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SOME OBSERVATIONS ON THE PROBLEM OF JELLY FISH INGRESS IN A POWER STATION COOLING SYSTEM AT KALPAKKAM, EAST COAST OF INDIA

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ABSTRACT

The paper reports results of a study on the seasonal distribution and abundance of jelly fishes in the coastal waters of Kalpakkam in the context of their ingress into the cooling system of a power plant. Three species of jelly fishes *Dactylometra quinquicirrha* (L. agassiz), *Crambionella stuhlmanni* (Chun) and *Chiropsalmus buitendijki* (Horst) were found in such abundance as to cause blockage of the cooling water intake screens. The seasonal variation in the incidence of the jelly fishes clearly showed that the periods of maxima and minima were different for each species. During the period of study (February 1988 to April 1989) three maxima were noted — May, July and October. On any given single day, maximum quantity of jelly fishes collected from the travelling screens was 29 tonnes (21 July 1988). The data are discussed with respect to (i) qualitative and quantitative variations in the ingress of jelly fishes at Kalpakkam, (ii) operational problems associated with jelly fish ingress and (iii) possible approaches to combat the problem.

Key-words: Jelly fish ingress, seasonal distribution, control measures.

INTRODUCTION

Aquatic organisms like mussels, oysters and clams cause major fouling problems in cooling water systems of power stations (Holmes, 1970; Eugene, Joan and Giannelli, 1982; Rains, Foley and Hennick, 1984). Jelly fish ingress into cooling conduits of the power plants, although do not cause a biofouling problem in the true sense of the term, a problem of considerable economic significance. While moderate ingress of jelly fish on to the intake screens may lead to a reduction in plant efficiency, large arrivals may even lead to forced shutdowns of the power plant. The revenue loss from the shutdown of a 500 Mw(e) power plant has been estimated to be of the order of Rs. 40 lakhs a day (Nair, 1987). Several examples of such incidences have been reported (Henager, Daling and Johson, 1985; Nair, 1987). In September 1984, the intake screens of St. Lucie power station in USA were plugged by jelly fish; at Takasego power station in Japan, a record quantity of 150 tonnes of jelly fish was removed in a single day and in India, the Madras Atomic Power Station (MAPS) suffered unscheduled outages on 30 October 1983, 4 November 1983 and 21 April 1985 during which the principal causative organisms were the jelly fish

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of the species *Crambionella stuhlmanni* (Chun) and *Dactylometra quinquicirrha* (L. agassiz).

In the present study an attempt has been made to assess the problem of jelly fish ingress at MAPS by following the numerical and weight-wise abundance of different species of jelly fish as they appeared on the intake screens during the period February 1988 to April 1989.

MATERIAL AND METHODS

The Madras Atomic Power Station consisting of two units with a total installed capacity of 470 Mw(e) is situated at Kalpakkam (12°33' N and 80°11' E) about 65 km south of Madras on the east coast of India. The cooling water for the power station (35 m^3/sec.) is drawn from the sea through a submarine tunnel and used as a 'once-through' system. The seawater cooling system consists of an intake shaft (48 m deep) and a forebay shaft (53 m deep) connected by a 468 m long tunnel (Fig.1).

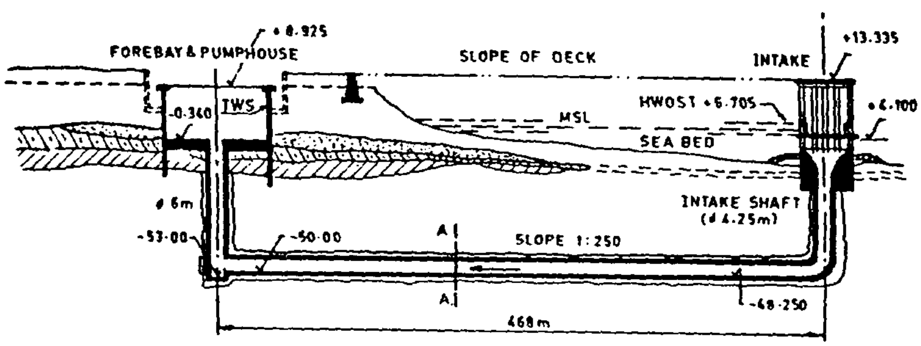

Fig.1. Schematic diagram of cooling water intake conduit of MAPS (Drawn not to scale; plus and minus signs of the figures indicate above and below the high water of spring tide).

