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High Vernal Phytoplankton Outburst, a Co-phenomenon of the Winter Mortality among Oosterschelde-oysters in 1963

by

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The long and severe winter of 1962-1963, in which the temperature of the water in the eastern section of the Oosterschelde (Figure 1) remained under -1.2°C from 24 December up to 4 March, inclusive, has been the cause of the almost complete destruction of the oyster stock in this area (Figure 2).

The mortality of the oysters amounted to some 75% early in March and to about 90% at the end of March. It came to a stand in April on 97 to 98%. During the long period of hibernation it was observed that gradually sand and silt penetrated in between the shells of the oysters, which could not get rid of it.

One of the most typical phenomena was, however, that this mortality was not attended with the bad smells of putrefaction processes. Presumably temperatures were too low for that in the second half of February and early in March. Softening and autolysis of the dead oysters' tissues was observed at that time, which could tentatively be ascribed to proteolysis, presumably activated by oxidation catalysts.

As soon as ice-conditions allowed the regular analysis of water samples from the Oosterschelde was resumed. The results obtained revealed some abnormal features:-

Though the ecological character of the small quantities of nitrite in the Oosterschelde is not yet fully understood, the high nitrite figures at the end of the winter, at water temperatures above 2°C, seemed to indicate abnormal processes (Figure 3).

The vernal outset of a phytoplankton bloom in a period with remarkably low phosphate figures, immediately followed by new supplies of phosphate, made the question arise whether there could be a relation between this phenomenon and the decomposition of dead oysters (Figure 4).

There must have been several incidental causes for the rapid lowering of the nitrite content after it had attained its maximum. Oxydation of nitrite to nitrate began when the temperature rose in the middle of March above 4°C, somewhat earlier in the eastern than in the western section of the basin of the Oosterschelde. This new nitrate supply was almost immediately used up as nutrient for the phytoplankton, but the possibility should not be excluded that part of the nitrite itself was taken up by the phytoplankton. The temporary drop in the nitrite content in the western section (H.W. line) early in the month of April could perhaps be ascribed to exhaustion, soon thereafter compensated by a new supply from the eastern section, possibly through mediation of a countercurrent aroused by westerly winds. If so, one could speak of a nitrite-flushing from east to west, which may also have led to the regular decline of the nitrite level, just after the phytoplankton bloom.

That the content of nitrite in the western section remained on a higher level later on is tentatively ascribed to the fact that the concentration of bacteria is lower in the western section than in the eastern section. It seems, however, possible that the higher content of nitrite in the western section after mid-April should at least partly be ascribed to the influence of the coastal seawater, which was to some extent mixed with precipitation and melting water from the rivers, which could contain some nitrite.

The increase of the nitrite level in the month of June might partly be due to the final regeneration of the phytoplankton products, partly to excretion and decomposition of the enormous quantities of zooplankton, observed in the month of May. At that time the water temperature was over 16°C. Of course one should also take into account the excretions of benthos and necton.

In March and April the phytoplankton bloom, which began late in February after a sunny period, reached the 3-5 fold (2530 Harvey units chlorophyll/litre) of the levels normally observed in spring. This excessive peak cannot be brought about by anything else than by the unusually high winter mortality of a large part of the bottom fauna in the eastern section of the Oosterschelde, leading to the mass production of plant nutrients.

Another indication of such a phenomenon was the new supply of phosphates late in March, when the phosphate level had already been reduced to zero in the eastern section (L.W. line). This supply continued for about 3 weeks in the period of the plankton outburst itself (Figure 5).

The outset of this new supply of phosphates coincided with the beginning of the decrease in nitrites, at temperatures above 4°C.

Normally the rapid multiplication of phytoplankton comes much earlier to a stand through exhaustion of nutrients. Nitrites, nitrates and phosphates tended in former years to disappear soon after the outset of the plankton outburst. In the year 1963, on the other hand, the period of phosphate absence was too short to stop phytoplankton multiplication. The simultaneous regeneration of both phosphorus and nitrogen components in the middle of March, prevented an early termination of the plankton production. Therefore, this prolonged vernal phytoplankton bloom and the reaching of an abnormally high level is ascribed to the excessive winter mortality which lead in due course to a huge production of plant nutrients.

