Report

Number 8

1971

THE UNIVERSITY OF WISCONSIN SEA GRANT PROGRAM

ANNUAL PROGRESS REPORT OF SEA GRANT ACTIVITIES

August 1971

WIS-SG-71-208

ANNUAL PROGRESS REPORT
OF
SEA GRANT ACTIVITIES

A REPORT OF PROJECT ACTIVITIES
CONDUCTED UNDER SEA GRANT INSTITUTIONAL SUPPORT
AT THE UNIVERSITY OF WISCONSIN

JUNE 1970 TO JUNE 1971

AUGUST 1971

WIS-SG-71-208

SEA GRANT TECHNICAL REPORT #8

THE UNIVERSITY OF WISCONSIN SEA GRANT PROGRAM

TABLE OF CONTENTS

INTRODUCTION

Progress is an ever-changing state. And the studies made by the University of Wisconsin's Sea Grant Program over the past year illustrate this concept. Contained herein is the Annual Report of Sea Grant Activities 1971. It must be kept in mind, however, that the reports that follow were compiled in January and that each program, because it is not static, has changed and grown even in the time this publication was being processed.

In the middle of a two-year grant, the programs which form the research core remain basically the same. Seven research programs -- the Green Bay Program, the Water Quality Program, Fisheries, Mineral Resources, Electric Power Production, Ocean Engineering, and Socio-Economic Aspects -- plus Education and Advisory Services, contribute their knowledge to the state and region, translating the Sea Grant College concept into a functional organization.

Over 80 faculty members from 23 different departments and several professional schools make up this state-wide program which extends to three campuses and University Extension. It is both regionally and globally concerned. Our region is the upper Great Lakes, with active programs on Lake Michigan and Superior. Lake Huron will be added as the scope of the program increased and the entire 3-lake complex comes under scrutiny. Globally, we are deeply committed to broadly based education in the marine environment. In addition, the marine mineral placer studies have global implications and are an integral part of our marine geology research.

Special Sea Grant matching funds of $207,000 appropriated for the 1971-71 program illustrate the solid support of the Sea Grant Program by the State Legislature and the University Administration. The Sea Grant Program continues to be guided by an Advisory Committee, which has full responsibility and authority to develop and administer this program. The Program is organized into subprograms. Maximum interaction is encouraged, and though some overlap is evident, this structure permits optimum unity and flexibility.

The accomplishments of the past year are obvious from the reports that follow. The Sea Grant film "Tools for Decision" has met with a fantastic response and is an unprecedented success. Educational opportunities are interwoven in every aspect and level of research, with over 40 graduate students and 100 or more undergraduates participating in various projects.

Through this broad and diverse participation of faculty and students, the University of Wisconsin has built a solid program of research, education and advisory services. We feel our progress is substantial and we look forward to building on our successes and to accepting the continuing challenge of man's interaction with the sea.

THE GREEN BAY RESEARCH PROGRAM

Green Bay, an estuary-like bay of Lake Michigan has for many years experienced a severe deterioration in water quality. The Green Bay Research Program is directed towards the analysis of the broad spectrum of pollution problems resulting in large part from the discharges of rural, municipal and industrial wastes via the Fox River. Initial efforts are placed on assessing the response of the aquatic ecosystem to the various waste inputs and on the reverse effect of the present environmental condition of the Bay on man's actual and potential water-based activities. The Program is designed to present data to the decision-making segment of society in the form of alternate solutions intended to provide an optimal mix of the different uses sanctioned in the Bay.

Research activities thus far have dealt with the problem of eutrophication in studies on nutrient sources in the drainage basin, nitrogen fixation in the algal community and the response of algal and benthic species to the nutrient enrichment. Other activities have dealt with such physical parameters as the flushing rate of the Fox River through the Bay, acoustic profiling of the bottom and sub-bottom structure, and recent sediment depositions in the lower Bay. Another aspect of the Program includes an analysis of the incorporation of organochlorine pesticides and chlorobiphenyls (PCB) in bottom sediments. Certain socio-economic uses of the Bay are being examined from the standpoint of water quality influences on recreational pursuits and the economic impact of commercial shipping on the Port of Green Bay.

One manuscript, based on a recently completed Sea Grant study, has now been published."Social Goals, Problem Perception, and Public Intervention: The Fishery", by Victor L. Arnold and Daniel W. Bromley appeared in the San Diego Law Review. A summary of this report is attached.

