MARITIME STRATEGIC EVALUATION FOR ISRAEL 2021/22

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A Model for an Israeli Academic Marine Monitoring System

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The prosperity and safety at sea of many coastal nation-states are associated with the maritime domain in their region. For several decades, maritime domains have undergone a significant process of geopolitical and environmental changes (Bueger, 2015; Bueger & Edmunds, 2017). Demographic growth and rising living standards are constantly increasing the pressure on the marine environment, forcing it to generate resources, and contributing to the shift away from land-based resources to find new resources at sea (Tournadre, 2014). The discovery of new resources and the technological development that allows them to be extracted increases the economic importance of Exclusive Economic Zones (EEZs) (Katsanevakis et al., 2015). In recent years, the use of the maritime domain for various purposes has increased. This is due to increased demand for the uses and activities that have historically existed in the area, such as sports and recreation, as well as fishing and shipping, and as a result of the emergence of new key players on the scene; primarily the discovery of natural gas and subsequent activities related to the extraction and processing of gas. The increasing pressure on the maritime domain such deliberate oil spills (Polinov et al., 2021) and the exploitation of its resources (Kark et al., 2015) as a result increase the pressure on the marine ecosystem (Halpern et al., 2008, 2015). The marine ecosystem provides critical services and functions as the basis for many human activities at sea (Cheung et al., 2009). It is home to a variety of marine species and provides ecosystem services such as stocks of marine food for fisheries and water for desalination, as well as regulatory services such as fertilizer processing and CO_2 sequestration (Planning Administration, 2016) to increase Israeli maritime security (Fig. 1).

Maritime security has been a buzzword in recent years (Bueger & Edmunds, 2017), while climate change and pandemic are among the main factors that weaken the maritime security of coastal countries (Agarwala & Polinov, 2020; Germond & Mazaris, 2019). State Maritime Safety achieves its meaning through identifying the participants in the process, identifying existing and potential problems and acting out of the desire to find approaches and solutions for them, while the practical meaning will always vary depending on the real situation. Therefore, striving for a universally acceptable definition of maritime safety and technological platforms is counterproductive (Bueger & Edmunds, 2017).

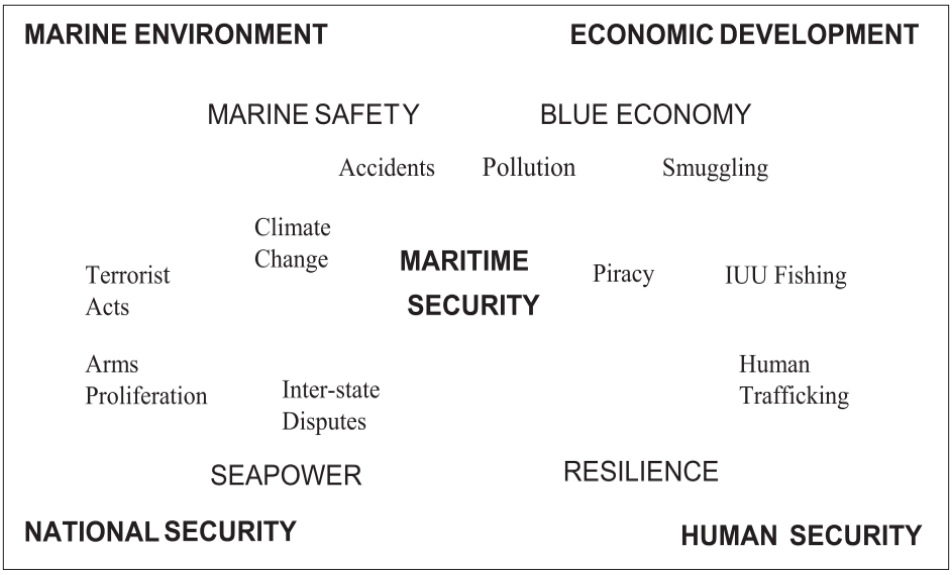

Figure 1: Range of threats for Israeli maritime security that the National Maritime Monitoring System should track (Bueger, 2015)

In this article, we try to develop geospatial concept to deal with the multilingualism of the concept, with a focus on Israel's maritime realm. The current model, based on a study of existing monitoring systems such as the Sea Coastal Monitoring System, is a consortium of supercomputers for modeling and managing large databases, whose members include Italian universities, national research centers, and private enterprises and is engaged in a wide range of research (Serra, 2021).