It can even be said that the mussels in the Oosterschelde, which developed such a very good condition in spring, indirectly got a good meal of oysters.

Besides the phosphates, the phosphorus content of the other non settling compounds was determined (Figure 6). For a large part this category consists of dissolved organic matter with some particulate matter which remains suspended in the water, such as flagellates and some zooplankton organisms.

The series of samples demonstrated a rapid rise in these phosphorus contents, especially in the eastern section (L.W. line), from the very moment the vernal bloom was a fact. The gradual decrease of these components followed after the phytoplankton bloom had reached its maximum. Observations in earlier years gave the impression that these components originate mainly from metabolic and decomposition products of the phytoplankton.

The increase of the phosphate level in May coincided with a decrease of the P-content of the non-settling compounds, exclusive phosphates. The rise in phosphates in May led to a modest increase of the quantity of phytoplankton at that time. Early in June, factors other than phosphates, viz. nitrates and nitrites, apparently limited the production of phytoplankton, but late in July a new bloom could be predicted for the months of August and/or September. This prediction is based on the production of nutrients. This may lead to good growth and to a good condition of the surviving Oosterschelde-oysters and of those imported from France.

Shell growth, a process of calcium-absorption and calcium-deposition, was possibly favoured by the low acidity of the Oosterschelde water. A high rate of photo-synthesis and a decreased bulk of bottom fauna lead at first to higher pH values in the eastern section (L.W. line). Early in May the pH values of the western section (H.W. line) surpassed those of the eastern section, which was a normal feature in the foregoing years.

The decline of the pH values in both sections in May tallies with the processes which have already been reviewed, the development of the zooplankton and the mineralisation of organic substances included.

For the organic substances, relative figures are given of the total of the more labile organic compounds, estimated by means of a weak wet combustion with potassium permanganate, of the non settling compounds (Figure 8). The averages of about 4.5 gram per m^3 observed in former years were largely surpassed in 1963. This also points to abnormal processes. The curves differ considerably from these for the P-content of the non-settling compounds, which tallies with earlier experiences.

The last factor to be discussed from the analysis of water samples is the dry weight of the suspended matter (Figure 9).

