A Note on the Hellenic Territorial Waters Violations by Turkey: Assessment and Forecast

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Abstract: This note focuses on studying and forecasting the pattern of the Hellenic territorial waters violation incidents by Turkish vessels. Using the Weibull distribution as the one that best fits the historical pattern of such incidents ranging between 2009 and 2021, the paper argues that the activity of the Turkish vessels in the Aegean when violating the Hellenic territorial waters is strongly correlated with the corresponding Hellenic FIR violations in the area. The paper predicts that, for the next few years, the cases of the Hellenic territorial waters violation by Turkish vessels will exceed the figure of 200 on a monthly basis on average. One must bear in mind, however, that such a forecast will be affected by various geopolitical developments in the area, like the aftereffects of the Afghan crisis, the political and economic develoments in Turkey and the Turkish reactions to the pronounced presence of France at the expense of that of the US in the area, following the AUKUS pact.

Keywords: Territorial Waters, Greece, Turkey, Weibull distribution, Forecast

INTRODUCTION

This note aims at emphasising on the statistical dimension of the tactics followed by Turkish vessels to violate the Hellenic territorial waters. Such tactics have been accentuated during the past several years together with the increased emigration flows from Turkey and its claims

concerning the so called, “Blue Homeland”. More specifically, we intend to focus on the extent to which such repeated violation cases of the territorial waters of Greece are random or, instead, reveal a specific behaviour model or line of reasoning. To do so, we first provide a description of the data used in the analysis, while the next section offers a brief but concise description of the prevailing geopolitical setting. We then describe the technical background attempting to fit the relevant Turkish behaviour to a statistical model which will then be used to forecast this behaviour in the future. Finally, the results and the conclusions drawn are presented in the last section of the paper.

THE DATASET DESCRIPTION

The dataset covers 13 years (Jan. 2009 up to Sep. 2021) as provided by the Hellenic National Defence General Staff and reports the six-mile Hellenic territorial waters violation incidents by Turkish fighting ships and coastguard vessels on a monthly basis[1]. Thus the dataset includes 153 observations ranging between January 2009 and September 2021, as depcted in Figure 1 and Table 1.