Seawater enters the intake shaft through 16 windows, each 3.2 m high and 2 m wide, located radially on the intake structure. Across each window two sets of screens, a weld-mesh screen (3×3 cm mesh size) and a trash rack (80×10 cm) are provided to prevent entry of large animals into the intake tunnel. From the intake shaft, water flows by gravity into the forebay. At the forebay 12 pumps (6 for each unit) draw seawater and circulate through the condenser and other heat exchangers. In the pumphouse water passes through the Travelling Water Screens (TWS), before going into the circulating seawater pumps.

The arrival of jelly fish was monitored by collecting them daily from the TWS, and transferring them manually to drums of 200 l capacity. The total number of drums was noted and a few drums were randomly selected for determining species composition and biomass. For total biomass, each drum was weighed on a weighing bridge. Using the above data the number of jelly fishes that arrived on any single day as well as their weight (wet weight) was calculated. The weld-mesh screens at the intake were lifted once every month and were examined to assess the damage due to the flow blockage by jelly fishes. Salinity and oxygen content of the surface water in the forebay was determined at fortnightly intervals following the procedures outlined by Strickland and Parsons (1972). Surface water temperature was measured with a mercury thermometer corrected to 0.1°C.

RESULTS AND DISCUSSION

Environmental features

Salinity of the surface water during the period of study ranged from 26.99 to 35.50 ppt. Low salinity was noted during November when North-East monsoon brings heavy rains and high salinity was observed during June, when summer conditions prevail at Kalpakkam (Fig.4). Surface water temperature ranged from 26.2 (December 1988) to 31.2°C (October 1988). It was characterised by two well defined maxima, one in May (30.9°C) and the other in October (31.2°C) and two minima; one in July (28.3°C) and the other in December (26.2°C). Surface dissolved oxygen values varied from 4.6 (June to 6.5 mg/l (November 1988) and seasonal differences were not well marked.

Jelly fish number and biomass

The jelly fishes collected on TWS consisted of three species, viz., *D. quinquicirrha*, *C. stuhlmanni* and *C. buitendijki*. Table I gives data on the numerical abundance of jelly fishes during the period of study. It was seen that maximum number of jelly fishes were recorded in May 1988 and the minimum in December 1988. No jelly fishes were observed during January 1989.

During the period of study, 12 out of 16 weld mesh screens at the intake were completely damaged during May. In October, November and June a total number of 8, 6 and 2 gates respectively were damaged allowing the jelly fishes to create significant flow blockages at the TWS.

The monthly variations in relative abundance (numbers) of jelly fish species are given in Fig.2. Among the three jelly fish species, *D. quinquicirrha* was the most dominant in February (100%), March (100%), April (91.3%), May (65.6%), July (50.1%), August (60.9%) and September (64.3%) of the year 1988 and February (55.0%) and March 1989 (56.9%). However, *D. quinquicirrha* was completely absent during December 1988 and January 1989. In June 1988 (76.6%), December 1988 (66.3%) and April 1989 (80.0%), the species *C. buitendijki* outnumbered the other two species of jelly fishes, but in October (84.3%) and November 1988 (79.8%) the jelly fishes arrivals were totally dominated by *C. stuhlmanni*.

Table I – Seasonal variation in jelly fish abundance (number) at Kalpakkam.

Month & year	*D.quinquicirrha*	*C.stuhlmanni*	*C.buitendijki*	*Total*
Feb 1988	2010	0	0	2010
Mar	5320	0	0	5320
Apr	23520	2039	195	25754
May	1013374	357058	175265	1545697
Jun	6831	112168	389495	508494
Jul	630963	591561	35674	1258198
Aug	14219	4302	4824	23345
Sep	4424	580	1876	6880
Oct	73907	508329	20603	602839
Nov	22278	97223	2357	121858
Dec	0	28	55	83
Jan 1989	0	0	0	0
Feb	82	0	67	149
Mar	244	0	185	429
Apr	19	0	76	95
	1797191	1673288	630672	4101151

Seasonal variation in jelly fish biomass is given in Fig.3. During the period of study, three peaks in the occurrence of jelly fishes were noticed; in May, July and October which accounted for 286, 204 and 129 tonnes respectively. In June (88 tonnes) and November (25 tonnes), also significant quantity of jelly fishes were collected on TWS. Maximum quantity of jelly fishes collected from the TWS on any single day was 29 tonnes, noticed on 21 July 1988.