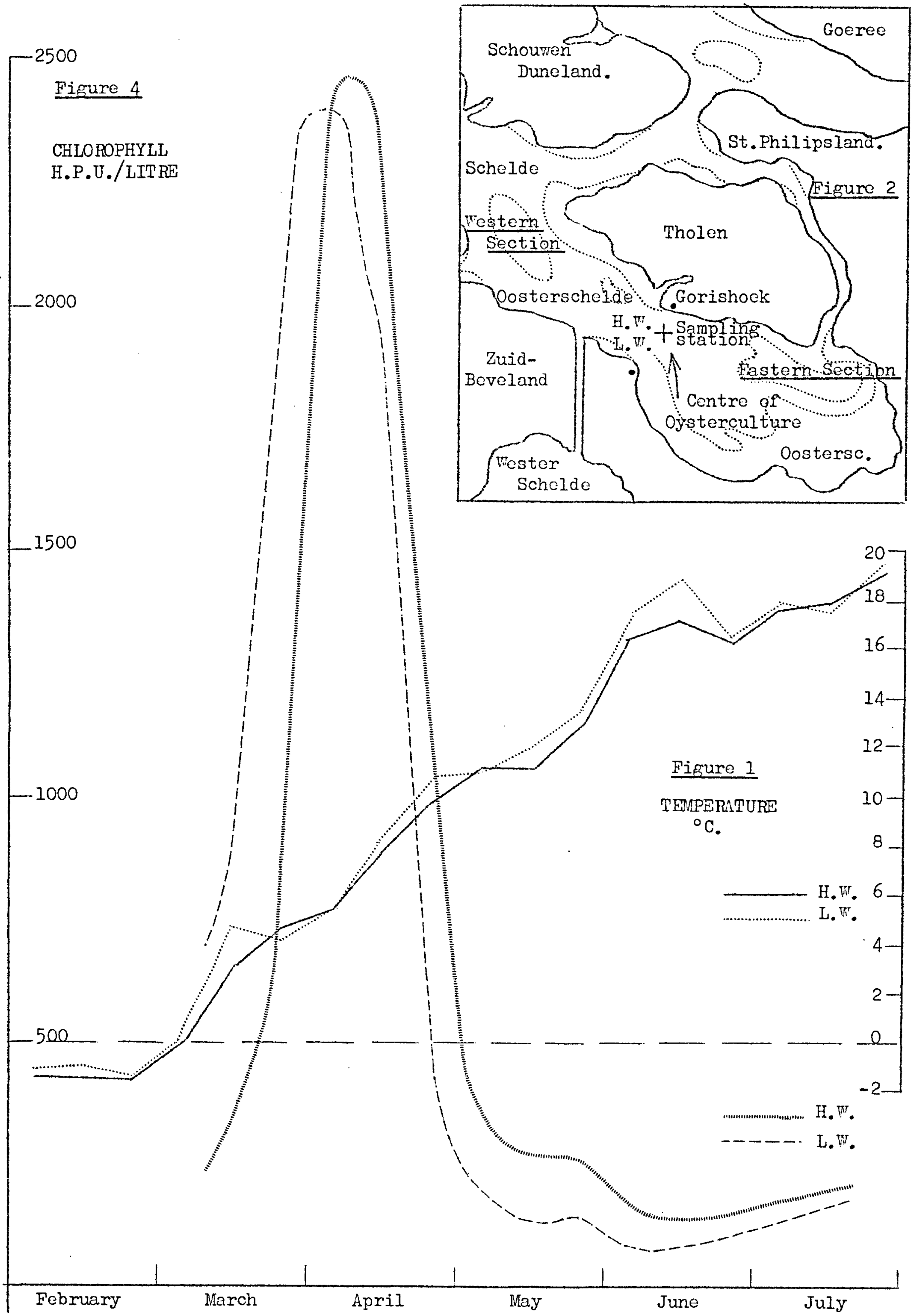
Normally the highest content is found in winter and early spring, especially in the shape of inorganic particulate matter. The organic matter of the phytoplankton tends to compensate the declining trend in spring and early summer.

Since the water was filtered by paper filters and not by membrane filters in the determination of the weight of the suspended matter, the smallest nanoplankton organisms were not incorporated in the dry weight. Especially the low water curve shows the influence of the technique used, since smaller phytoplankton organisms prevail in the eastern section of the Oosterschelde, which is demonstrated by the fractionated chlorophyll-technique.

Late in April the quantity of total particulate matter in the eastern section surpassed that in the western section. The development of a rich zooplankton may have been responsible for this sympton. In July the difference became smaller.

The trends in the ecological factor discussed above cannot give a complete and detailed insight in the various processes operating in the basin of the Oosterschelde in the first half of 1963.

The data presented do, however, suffice, with those not presented here in view of the limited scope of this paper, to demonstrate that the long and severe winter led to an unusual ecological pattern after thawing up, to be understood as mass mobilization and ultimate mineralization of organic matter due to a large-scale mortality of oysters and other invertebrates.



