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THE MED POL JELLYFISH PROGRAMME - A REVIEW

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This document was prepared by Dr Victor Axiak from the University of Malta in consultation with the Co-ordinating Unit for the Mediterranean Action Plan of UNEP. It is based on the progress and final reports received from MED POL collaborating centres up to November 1985. It was prepared as a draft document for the Jellyfish Review Meeting (Trieste, 27-29 January 1986), during which additional information and corrections brought up by the participants are to be incorporated. A new up-to-date version of the document will be produced after the meeting.

INTRODUCTION

To each Mediterranean coastal state the sea is a precious asset, not only because of fisheries, but also because its beaches attract millions of tourists annually and swimming and other water sports are considered as national recreational amenities which are taken for granted. It was therefore inevitable that the recent widespread invasion of coastal waters by masses of stinging medusae of Pelagia noctiluca would cause regional concern which in certain cases rapidly developed into alarm.

In the first part of 1983, during the Third Meeting of Contracting parties held in Dubrovnik, UNEP was requested to take action within the framework of MED POL. A "Project on Jellyfish in the Mediterranean" was immediately launched and has been underway since then. The overall objective of this project was to assess the importance and implications of this phenomenon on fisheries, human health and recreation and to identify the possible causes with the aim to control or possibly minimize its negative effects (UNEP, 1984). 28 centres and national marine institutes are at present participating in this programme through 30 projects. The aim of the present paper is to summarize and briefly review the relevant data presented in the various progress and final reports submitted to UNEP by November 1985, and to help in the assessment of progress made towards the realization of the original objectives of the present programme.

MONITORING

In an effort to assess the geographical and temporal extent of the problem, to identify the likely causitive environmental factors, and to help in the development of predictive models, monitoring of coastal jellyfish aggregations was undertaken by several institutes. The areas investigated include the French Mediterranean coastal waters, the Ligurian and Central Mediterranean, the Greek coastal waters and the Adriatic. Various monitoring methodologies were utilized including systematic plankton sampling, as well as the collection of sighting reports from volunteers as indicated by UNEP (1983). Moreover a chronology of past occurences was established through a bibliographic search from records and collections of the British Museum (Natural History), of the Museum national d'Histoire naturelle and of the Station Zoologique de Villefranche-sur-Mer, dated from 1766 (Goy, 1984). Past records and observations of coastal aggregations of Pelagia noctiluca present only qualitative information and often this is not accompanied with sufficient additional data on the prevailing environmental parameters at the time. However, they are the only present means of assessing any long term fluctuations in the populations of Pelagia. The resulting emerging picture of past and present occurrences of coastal aggregations of Pelagia is as follows:

Pelagia noctiluca normally occurs in offshore open waters but may sometimes be found in enormous quantities in coastal regions. The huge magnitude of its population fluctuations in coastal areas may be considered as a characteristic feature of its population dynamics, such that at one time no single specimen may be found, while within a few years the same area may be invaded by enormous numbers. Unlike populations fluctuations of many other marine species, those of Pelagia are not seasonal, but follow a pattern of local abundance for several successive seasons (eg. 6 to 12 year periods) with little inter-year variations, followed by rare occurence or absence for several years. This phenomenon is not of recent origin and has been observed in several regions at least since the eighteenth century, or soon after this species was first described in the literature.

The recent occurences of coastal aggregations of Pelagia since 1977 cover a wide geographical extent along the Northern, Central and Eastern Mediterranean as well as the Adriatic (UNEP, 1985). The years of maximum occurrences were generally from 1979 to 1983, with local variations from region to region. For example, in the Gulf of Trieste (a zone which has been recently monitored with particular consistency), Pelagia first appeared in the spring of 1977, and for the subsequent years, with particular intensity during the months from May to October (Rottini-Sandrini et al, 1980). More recently, aggregations of Pelagia in the eastern part of the Gulf of Trieste were reported in 1983 and less so in 1984. Coastal aggregations were again observed in 1985 starting in January and then from April till at least June.