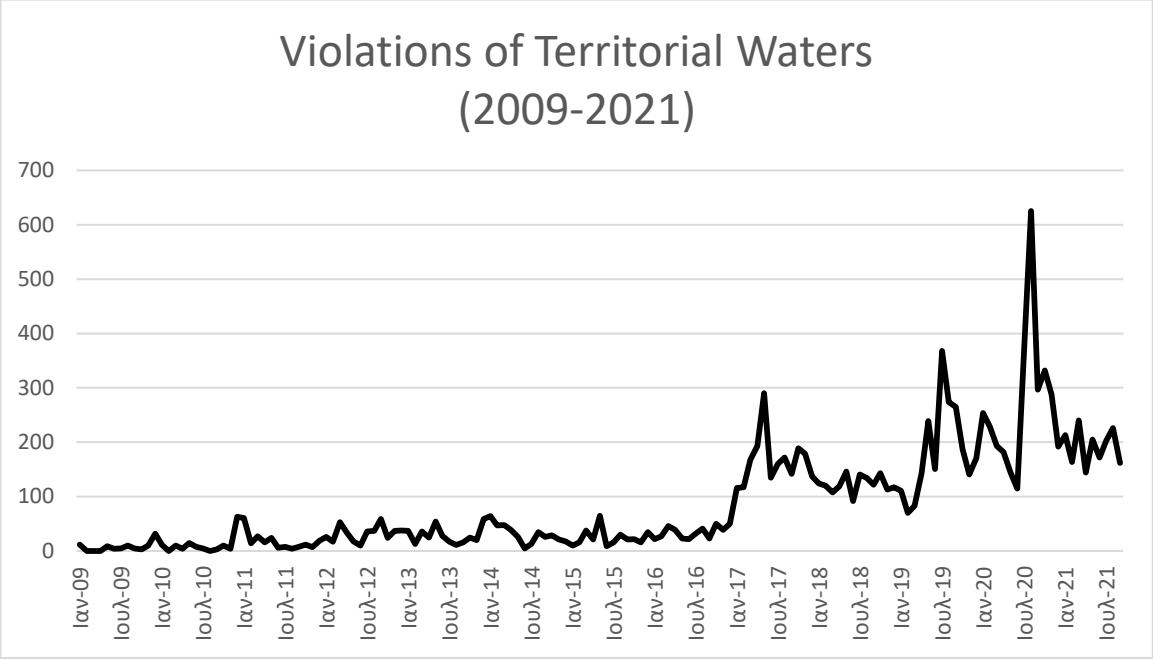

FIGURE 1. The overall picture at a glance, Source: Hellenic National Defence General Staff.

[1] https://geetha.mil.gr/en/violations/violations-of-territorial-waters/

TABLE (1). A brief descriptive summary of the monthly dataset, source: Hellenic National Defence General Staff. https://geetha.mil.gr/en/violations/violations-of-territorial-waters/

Period: Jan-2009-Sep-2021	**Violation Incidents of Hellenic Territorial Waters**
Total Incidents	12,869
Total Months Observed	153
Monthly Minimum	0
Monthly Maximum (outlier)	625
Second Monthly Maximum	368
Monthly Mean	84
Monthly Standard Deviation	97
1st Monthly Quartile	16
3rd Monthly Quartile	141
Interquartile Monthly Range	125

Averaging the data on a per-month basis, the following graphs (Figure 2 a, b) show a significant rise of all July and August observations of each year, obviously due to the favourable weather conditions usually prevailing during these months. This difference can be supported using statistical hypothesis testing, but we feel that this conclusion can be readily reached just by observing the per-month graphs.