Israeli Maritime Security

Israel's EEZ area in the Mediterranean is about 24,000 km^2 (vs 20,500 km^2 according to the 1967 Israel border) and can meet many of the needs of society, the economy, and the environment (Planning Administration, 2020). It contains enormous potential energy resources, is a major source of domestic water production, and also contains valuable natural and heritage resources (Rettig, 2017). The maritime domain is the main commercial and infrastructure bridge to the rest of the world and can be seen as a future land reserve for infrastructure development and perhaps even urban development. At the same time, the sea area is also Israel's "blue lungs," offering vast open seascapes and opportunities for recreation and entertainment (Gour Lavie, 2018). In recent years, marine domain, due to nascent human activities, has become an arena of conflict between these uses and the natural and heritage resources it

harbors (Fröhlich, 2016; Kark et al., 2015; Laubier, 2005). Moreover, the technological improvement increases the more complicated (Chorev, 2020). However, there has been no overall maritime planning so far, and there are currently no strategies about this area, especially when compared to the level of administrative concern and planning efforts set aside for the land-based portion of Israel (Technion, 2015).

This article presents a conceptual model of regional monitoring system of the sea-neighboring territories of Israel based on modern methods of remote sensing of the sea and data processing in Geographic Information Systems (GIS), with the main goal of ensuring the range of threats to Israel's Maritime security.

Israeli Academic Marine Monitoring System (IAMMS)

The proposed IAMMS aims to develop long-term knowledge in the field of oceanography, oil and gas, marine environment, regional security and foreign policy, mobility of goods and people, maritime law and security, with a focus on relevant areas for Israel's maritime security (see Fig. 2):

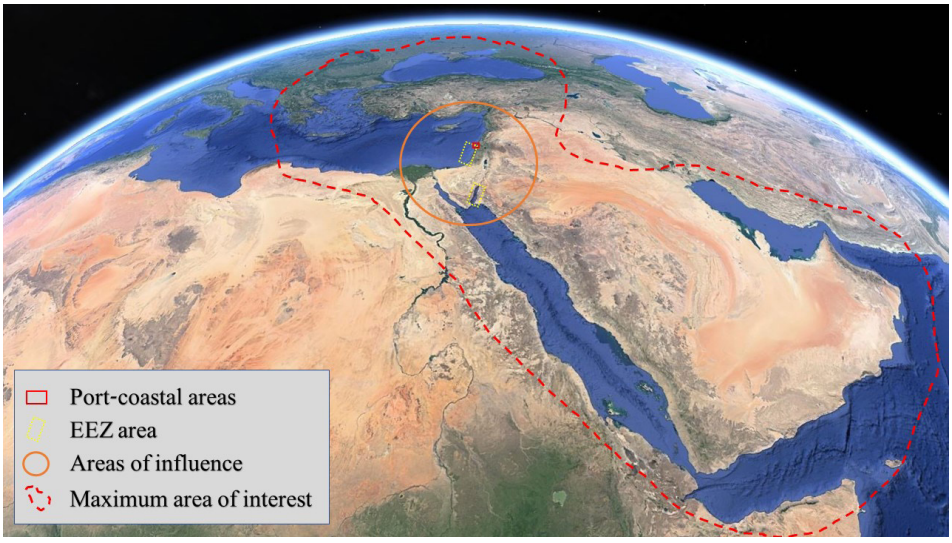

Figure 2: Proposed areas for the Israeli Maritime Environmental Monitoring Program

1. Ports/coastal area: an area with high sensitivity due to the presence of a large number of infrastructures important to the state, dense populations along the coastlines.
2. EEZ: an area in which Israel has the full right to extract useful natural resources, but also because of "freedom of navigation" all types of ships are free to sail

through this area. Due to the dominant southwestern currents, the coastal zone is heavily influenced by various processes in this area.

3. Area of influence: the different types of processes of origin in this territory in many cases do not have a direct impact, but rather have an impact indirectly through political and economic processes, for example, Turkish geophysical research in the EEZ of Cyprus.
4. Security: remote areas in which Israel is conducting activities that can have a significant impact on Israeli maritime security. An example is the Iranian attack on ships (with Israeli ownership) in the Persian Gulf and the impact of these attacks on the freedom of navigation of ships under Israeli ownership.