Reports from the Istrian Peninsula (Adriatic) indicate that in the autumn of 1984, Pelagia was recorded rather continuously in the coastal waters with most of the individuals occuring between 1 to 4 meters water depth. During the winter they were located at offshore areas not less than 10 km from the coast, only to return again to coastal waters by April 1985. Report from Dubrovnik area (Southern Adriatic) indicate that for 1984, coastal aggregations were more common from May till October, while for 1985 they first appeared in April and by May "masses" of them were being observed.

Monitoring reports from the open waters of the Western Mediterranean made by Goy and co-workers (MEDPROD IV, October-November 1981) indicate that while Pelagia noctiluca ephyrae were present in Atlantic waters, none were present within the Straits of Gibraltar itself, or in the Alboran Sea. The TROPHOS cruise (April-May, 1982) indicate that the ephyrae were generally absent in off-shore waters of the Cote d'Azur, while more recent field data (FRONTAL and MEDAL, 1984, 1985) showed that adult Pelagia were found to be aggregated on both sides of the Liguro-Provincial front associated with high productivity. Further coastal sightings by volunteers from the Cote d'Azur (Bernard, Progress Report, 1985) and the Italian Ligurian area (Carli, Progress Report, 1985) for the last part of 1984 are also available.

From the Central Mediterranean, recent reports of coastal aggregations of Pelagia around the Maltese islands were first made in 1980 reaching a maximum intensity in 1982 and 1983 and decreasing in 1984 (Axiak, 1983, 1984). In 1985 no Pelagia were observed. Similar reports on the absence of Pelagia from Sicilian coastal waters during the last months have been made by Pappalardo (Rottini-Sandrini, Progress Report, 1984).

Monitoring reports from Greek waters (Papathanassiou, Progress Report, 1985) indicate that during the summer months of 1983, 2 to 13 individuals per 1000 cubic meters were found in the Gulf of Saronikos while no Pelagia were ever recorded in Elefsis Bay which has a major sewage outfall. For 1984 and 1985, very low numbers of Pelagia were generally reported in the same Gulf and in other Greek waters. Similar reports were received from Castritsi-Catharios (Progress Report, 1985).

From these reports it is apparent that the geographical extent of the occurence of Pelagia is recently decreasing to include mostly the Northern Mediterranean and the Adriatic.

OTHER FIELD AND LABORATORY RESULTS

Field observations from the Adriatic (Malej, Progress Report, 1985) distinguished between two types of coastal aggregations of Pelagia: "passive aggregations", characterized by surface groups of randomly orientated individuals, and "active aggregations", in which the individual medusae were all orientated in the same direction and swimming actively. No size segregation was observed within these aggregations and assuming that size may be related to the reproductive state of the individuals (which is not always the case as shown by Rottini-Sandrini et al, 1983), this may indicate that such aggregations do not result from active "swarming" of individuals for some specific biological purpose, even though the existence of such aggregations would be beneficial for the species for fecundation. It has been argued by Legovic and Rottini-Sandrini (1984) that the stability and persistance of an aggregation is much dependent on the seawater temperature and since Pelagia's motility as found in laboratory experiments (Rottini-Sandrini, Progress Report, 1984) reaches maximum intensity at about 18°C, it may be expected that the swarm would decrease in colder or warmer waters. These conclusions need to be further confirmed by more field data since massive swarms reported from the Central Mediterranean (Axiak, 1983, 1984) often occured in temperature higher than 21°C. The later coastal aggregations were not identified as active or otherwise but were never found associated with other floating material - i.e. were not being maintained simply by convergent water currents.

Salinity was also shown to affect the motility of Pelagia in the laboratory, such that the optimum salinity was found to be between 36 and 37 ppt, while at lower salinities anomalous changes in pulsation rates occured often resulting in sinking (Catalano et al, 1984).

The ecological significance of such results is still to be determined since salinities of less than 36 ppt are seldom found in open Mediterranean waters, while in coastal waters they may only be found in highly localised areas.