A perusal of the literature on cnidarian medusae in Indian waters reveals that most of the studies have been restricted to hydromedusae. The only report pertaining to the distribution of scyphomedusae is that of Santhakumari (1978) who stated that the highest concentration of scyphomedusae was towards the northern part of the Indian Ocean, especially in areas enriched by upwelling and land drainage. The same author also mentioned that the distribution and abundance of scyphomedusae are closely associated with the availability of copepods and fish larvae. In the present study, *C. stuhlmanni* was found to be associated with the low saline conditions in the coastal waters during October and November following the onset of NE monsoon rains (Fig.4). On the other hand *D. quinquicirrha* was found to be more abundant from February and September when south-west monsoon winds prevailed in this area. During this period the salinity values are not lowered as the SW monsoon does not bring much rains to this area. Chandramohan and Prasad (1989) also noticed an abundance of *C. stuhlmanni* at Visakhapatnam during NE monsoon period. Surface temperature and dissolved oxygen values did not show any significant correlation with the distribution of scyphomedusae. A detailed study of the water masses in the Bay of Bengal and their associated fauna of scyphomedusae is required before definite conclusions on jelly fish distribution can be drawn.

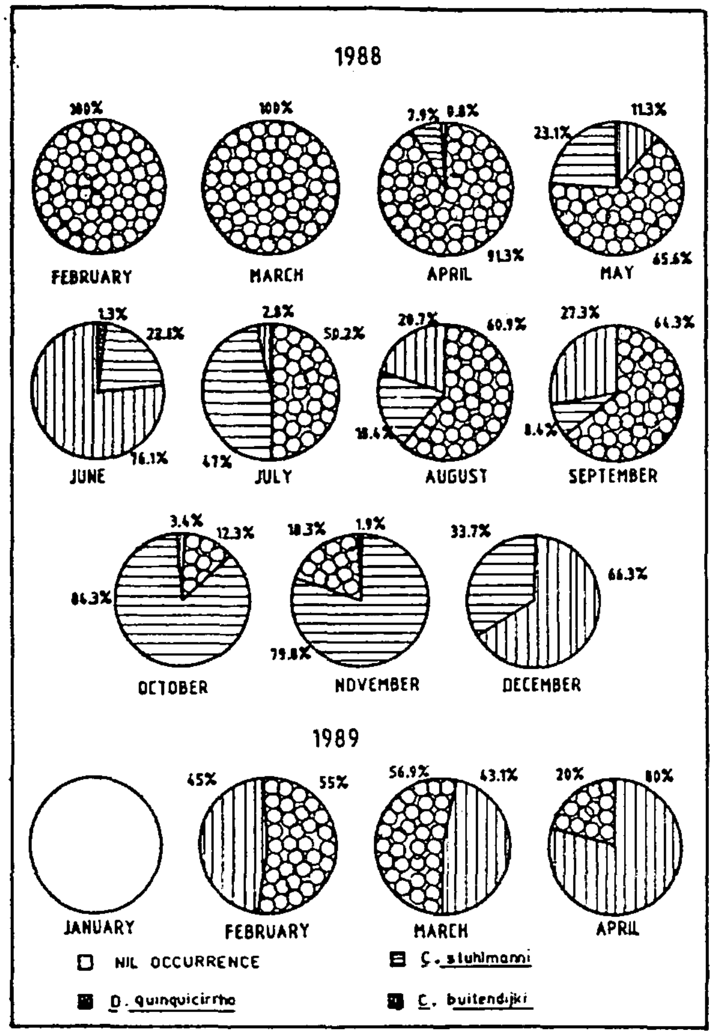

Fig.2. Monthly variations in relative abundance (numbers) of jelly fish species during February 1988 to April 1989.

The problem of jelly fish ingress at power station intake

The distribution of jelly fish in the ocean is "patchy" and governed to a large extent by the prevailing ocean currents. As they approach the vicinity of the power station intake, the strong velocity gradient generated by the pumps draws them to the intake screens and blocks the flow of water, eventually forcing a plant shutdown. As these passively drifting parachute-shaped animals are not capable of much independent movement, they cannot be made to move against the strong velocity gradients. In this context, it may also be mentioned that not only jelly fishes but other gelatinous plankton like salps can also become problematic to cooling