In 2021, the Eastern Mediterranean and surrounding regions were characterized by environmental instability. One of the oil spill incidents occurred in February 2021—an oil spill from an unspecified source (possibly an Iranian tanker that left the Suez Canal) reached the coast of Israel (Ministry of Environment Protection, 2021), without any early detection at sea, which led to severe pollution of Israeli territory. In addition, in 2021, the desalination plants stopped several times due to sea pollution, apparently due to algal blooms, also without early warning. The ongoing pollution problem of the Banias in Syria, which miraculously did not reach the coast of Israel, continued to pour oil for three months; there are also potentially dangerous sources of pollution of the sea. In most cases, Israelis and decision-makers are aware of such ecological incidents, with late forestry opportunities to react as early as possible and thereby reduce potential harm.

In the Red Sea region, the signing of the Abraham Accords brought an increase in the number of tankers shipping to the terminal in Eilat. About five oil tankers arrived in the first months of 2021 from Saudi Arabia. While we know little about the ships that arrived at the port of EAPC Eilat oil terminal and their ecological history, it is possible to say with a high level of accuracy that this made a certain negative contribution to the local marine ecology, apparently without a detailed environmental analysis and compliance with the Ministry of Environmental Protection's rules or its approval, which led to the suspension of work. At the same time, several kilometers away in the port of Aqaba, most of the time at least one tanker would be in the process of unloading while another one would be waiting (see Fig. 3).

Another significant incident was the Suez Canal congestion on March 23, 2021, by the "*Ever Given*" cargo ship (Fig. 4), which lasted for about a week. This instantly affected at least 400 ships and led to significant economic damage to the maritime industry ($15-17 billion), the remnants of which will appear in the global economy for a long time (Man-Yin Lee et al., 2021).

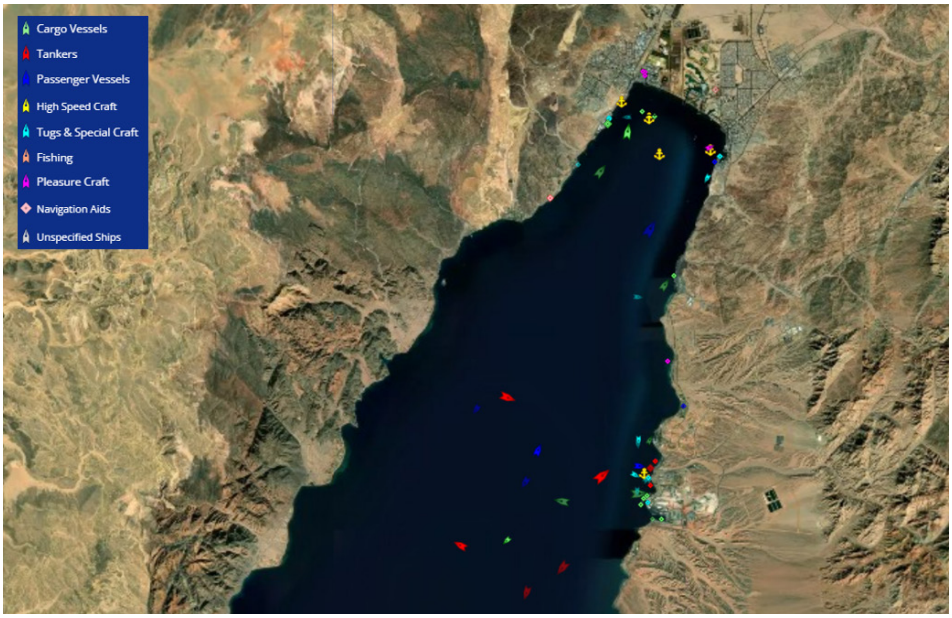

Figure 3. Vessels in Gulf of Aqaba. Red vessels represent oil tankers (source: www. marinetraffic.com, 24/11/2021, 16:00). Eight tankers in Aqaba port, zero tankers in Eilat port.

