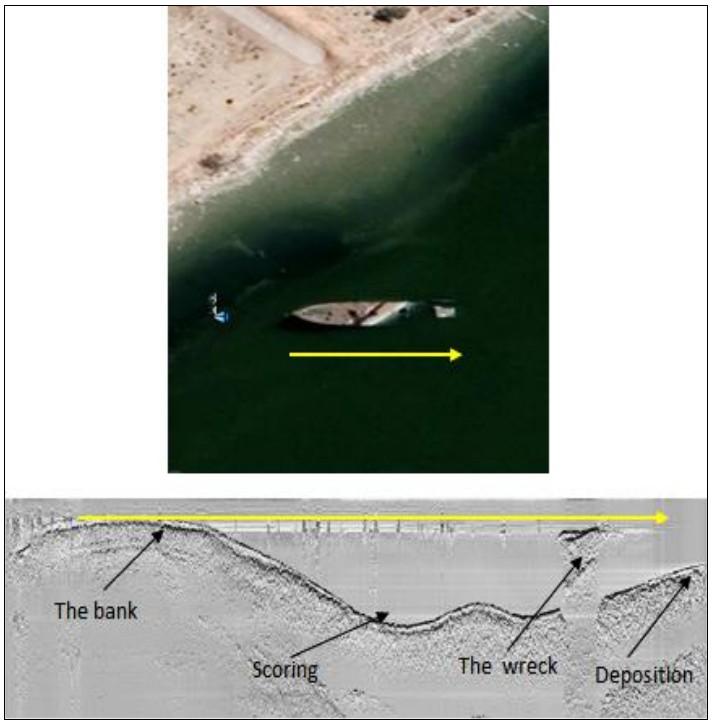


Figure 16 Change in the morphology of Shatt Al-Arab bottom represented by scoring and deposition caused by the wreck of Station 4, the yellow arrow represents the direction of the SBP survey line.

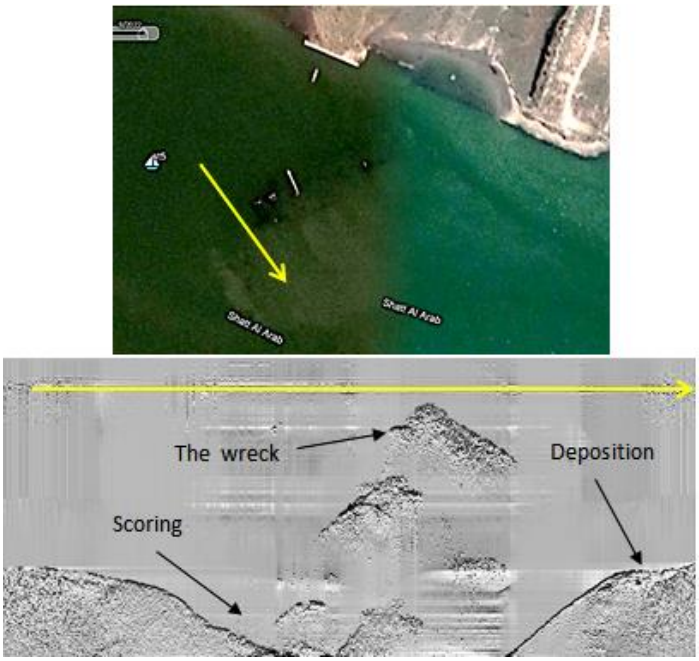


Figure 17 Change in the morphology of Shatt Al-Arab bottom represented by scoring and deposition caused by the wreck of Station 5, the yellow arrow represents the direction of the SBP survey line.