Chemical analysis carried out by Malej (Progress Report, 1985) on Pelagia indicated that the mean dry weight amounted to 6.6% of the total weight, of which approximately 35.2% to 62.5% was protein, 4.1% to 10% lipid and less than 3% carbohydrate. The caloric value was calculated to be 3.1 to 4.1 J per mg dryweight indicating that the high abundance and considerable dry weight render Pelagia a considerable food energy source for possible predators despite its low caloric value. Unfortunately very little is still known about the latter. In this respect, Mastronicolis et al (Progress Report April 1985) investigated the lipid contents of Pelagia and of the fish Boops boops which is one possible predator. Only preliminary results are available and these have not yet helped in our understanding of such trophic interactions.

Preliminary $\delta^{13}C$ analysis (Malej, Progress Report June 1985) indicated that values tend to increase with increasing size and these data has been tentatively interpreted as a change in Pelagia diet with age. Laboratory investigations by Malej showed that the rates of oxygen consumption and ammonia excretion were greatly influenced by ambient temperatures, such that at 23°C the respiration was high enough to produce a negative index of energy budget - if Pelagia would ingest all the zooplankton available per cubic meter in the Adriatic. These results are considered to be of great ecological significance if confirmed by field observations. A lowering of temperature to 16°C decreased the rate of excretion by more than twofold and decreased the overall metabolic activities such that in the field a migration towards colder waters could restore a positive index of energy budget. These results indicate that the enormous increase in biomass of Pelagia especially during the summer months must be somehow related to a significant increase in planktonic productivity to support the resultant energy demand.

A significant amount of work has been carried out on the reproduction activities of Pelagia (Rottini-Sandrini, Progress Report, 1984). The early developmental stages have been studied in detail including the vitellogenetic processes. It has been shown by laboratory experiments that temperature greatly influences the rate of early development so that while at 13.5°C the rate is almost half of that at 19°C, at 4.5°C no development takes place (Avian, 1984). Such data is essential to assess the reproductive potential of this species and how it may be controlled by the environmental factors prevalent in the Mediterranean. In this respect, the apparent absence of ephyrae of Pelagia from open Western Mediterranean waters and their presence in coastal waters during the summer months (as observed during the TROPHOS cruise, Goy, Progress Report, 1985) may be significant. Goy suggests that while the Pelagia adults are essentially open water pelagic forms, their ephyrae may form part of the coastal pelagic system. Moreover the same author asks whether the life cycle of Pelagia may be modified by environmental factors in some as yet unknown manner, perhaps to include some resistant of sessile stage during the long periods when no coastal swarms are reported (Goy, 1984).

Several investigations on the cytological and biochemical aspects of the stinging mechanism of Pelagia and on the identification of toxins are in progress (Rottini-Sandrini, Progress Report, 1985). Salleo has studied the particular discharge mechanism of the nematocysts, indicating that the chemical nature of the walls of their capsules may play a role in the stinging effect. Sedmak (Progress Report, July 1985) detected two types of proteolytic enzymes which are usually associated with animal toxins. These differ in their pH activities and maybe also in their specific intracellular or extracellular activities. The toxicological properties and origin of such proteases are at present being investigated. Maretic (Progress Report, August, 1985) indicated that investigations on antibodies production applying the ELISA method to the serum of people stung by Pelagia are being undertaken at Pula, Yugoslavia.

CAUSES LEADING TO THE PELAGIA PHENOMENON

The following causitive factors may in fact be found to be interrelated and are here treated separately only for the sake of clarity.

