A RESEARCH PROJECT

of the

ONTARIO WATER RESOURCES COMMISSION

REPORT ON

CLADOPHORA INVESTIGATIONS

OBSERVATIONS ON THE NATURE AND CONTROL OF EXCESSIVE GROWTH OF *CLADOPHORA* SP. IN LAKE ONTARIO AND LAKE ERIE

BY

John H. Neil

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Observations on the Nature and Control of Excessive Growth of *Cladophora* sp. in Lake Ontario and Lake Erie

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The
Ontario Water Resources
Commission

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INTRODUCTION

Cladophora is a plant classified under the algae group that is typically found growing attached to the bottom on rocky wind swept shoals of the Great Lakes. It grows in abundance only along certain sections of the Great Lakes shoreline, particularly in the Port Credit to Hamilton area of Lake Ontario and in Lake Erie east from Port Maitland to the Niagara River. Significant *Cladophora* growths also develop in other isolated locations in Lake Ontario, Lake Erie and the St. Lawrence River. Problems caused by *Cladophora* accumulations have also been reported from the United States waters of Lake Ontario and Lake Michigan.

Cladophora growths first appear in the spring during the latter part of May. During the month of June a rapid growth takes place but after the initial development a variety of growth patterns have been observed. The algae may cease to grow when the filaments are a few inches long or they may continue to grow until they are two feet long and cover the bottom completely. In late June and early July onshore winds scour the algae off the bottom and pile it along the shore. The quantity of algae and the time of its appearance along the shore depend on the winds and currents and a heavy growth on the beds may not develop into serious shoreline conditions if the wind and current are not suitable to bring it ashore.

The accumulations may range from only a trace to piles three feet deep and forty or fifty feet wide and these may cover extended sections of shoreline. When the attachment of the algae to the bottom loosens in late June a favourable wind condition will usually bring in most of the available algae. Subsequently, further and generally smaller quantities will continue to wash in.

When the algae accumulations develop along the shore, that portion of the algae lying on the warm water begins to decompose. Within two or three days the algae loses its typical woolly texture, turns black and in the process of decomposition develops a strong "pigpen" odour. That portion of the algae which has been thrown high enough on the beach to dewater, dries, develops a hard cardboard-like consistency and does not create any odour nuisance. A small dipterous fly is attracted to these accumulations and may constitute a nuisance by virtue of their numbers.

The Ontario Water Resources Commission has published previous reports in the years 1959, 1960 and 1961 entitled *Cladophora* Investigations; Observations on the Nature and Control of Excessive Growths of *Cladophora* sp. in Lake Ontario and Lake Erie.

RESEARCH PROGRAM 1962

Excessive growths of *Cladophora* have long been recognized as a problem in both Lake Erie and Lake Ontario and concern has frequently been expressed by municipal officials and property owners alike. As most of the previous work had been done in Lake Ontario, it was decided that in 1962 greater emphasis would be placed on studies in Lake Erie. It was also hoped that generally warmer water and perhaps a more dependable algae crop would facilitate the field testing of algicidal chemicals. More information was also desirable on the extent of shoreline affected by this problem and some detailed surveys were needed into the specific lake conditions which promoted *Cladophora* growth.

The testing of a number of chemicals in the field to screen their effectiveness as

algicides is time consuming and natural variables render the results difficult to interpret. In order to circumvent these problems it was decided that an attempt would be made to develop a laboratory screening procedure. This procedure proved to be effective and a number of chemicals were studied to determine their relative toxicity to *Cladophora*.

The two chemicals which were found to be most effective on the basis of laboratory studies were ones which had previously appeared promising in lake trials. For this reason, a sufficient quantity of chemicals was purchased to enable an extensive treatment on growth areas.

Some municipalities, individuals, and beach associations have attempted to clean up accumulated algae along the shoreline using mechanical means. It was felt that these procedures could be improved and that some initial investigation should be made in this regard. Further investigations were also to be attempted into the effectiveness of odour control agents on the decomposing accumulations along the shore.

LABORATORY TESTING OF ALGICIDES

The field testing of chemicals to determine their algicidal properties is subject to many variables such as water movement and uncontrolled temperature and the results of such experiments are difficult to interpret. Furthermore, wide variations in turbidity makes observations difficult and the rough water typical of the exposed location where *Cladophora* normally grows frustrates the researcher. In order to screen a number of chemicals rapidly and to determine the effects of various concentrations

and exposure time, a laboratory procedure was devised which proved to be very satisfactory.

In this procedure three-litre volumes of the test solutions and controls were prepared with Toronto tap water adjusted to the desired temperature. Fresh samples of the alga were obtained from attached growths in Lake Ontario and portions exposed to the solutions within three hours of collection. After the exposure period the *Cladophora* was transferred to clean tap water at the same temperature and maintained, with dawn to dusk lighting, for six days. Sub-samples were examined under sixty power magnification, one, three and six days after exposure, and the percentage of cell damage estimated. Results presented here are based on six-day observations, but usually those at three days were identical. Cells were considered damaged when they showed an apparent shrinkage of the cell contents which subsequently disintegrated, leaving only the cell walls visible. With a large percentage of cell damage the alga became muddy-green in gross appearance, slick to the touch instead of woolly, and fragmented easily in water. Controls remained in their original green condition throughout the tests with cell damage less than five per cent in all but one case. The exception was the control held at 71°F, which exhibited terminal cell damage to the extent of 20 per cent of the total mass.

The effects of temperature and length of exposure period on the toxicity of Hydrothol (Penco 47) and Aqualin were examined in the first series of tests. Samples of the alga were exposed to 1 ppm active Hydrothol and 10 ppm active Aqualin at 60, 65 and 71°F, for one and four hours. The percentage of cell damage observed in each case is given in Table I and illustrated in Figure 1.

TABLE I. Damage to *Cladophora* by two algicides at varying temperatures and exposure periods.

Product	Percentage Cell Damage					
	1-hour Exposure			4-hour Exposure		
	60°	65°	71°	60°	65°	71°
Hydrothol, 1 ppm active	40	50	90	98	98	100
Aqualin, 10 ppm active	90	95	100	100	100	100

These results indicate that both chemicals were efficient algicides with an exposure period of four hours, effecting at least 98 per cent cell damage. Moreover, there was no great difference in efficiency at the three temperatures. The four-hour exposure was generally more effective than the one-hour period. The exception was Aqualin at 71°F which produced maximum cell damage in only one hour. The data for one-hour exposures indicate differences in efficiency of the chemicals due to temperature variation. The cell damage produced by Aqualin was reduced only ten per cent by exposure at 60°F, rather than 71°, but with the 11° reduction in temperature the damage by Hydrothol decreased from 90 to 40 per cent.

