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Jellyfish Stranding in the Moroccan North-West Mediterranean Coastline

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Abstract

In the recent years, the frequency and the geographic distribution of jellyfish blooms have been increased in the Mediterranean north-west coastline of Morocco, since 2011 this area has been subjected to successive blooms and stranding of *Pelagia noctiluca*; our research was aimed to study the causes of jellyfish blooms and stranding in our coastline. We have evaluated three parameters that we are suspecting to be responsible of Jellyfish stranding on the northern coast of the Mediterranean Sea in Morocco. The evaluation of the relations between sea surface temperature, waves height and the wind direction causing the stranding of Jellyfish, demonstrated that the correlation scores was found to be statistically significant with $r(33) = 0.445$, $p < 0.01$, for sea surface temperature (°C) and $r(33) = 0.694$, $p < 0.001$ for waves height (m), moreover a one-way analysis of variance (ANOVA) was calculated on wind direction causing stranding of jellyfish, the analysis was found to be very significant, $F(1, 31) = 25.823$, $p = 0.001$.

Introduction

Jellyfish stranding one of the most important, and complicated topics that scientists all over the world are try to understand. Obviously, Jellyfish spatiotemporal dynamics are highly variable, as well blooms occur irregularly are difficult to predict [1,2]. *Pelagia noctiluca* (Forsskål 1775) most common jellyfish species in the Mediterranean waters, it is widely distributed from the warm subtropical waters of the Gulf of Mexico and the Mediterranean Sea to the temperate waters of the North Sea [3-6] and up to 4°C of latitude [7,8].

Pelagia noctiluca is an important non selective planktonic predator [9-13] feeding on almost all types of zooplankton and ichthyoplankton [14,15] in fact, Many fish compete for the same zooplankton prey as jellyfish [15], moreover fish are also predators of jellyfish, with benthic including reef fish species ingesting polyps, as well as pelagic fish species eating ephyrae and small individuals [16]. However, the declination of such fish opens up ecological space for jellyfish proliferations. Moreover, Coastal eutrophications encourage phytoplankton blooms that can ultimately lead to jellyfish outbreaks [17]. The greater tolerance of polyps and medusa than fish to low-oxygen conditions ensures that jellyfish survive, even reproduce during hypoxic events, which fish are unable to do, such 'dead zones' are thought to favor jellyfish [18]. Warmer temperatures also accelerate medusa growth and ephyrae production [19]. Jellyfish appear to be sensitive to climate variability, with their abundance being related to large-scale climate indices such as the North Atlantic Oscillation (NAO) [18], El Nino Southern Oscillation [19] and the Pacific Decadal Oscillation [20].

Material and Methods

Study area

M'Diq Having as geographical coordinates 35° 41'N 5° 19 '31 W, is a seaside resort the population lives almost exclusively on fishing and summer tourism activities, it hosts more than 100,000 tourists each year. M'Diq is located 7 km from Tetouan city, and it's bounded on the north by Fnideq municipality, on the south by Mallaliyine commune, on the west by Alleyine commune and on the east by the Mediterranean Sea. M'Diq covers areas of 480 hectares of which 153 hectares are urbanized (Figure 1). The selection of this area is based on the presence of jellyfish blooms along the beaches.

Sampling strategy

Jellyfish survey strategy used for our study was inspired of the method used by Doyle [8] for the study of jellyfish species repartition across the Irish and Celtic Sea shores. We were used to Cross daily M'Diq coastline area, while counting stranded Jellyfish species. We did use the Quadrate method to calculate the density of jellyfish stranded per square meter. The study was conducted during Jun 2011 to December 2017 (Table 1 and Figure 2).

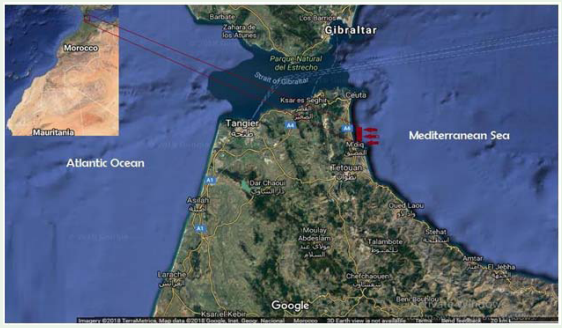

Figure 1: Geographical location of M'Diq beach our study area in the Mediterranean coastline of Morocco Google Map.