Increase in Productivity due to eutrophication of pollution:

As indicated earlier, the enormous increase in jellyfish biomass must be somehow associated with a corresponding increase in the productivity of the ecosystem. It has been suggested that this may have resulted from increased coastal eutrophication caused by organic pollution. Work by Dugdale et al (Progress Report, August 1985) indicate that the other medusa Aurelia aurita is able to take up glycine directly from solution in sea water in the order of 1% to 2% of its dry weight carbon content, so that dissolved organic matter in eutrophic zones may be an important source of nourishment for medusae. No comparable data on Pelagia is as yet available. Moreover, Pelagia was never found in significant numbers in Elefsis Bay (Greece) which is known to be relatively polluted by a major sewage outfall (Papathanassioú, Progress Report, 1985), while massive Pelagia aggregations were reported in clean low productive coastal waters around Malta (Axiak, 1983, 1984). Furthermore, observations of coastal Pelagia aggregations since 200 years ago, do not help to confirm such hypothesis. Nutrient enrichment of waters may also be due to natural hydrodynamic features and in this respect Goy's report of an increased occurrence of Pelagia associated with a high productivity zone in the Ligurian Sea may be significant.

Major displacements of water masses:

Vucetic (UNEP, 1985) suggested that Pelagia may have entered the Mediterranean from Atlantic waters via the Straits of Gibraltar and that increased water ingression from the Central Mediterranean into the Adriatic may explain the recent blooms of Pelagia in that region. However, Goy's reports of the absence of Pelagia at the Straits of Gibraltar during a period of widespread coastal aggregations in the Mediterranean, go against the first suggestion by Vucetic. Furthermore, while increased Adriatic ingression might help explain Pelagia blooms there, it certainly leaves unexplained the occurrence of similar phenomena in the rest of the Mediterranean. Current investigations on the changes in the planktonic community structure near Dubrovnik (Benovic, Progress Report, June 1985) might further help to clarify the extent and importance of ingression from the Mediterranean in relation to planktonic life especially during the months of massive coastal aggregations of Pelagia in this area.

Major population changes in the predators and/or competitors of Pelagia:

Using a simple predator-prey model (non-linear differential equations), Legovic (Progress Report, July 1985) has shown that if the populations of natural predators of Pelagia decrease (eg. by overfishing), then the jellyfish populations would increase and any natural density fluctuations would increase in amplitude. The author has suggested a correlation between an increase in fish catch in the Adriatic with the recent Pelagia blooms. Likewise, Vucetic (Progress Report, July 1985) has suggested an association between increased tuna fish catch and the occurrence of Pelagia swarms. More field data is required to prove or disprove these suggestions. Furthermore, increased fish catch and increased jellyfish populations may not necessarily represent a cause and effect relationship, but may well both be manifestations of the same environmental cause(s), for example an increase in general productivity.

Major hydroclimatic changes:

Based on qualitative information dating back since at least the last century, Goy (1984) suggested that a correlation exists between the occurrence of periods of coastal swarming by Pelagia and global hydroclimatic fluctuations. It is argued that the controlling factor(s) must be external in origin, due to the characteristic features of Pelagia population dynamics already described earlier on. Moreover, the wide geographical extent of this phenomenon may be more easily explained by such a hypothesis, since in this case the suggested causitive effect is of equally wide spatial dimensions. In its present form this hypothesis essentially states that some set of environmental factors (including low seasonal variations in water temperatures) linked with hydroclimatic changes cause a decrease in the influence of factors normally controlling Pelagia population (e.g. low coastal water temperatures in winter on larval development) which in turn lead to a period of "unchecked" increases in Pelagia numbers. This hypothesis implies that the Pelagia phenomenon is an amplified expression of important changes in the physico-biological environment. Such accompanying changes as exhibited by some other component(s) of the ecosystem of the region, have yet to be identified. Moreover such long term ecological changes may only be studied through data collected from equally long term quantitative monitoring of the pelagic ecosystem. This type of data is rather limited for this region.

IMPACT ON HUMAN ACTIVITIES

The health implications of the occurrence of Pelagia aggregations in inshore bathing waters may be considerable (Cezarovic; Maretic; Vlachos and Konteos, Progress Reports, 1985). Pelagia may inflict quite powerful stings and the severity of the cases varies considerably (Maretic, 1980, 1984), depending on the extent and duration of skin contact with the medusa, as well as on the sensitivity of the victim. According to the more recent epidemiological reports from Greece (Vlachos and Kontoes, July 1985 Progress Report), the majority of victims were adults and maximum frequency of stinging incidents was reported in July and August. The symptoms were mainly local and in some cases systematic, only rarely involving shock. Local treatment mainly involves the application of antihistamines and corticosteroids, though other remedies have been tried.