Schouwen
Duneland.
Goeree
St.Philipsland.
Schelde
Figure 2
Western
Section
Tholen
Oosterschelde
Gorishoek
H.W.
L.W.
Sampling
station
Zuid-
Beveland
Eastern Section
Centre of
Oysterculture
Oostersc.
Wester
Schelde
2500
Figure 4
CHLOROPHYLL
H.P.U./LITRE
2000
1500
1000
500
20
18
16
14
12
10
8
6
4
2
0
-2
Figure 1
TEMPERATURE
°C.
H.W.
L.W.
H.W.
L.W.
February
March
April
May
June
July

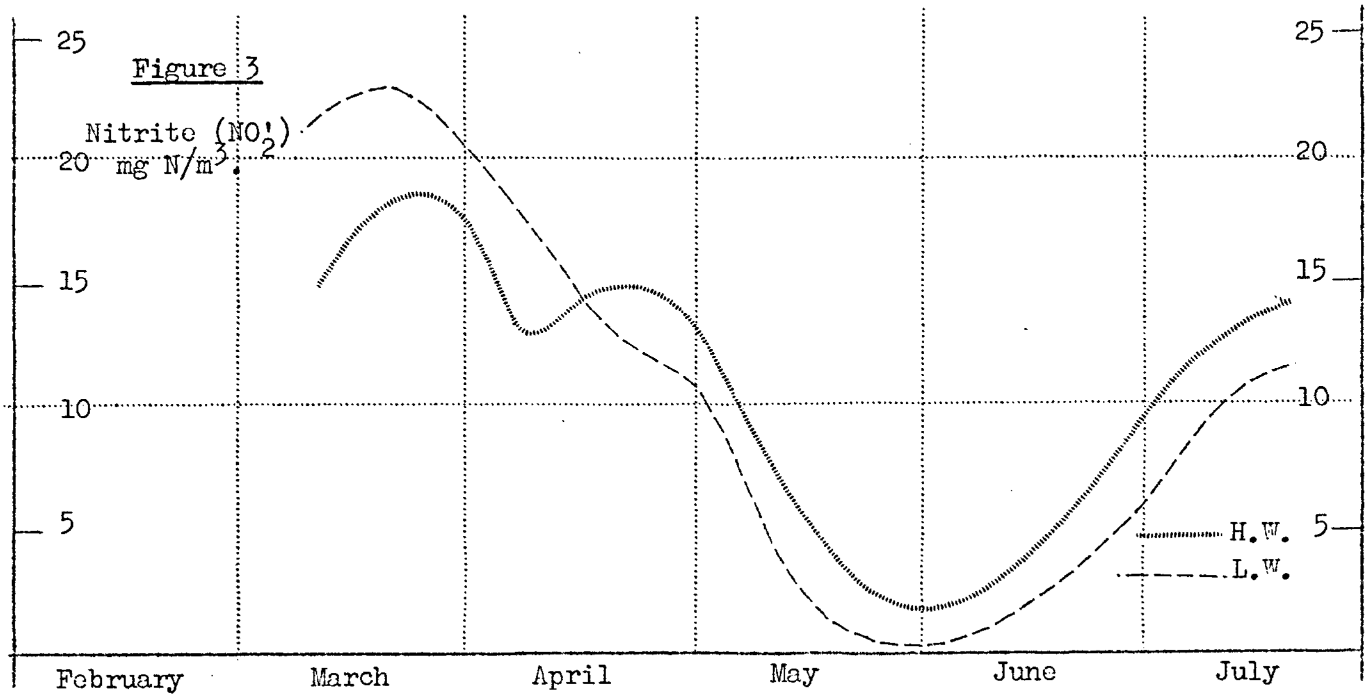


Figure 3
Nitrite (NO_2') mg N/m^3.
25
20
15
10
5
H.W.
L.W.
February
March
April
May
June
July