In the second series of tests several algicides were screened for potential toxicity to *Cladophora* by exposing portions of the algae to various concentrations of each at 65°F, for periods of one and four hours. Formulations tested in this manner included Hydrothol, Aqualin, Hyamine 3500, diquat, paraquat, copper sulphate and NIA 5625, an experimental chemical. Phygon, Penco 191, Garlon and copper sequestrene produced less than 80 per cent damage in four hours in preliminary tests at one concentration, so were not tested further at the time. Results of the series are presented in Table II and III, with those from Table II illustrated graphically in Figure 2.

TABLE II. Damage to *Cladophora* by three algicides at varying concentrations and exposure periods at 65°F.

Product	Concentration ppm active	Percentage Cell Damage	
		1-hour Exposure	4-hour Exposure
Hydrothol	0.25	< 10	50
	0.50	10	50
	0.75	25	98
	1.00	50	98
Aqualin	1.0	10	30
	3.0	60	100
	6.0	75	100
	10.0	95	100
IA 5625	0.10	< 10	40
	0.25	20	70
	0.50	40	80
	0.75	60	90
	1.00	95	100
	3.00	100	100
	5.00	100	100

TABLE III. Damage to *Cladophora* by four algicides at varying concentrations and exposure periods at 65°F.

Product	Percentage Cell Damage					
	1-hour Exposure Concentration (ppm)			4-hour Exposure Concentration		
	1	3	5	1	3	5
Hyamine 3500	<10	50	70	10	75	80
Diquat	50	75	100	50	95	100
Paraquat	50	75	100	95	95	100
Copper sulphate*	0	10	95	<10	20	80

* concentration as salt

The data indicated that by to the concentration where maximum damage occurred at one hour, cell damage was generally more extensive with the four-hour period. An antomology occurred in the case of the copper sulphate (Table III) which appeared to be somewhat more damaging at 5 ppm salt for the shorter contact time. Damage of 95 per cent or higher was observed with four-hour exposures to Hydrothol at 0.75 ppm active, NIA 5625 and paraquat at 1 ppm, and diquat and Aqualin at 3 ppm. This degree of efficiency with one hour of contact required Aqualin at 10 ppm, diquat and paraquat at 5 ppm. The efficiency of the experimental formulation NIA 5625 was still 95 per cent at 1 ppm with the shorter contact time, while that of Hydrothol was considerably lower. The advantage of maintaining the longest possible contact period is obvious.

While these laboratory findings were not expected to be strictly comparable to field conditions, they do indicate the relative algicidal merits of the several chemicals considered, and those worthy of further investigation. Aqualin, diquat, paraquat, Hydrothol and NIA 5625 exhibited good algicidal properties against *Cladophora* and fall into this category. The latter three are noteworthy for their activity at low concentrations.

LAKE ERIE

Survey of Growth Areas

In May 1962, some general observations were made along the north shore of Lake Erie between Port Maitland and the Niagara River. As a result of this survey, the

area fronting on Wainfleet Township was selected from intensive study. Two points, namely Rathfon Point and Grabens Point, were surveyed in detail and later used as test plots for algicide trials. Rathfon and Grabells Points lie three miles and six miles respectively, west of the town of Port Colborne. Measurements were made to determine the length of the rocky shoreline of these points and to mark in the depth contours offshore in order to determine the extent of bottom suitable for algae growth. Grabells Point (Figure 1) was found to have a continuous rocky shoreline for a distance of 4,225 feet. Offshore, the three, six and nine-foot contours were sounded and plotted on a map. The type of bottom in this area was also noted. The total area of rock bottom lying within the nine-foot contour was found to be 133 acres, and there were 84 acres within the seven-foot contour.

At Rathfon Point the rocky shoreline extended for 5,200 feet (Figure 2). At this point the three, five, seven and part of the nine-foot contours were plotted and observations were made on the type of bottom present. A shelf dropping off into water greater than nine feet in depth followed the shore very closely along the westerly 600 feet of Rathfon Point. The width of the shoal then increased and extended in an easterly direction. The central portion was essentially solid rock whereas the easterly area was composed of mixed bedrock and a boulder-sand bottom. This ultimately gave way to a pure sand bottom. A total of 20.1 acres of continuous bedrock where the depth was less than seven feet was calculated to be present and there was an additional 26 acres of bottom composed of a boulder-sand mixture.

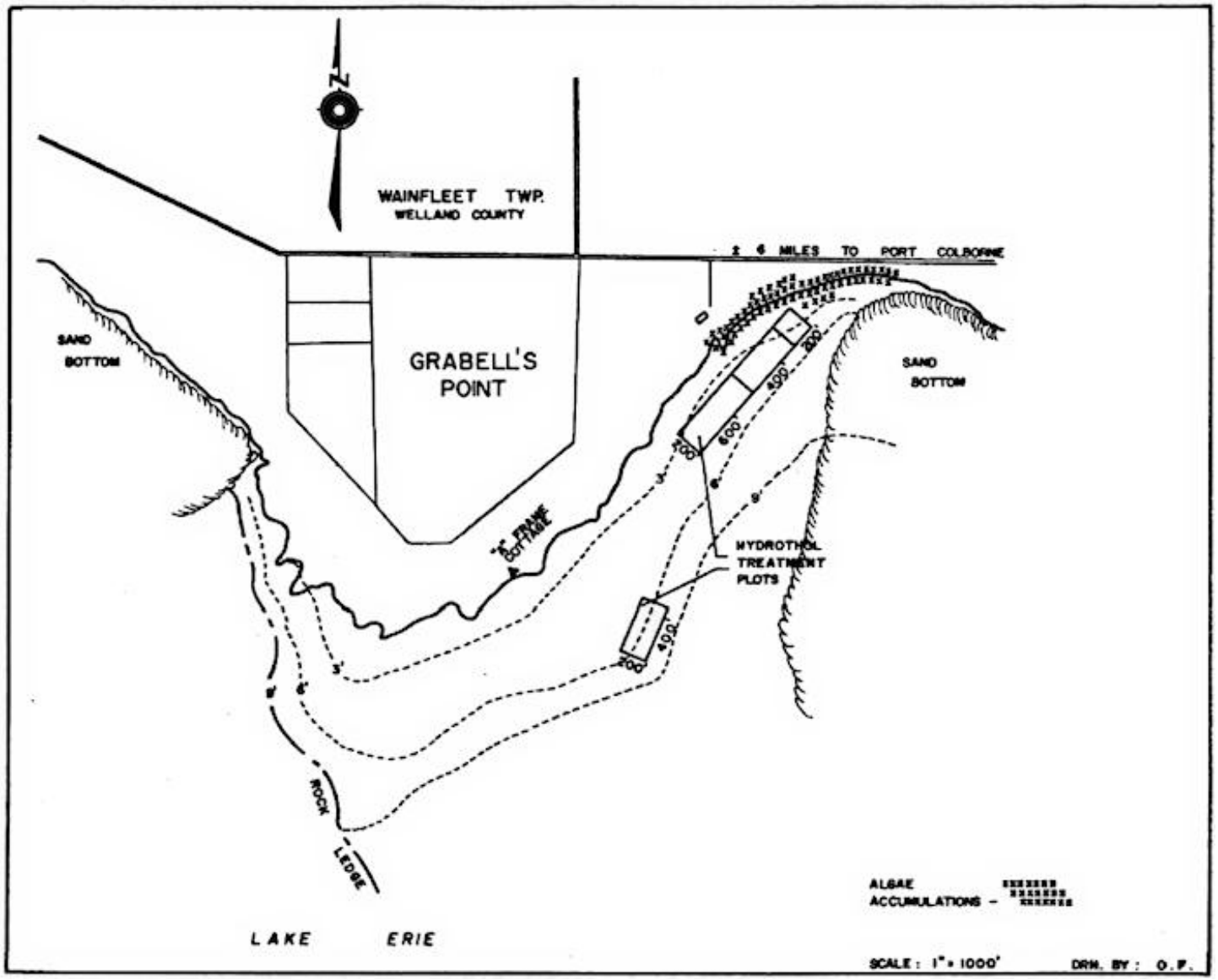

Figure 1. Grabell Point.