Jellyfish identification & environmental variables

Pelagia noctiluca is the only jellyfish species was found stranded in the Mediterranean north-west coastline of Morocco. We have used Russell taxonomic for the identification of the stranding jellyfish. Sea surface Temperature was recorded in situ (independent points) for each survey. In addition measures of waves height and wind direction was obtained from PREVIMER web-sites. These parameters recorded for every day of the six years were used for correlation analyses to find if they are causing Jellyfish stranding.

Table 1: Scientific classification of study sample of Jellyfish.

Kingdom:	Animalia
Phylum:	Cnidaria
Class:	Scyphozoa
Order:	Semaeostomeae
Family:	Pelagiidae
Genus:	Pelagia
Species:	P. noctiluca
Binomial name	
Pelagia noctiluca	
(Forsskål, 1775)	
Synonyms	
Medusa noctiluca Forsskål, 1775	
Pelagia perla (Slabber, 1781)	

Figure 2: Pelagia noctiluca sample (source AOUITITEN).

Cluster analysis

Part of the data obtained from the samples was statistically calculated, analyzed using Microsoft Excel software. However Pearson Correlation analysis were used to determine whether there is relationship between our quantitative variables which are sea surface temperature, waves height and Jellyfish stranding, as well as ANOVA test were used to determine if there is a relationship between our quantitative variable wind direction with Density of jellyfish stranded, this tow test were statistically calculated, analyzed and compared using SPSS software.

Results and Discussion

Physical parameters of water

Analysis of the samples of water in our zone of study has yielded several physical and chemical characteristics of the environment where *Pelagia noctiluca* stranded. Physical water measures including the temperature shows that the appearance of the jellyfish *Pelagia noctiluca* starts in our coastline at a sea surface temperature of 21°C, the maximum abundance is reached at a sea surface temperature of 25.61°C, then P. noctiluca start to disappear at a sea surface temperature of 16 °C, moreover we have observed that when the waves have the height between 1.20m to 2m, we have probably appearance of *Pelagia noctiluca* (Figure 3).

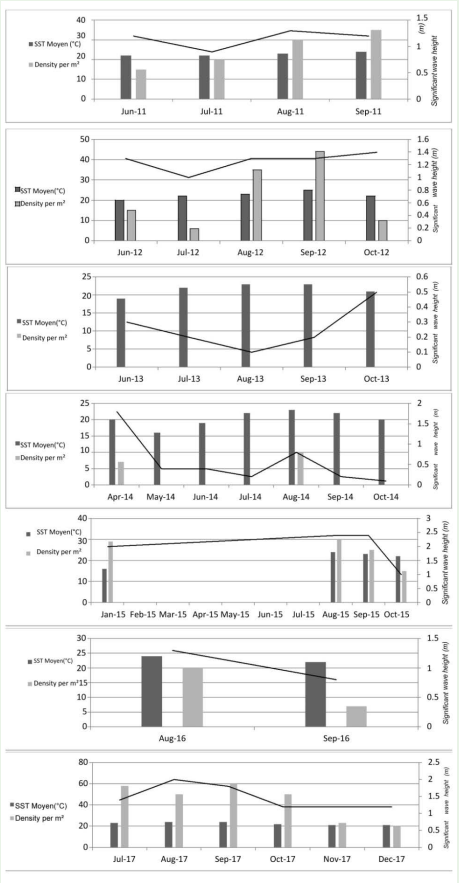

Figure 3: Monthly variation of (SST) sea surface temperature (°C), Waves height (m) and the density of jellyfish stranded per m² (from 2011 until 2017).