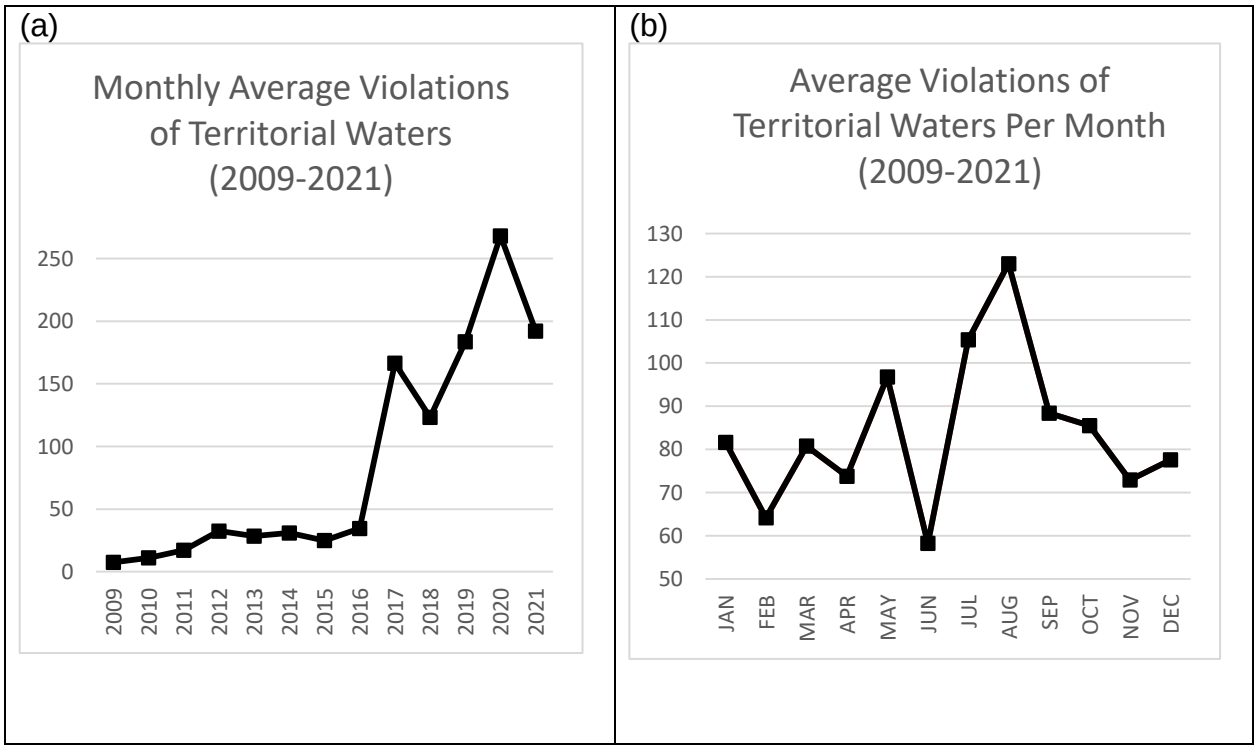

Figure 2. Monthly Averages, source: Hellenic National Defence General Staff.

A compehensive picture of the activity regarding Hellenic territorial waters violation incidents by Turkish vessels may be provided by using a histogram (Figure 3) to depict the general distribution of the data. One can observe an extreme outlier (Aug. 2020) of 625 such incidents, the second maximum being 368.

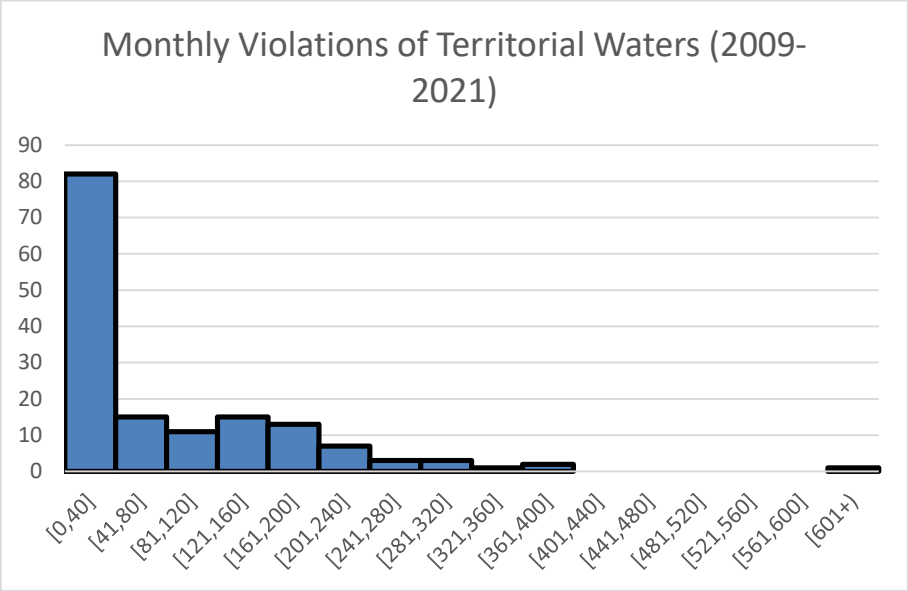

Figure 3. Frequency of Hellenic Territorial Waters Violation Incidents, source: Hellenic National Defence General Staff.

TRACING THE REASONING FOR OFFENSIVE BEHAVIOUR BY TURKEY

The issue of the Turkish claims against Greece and, particularly, the way in which such claims are expressed has been a popular issue in the literature (Sezgin, 2004, Andreou and Zombanakis 2006, Katsaitis et al. 2019). The focus on the pattern of such a behaviour, though, seems to have been neglected with the conclusions derived from such a focus not appropriately assessed. Symeonidis and Zombanakis (2020) have dealt with the Hellenic FIR violations by Turkish aircraft. However, violations of Hellenic airspace is not the only form of pressure exercised by Turkey. Turkish aggressiveness has extended in the Aegean Sea in the form of violation of Hellenic territorial waters by Turkish vessels, with the latest form of pressure being the dispatch of drill-ships in the Aegean, which Turkey calls “Blue Homeland” and the eastern Mediterranean. The summer of 2020 developments in the Aegean have been indicative of the extent of the tension that can prevail is such cases. Over and above such friction incidents, however, remains a permanent, albeit equally menacing source of threat which is the massive inflow of illegal emigrants from Turkey which is expected to culminate in the next few years following the Afghan crisis.