The extent of concern by local inhabitants and tourists is still considered to be significant, and in some cases the occurrence or otherwise of Pelagia in local bathing waters has become almost as important a topic as the local weather report!

The possibility of impact of coastal jellyfish aggregations on fishing operations was discussed by Rottini-Sandrini et al and Malej (1984). Though significant interference with fishing activities in the Gulf of Trieste have been reported, no reliable information is as yet available from other Mediterranean areas. Moreover, Pelagia's feeding rates and habits in the field are not yet fully understood, and its real impact on existing fish stocks (e.g. on fish eggs and yolk-sac larvae) in largely unknown.

CONCLUSIONS AND RECOMMENDATIONS

Very little was known prior to the initiation of the MED POL Jellyfish programme regarding the temporal and geographical extent of caostal Pelagia aggregations in the Mediterranean. It has now been established that these occurrences are not of recent origin and have been recorded at least since the eighteenth century, elsewhere. Since 1977, such occurrences have been reported to occur in several Mediterranean coastal waters, more frequently but not necessarily in summer. More recently, the geographical extent of this phenomenon is decreasing. The present monitoring programme has indicated that there is not direct link between the occurrence of jellyfish aggregations and coastal pollution, though the possibilities of some other indirect anthropogenic influence (e.g. overfishing) are still being investigated. The various hypothesis regarding the causative factors leading to such blooms, have been outlined above and information made available by the present monitoring programme may help in identifying the more likely of these.

It is essential that such a monitoring programme would continue over a long term basis. However, if this is to help in our understanding of the causative factors leading to this phenomenon, it must be comprehensive enough to include all relevant environmental and biological parameters as already indicated elsewhere (UNEP, 1983). Its specific objectives should be:

(1) to investigate any correlation with local pollution, eutrophication or other means of nutrient enrichment,
(2) to relate flulctuations in Pelagia populations with changes in the planktonic ecosystem in general,
(3) to investigate the reproductive strategy of species in the field and to identify the controlling environmental parameters, and
(4) to investigate the behaviour and activity of individual aggregation formations of Pelagia (including vertical and horizontal movements).

As a result of this MED POL Jellyfish Project, much more information is now available on the physiology, reproduction and normal behavioural responses of this species. Though much more work still needs to be done, it is felt that the elucidation of the reproductive and developmental processes, together with the physiological and behavioural responses of different life stages of Pelagia to the prevalent regional environmental conditions, should be given priority. Every effort should be made to ensure that data produced from laboratory experiments would be ecologically relevant and may be confirmed in the field. The specific objectives of such research activities should be:

(1) to identify the causitive factors leading to coastal Pelagia aggregations, and
(2) to help in the development of predictive models.

The present project has also helped to identify the extent of impact on human health and to a lesser degree on other human activities (like fisheries and tourism), of this phenomenon. With regard to health aspects, while toxicological research is desirable, it is doubtful whether such investigations would lead to practical advances in therapy and medical treatment in the very near future. On the other hand, much may and should be done with respect to proper health education. This would help to minimize the psychological impact on bathers as well as prevent the aggravation of symptoms in victims resulting from improper "first aid" practices (such as flushing the affected area with fresh water and rubbing the skin vigorously).

No reliable and practical control measure has yet been developed in this region or elsewhere, which would protect open beaches and bays from jellyfish, though any progress in this field should be followed attentively.

Finally it should be emphasized that this biological phenomenon should not be treated as isolated from other physical chemical and biological phenomena. A multidisciplinary approach is required to fully understand its implications. This programme may well be integrated with any other ongoing regional research and monitoring activities involving studies of the physical, chemical and biological characteristics of the pelagic zone, the development of regional ecosystem modelling, water atmospheric interactions, and regional climatology.

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