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JELLYFISH BLOOMS IN THE MEDITERRANEAN

LES PROLIFERATIONS DE MEDUSES EN MEDITERRANEE

Proceedings of the II Workshop on Jellyfish
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(Trieste, 2-5 September 1987)

Actes des IIèmes journées d'étude sur les méduses
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COASTAL AGGREGATIONS OF THE JELLYFISH Pelagia noctiluca (SCYPHOZOA) IN MALTESE COASTAL WATERS DURING 1980-1986.

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ABSTRACT

The temporal and spatial distributions of coastal aggregations of the scyphomedusa *Pelagia noctiluca* around the Maltese Islands during the period 1980 to 1986 were investigated by means of sighting reports from volunteers as well as by periodic monitoring at fixed stations both offshore and onshore. The available data indicate that the outbreaks of coastal aggregations of this species started in 1980 and reached maximum densities during 1981-1983. During the period 1984 to 1985, these occurrences decreased both in duration and population density, with coastal aggregations being more frequent during March and April. Such aggregates were characterized by large numbers of small medusae, probably of recent spawning. Sexually mature medusae as well as ephyrae were however present in coastal waters almost throughout the year for the period 1981-1982. The geographic distribution of such aggregates of jellyfish in the coastal areas indicate that they are passive accumulations, the pattern of which is largely determined by the prevalent wind direction.

1. INTRODUCTION

Several species of scyphozoa have been recorded in Maltese coastal waters, including *Charybdea marsupialis, Pelagia noctiluca* and *Cotylorhiza tuberculata*. Coastal aggregations of the last two species have been known to occur. However, during the early 1980's the numbers of *P. noctiluca* in coastal waters assumed uncommon proportions both as regards density as well as geographical and temporal extent. Preliminary studies of this phenomenon were initiated in January 1982 and these eventually developed into a programme of monitoring within the framework of the MEDPOL Jellyfish Programme. The aim of this project was to identify the characteristic features of such coastal aggregations of this species and the major environmental factors associated with such aggregations.

2. MATERIALS AND METHODS

Initially, systematic population counts at six fixed coastal stations were undertaken. However, due to the high variability in the occurrence of inshore aggregations of *Pelagia*, it was virtually impossible to collect reliable data in this manner, unless the number of stations as well as the frequency of counts were substantially increased. This proved to be beyond the resources available. Therefore, volunteers were asked to report sightings of jellyfish stranded on the shore and/or in the immediate vicinity of the coastline (i.e. within 1 to 3m off the shore) as well as jellyfish sightings at sea following the methodology outlined in UNEP (1983). Shore sightings were reported by coastal touristic establishments and the Beach Cleaning Section of the Department of Tourism as well as by other volunteers using a standard report sheet. Sightings at sea were reported by the Maritime Section of the Task Force (local coast guards during their normal coastal patrolling duties). Such reports included data on the prevalent wind direction and speed. Jellyfish aggregates reported were classified as large, with more than 10 individuals per m^3, medium and

small, with less than one individual per m3. Species identification charts enabled volunteers to indicate the type of jellyfish seen.

Systematic shore sightings and counts were carried out at two fixed coastal stations: Bighi, Kalkara Bay and Haywharf, Marsamxett. The number of jellyfish stranded on the shore or within 2m off the shoreline, along a measured distance was recorded daily during 1984 and 1985 together with surface sea temperature (SST) and wind speed and direction as indicated in UNEP (1983).

Medusae and ephyrae in the plankton were sampled using plankton nets with mouth diameters 1m and 1.5mm nylon mesh for the former, and 0.5m and 200 μ nylon mesh for the latter. Nets were towed for 10 mins. at the surface at a speed of 2 knots. Samples were fixed in 5% formalin (neutral). The sampling station is indicated in Fig. 1. Seawater temperature and salinity at the surface and at 1m depth were recorded by a Salinity Temperature Bridge Type M.C.5. Water samples for nutrient and chlorophyll analyses were collected from a depth of 1m by a plastic Van-Dorn bottle. Analyses were carried out as described by Strickland and Parsons (1972) within 24h of collection.