The research question that this note aims at tackling is how long and to what extent Turkey will be able to continue indulging in such forms of pressure against Greece having already made its presence felt in several international fronts like Syria, Libya and Iraq. The reasoning of becoming involved in such expensive military exercises is directly opposed to the considerable economic problems faced by Turkey. Indeed, the Turkish economy following a period of overheated economic growth fueled by foreign borrowing, easy and cheap credit, and government spending, now faces an excessive current account deficit together with large amounts of private foreign- currency denominated debt, a strongly devalued domestic currency and a double-digit inflation rate. Despite that, the authorities insist on consumption-led growth encouraged by very low interest rates. This means that our forecasts on the aggressive behaviour of Turkey in the area of the Aegean and the eastern Mediterranean may eventually require a downward adjustment to take into account the economic aspect of this issue, an aspect which points to a further downsizing as the latest data indicates.

The extensive Greek diplomatic and political campaign during the past few years, together with the procurement of latest technology equipment has aimed at adding to the deterrence potential of the country against the Turkish expansionary tactics followed in the context of the so-called, “Blue Homeland” doctrine. The fact remains, however, that past experience leaves little room for optimistic forecasts regarding the response of Turkey in such cases and the only question pending to answer is the time and place of such a response. By contrast, we believe that the latest developments and especially the AUKUS security pact together with the France – Greece raprochement through a recent defence agreement and the expected massive flow of Afghan emigrants will tempt Turkey to test the tolerence limits of the Greek side. Irrespective of whether the aim of the Turkish expansionary tactics is to profit from the energy resources in the Aegean and the Eastern Meditarranean, or, instead, an unobstructed access to North Africa, the pressure exercised is expected to be intense in the years to follow.

Bearing in mind the above background we feel that the mathematical and statistical model presented herewith can provide a reliable guideline for forecasting and calculating probabilities of occurrences for the Hellenic territorial waters violation cases in anticipation of the consequences of the Afghan crisis. However, its results require careful interpretation since our forecasts rely on the logistic model, which uses an exogenously determined fixed upper bound. More specifically, based on empirical and historical data, as it will be explained later on, we impose a monthly average ceiling to such incidents of 245 occurrences. This model, therefore, is especially applicable for short- and medium-term forecasts during a time-period in which the prevailing geopolitical and economic conditions are not expected to change dramatically.

THE TECHNICAL BACKGROUND

Correlation between Territorial Waters and FIR Violation Incidents

The monthly observations of the Hellenic territorial waters violation incidents show a remarkable positive correlation with the corresponding FIR violation cases for the same period (Figure 4).