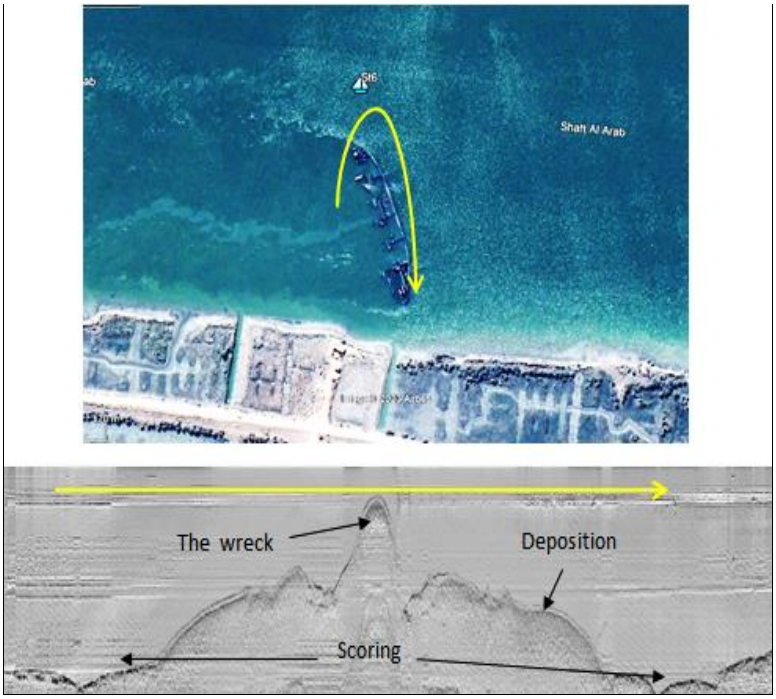


Figure 18 Change in the morphology of Shatt Al-Arab bottom represented by scoring and deposition caused by the wreck of Station 6, the yellow arrow represents the direction of the SBP survey line.

Many shipwrecks were identified in Shatt Al-Arab course where these debris and shipwrecks serve as barriers that trap and accumulate river sediments in their vicinity. These apparent and sunken shipwrecks and debris represent major environmental pollutants through their large size, interception of the river flow, their load, and the way they sank. Therefore, the underwater obstacles contributes to changing the Thaloq Line (the international river line border between Iraq and Iran). Additionally, these obstacles affect the use of the navigation channel, as they hinder the use of the channel for navigation purposes, especially for medium and large-sized ships.

In recent years, due to the decrease in the discharge and then the decrease in flow energy of Shatt Al-Arab River, these underwater obstacles have been increased due to the accumulation of sediments around them. The failure to remove shipwrecks leads to their partial or complete burial under sediments, making it extremely difficult to remove them in the future

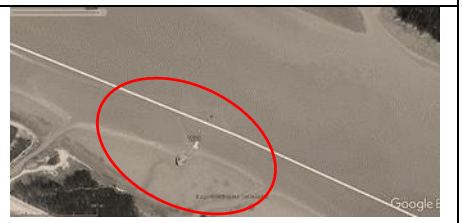
Shipwrecks details	2004	2021	2023
E 48°34´27.08" N 29°56´40.00" Skeam Nose (cargo ship), with 151m length, 19.28m width and 15.5 height, weight 8699 tons, it's from British and sunk in 1980, stable on its base.			
E 48°30'52.73" N 29°57'34.72" Tenin (Oil Tanker), with 183m length, 32.5m width and 12.5 height, weight 6200 tons, it's from Caprice and sunk in 1980, stable on its base.			
N 30° 23´ 20.41" E 48° 10´ 51.81" Two shipwrecks (cargo ship, with 141m length, 22m width and 9 height, weight 6500 tons), (Media, Indian cargo ship, with 128m length, 20m width and 8 height, weight 5800 tons		 2011	
N 30° 29´ 36.71" E 47° 52´ 16.29" Station 4 Al-Sehaila (Iraqi Oil Tanker), with 102m length, 16m, sunk in 2003, stable on its base.		 2016	

Figure 19 Sedimentary and morphological effect by shipwrecks which recorded for many years.

Conclusions

The current study revealed that there were 66 distinct sites for these wreck targets, some sites contained more than one wreck. The targets identified were medium and small boats, tankers, pontoons, bridge structures, tugs, unknown wrecks, and many shipwrecks were discovered wholly submerged in the river. The number of targets in the section extending from Al-Maaqal port to Abu Floos port is more than any section of the river because of the human river activities. There are a lot of targets are not recorded in the data at the General Company for Iraqi Ports
SBP sections and satellite imagery have shown that the presence of many shipwrecks, especially huge volumes, made a significant change in the shape of river banks over many years by trap sediments and this was associated with the decrease in river drainage and the inability of the river's energy to transfer the sediment to long distances. Thus the latest significant changes in the shape of the river bottom and if it is not recovered the effects will be greater on the morphology of the river. Not just that, but the presence of these wrecks causes obstruction of river traffic and may cause danger to large boats as well as causing pollution of the river.

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