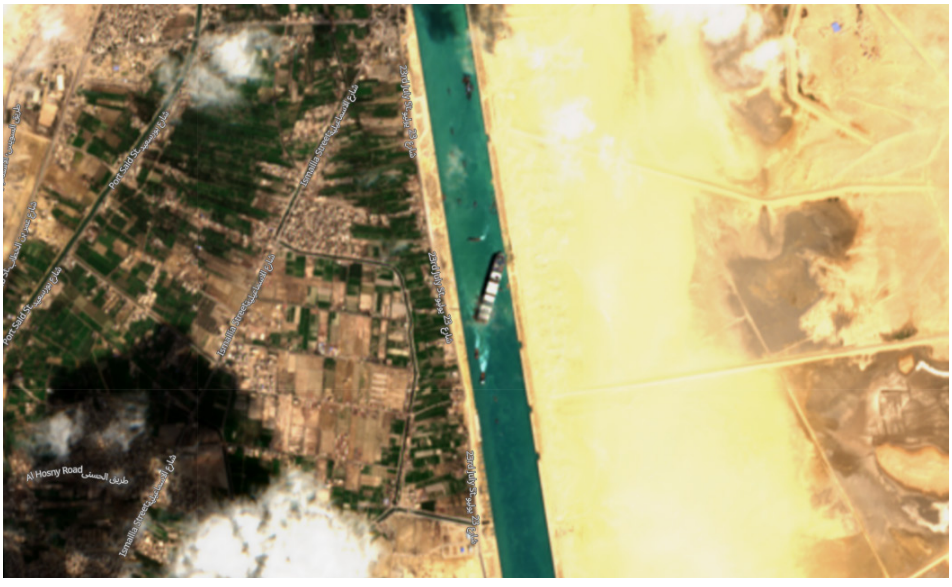

Figure 4. Satellite image of Sentinel-2 showing the "*Ever Given*" stuck in the Suez Canal (29/03/2021).

Overall, 2021 has been characterized by a significant increase in activity in the Red Sea region, both military and with incidents of attacks on ships as part of the Israeli-Iranian campaign and civilians.

Levels of Israeli National Monitoring Platform

- **Early detection**: Early detection of events in the marine environment that could affect the national security of Israel: desalination, seawater quality, port management, protection of seabed infrastructure, mapping the impact of various maritime activities—all highly dependent on the seawater quality.
- **Validation**: A remote sensing platform could be used as a validation method for the processes that take place in the marine domain.
- **Evaluation**: Evaluation of short-term and long-term marine environmental processes, such as sea surface temperature (SST) or sea salinity.
- **Analyzing**: Spatial and temporal processes analysis in nearby areas that could potentially affect Israeli maritime security.

Methodology

The proposed IAMMS describes the general principles of the system with the main purpose of integrating, maintaining, and supporting monitoring, planning, legislation, research, and study of processes in the seas and oceans for the various strategic needs of Israel. The purpose of this platform is to collect relevant information based on various data sources such as remote sensing, buoys and data processing using Geographic Information System (GIS) methods for efficient and fast spatial and temporal monitoring of Israel's marine environment in the Mediterranean Sea and the Red Sea.

Remote Sensing

Remote sensing is the process of detecting and monitoring objects and their physical characteristics by measuring reflected radiation at a distance (usually from satellites, aircraft, and drones) without any physical contact. An important aspect of remote sensing is the "footprint/spectral signature" of the particular object. By constant monitoring of a certain area with the uses of spectral analysis techniques, it is possible to determine in advance various physical changes of the object even before the human eye can observe these changes. The current number of satellites and their support systems, with daytime time coverage and a high spectral and geometrical resolution, currently monitors a variety of objects, regardless of weather conditions. Organizations such as NASA and the European Space Agency (ESA) provide free

public domain satellites, thereby allowing them to observe and provide results in near real-time.

Sentinel-1

This mission is composed of a constellation of two satellites, Sentinel-1A and Sentinel-1B, which share the same orbital plane. They carry a C-band synthetic-aperture radar instrument that collects data in all kinds of weather, day or night. This instrument has a spatial resolution of down to 5 meters and a swath of up to 400 kilometers.