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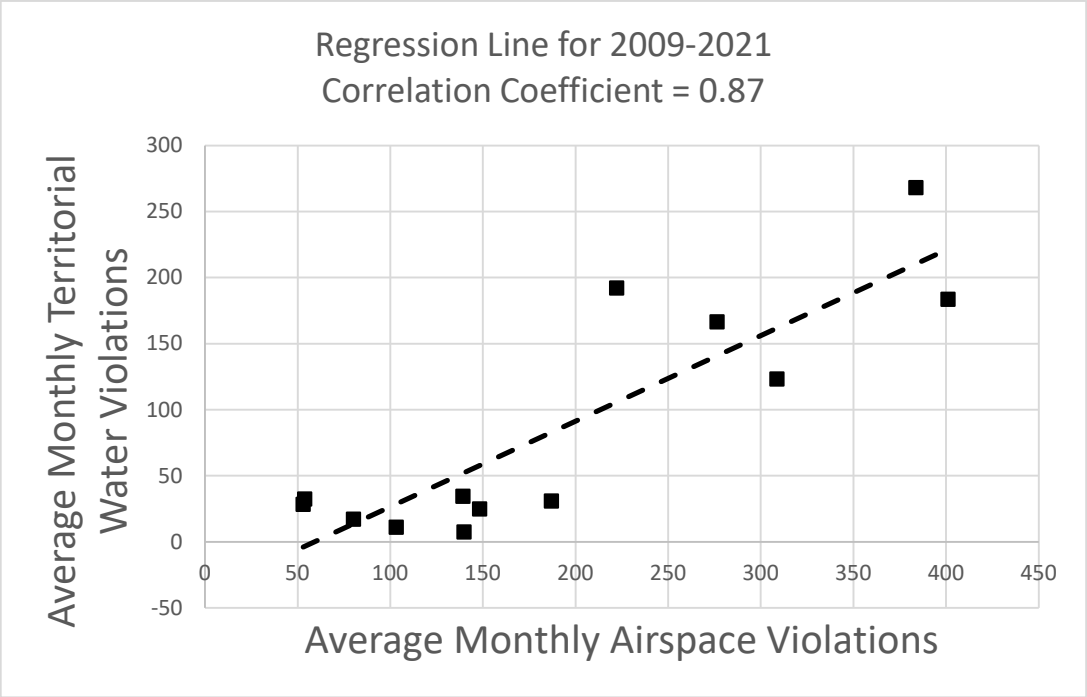

FIGURE 4: Linear regression for Hellenic territorial waters vs. FIR violation incidents for the period Jan2009-Sep2021.

The coefficient derived is $r = 0.87$, showing strong positive correlation between FIR and territorial waters violation incidents[2].

The Probability Model

Given that our research question is to investigate the statistical pattern of the Hellenic territorial waters violation cases and bearing in mind their strong positive correlation with the corresponding FIR cases, we use as a guideline earlier work on the latter (Symeonidis and Zombanakis, 2020). More specifically, based on the shape of the histogram presented in Figure 3 above, it is reasonable to assume that the Hellenic territorial waters violation incidents follow a right-skewed (positively-skewed) statistical distribution. Applying the statistical method of Hypothesis Testing for goodness-of-fit (Anderson *et al.*, 2018), we can show that the Weibull distribution (Weibull, 1951) is an appropriate choice for a model in this case.

The Probability Density Function of the Weibull distribution is given by

[2] We performed a standard hypothesis test for Pearson's correlation coefficient: The null hypothesis, H_0, states that no correlation between the two variables exists, while the alternative hypothesis H_1 states that there is positive correlation (increasing territorial waters violations are associated with increasing airspace violations). The test statistic is: $\sqrt{\frac{n-2}{1-r^2}}$, where $n = 153$ and r is the calculated correlation coefficient. This is a one-sided H_1, and we perform the test at a 5% significance level. Since the test statistic is greater than the critical value from a t-distribution $(5.80 > 1.80)$ we conclude that there is significant positive correlation and we reject the null hypohesis.

$$f(x) = \frac{\beta}{\alpha}\left(\frac{x}{\alpha}\right)^{\beta-1} e^{-\left(\frac{x}{\alpha}\right)^{\beta}}$$

where α, β are positive parameters. This distribution is widely used to model time-to-failure of components (Rinne, 2009, McCool, 2012).

The null hypothesis H_0 will assume that the monthly territorial waters violation incidents follow this distribution, with the alternative hypothesis H_1 stating the opposite. To test this hypothesis we calculate the χ^2 (chi-squared) statistic with reasonable, arbitrary chosen initial parameters α, β. This statistic is equal to $\sum_i \frac{(O_i - E_i)^2}{E_i}$, where O_i is each observed value and E_i is the corresponding expected value based on the assumed distribution.

We use Microsoft Excel's Solver in order to minimise this sum, hence optimising the parameters α, β. The solution yielding $\alpha = 71.93$ and $\beta = 0.7209$ means that we cannot reject the null hypothesis at the 5% significance level.