Histological studies of the gonads of several individuals caught during 1982 were carried out as indicated by Rottini-Sandrini *et al.* (1983).

3. RESULTS

The first recent coastal aggregations of *P. noctiluca* were observed in April-July 1980 (Axiak, 1983). It is most likely that in the period 1958 to 1960, similar large aggregations of the same species were observed in local coastal waters. Although accurate population counts for the period 1980 to 1983 are not available, our reports indicate that during this time, huge quantities of jellyfish were stranded on several stretches of the coastline. Maximum densities of 30 individuals m^{-3} in the sea and 50 individuals m^{-2} on shore have been recorded. The animals varied in size from 3 to 12 cm umbrella diameter.

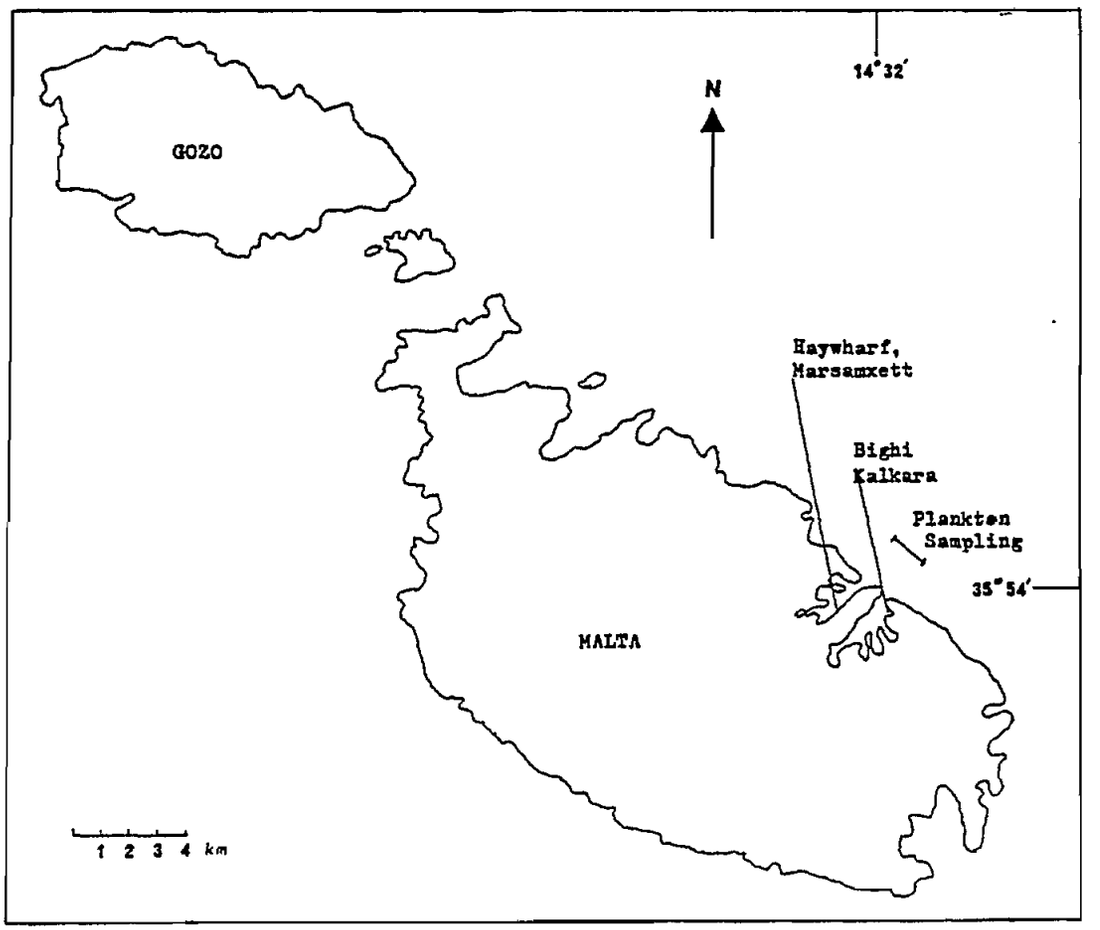

Fig.1. Locations of stations for shore counts and plankton sampling

Table 1. Montly occurrence of coastal aggregations of *Pelagia noctiluca* in the various sectors as indicated in Fig.2.. Densities reported as high (H), medium (M) and low (L) or none (-). For further explanations see text.