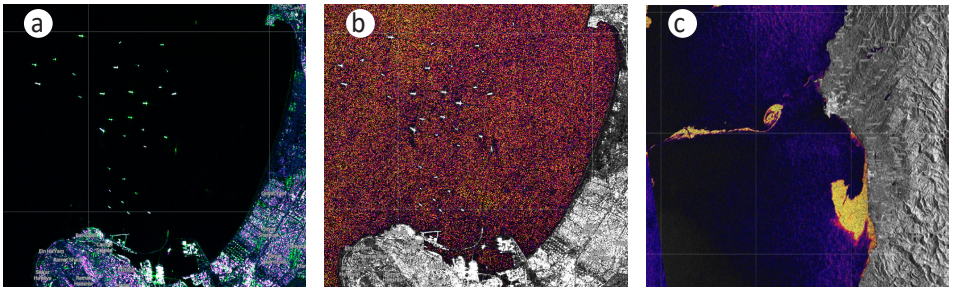

Figure 5: Sentinel-1 images of Haifa Bay (left and center) and detection of the oil spill from the Banias Refinery (Syria) during August–September 2021 (right). The left figure enhances the urban area, center, and right figures by using a mathematical index for the detection of oil spills (right) and algae bloom in Haifa bay (center)

As shown in Figure 5, it is possible to distinguish ships in the port area of Haifa, despite weather conditions. Using mathematical indices (Figure 5 [right]), it is possible to analyze the content of the pollution (oil, algae, etc.) in seawater. With a repetition time of approximately two to three days in Israeli latitudes, Sentinel-1 images allow Israel to perform constant spatial and temporal analysis.

Sentinel-2

The Sentinel-2 satellite carries a single multispectral instrument with thirteen spectral channels in the visible/near-infrared and short wave infrared spectral range.

Within the thirteen bands, Sentinel-2 images provide a wide range of coastal and marine observations. The ten-meter spatial resolution of RGB channels allows object detections with a size larger than ten by ten meters (see Figure 6). Moreover, information gathered in "Infrared" and "Short Wave Infrared" spectrums can be applied in marine environmental monitoring, disaster management, and mapping of human footprint.

Figure 6: Sentinel-2 RGB image of Syrian Tartus port

Sentinel-3

Sentinel-3 is a multi-instrument sensor that focuses on ocean surface topography as well as land and sea surface temperature. The platform carries the Sea and Land Surface Temperature Radiometer (SLSTR), the Ocean and Land Color Instrument (OLCI), as well as a Synthetic Aperture Radar (SAR) and a Microwave Radiometer (MWR).

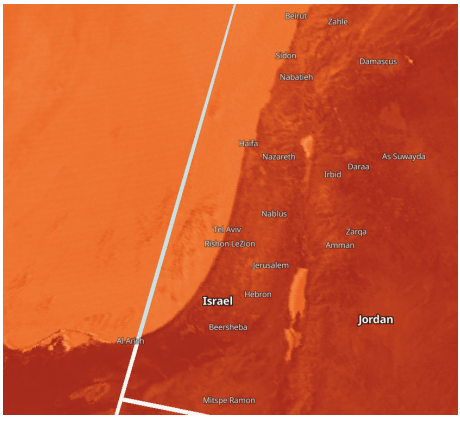

Figure 7: Sentinel-3 provides sea surface temperature globally on daily basis. Spatial resolution is 300 meters per pixel

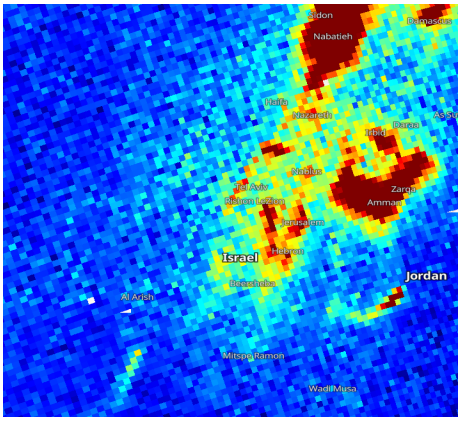

Figure 8: Air pollution (NO_2) over Israel derived from Sentinel-5. Spatial resolution is approximately 5.5 kilometers by 3.5 kilometers per pixel

Sentinel-5

Sentinel-5 is focused on air quality and composition-climate interaction with the main data products being O_3, NO_2, SO_2, HCHO, CHOCHO, and aerosols. Additionally, Sentinel-5 will also deliver quality parameters for CO, CH_4, and stratospheric O_3 with daily global coverage for climate, air quality, and ozone/surface UV applications.