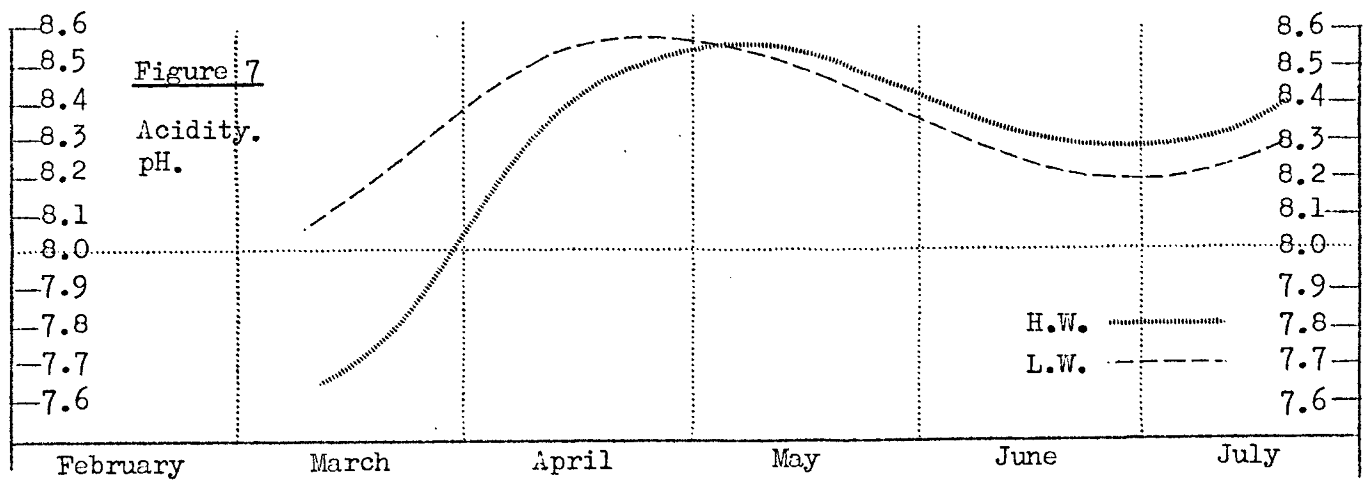


Figure 7
Acidity.
pH.
8.6
8.5
8.4
8.3
8.2
8.1
8.0
7.9
7.8
7.7
7.6
H.W.
L.W.
February
March
April
May
June
July