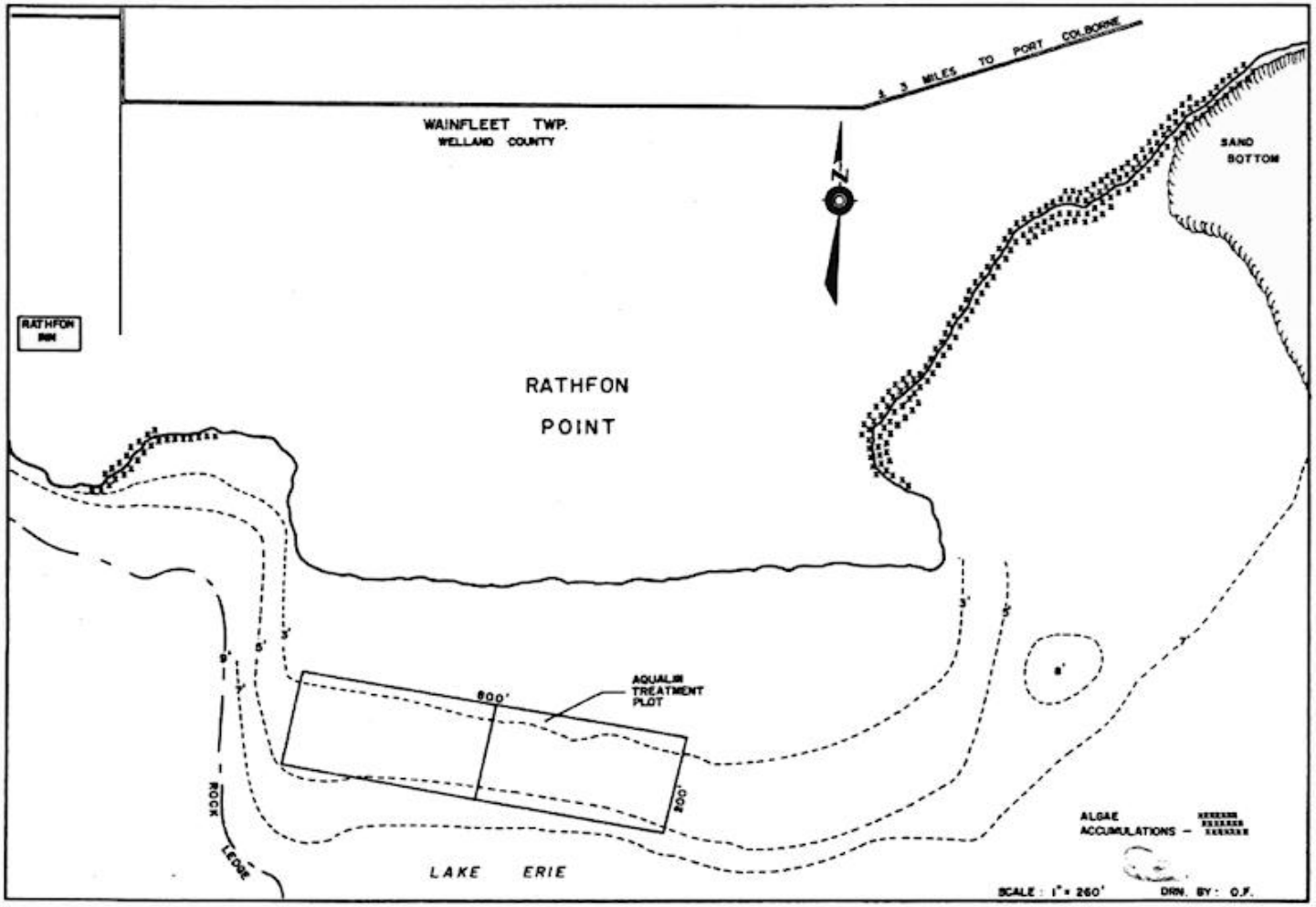

Figure 2. Rathfon Point.

Observations on Cladophora Growth

The first observations on the growth areas were made on May 17th, at which time the algae had just started to develop. Thereafter, observations were made at approximately weekly interval. During June the crop increased and on June 6th, detailed observations were made of the *Cladophora* conditions on both Grabells Point and Rathfon Point by scuba diving. The rocky bottom in bath of these areas was found to be almost 100% covered with *Cladophora*, having a filament length of three to five inches. Continuous observations were made offshore to the point where the algae ceased to grow. This occurred at a depth of about thirteen feet. There was an obvious lessening of the length of filaments and the percentage of bottom coverage between nine and thirteen feet. The total crop had a light green appearance with the exception of the vicinity of Rathfon Point immediately facing Rathfon Inn where the beds were noticeably darker in colour. Large numbers of fish were noted, particularly at Grabells Point. Bass nests were common in the algae beds and newly hatched fry of an unknown species were numerous, particularly in the near shore areas.

On June 27th, at the time of chemical applications on Grabells Point the appearance of the algae had changed somewhat. In the areas near shore particularly, the beds in gross appearance had a lighter green to almost a straw colour. On close examination, most of the basal parts of the plants were green changing to the straw colour towards the end of the filaments. Growth had continued in the interval and the filaments on the beds were as much as ten inches in length. On July 6th, the gross appearance of the algae had lightened a little more and there did not appear to be any

extensive additional growth on the beds. On July 13th, the algae had not grown any more. There was still the bleached appearance to extensive areas of the beds and there was evidence that the algae had loosened considerably on the bottom. The algae loosened from the bottom and twisted into rope—like strands, or collected in loose balls on the bottom. This left some parts of the bedrock exposed. Shortly after this date, onshore winds began to blow algae accumulations ashore and by the 24th of July most of the crop from these two points was piled up along the shore and beginning to decompose (see Figures 1 and 2). On July 24th, the beds were carefully observed by diving from the shore to the outer extremity of growth on Grabells Point. The bottom from the shore—line to nine feet was essentially clear of algae. The rock and cobblestone bottom which had been completely covered before, was now clear with the exception of some brown bits of obviously unhealthy algae. After nine feet the algae was green, six to eight inches in length, generally not too firmly attached and had much the appearance as the general crop on July 13th. It would appear that the waves and currents that had dislodged the crop at depths of less than nine feet had not affected the algae in the deeper water.