The importance of this result in forecasting the pattern of the Hellenic tarritorial waters violation incidents by Turkey is illustrated as follows: To calculate the probability that e. g. in a given month we will observe a number ranging between 20 and 60 such cases, we calculate the shaded area of Figure 5 using Microsoft Excel:

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WEIBULL.DIST(60, 0.7209, 71.93, 1) – WEIBULL.DIST(20, 0.7209, 71.93, 1)
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FIGURE 5: Graph depicting the area (and hence probability) under the Weibull Distribution curve for territorial waters violation incidents.

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The result is approximately 0.256, which means that the probability of such an event is about 25%. Thus, we provide a direct, hands-on, practical tool for assessing the probability of such an event based on a series of historical data.

FORECASTING THE FREQUENCY OF HELLENIC TERRITORIAL WATERS AND FIR VIOLATION INCIDENTS: LOGISTIC FORECAST WITH UPPER BOUND

Having established the strong postive correlation between the two datasets, we will first revisit the procedure followed in Symeonidis and Zombanakis, 2020). The model used in this work is the logistic growth model. Both datasets for the period Jan. 2009-Sep. 2021 exhibit rapid growth. Linear regression could be beneficial, but we feel that it does not capture the overall data behaviour[3]. Given this behaviour, we opt for the logistic growth model, which exhibits a rapid initial rising pattern followed by a saturation based on the maximum possible cases that can be expected on a monthly basis. We, therefore, resort to a logistic least-squares fit for the average monthly data for each year. We calculate the squared differences of the actual minus the predicted values from the model and use Microsoft Excel's Solver to minimise the sum by varying the parameters in the exponent. The maximum number for the monthly incidents is an upper bound or "carrying capacity", based on empirical and historical observations.

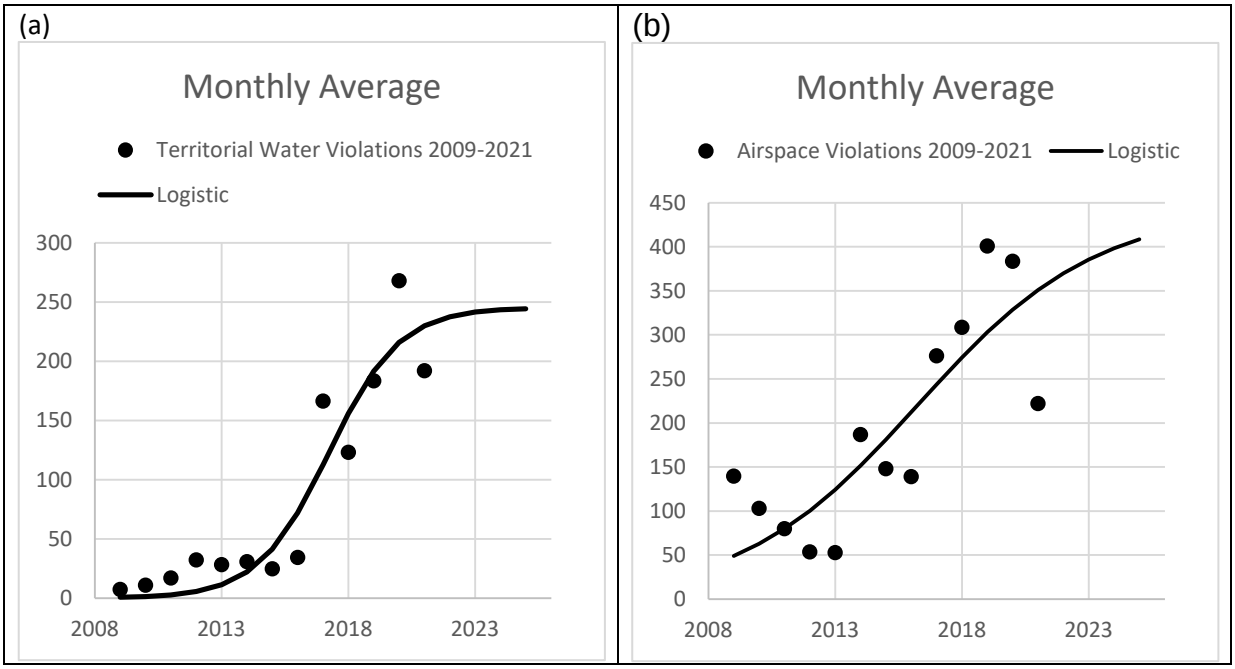
Logistic Growth Model (k, t positive parameters): $\frac{\text{Upper Bound}}{1+e^{-kt}}$