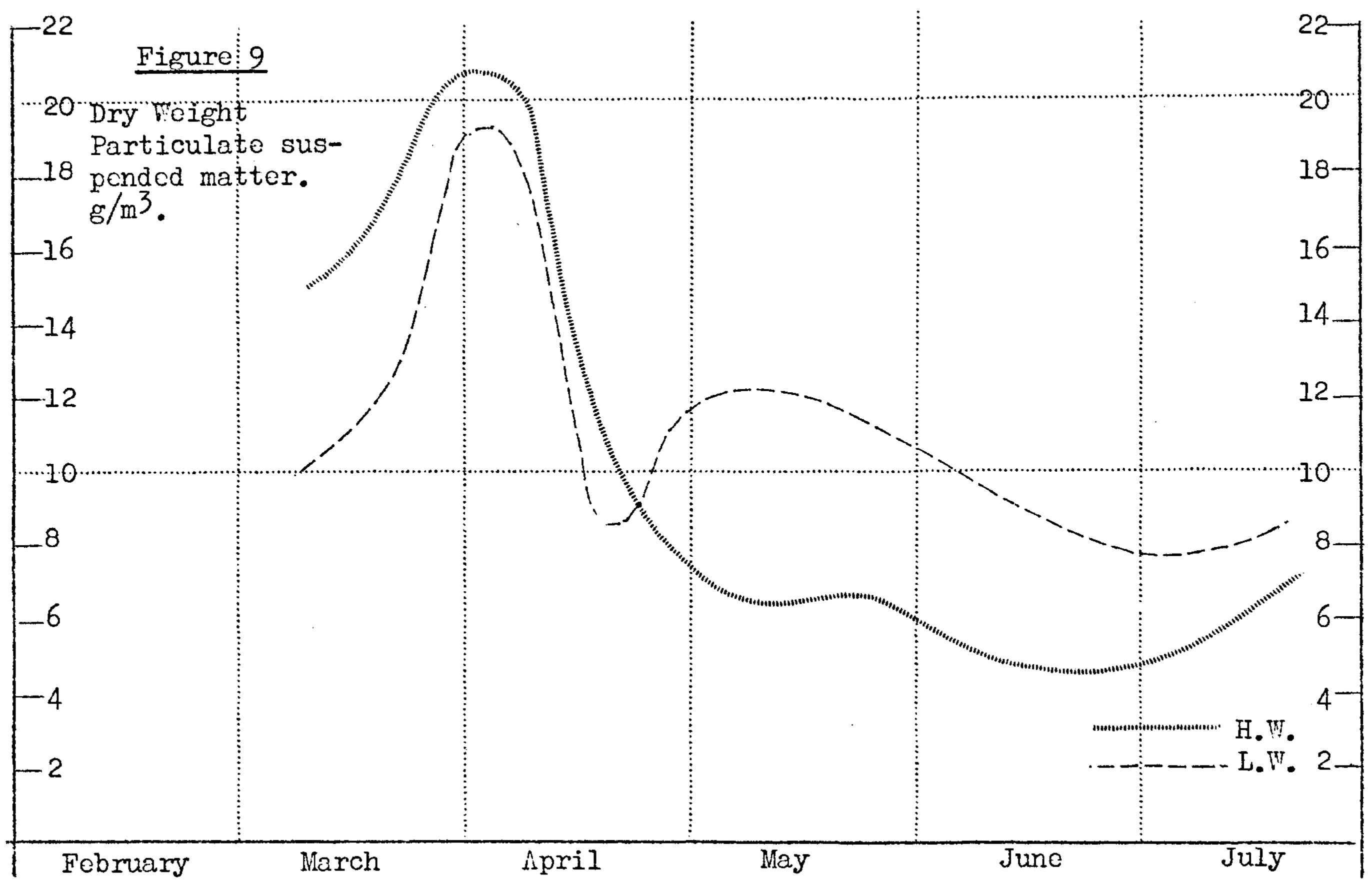


Figure 9
Dry Weight
Particulate suspended matter.
g/m^3.
22
20
18
16
14
12
10
8
6
4
2
H.W.
L.W.
February
March
April
May
June
July

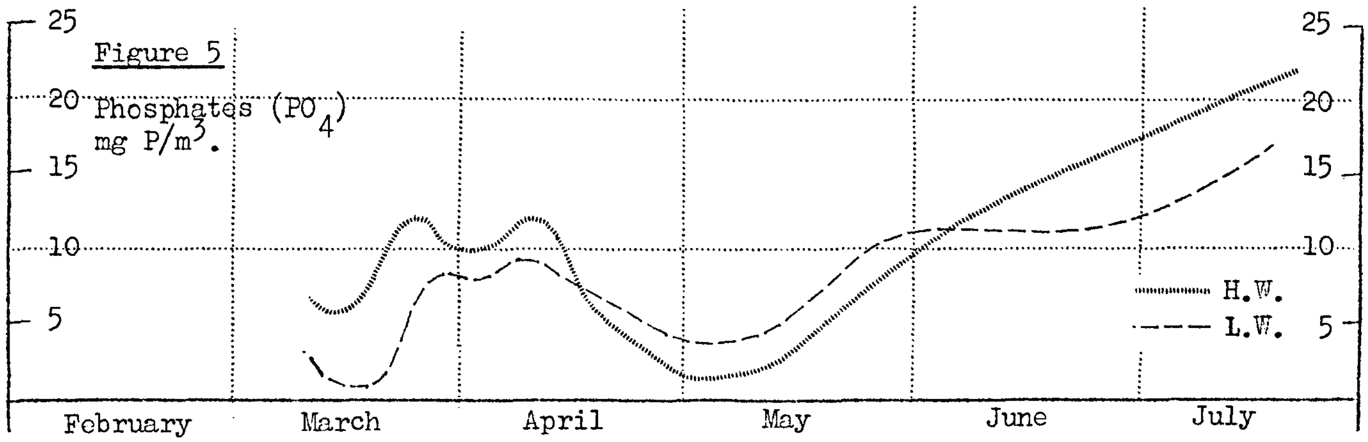


Figure 5
Phosphates (PO_4)
mg P/m^3.
25
20
15
10
5
H.W.
L.W.
February
March
April
May
June
July