Further observations were made of the algae growths on these points on July 30th, August 9th, 23rd and September 10th and no significant regrowth was observed to develop. A few strands of light green algae did develop but only a very small percentage of the bottom was covered.

Further accumulations arrived at the shoreline after the initial cleaning of the beds that occurred between July 13th and July 24th, but these were minor in nature and

never assumed the proportions of the initial deposits. On July 23rd, a survey of approximately sixty miles of shoreline was made to determine the position and extent of the algae accumulations on that date. Algae was found to have accumulated in eighteen places affecting a total linear beach line of about eight miles.

The condition of algae growing in beds in the vicinity of Crystal Beach was observed on several occasions. On July 5th the algae growing on Point Abino had much the same appearance as that at Rathfon and Grabens Points. The *Cladophora* growing near the easterly limits of the village of Crystal Beach, in the vicinity of the sewer outfall and further eastward for at least one mile, was found to be much more lush in appearance. The filaments were longer and the green colour was much darker. No large accumulation came ashore on Point Abino but the usual heavy crops of algae drifted in during the summer at Crystal Beach.

On September 24th, the bottom throughout this same area was still covered by a healthy dark green mat of algae.

Algicide Trials

The selection of chemicals for trial use in Lake Erie was based on the laboratory tests and previous field studies. The laboratory tests indicated that Hydrothol and Aqualin would probably be the most effective and economical algicides. In previous years a number of field trials were made using 0.25 ppm and 0.5 ppm Hydrothol and 3 to 10 ppm Aqualin. Some fairly good kills had been obtained but the results were not

consistent.

In Lake Erie it was anticipated that the warmer water would permit early treatments and allow for re-treatment should subsequent growths develop. The applications in Lake Erie were to be made as soon as a significant growth was present and the water temperature high enough to permit effective treatment. The concentrations of the algicides tested were to be sufficiently high to secure effective algae control and the areas treated were to be large enough so that water movement along the shore would not move the treated water off the plot before the chemical had acted. The treated areas were to be observed on a regular basis and if new crops of algae developed within the plots, subsequent applications of chemicals would be made. In this way the frequency of treatment necessary for algae control would be established.

Hydrothol Application

The area chosen for the treatment with Hydrothol lay on the east side of Grabell Point, over a section of bottom that was entirely covered with *Cladophora,* (Figure 1). The treatment of 0.93 ppm was applied on June 28th to two plots, (1) an area 1200 feet by 200 feet having depths ranging from two to four feet with a total volume of 18 acre-feet, and (2) a plot 200 feet by 400 feet ranging in depth from five to seven feet and having a total volume of 12 acre-feet. The weather was clear and calm, and the water temperature had risen to 72°F in the shallow plot and to 68°F in the deeper area. Dye placed in the water to measure currents indicated that there was little or no water

movement. At the time of treatment the algal filaments were six to ten inches long. Most of the algae was light green in colour, though some bleaching was evident towards the tips of the filaments.

The liquid chemicals were applied from the Commission boat, using a centrifugal pump fitted with a dual intake. The algicides were metered into the diluting volume on the suction side of the pump and the mixture forced out through a distribution boom. This boom was fitted with nozzles which trailed on the bottom behind the boat and released the algicides directly into the *Cladophora* bed.

Fish were numerous in the treated areas. Perch, *Perca flavescens*, carp, *Cyprinus carpio*, smallmouth bass, *Micropterus dolomieui dolomieui*, and alewives, *Pomolobus pseudoharengus*, were the principal species observed and a large number of recently hatched fry were sighted. During and following the treatment a few fish were noted in the treated section. No mortality of any kind was found even among the recently hatched fish. Laboratory studies have indicated that Hydrothol is toxic at concentrations less than those used for *Cladophora* control. It has not however, caused any known fish mortality when used for *Cladophora* treatment.

The first observation of the treated area was made eight days after treatment on July 6th. The boundaries of the treated plot were evident from shore as the whole treatment area had a white appearance in contrast to the olive-green colour of the surrounding area. Close examination revealed that the algae filaments were bleached and microscopic examination of the individual cells showed them to be disrupted and

to have lost most of their cell content. Some apparently viable green cells remained near the base, close to the point of attachment to the rocks. The algae had a slimy feel in contrast to a natural woolly texture, which indicated that the material was breaking down in place rather than being loosened from the rocks and perhaps going ashore. The algae on the plot in deeper water was also affected by the Hydrothol but there was still some green in evidence throughout the plot.

The next observation was made on July 13th, seven days later, and at this time further deterioration of the algae on the two plots was evident. The rock bottom and cobblestones which had previously been obscured were now apparent particularly in the shallower plot. Some green basal cells were still evident in the area to which chemical had been applied but no evidence of regrowth was found. The algae in the area surrounding and unaffected by the treatment showed a decline in the vigour in the crop and as was previously described, was beginning to loosen from the bottom and "rope up".

The next inspection was made ten days later on July 24th. On this day most of the loose algae from the entire point had been blown ashore so that both the plots and the surrounding area were relatively clean. There was no observable difference between those areas which had been treated and the surrounding beds. Subsequent inspections were made on August 8th, 23rd and September 10th. Some small fringe growths developed on the bottom, late in the summer on Grabell Point outside the areas treated. As little or no growth took place in the treated areas, it was believed that some continuing control had been obtained in the areas treated. This observation,

however, could not be positively established because of the general poor growth over the entire area.

Aqualin Treatment Plot

On July 6th, Aqualin was applied to a plot fronting on Rathfon Point. The area treated was 200 by 800 feet with depths ranging from two to five feet and a volume of 12.9 acre-feet (Figure 2). This application was made early in the morning when the water was calm and the temperature 68°F. Dye tracer was used to measure water movement and this was determined to be westerly at 10 feet per minute. The growth of algae covered 90% of the bottom and the filaments were approximately six inches long. Some bleaching was again apparent in the terminal areas of the filaments but the bulk of the algae was light green in colour. The Aqualin was metered through the apparatus previously described to provide a concentration of 12 ppm.

At the time the Aqualin was applied, no fish were observed in the plot. During the treatment and immediately afterward, some bullheads, *Ictalurus nebulosus*, were observed to surface and some of these subsequently died. A total of perhaps 40 were killed in all.

The first observation on the effect of the treatment was made on July 13th, seven days later. The area to which the chemical had been applied Was immediately apparent from the bleached white appearance. Closer examination made by diving within the plots showed the algae to be completely white and there were no remaining green cells

in the basal portions of the filaments. The line of demarcation at the east end of the plot was sharp while on the westerly edge and beyond the outside edge there was an extended kill. This was the result of water currents and diffusion carrying a toxic concentration of the chemical considerably beyond the boundary of treatment in a 'downstream' direction. Outside the plot to the west and offshore the algae was at first totally killed, then there was less and less effect with the basal portions of the filaments becoming greener until the green colour extended to the terminal cells. In all, an area perhaps half again as large as the original plot was seriously affected.