	SECTOR																
1984	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Jan	-	-	-	-	-	-	-	-	-	-	H	-	-	-	-	-	-
Feb	-	-	-	-	-	-	-	-	H	-	-	-	-	-	-	-	-
Mar	-	M	-	H	-	H	-	H	H	-	M	L	-	H	-	-	L
Apr	H	F	-	-	M	L	-	H	H	H	H	H	-	-	-	-	H
May	L	M	-	-	-	-	-	-	L	-	-	-	-	-	-	-	H
Jun	-	-	-	-	-	-	-	-	L	-	-	-	-	-	-	-	L
Jul	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985																	
Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mar	-	-	-	-	-	-	-	-	-	M	H	M	L	L	H	-	M
Apr	-	-	-	-	-	-	-	-	-	M	H	M	L	L	H	-	M
May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Reports of coastal aggregations were more frequent during the summer months for the period 1980-1983. During the winter months, isolated individuals of *P. noctiluca* and less frequently coastal swarms of medium size were reported. Reports from volunteers also indicate that for this period, coastal aggregations were more frequenly sighted during March, April and May up to 10km off Malta (Axiak, 1983). Such early spring aggregations were characterized by very small individuals of 10 to 20mm diameter. Ephyrae and planulae were collected from coastal waters during 1981-1982 during February, April, May, July and December (Rottini-Sandrini et al., 1983). Individuals with fully mature gonads were collected in February, June, July and December 1982.

More quantitative data are available for the period 1984-1986. Table 1 shows a summary of the data collected from monthly reports of sightings of jellyfish aggregations in various sectors of our coastal waters as indicated in Fig. 2. High density aggregations (i.e. more than 10 individuals m^{-3}) were reported from January till May for 1984 and in March for 1985 in areas ranging from 1 to 13 km offshore. No coastal aggregations were reported after May 1985. Aggregations during January to April were again characterized by the presence of large numbers of small medusae ranging from 10 to 20m umbrella diameter.

The highest densities and more frequent reports were recorded in March and April 1984, although these were still less than those during 1980-1983. Tables 2 and 3 show the daily reports of sightings at sea in the various coastal sectors for these peak months. Data on the prevalent wind direction are also included. To present such data graphically, each report of high, medium or low density aggregations was assigned a score of 3, 2 and 1 respectively; the mean daily scores for each sector over this period (i.e. March, April 1984) were calculated and are presented graphically in Fig. 2. The percentage frequencies of wind speed and direction for the period January-March 1984 are also shown in Fig. 2 and these indicate that for this period the prevalent wind direction was from the NW.

Data from shore sightings and counts at the two fixed coastal stations for 1984 and 1985 are summarized in Tables 4 and 5. These indicated that maximum densities of approximately 0.8 individuals m^{-2} were recorded in May for both years, while no jellyfish were observed during the summer months. No significant inshore aggregations of *Pelagia* were observed in 1986 and 1987.

Table 2. Daily sighting reports for March 1984 of coastal aggregations of Pelagia noctiluca, showing sector (see Fig. 2); reported density : low (l), medium (m), high (h), as well as prevalent wind direction on site