In this work we will follow a rule-of-thumb for determining the upper bound for both datasets. We will assume that the upper bound in the average monthly violation incidents can be approximated by $\frac{2}{3}$ of the historical maximum. The selection of this value as an upper bound comes as a compromise between our assumption regarding the saturation of the observations through time, and the expected consequences of the Afghan crisis in the next few years on the emigration flows pressure exercised on the Greek borders. This means that (a) for the Hellenic territorial waters violation incidents we will neglect the extreme outlier[4] of 625 and we will assume an upper bound for the model equal to $\frac{2}{3}(368) = 245$ and (b) for the Hellenic FIR violation cases we will assume an upper bound for the model equal to $\frac{2}{3}(663) = 442$. This adjusts the maximum that was used in Symeonidis and Zombanakis, 2020 in the light of recent developments in the region of Eastern Mediterranean.

[3] Although an exponential model for such increase would be appropriate for the initial part, it is probably too emphatic in terms of growth (MacKendrick *et al.*, 1912, Edelstein-Keshet, 1988, Allen, 2007). Such an option may not reflect reality due to the limited property and human resources (such as available vessels, personnel, logistic support etc.).

[4] This is a value recorded during the August 2020 crisis between Greece and Turkey and is must therefore be considered as an outlier under normal circumstances.

The models and the corresponding graphs for forecasting until 2025 are shown in Figure 6(a,b).



$$\text{Monthly Territorial Waters Violations Incidents} = \frac{245}{1 + e^{-0.718\times(Year-2017.225)}}$$

$$\text{Monthly Airspace Violation Incidents} = \frac{442}{1 + e^{-0.286\times(Year-2016.279)}}$$

FIGURE 6: Forecasting until 2025 (a) territorial waters violation incidents, and (b) airspace violation incidents, using an upper bound.

An example of the forecast works as follows: For the year 2023, the model predicts that on a monthly basis, the Hellenic territorial waters violation incidents will amount to an average of

$$\text{Monthly Territorial Waters Violation Incidents} = \frac{245}{1 + e^{-0.718\times(2023-2017.225)}} = 242$$

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DISCUSSION AND CONCLUSIONS

The aim of this note has been to study and forecast the pattern of the Hellenic territorial waters violation cases by Turkish vessels. Following specific criteria we have concluded that the historical data of such incidents since 2009 tend to fit the pattern of a Weibull distribution and are highly correlated to the pattern of the Hellenic FIR violation cases by Turkish atrcraft. Based on this finding we can now provide a tool that contributes to calculating any frequencey distribution of such occurences in the future. More specifically, we predict that, in monthly average terms, the Hellenic territorial waters violation cases will be of the order of 200 per month, or even higher. Such a forecast, however, must take into account, not just the technical aspect of model, as this is provided by the specific distribution chosen, but also, the expected geopolitical developments in the area. In particular, a great deal regarding the pressure expected to be exercised on the Hellenic sea borders will depend on the Afghan crisis after-effects and especially, on the increase in the number of emigrants pushed towards the Hellenic territorial waters. To a very large extent, such a pressure will also depend on the political and economic develoments in Turkey and the response of this country to the pronounced presence of France at the expense of that of the US in the area, following the AUKUS pact.

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