The next observation was made on July 24th, ten days later. In the interval the storm which had removed the algae crop from Grabell Point had the same effect on Rathfon Point and the algae from both the treated and untreated areas alike had been removed and was piled in the cove at the easterly end of the point (see Figure 2). Subsequent investigations on July 30th, August 8th and 23rd and September 10th showed that only a minor regrowth had occurred. Again there was evidence of control of regrowth within the treated area but this could not be positively established.

LAKE ONTARIO

Observations of Cladophora Growth

Less detailed observations were made of the conditions of *Cladophora* growths in Lake Ontario in 1962 than in the three previous years, because of the decision to undertake most of the experimental work in Lake Erie. The growth was known to have

been established by May 29th since samples of algae for laboratory tests were collected from Lake Ontario at Oakville at that time. On this date filaments three or four inches in length were found in the areas near shore.

On July 11th detailed observations were made by scuba diving in the area off Park Street and near the point east of the ninth line (Figure 5). The observations at Park Street were made by beginning close to shore and swimming outwards, following the bottom, until the algae ceased to grow. The growth from 0 to 12 feet was generally heavy, covering almost 100% of the bottom with filaments eight to twelve inches in length. Algae covered the bottom evenly and was attached, though not strongly as the bulk of the material could be gathered readily by hand. After 12 feet, the growth was less dense, the length of filaments was shorter and open areas were present. There was, however, still a considerable crop of algae on the bottom. At 23 feet, the algae disappeared rather abruptly. Large boulders extending above the 23-foot level had growths of algae on the upper surface but the bottom, while still clean bedrock and boulders, supported no algae.

A similar survey was made at the rock shoal east of the Ninth Line (Figure 6). From 0 to 12 feet the bottom was covered almost 100 per cent by a luxuriant rich green growth. In the shallower areas some of the algae was balled-up and twisted into rope-like masses extending to the surface from a depth of about four feet. The remainder of the area was uniformly covered to a depth of eight to twelve inches but again the filaments were not strongly attached to the bottom. No observations were made at depths greater than twelve feet.

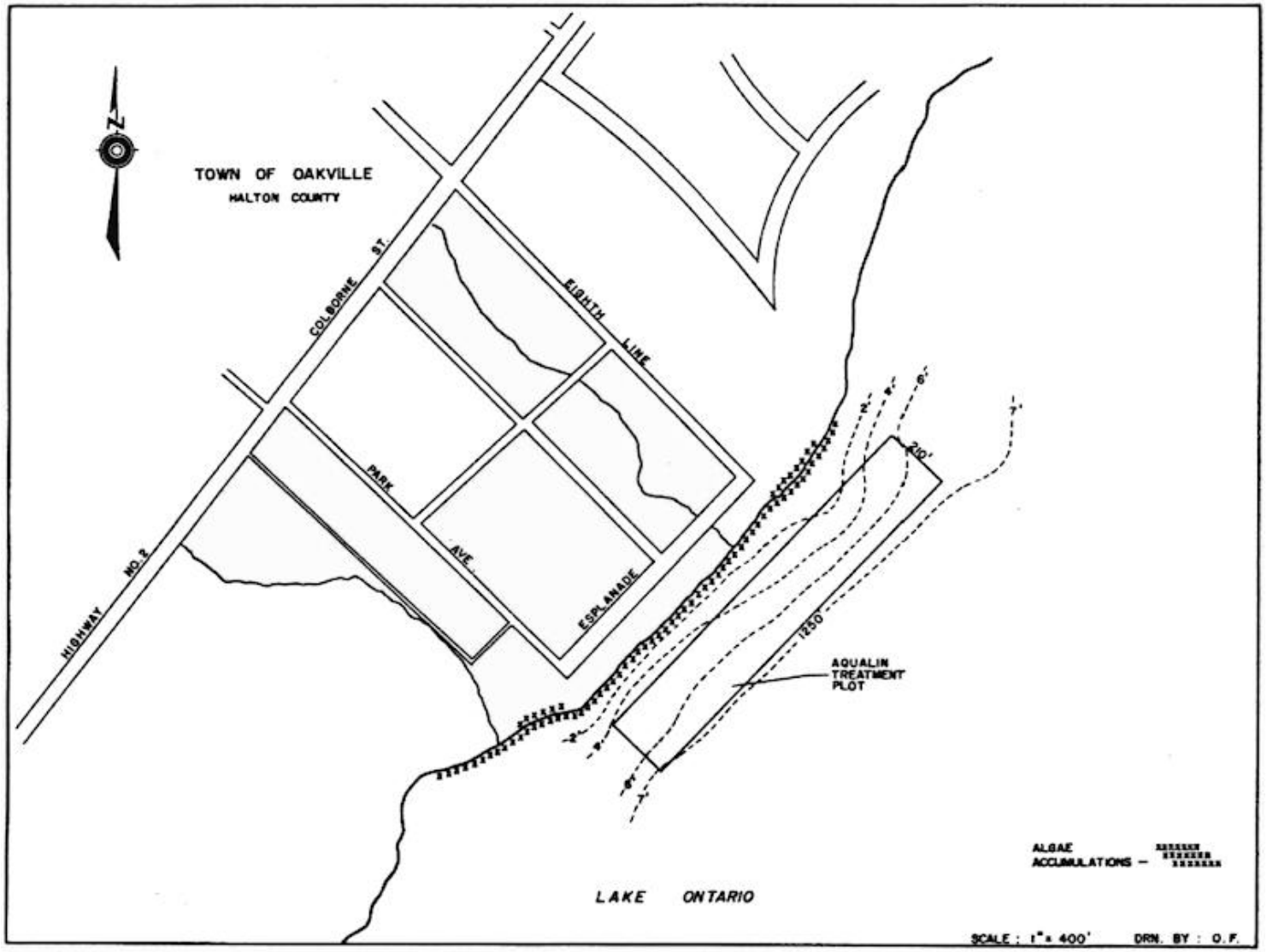

Figure 3. Lake Ontario - Aqualin Treatment Plot.