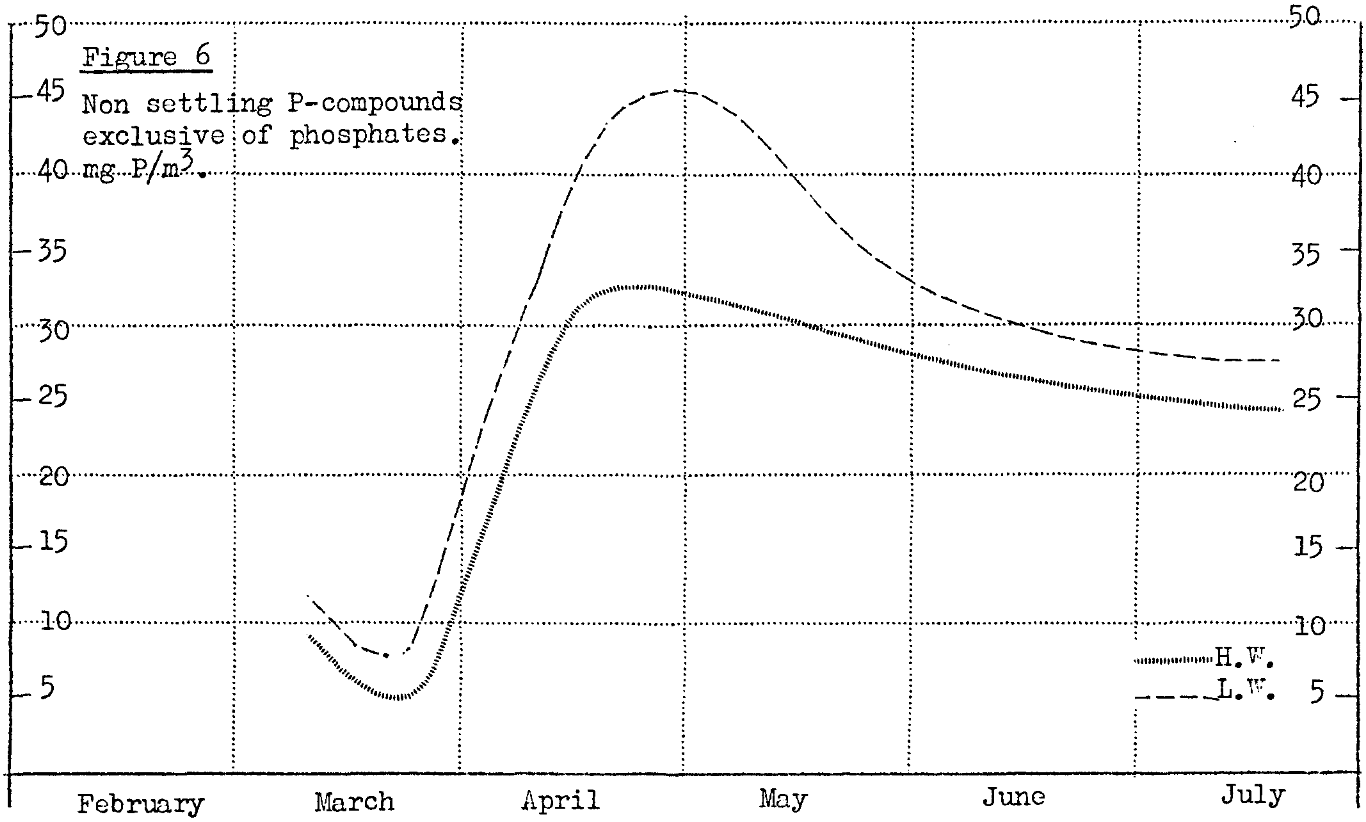


Figure 6
Non settling P-compounds
exclusive of phosphates.
mg P/m^3.
50
45
40
35
30
25
20
15
10
5
H.W.
L.W.
February
March
April
May
June
July