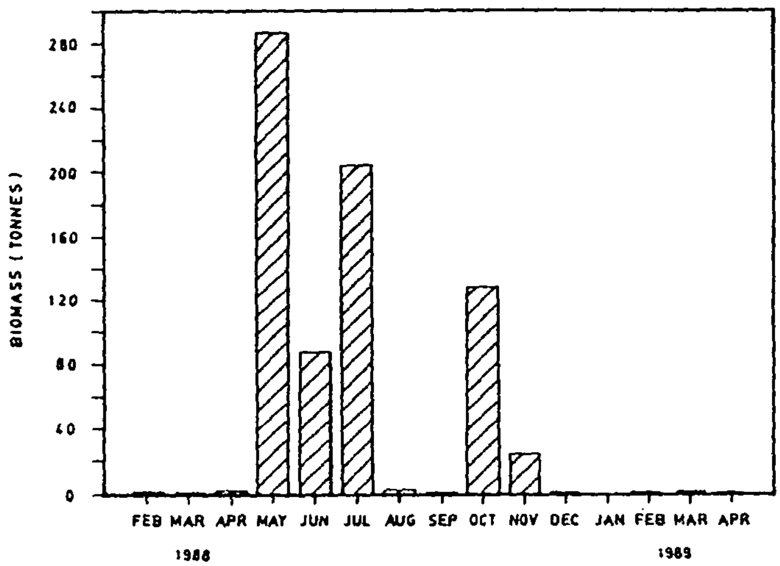

Fig.3. Seasonal variation in jelly fish biomass.

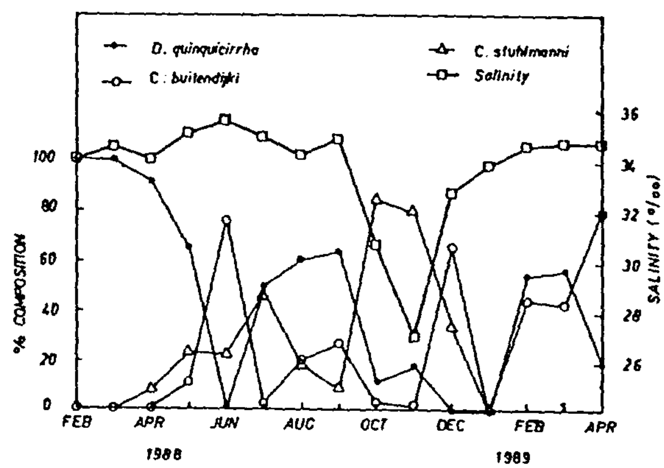

Fig.4. Relative abundance of jelly fish in relation to salinity.

water intake systems when they occur in great abundance (Lodh, Gajbhiye and Nair, 1988). Repellants or electrical or acoustic shocks are of no avail. Even biocides are ineffective, as alive or dead, they still block the flow of water. Though they are soft, if attached to the meshes of the screens it will not be easy to remove them; they offer great resistance to water flow thereby causing damage to the screens. Our data shows that *D. quinquicirrha* and *C. stuhlmanni* were particularly important in causing damage to the intake gates and thereby adversely affecting plant performance.

Control measures

Jelly fish ingress may be controlled by (1) preventing their inflow, or (2) by letting them pass freely. To prevent jelly fish from flowing in with water current, fish netting can be installed in front of the water intake where inlet water velocity is low. This method is adopted at many power plants including Tarapur Atomic Power Station. Kansai Electric Company (Japan) has tried air bubbles injected at the bottom in front of the water intake shaft to push jelly fish upto the surface.

The method of letting jelly fish pass freely is practised when there are no nets in the water system or where the nets are removable. This method has been adopted in some Japanese power plants. In this method, devices are needed to collect jelly fishes in the pumping station such as travelling water screens which are provided with collection racks to trap and to remove the jelly fish as and when they hit the screen. It has also been reported that even if jelly fish flow into condenser water boxes they are cut up and pushed through the tubes provided the differential pressure is not less than 0.25 kg/m^2 in 25 mmϕ tubes.

Since, most of the common fouling control measures cannot effectively tackle the problem of jelly fish ingress, it appears prudent to develop an early warning system for dealing with massive arrivals at the power station intakes. Such a system will be helpful to the power station authorities by giving them ample time to intercept jelly fishes at a good distance away from the intake either by netting or by deflecting them. To be able to develop such an early warning system it is essential to have extensive data on the spatial and temporal distribution of scyphomedusae. One way to organise collection of data may be by ship's observations as well as by observations from shore stations. Since the problem of jelly fish ingress at cooling systems can occur anywhere along the coast it is necessary to have such information both from the east and west coasts. It is also worthwhile to examine whether remote sensing techniques can be applied in this context.

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