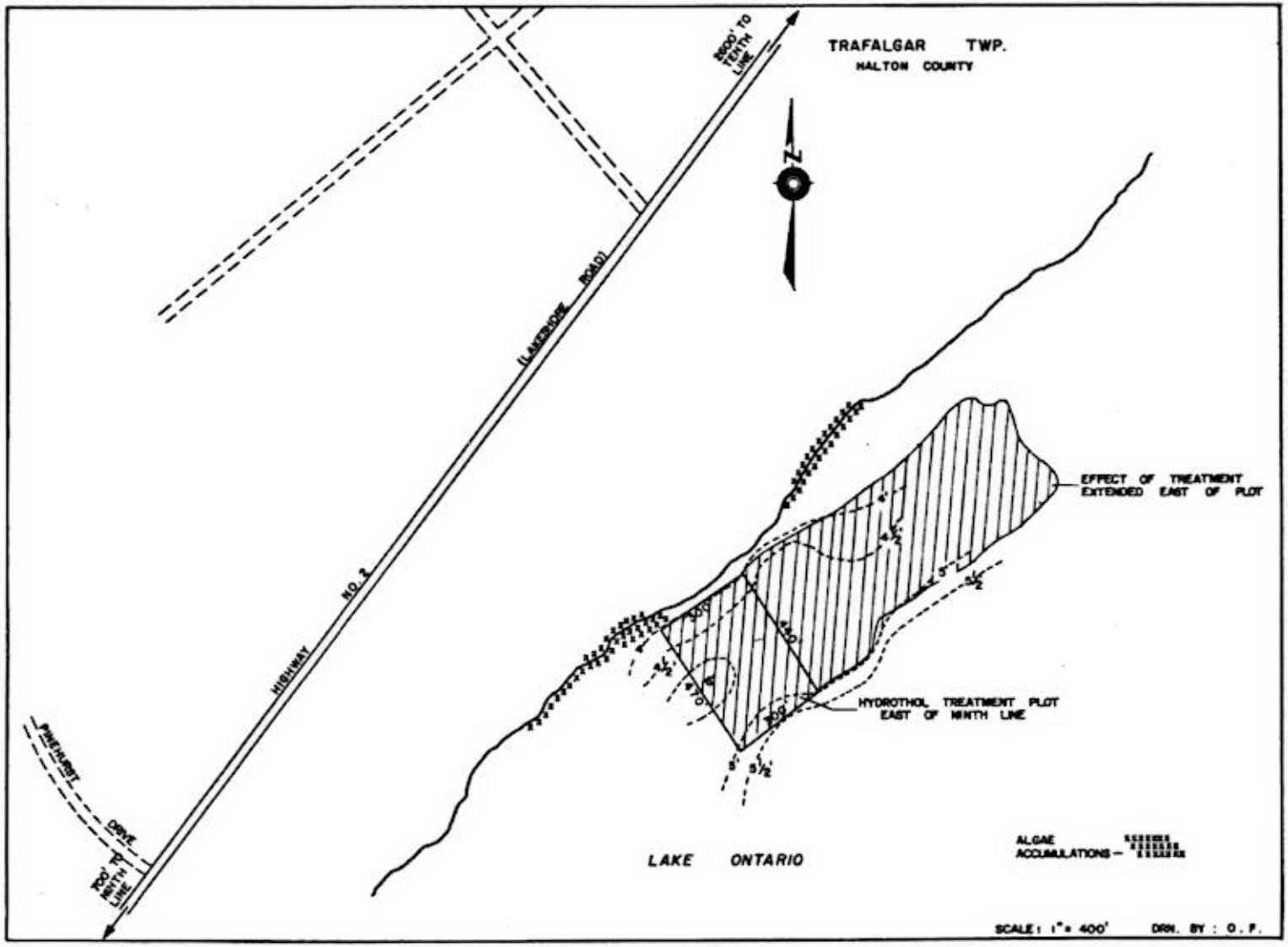

Figure 4. Lake Ontario - Hydrothol Treatment Plot.

Generally, observations on *Cladophora* beds and shoreline accumulations were noted on the weekly sampling surveys that the Commission carried out between Port Credit and Hamilton. Many shoreline accumulations were noted and odour resulting from the decomposition of this material was common.

In connection with the evaluation of the efficacy of algicides applied in the Oakville area, a number of observations were made of the general algae conditions in the vicinity of the treatment plots. While turbid water and very low water temperatures hampered these observations, lush *Cladophora* beds are known to have remained established until early October at least.

Algicide Trials

Sufficient chemicals were purchased to permit two treatments of the areas in Lake Erie, should this have been necessary. By the middle of August it was apparent that no algae was growing in the general areas where the treatment had previously been applied and for this reason chemical was available for testing in Lake Ontario.

Aqualin Treatment Plot

On August 21st an application of 7 ppm of Aqualin was made to a plot 1250 by 210 feet opposite Park Street (Figure 5). The depth varied from four to seven feet and the total volume was 33 acre-feet. The day that the Aqualin was applied was calm, the water temperature 590 and there was a slow easterly movement of the water at three

to five feet per minute. The algae growth was eight to twelve inches long, dark green in colour and covered 95% of the bottom. The chemical was applied using the apparatus previously described so that it was applied directly into the *Cladophora* growth.

Before treatment, a number of carp, *Cyprinus carpio*, were observed in the area. During the treatment a number of bullheads, *Ictalurus nebulosus*, were killed. It is likely that a number of other fish were also affected, as herring gulls were attracted to the area and were observed to be feeding during the final stages of the treatment.

Observations of the treated areas were attempted on August 31st, September 6th, 10th and 26th. On August 31st the water was very turbid but samples scraped from the bottom within the plot showed some evidence of deterioration. This was taking place *in situ* as much of the material brought up had a brown appearance and a slimy feel. On September 6th, the water was still turbid but diving indicated that some change had taken place though the kill was by no means complete and patches of healthy algae remained within the treated area. A further attempt to evaluate the effectiveness of this treatment was made on September 10th but the water was again turbid and as the water temperature was 48°F on this occasion, only limited observations could be made by diving.

On September 26th, thirty-six days after treatment, the water was very clear and good observations could be made from the surface. At that time, the tracks of the hoses which carried the chemicals into the water and produced a local kill could still be

seen, but healthy growths occurred between these tracks. It was estimated after comparing the treated area with the growths in the surrounding beds that fifty per cent control had been achieved at that time.

Hydrothol Treatment Plot

On August 24th, Hydrothol was applied to a plot 300 by 470 feet at a concentration of 1.1 ppm on the shoal east of the Ninth Line. The water depth in this area was four to six feet and the total volume treated was 16.2 acre-feet. The water temperature at the time of treatment was 68°F and a current of seven feet per minute was measured, moving parallel to shore in a north-easterly direction. There was some swell remaining from a blow on the previous day and while the water was turbid it was estimated by diving that 75% of the bottom was covered with a growth seven to twelve inches long and lush green in colour.

No fish mortality resulted from this chemical treatment. The first observations made under the adverse conditions previously described in the section dealing with Aqualin, indicated that a good kill of the algae had been achieved. Samples taken from the bottom and limited observations made by diving, showed that all samples had a slimy texture and were bleached or brown in colour. Rocks awash at the surface in the treated area that normally were ringed by a heavy growth of *Cladophora* were completely cleared and there was evidence that the effect extended towards the north-east in the direction that the current was moving the day the chemical was applied. On September 26th, thirty-three days after treatment when the water was

clear enough to permit good observations from the surface, virtually no algae remained in the treated area or in a further 600 feet to the north-east. The algae growing away from the treated area retained the characteristic green colour. It was estimated that the algae kill from this treatment was 95% effective.