	Sector No.																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Day																	
1	a/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	h/E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	h/V	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	a/W	-	-	-	-	-	-	a/NE	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	h/NW	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	h/NW
12	-	-	-	-	a/NW	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	l/o	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	a/W	-	-	-	-	-	-	h/NNE		-	-	-	-	-	-	l/N
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	a/NW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	l/NW	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	h/SW	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	-	l/NW	-	-	-	-	-	-	m/SW	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	l/SW	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	m/NW		-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Regular plankton sampling could not be carried out on a monthly basis as originally planned. Moreover, it was initiated during the second half of the time period under consideration (i.e. 1980-1986) when the occurrences of jellyfish aggregations were much less frequent and less intense. The various environmental parameters recorded at the plankton sampling station are presented in Table 6. Except for nitrates, all the other parameters are comparable to similar data obtained for coastal waters in the Central Mediterranean. The unusually high levels of nitrates are due to the presence of a major sewage outfall in the vicinity. In fact, on several occasions during sampling the effluent plume was sighted in the vicinity. Single ephyrae which ranged from 0.5 to 1mm diameter were collected in March and June 1984 and then in April 1985. No medusae or ephyrae were ever recorded as from May 1985.

Other observations were reported by divers and local fishermen. Several species of fish, including *Boops boops, Spondyliosoma cantharus* and *Oblada melanura*, have been observed to feed on *Pelagia* in our coastal waters. In many cases, specimens of *P. noctiluca* observed inshore had incomplete manubria or significant areas of their oral tentacles missing. This damage may be due both to abrasion against the bottom of the shore as well as to predation.