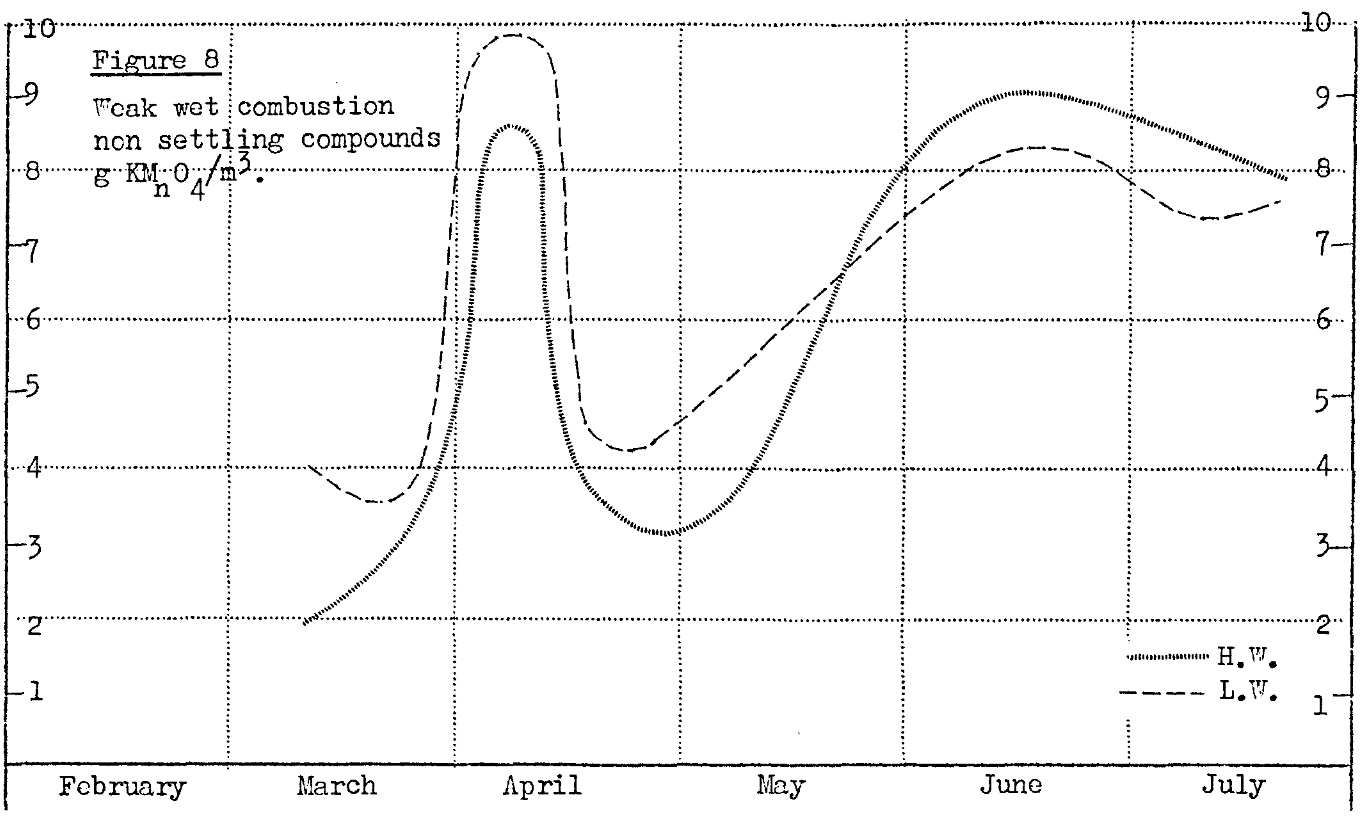


Figure 8
Weak wet combustion
non settling compounds
g KM_nO_4/m^3.
10
9
8
7
6
5
4
3
2
1
H.W.
L.W.
February
March
April
May
June
July