CONCLUSIONS FROM CHEMICAL STUDIES

Hydrothol gave good to excellent control at concentrations of 0.93 and 1.1 ppm in both Lake Erie and Lake Ontario. The excellent results in Lake Ontario occurred in a water temperature of 68°F and at a time when there was some turbidity and a water current of seven feet per minute. Previous Hydrothol treatments in 1961 also provided some control of *Cladophora* at lower concentrations and when the water was as cold as 60°F.

Aqualin gave good control in Lake Erie at 12 ppm in 72°F water but unsatisfactory control in Lake Ontario at 7 ppm when applied to water 59°F.

The following cost estimated has been made for treating one acre of water averaging four feet in depth.

Hydrothol	- concentration 1 ppm	=	$ 65.00
Aqualin	- concentration 10 ppm	=	$ 70.00

The cost of applying the chemical is not included in these figures. These are concentrations which are known to have provided good control under favourable treatment conditions. It is probable that good control could be achieved at a lower rate

by choosing **a** time when water temperatures and water movement are favourable and when extensive applications could be made at one time.

While the cost figures quoted are comparable, Hydrothol has certain inherent advantages in that it is less toxic to fish, is easier to handle and can be applied in a liquid or granular formulation from aircraft.

The laboratory studies have indicated NIA 5625, copper sulphate, Paraquat and Diquat to exhibit algicidal properties against *Cladophora*. The experimental chemical NIA 5625 only became available late in the season and sufficient quantity was not available for field testing. Laboratory results have shown it to be at least as effective as any other product tested to date. Further studies will be taken to determine its effectiveness and cost for *Cladophora* control.

Copper sulphate has been thoroughly tested in the lake. Concentrations up to 10 ppm have not shown any lasting effect and for this reason it cannot be considered as a suitable algicide for the control of *Cladophora*. Paraquat and Diquat have demonstrated a toxicity to *Cladophora* at 5 ppm in the laboratory study. The cost of treatment with either of these chemicals at this concentration would not be competitive with that of Hydrothol or Aqualin.

TESTING OF DEODORANTS

Two bactericidal products were tested during the summer of 1962 to determine their effectiveness in reducing septic odours caused by the decomposition of shoreline accumulations of *Cladophora*. These products, Hyamine 2389 and Ozene, were applied on July 30th.

Hyamine 2389

Hyamine 2389 is a quaternary ammonia compound which is used as a disinfectant, an algicide and a deodorant in sewage plants and garbage dumps. A strip of decomposing algae approximately 300 feet long and varying in width from 50 to 100 feet wide was treated with five U.S. gallons of this product. The total area treated was estimated to be one half acre and the depth of algae on the plot varied up to three feet, with an average depth of one foot. A similar adjacent accumulation occurred nearby, which extended out to open water. This was left untreated to provide a control area.

The odour during the period of treatment was extremely foul, characterized by a pungent sulphide smell. The five gallons of Hyamine 2389 applied by adding one pint of the bactericide to each 45 gallons of water and spraying this under pressure, using a gasoline-operated portable pump. The pump was placed in a light aluminum skiff which was dragged over the surface of the rotting algae to permit treatment of the entire area.

The plot was revisited on the day following treatment and there was a definite decrease in odour on the area treated. It was necessary to bend down close to the surface of the plot to detect a distinctly offensive algal odour. The odour from the untreated control area adjacent to the plot, was very strong, just as it had been the day before. An inspection of the plot on the ninth day following treatment revealed that little smell could be noticed either from the treated or untreated areas since the wind was blowing out to the lake. Occasionally an unpleasant whiff of decomposing algae would be noticed and it was doubtful whether the treatment was providing any beneficial effect at this time. The cottages facing the plot were unoccupied so that it was not possible to obtain any comments concerning the effectiveness of the treatment during the week following the application of Hyamine.

Ozene

Ozene, a water emulsifiable formulation of Orthodichlorobenzene, was applied to a small accumulation of algae that was estimated to occupy an area of 2500 square feet. The average depth of the decomposing algae was six inches. One gallon of Ozene was applied by mixing each of four quarts with 45 gallons of water and spraying this under pressure, as with the Hyamine.

The accumulation was distinctly odorous before the Ozene was applied but the smell became masked by the antiseptic smell of the Ozene as the treatment progressed.

On the day following the treatment the antiseptic smell was still very noticeable and there was a definite reduction of the offensive algal odour. Eight days later there was no apparent benefit. Reports from cottagers in the immediate vicinity indicated that a strong creosote odour persisted for two days following the application. It was concluded that the smell of the Ozene in supplanting the odour of the decomposing algae did not provide a satisfactory solution to the problem.

MECHANICAL BEACH CLEANING

Several municipalities fronting on Lake Erie have attempted to gather and dispose of accumulations of algae as they are washed ashore. A variety of methods have been employed which have included at least the following procedures; hand raking, bulldozing into piles and burying, raking or scraping into windrows for subsequent loading onto trucks manually or by front-end loader, or scraping and gathering with a front-end loader for piling above the water line or for subsequent disposal by truck. Attempts have also been made by individuals to wash down the rocks with high pressure hoses and to dislodge accumulations of decomposing algae using the wash of an outboard motor.

Many areas where algae accumulates are sufficiently rough, by virtue of shelving rock or boulders strewn on the beach, that it is difficult or even impossible to employ conventional equipment.

TABLE IV. Summary Of Information From Beach Cleaning Questionnaire.

	Dates Of Removal 1962	No. Of Hours Worked	Estimated No. Of Cubic Yards Removed	Method Of Disposal	Equipment Used And Cost	Hand Labour Cost	Total Cost Of Operation
Rock Point	August 3, 4	32	15	Trucked Away	½ Ton Truck $ 25.00	$ 45.00	$ 70.00
Cedar Bay Walnut Park	July 12, 13, 24, 26,30,31						
	Aug. 1, 2, 4, 6, 8, 9, 10, 11 18, 22,23, 31	76 ¾	100	Piled On Shore	Tractor And Front End Loader	$9.70	$287.70
	Sept. 1				$ 278.00		
Grabells Point	August 8	10	1	Piled On Shore And Pushed Into Lake	Tractor With Rake	$ 20.00	$119.50
Morgans Point	August 9	6		Picked Up On Shore	$ 99.50		
Crystal Beach	June 29						
	July 6, 13, 16, 19 23, 25, 29	173	185	Trucked Away And Some Piled On Shore	Tractor With Rake And Bulldozer And Truck	$259.50	$576.45
	Aug. 3, 6			-	$316.95		

Also, after the algae has started to decompose, it loses its woolly structure and becomes sludge-like and in this condition is impossible to rake, gather or load.

It was felt that improvements could be made to the conventional types of collecting devices and for this reason a survey was made to obtain information from the beach associations and municipalities which had attempted collection and disposal of shoreline accumulations during the summer of 1962. To obtain this information a questionnaire was sent out and four replies were received. Table IV provides a summary of the information obtained.