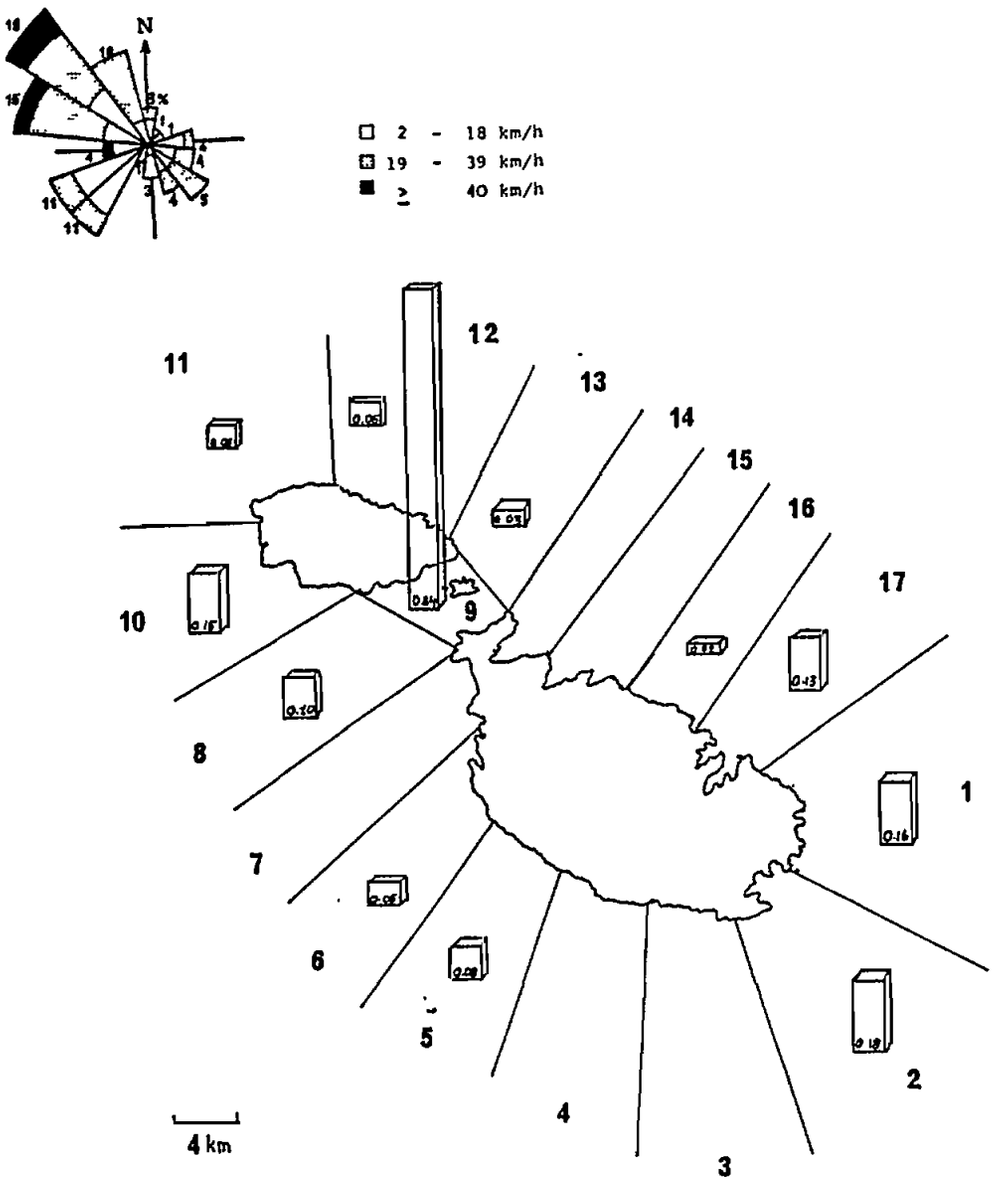

Fig. 2. The distribution of coastal aggregations of *Pelagia noctiluca* in various coastal sectors during March, April 1984, as indicated by reports of sightings at sea by volunteers. The bars indicated the relative frequency and density of aggregates in each sector (1 to 13 km offshore) as explained in the text. The percentage frequencies of wind speed and direction for January-March 1984 are also indicated

Table 3. Daily sighting reports for April 1984 of coastal aggregations of *Pelagia noctiluca*, showing sector (see Fig 2); reported density: low (l), medium (m), high (h); as well as prevalent wind direction on site

	Sector No.																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Day																	
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	h/W	-	-	-	-	-	-	-	-
3	m/E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	l/NW
4	-	-	-	-	-	-	-	-	-	m/N	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	l/W	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	m/NW	-	-	-	-	-	-	-	-
8	f/NW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	l/NW	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	h/NW	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	h/NW	-	-	-	-	-	-	-	-
14	-	l/NW	-	-	-	-	-	-	m/NW	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	m/NE	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	l/NW	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	f/NW	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	h/N	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	h/NE	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	h/V	-	-	-	-	-	-	-	-
22	h/W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	h/W
23	-	-	-	-	a/V	-	-	-	l/V	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	h/V	a/NW	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	l/E	a/NE	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	h/SE	h/NE	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	a/W	-	h/W	-	-	-	-	-	-
28	-	-	-	-	l/V	-	-	-	l/SW	-	-	-	a/SE	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-		-	-	-	-	-	-	l/E	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	h/W	-	h/SSE	-	-	-	-	-

4. DISCUSSION AND CONCLUSIONS

Outbreaks of offshore and coastal aggregations of *P. noctiluca* have been reported in several Mediterranean areas since 1977 (Vucetic, 1985, Axiak and Civili, 1986). This phenomenon is not of recent origin and has been reported to occur in other regions since the 18th century and at least during 1898-1903 and 1908-1912 along the French Mediterranean coastline (Goy, 1984). Vaissiere (1984) reported dense aggregations again in the latter area during 1959. Locally, there are indications that coastal swarms of *Pelagia* occurred during 1958-1960 (Axiak, 1983).

In more recent times, the first dense coastal aggregations of this scyphomedusa were observed in 1980. During 1981-1983, this phenomenon was recorded on an unually large scale, with large numbers of *Pelagia* being reported on several occasions in all coastal areas and in most bays with apparently equal frequency throughout the year. During 1984, most coastal aggregations occurred in March-April while a year later they again recurred during March although at an ever decreasing density. During 1986, no significant aggregations were reported in our coastal waters. Therefore, a seasonal pattern in occurrence was evident when this phenomenon was on the decline, with peak densities being recorded in the early spring months.

Such early spring coastal aggregations were always characterized by the presence of a significant proportion of small medusae, which were presumably of recent spawning. Therefore it has been suggested (Axiak, 1984) that in the Central Mediterranean the reproductive rate of this species may be more pronounced during early winter. However, during the years of maximum occurrence (1981-1982) sexually mature individuals as well as ephyrae were recorded throughout the year.