Nighttime Lights

Remote sensing of nighttime lights (NTL) offers a unique ability to monitor human activity from space during the night by measuring low lights. Since the 1990s, many studies have taken advantage of the ability to monitor artificial lights from space and quantify the relationships between human activity and other variables or nighttime brightness, as well as quantify the extent and rate of human activities (see Fig. 8). In the past decade, nighttime light remote sensing images show significant application potential in the marine domain, such as mapping shipping activities (Zhong et al., 2020). The Visible Infrared Imaging Radiometer Suite (VIIRS) instrument is considered to be one of the most popular in the academic field with a spatial resolution of 350 to 750 meters.

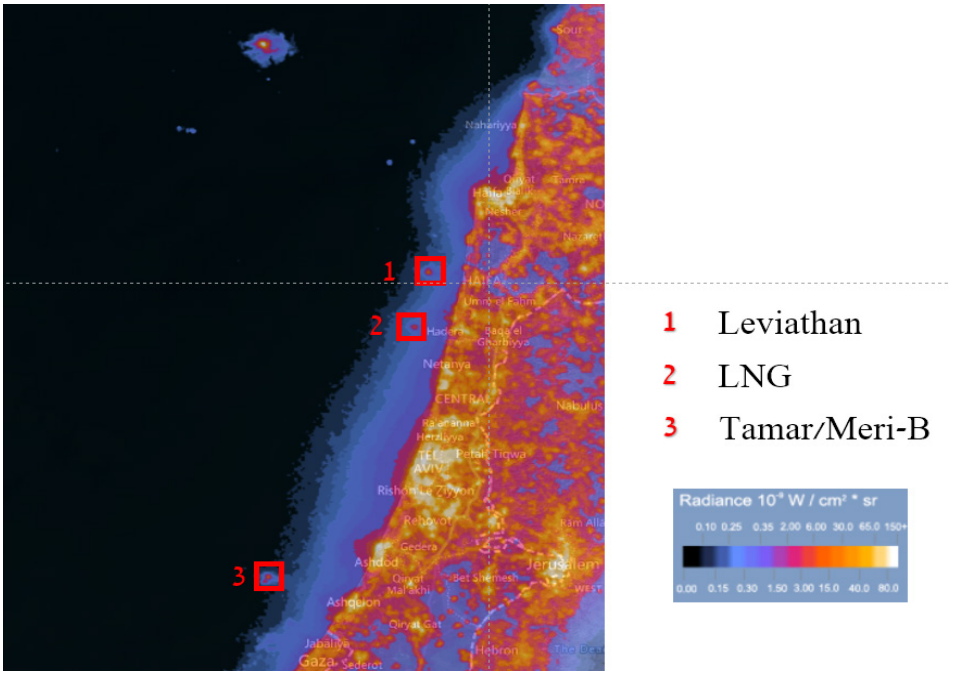

Figure 9: Average NTL over Israel EEZ in the Mediterranean Sea in 2020

As presented in Figure 10, NTL data indicated a stable amount of NTL from 2013 to 2019 and two periods (end of 2018 to end of 2019, middle of 2020 to August 2020) of a significant decrease in the overall sum of NTL produced in the vicinity of the exploded Beirut dock, which points to an attempt to lower the nighttime lighting in the area. Using suitable computer systems and creating logical laws, such changes can be detected in real-time.

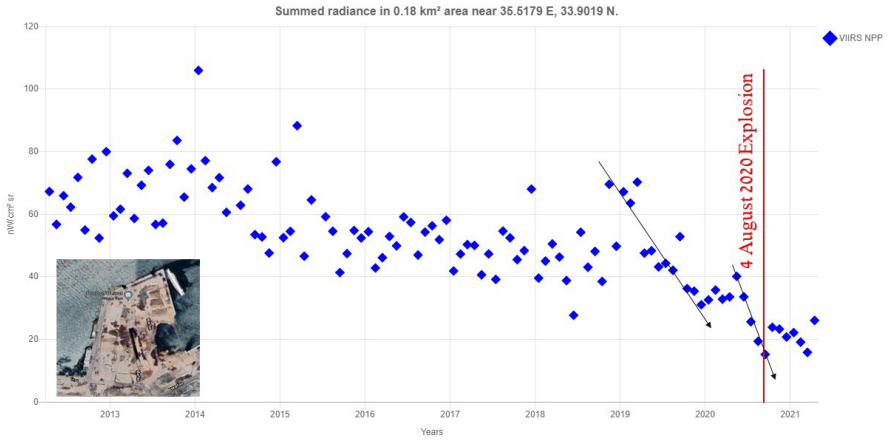

Figure 10: Analysis of NTL values above the explosion on 4 August 2020 Beirut dock, using VIIRS