Rock Point

Rock Point, located in Sherbrook Township, is a public provincial park operated by the Department of Lands and Forests. As heavy accumulations do not normally occur and since manpower is available, collections are normally made by hand. The procedure employed is to gather the material along the waters edge with manure forks, pile it onshore and allow it to drain before trucking it away. In 1962, collections were necessary on two days and 32 hours of hand labour was required to remove 15 cubic yards. The total cost of this operation was estimated to be $70.

Figures for 1961 were included, which indicated that the condition had been considerably worse in 1961. In that year, shore collections were required on five occasions and a total of 33 cubic yards of algae were removed after 73 man-hours of labour.

Cedar Bay (Walnut Park Section)

Cladophora accumulations along the shore have been a continuing problem to the summer residents of Walnut Park for a number of years. During the past two or three years an active beach association has contracted for the removal of boulders near the waters edge by bulldozing, in order that algae drifting ashore can be collected mechanically.

While a variety of farm equipment has been employed, most of the collections have been made using a front-end loader on a farm tractor, modified to improve the operation of collecting and lifting the algae. In 1962, all or part of nineteen days were used in gathering the algae that had drifted ashore and depositing it in piles on the beach above the high-water line. This procedure was found to be quite successful though pockets of the algae were difficult to remove in some areas of shelving rock. A total of 77 hours was used in gathering and piling an estimated 100 cu. yards of *Cladophora*. The total cost of the algae control programme in 1962 was $287.70.

Grabell Point and Morgans Point

On August 8th and 9th a diesel farm tractor was employed in a cleaning operation sponsored by Wainfleet Township. The algae had been ashore since the latter part of July and much of it was in an advanced stage of decomposition. Some of the material could be removed but a considerable quantity had to be pushed back in the lake. This was reported to be effective in controlling the nuisance along this portion of the

shoreline as the material disappeared shortly and did not wash up on the shore again. A total of 16 hours was required for these operations and the cost was $119.50.

Crystal Beach

Cladophora was washed ashore and removed on ten occasions from shoreline owned by the Village of Crystal Beach. This operation necessitated 282 hours of labour and an estimated 185 cu. yards of material were handled. The total cost of this operation was $576.45.

This area at Crystal Beach probably receives consistently the greatest accumulations of algae in Lake Erie. The portion of beach most affected is used extensively for bathing and an effort is made by the municipality to keep it as clean as possible. In spite of these efforts, the methods used remove only the gross accumulations of algae and leave pockets around the shelving rock and mixed in the sand.

It may be concluded from the observations made and the information received from the municipalities using mechanical collection methods, that this procedure is effective in removing gross accumulations. Hand labour is the only method presently available which will completely clean the beach. Mechanical cleaning is effective only when the algae is first brought ashore and before decomposition takes place. Its efficiency can be improved if obstructions, such as boulders, are removed from the beach. This method is relatively inexpensive in comparison with chemical treatment of

algae on the beds in the lake and while it is not entirely satisfactory, a tolerable condition can be achieved.

There is considerable room for improvement in techniques of collecting and disposing of the algae which would make this procedure more efficient and probably less expensive. It is recommended that further studies be planned in this regard.

SUMMARY

Detailed surveys of growth areas were made at Rathfon Point and Grabell Point in Lake Erie. Algae was found to grow to a depth of about 13 ft. In depths greater than 7 feet the quantity of algae was considerably less. At depths greater than 9 feet wave action did not dislodge the crop. The total area of growth having a depth of 7 feet or less was 84 acres at Grabell Point and 20 acres at Rathfon Point. These were typical of many rocky points which support growths that eventually cause malodorous conditions and many larger and smaller areas are to be found in the easterly end of Lake Erie. One cursory survey made on July 23rd indicated that nuisance conditions occurred at 18 places, affecting 8 of the 60 miles of shoreline surveyed.

Observations in Lake Ontario indicated that algae grows in quantity to a depth of 23 ft. Estimates of the total growth areas have been made in previous reports (Cladophora Report, OWRC 1961).

Cladophora developed an unhealthy appearance early in July in all of the area of Lake Erie under observation with the exception of Crystal Beach. This was manifested by a weakening of the filaments and a bleaching of colour. Shortly after this time accumulations began to come ashore and while some growth continued, no pronounced crop developed during the remainder of the season. The algae in Lake Ontario was dark green in colour and continued its growth throughout the summer.

A laboratory method of testing the effectiveness of various algicides against *Cladophora* was devised. A total of 70 tests were made using a number of chemicals at different temperatures, exposure times and concentrations. These laboratory studies showed Hydrothol (Penco 47 or TD 47), Aqualin and NIA 3625 to be the most effective chemicals.

Field studies indicated that Hydrothol was effective in killing *Cladophora* in tests made in Lake Erie and Lake Ontario. Aqualin worked well in Lake Erie but was not satisfactory in Lake Ontario. Both chemicals cost about $65. per acre of lake bottom treated at the concentration used. Some reduction in this cost may be possible when large applications can be made under favourable environmental conditions.

Hydrothol has certain advantages over Aqualin in that it is easier to handle and may be applied by aircraft. While both chemicals are toxic to fish, field tests have shown Hydrothol to be less hazardous in this regard. Sufficient quantities of NIA 5625 were not available for field testing in 1962. It is toxic to fish in about the same range as the Hydrothol. Laboratory studies indicate that it may be effective in controlling

algae at the same or lower concentrations than Hydrothol.

Two chemicals were applied to control odours associated with decomposing accumulations of algae. Hyamine 2389 provided some temporary relief. Ozene gave some immediate odour suppression but the residents objected to the antiseptic smell of the compound.

A questionnaire was circulated to parks, municipalities and beach associations that collected algae accumulations mechanically for disposal and four replies were received. The total quantity estimated to be removed in three of the four reported beach areas was 400 cubic yards. Th total number of hours work involving power equipment was 212 and 229 hours were spent in removal by hand labour. Th total cost of these four operations was $1,053.65. It was generally concluded that this method of alleviating the nuisance of accumulated algae at the shoreline was effective where local conditions permitted the use of mechanical equipment, but that better methods could probably be devised.

RECOMMENDATIONS

1. Field tests of the algicide NIA 5625 should be carried out for Cladophora control, to determine its effectiveness and cost.

2. Laboratory screening of likely chemicals should be continued and field tests carried out on any which appear to hold promise.

3. A study should be undertaken to develop equipment suitable for the removal of algae accumulations that are washed ashore. It is proposed that this be carried out by mechanical consultants such as a university engineering group working under the direction of the OWRC. Sufficient funds would be required to permit field trials of equipment, modified or constructed to the specification of the consultant.

4. Where *Cladophora* control is undertaken by commercial applicators for municipalities, the Commission should provide technical assistance and an appraisal of the effectiveness of the treatment for that municipality.

5. The Commission should continue its studies into factors promoting the growth of nuisance quantities of *Cladophora.*