Table 4. Sightings and counts for 1984 and 1985. Station : Haywharf, Marsamxett.

Month	Day of Sighting	SST in °C at sighting or range	Estimated Density (ind m^{-2})
Mar 84	28	15.5	0.02
Mar	29	16	0.04
Apr	27	17	0.04
Apr	28	17	0.004
May	17	19	0.09
May	18	17.5	0.32
May	23	17.5	0.8
Jun	-	17-21	0
Jul	-	23-27	0
Aug	-	26-27.5	0
Sep	-	24-26	0
Oct	-	N.A.	0
Nov	-	N.A.	0
Dec	-	N.A.	0
Jan 85	-	N.A.	0
Feb	-	N.A.	0
Mar	31	15	0.85
Apr	-	15-17	0
May	-	18-22	0
Jun	-	22-23.5	0
Jul	-	N.A.	0
Aug	-	N.A.	0
Sep	-	N.A.	0
Oct	-	N.A.	0

Table 5. Sightings and counts for 1984 and 1985. Station : Bighi, Kalkara

Month	Day of Sighting	SST in °C at sighting or range	Estimated Density (ind. m^{-2})
Mar 84	27	16.50.02	
Mar	28	170.23	
Apr	24	17	0.004
Apr	25	18	0.004
May	17	19	0.09
May	18	18.5	0.8
May	25	18.5	0.02
Jun	5	18.5	0.008
Jul	-	23-27	0
Aug	-	26-27.5	0
Sep	-	24-26	0
Oct	-	22.5-25	0
Nov	-	20-22.5	0
Dec	-	16-19	0
Jan 85	-	15-16	0
Feb	-	14-15.5	0
Mar	26	16	0.004
Mar	28	16	0.33
Apr	3	17	0.004
Apr	12	18.5	0.8
May	-	18-22	0
Jun	-	22-23.5	0
Jul	-	24-28	0
Aug	-	27-29	0
Sep	-	25-26	0
Oct	-	21-23	0

Table 6. Various parameters of surface sea water at plankton sampling station (see Fig. 1)

Data	Temp °C	Salinity ppt	Nitrates μ- at N/l	Phosphates μ- at /l	Chlorophyll-3 mg m^{-3}
22/3/84	15	NA	7.8	0.07	0.18
12/6/84	20.5	37.5	2.6	0.15	2.05
3/4/85	15.8	37.9	5.5	0.21	0.46
20/5/85	19.8	37.7	15.4	0.12	0.35
19/6/85	22.2	37.6	17.3	0.08	0.26
22/7/85	27	37.8	18.3	0.04	0.36
20/9/85	24	37.6	48.0	0.34	0.12
27/11/85	19.6	37.6	27.1	0.14	0.29
2/2/86	15	36.5	NA	NA	NA
6/3/86	NA	NA	26.2	0.17	0.47
10/4/86	15.8	37.0	22.9	0.09	0.09
22/5/86	20.0	36.8	21.5	0.17	0.18
27/6/86	23.8	36.8	17.03	0.16	0.21
30/7/86	25.8	36.8	20.5	0.18	0.17
29/8/86	27.6	37.0	16.9	0.13	NA
14/10/86	24.8	37.1	NA	0.104	NA

The spatial pattern of aggregations of *P. noctiluca* in our coastal waters was mostly determined by the prevalent wind direction and speed. During periods of light surface winds (less than 18 km h^{-1}) the surface current sets along the coast to the southeast for the greater part of the day (Havard, 1980). During periods of strong northwesterly winds (more than 40 km h^{-1}) the current sets always to the southeast with a maximum velocity of 0.5 m s^{-1} with a diurnal variation in speed but not in direction. From the present study it is evident that the higher reports of aggregations in the south east coastal sectors of both Gozo and Malta may be at least partly explained as passive accumulations of these medusae in the eddy sea water currents resulting from the prevalent northwesterly winds. A similar island effect has been reported by Zavodnik (1987) for coastal aggregations of this species in the Northern Adriatic.

5. ACKNOWLEDGMENTS

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