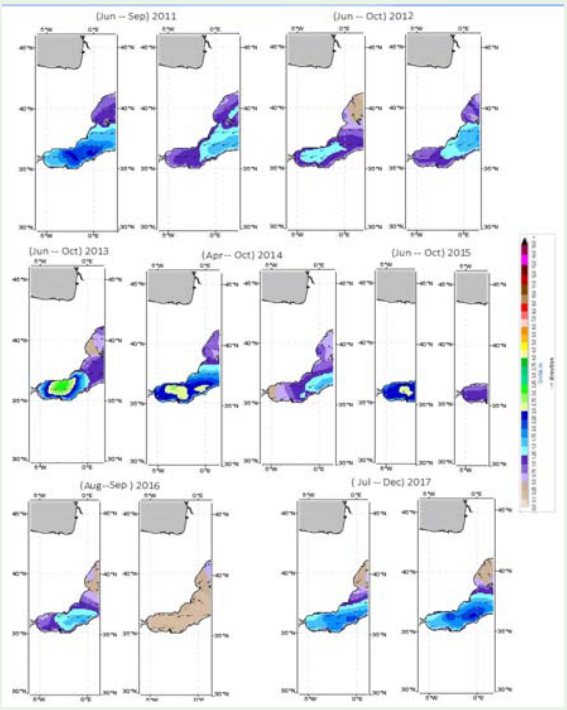

Figure 4: Satellite-derived sea-surface significant wave's height and wind direction (model WAVEWATCH III following Douglas Sea and swell scale protocol, 1921). Instrument for the stranding months from June 2011 to December 2017.

Table 2: Relation of correlation between sea surface Temperature and the density of *Pelagia noctiluca* stranded.

		Density of jellyfish stranded per m²	Sea Surface Temperature (°C)
Density of jellyfish stranded per m²	Pearson Correlation	1	0.445**
	Sig. (2-tailed)		0.01
	N	33	33
Sea Surface Temperature (°C)	Pearson Correlation	0.445**	1
	Sig. (2-tailed)	0.01	
	N	33	33

**Correlation is significant at the 0.01 level (2-tailed).

Table 3: Relation of correlation between sea wave's height and the density of *Pelagia noctiluca* stranded.

		Density of jellyfish stranded per m²	Sea waves height (m)
Density of jellyfish stranded per m²	Pearson Correlation	1	0.694**
	Sig. (2-tailed)		0
	N	33	33
Sea waves height (m)	Pearson Correlation	0.694**	1
	Sig. (2-tailed)	0	
	N	33	33

**Correlation is significant at the 0.01 level (2-tailed).

Table 4: Descriptive Relation between wind direction and the density of *Pelagia noctiluca* stranded.

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
East	23	26.7	16.463	3.433	19.58	33.81	6	60
West	10	0	0	0	0	0	0	0
Total	33	18.61	18.481	3.217	12.05	25.16	0	60

Density of jellyfish stranded per m²

Table 5: ANOVA test to determine the relationship between wind direction and the density of *Pelagia noctiluca* stranded.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4967.009	1	4967.009	25.823	0
Within Groups	5962.87	31	192.351		
Total	10929.88	32			

Density of jellyfish stranded per m²

Wind direction

We have observed that when the east wind blows on our beaches, we have probably appearance of *Pelagia noctiluca* and if it's not, we will not found any jellyfish even if the sea surface temperature is high enough to have stranded jellyfish (Figure 4).

Statistic analysis

Statistical analysis was carried out using statistical tests software package, with the intention of studying the relation between sea surface temperature, sea waves height and Jellyfish stranding. To determine whether there is relationship or not a Pearson Correlation test shows that the density of jellyfish stranded and Sea waves height have a statistically significant linear relationship $r(33) = 0.445$, $p < 0.01$ (Table 2), meaning that these variables tend to increase together (greater Density of jellyfish stranded is associated with greater Sea waves height). Moreover we have found that the relationship between the Density of jellyfish stranded and Sea waves height was a positive correlation between the two variables, $r = +0.694$, $n = 33$, $p = 0.001$ (Table 3).

A one-way analysis of variance (ANOVA) was calculated on wind direction causing stranding of jellyfish. The analysis was significant, $F(1, 31) = 25.823$, $p = 0.001$ (Tables 4 and 5). East wind cause the stranding of jellyfish ($M = 26.70$, $SD = 16.463$) more than the West wind ($M = 0.00$, $SD = 0.000$).

Conclusion

The greater sea surface temperature, important waves height and east wind direction are the three parameters causing the stranding of the Jellyfish *Pelagia noctiluca* in our zone of research, the correlation scores for all the parameters was found to be statistically significant with $r(33) = 0.445$, $p < 0.01$, for sea surface temperature (°C) and $r(33) = 0.694$, $p < 0.001$ for waves height (m) as well as a one-way analysis of variance (ANOVA) was calculated on wind direction found to be very significant, $F(1, 31) = 25.823$, $p = 0.001$.

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