Automatic Identification System (AIS)

One of the most important technological advances in the maritime industry over the past decade has been the introduction of an Automatic Identification System (AIS). Its tracking system allows—based on the GPS transmitters on the ship—free reporting of the ship's position every five seconds to five minutes. In addition, the signal includes additional information about the age of the vessel, its flag, and other stable and dynamic information. Millions of signals are analyzed using artificial intelligence and other algorithms to detect ship anomalies and avoid collisions and other accidents. The data that can be collected from AIS data can provide a broad overview of various aspects of maritime safety.

Israeli Organizations and Their Datasets

In addition to the widespread free and open access to data provided by NASA, NOAA, ESA, and other organizations, Israeli datasets should also provide free access and be integrated into such a global monitoring systems, primarily for data validation and calibration. For example, the Israeli Coastal and Marine Engineering (CAMERI) and

the Israel Oceanographic and Limnological Research (IOLR) allow limited access to the collected data for local and foreign researchers.

Besides presented datasets in this article, the IAMMS could be fed by additional datasets provided by free access such as Global Monitoring for Environment and Security (Copernicus) and European Marine Observation and Data Network (EMODnet), etc., that provides a wide range of oceanographical, physical, chemical, and biological data.

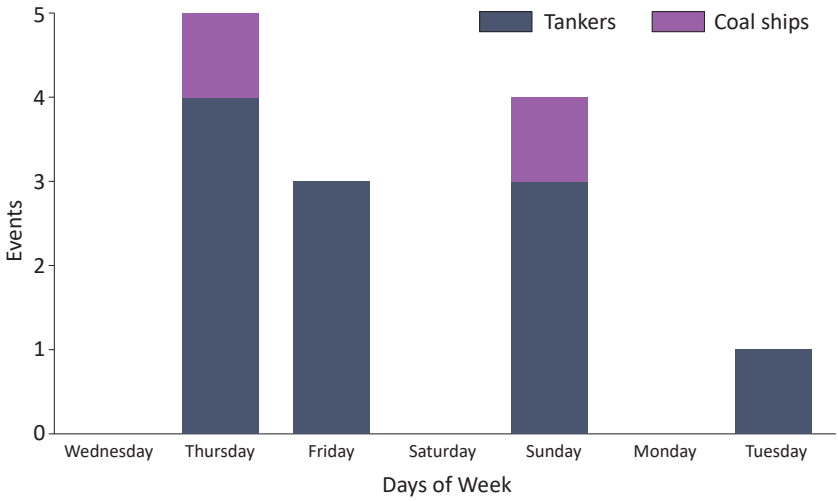

Figure 11: An example of weekly shipping statistics of the Hadera coal power plant and oil tankers in Haifa ports

Conclusion

the last two years have clearly demonstrated the global dependence on navigation. Israel, on the other hand, is in an even more sensitive environment, while it is easy to influence state security from the sea. The oil pollution of Israel's shores in February 2021 highlighted the weaknesses in Israel's maritime security in civil emergencies scenarios. Moreover, the fact that 70% of Israel's drinking water is desalinated water, which leads to a high dependence on access to clean seawater. Therefore, Israel needs to develop an independent open-access database of the Israeli maritime domain that will combine all of the methodologies and data sources: remote sensing, AIS, buoys, and other marine sensors and databases. The current development of remote sensing technologies and computational capabilities will expand the information gathered and analyzed about objects in the sea in real-time, to include

not only the location of the investigated object but also their spatial and temporal signature. GIS technologies will be used as analytical tools to perform such analysis. Such a database must be made available to a wider academic audience for research and will be instrumental in improving Israeli maritime and geostrategic research and the monitoring of deep-sea areas while facilitating the effective response to any type of event, whether it be the result of an accidental (human-made) or natural event. Finally, the findings should be open-access and transparent to international maritime organizations, governments, policymakers, and stakeholders in formulating effective strategies for monitoring the marine environment.

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