Progress on the specific segments of the Program is presented in each individual project below:

THE ROLE OF N_2-FIXING BLUE-GREEN ALGAE IN EUTROPHICATION OF GREEN BAY

R. H. Burris and Larry Vanderhoef

The city of Green Bay discharges large volumes of industrial and domestic wastes into Green Bay, and nutrients from these wastes support abundant plant growth. In examining the

pattern of flow from the Fox River that carries the nutrients along the east shore of the Bay an especially heavy nutrient concentration is found there. Measurements of biological N_2 fixation in the Bay reflect this pattern. The attached map of the southern portion of Green Bay indicates sampling stations. Station 3 near the eastern shore gave 5.8 nmoles C_2H_2 formed per liter of water/hr, whereas station 5, near the middle of the Bay gave 0.3. Stations 6 and 10 near shore gave values of 1.6 and 3.9, whereas stations 5 and 8 gave values of 0.3 and 0.3, respectively. It is evident that nutrient concentrations supporting algal growth were most abundant along the eastern shore of the Bay.

Sampling in Green Bay during the summer of 1970 was hampered by lack of a suitable ship to serve as a base for sampling. This deficiency has now been remedied and an excellent cruiser-type vessel is now available for this and other Lake Michigan research. Collections were made from a small boat and were subject to vagaries of the weather. Data were accumulated primarily from the southern section of Green Bay, the section showing by far the greatest eutrophication. Our earlier examinations have revealed that sections of the southern part of Green Bay support biological N_2 fixation at 300 times the rate of the northern, nutrient-deficient portion of the Bay.

Decrease in N_2 fixation as nutrient concentrations diminish with distance from the city of Green Bay are illustrated by data from stations 21, 22, 23, and 24 which showed, respectively, 19.7, 7.6, 2.8 and 1.6 nmoles C_2H_4 produced/liter/hr. Comparable tests in northern Green Bay at stations 25, 26, 27 and 28 showed, respectively, 0.12, 0.27, 0.06 and 0.05 nmoles $C2H_4$/liter/hr. The population and activity of blue-green algae in the north section is far less than in the south section of the Bay.

Comparison of samples from eutrophicated lakes with Green Bay in the summer of 1969 indicated the following activities as nmoles ethylene produced/liter of water/hr.: Lake Mendota 3.50, Little Arbor Vitae Lake 4.99, southern Green Bay 8.10. Oligotrophic lakes showed the following: Trout Lake 0.29, Crystal Lake 0.01 and northern Green Bay 0.20.

In general, activity for acetylene reduction decreases with depth. For example, samples at station 19 from depth of 0, 2 and 5 meters gave 180, 81 and 23 nmoles ethylene/liter of water/hr, respectively; station 43, 0.63, 0.16 and 0.11; and station 29, 0.06, 0.02 and 0.01.

Diurnal fluctuations in N_2 fixation are evident in Green Bay. Activity is low at night and generally increases to a peak value around noon and then declines until sunset and through the night. This pattern is disrupted by clouds and the accompanying change in light intensity.

THE MARINE RECREATIONAL USES OF GREEN BAY: A SURVEY OF HUMAN BEHAVIOR AND ATTITUDE PATTERNS

R. B. Ditton and T. Goodale

Under the University of Wisconsin Sea Grant Program, a reliable survey instrument is being developed that will probe and report (1) boating, swimming and fishing participation on Green Bay, (2) the water quality parameters seen as critical according to user groups affiliation, (3) belief and attitudinal responses to the perceived water quality of Green Bay, and (4) the relationship between respondent attitudes toward perceived water quality and recreation behavior. Within the perspective of other recreation participation determinants, water quality will be evaluated as a recreation demand shifter.

The sample is comprised of approximately 4,000 households in the five-county area. With the cooperation of many groups and agencies, as complete a listing of households as possible has been compiled . Geographically-proximate clusters of ten or eleven units were identified, numbered, and selected using a table of random numbers. Thus this sample is a representative, random one of approximately 400 clusters of ten or eleven households each. Should time and other resources permit, a random sample of the secondary school age population will be included.

A questionnaire is used for gathering data. The size of the study and study area, plus other restraints, precludes use of other techniques. However, some additional data may be gathered from a limited number of respondents using certain proven projective techniques. The questionnaire should permit certain new avenues of description and analysis while avoiding weaknesses encountered by other researchers of water-based recreation and water quality perception. A pre-test of the present instrument has been completed, with a test-retest replication on approximately 100 household heads or spouses randomly selected from an area immediately adjacent to the five-county area. This will provide a test of reliability as well as identify any problematical elements in our present instrument design.

NUTRIENT INPUTS IN GREEN BAY

Paul Sager and James Wiersma

Broadly stated, the objectives of this project have been to quantify the nutrient inputs to Green Bay and examine their dispersal in waters of the lower Bay. Because nutrient inputs can result from different types of activities in the drainage basin, the following sources are being evaluated in order to establish the relative importance of each.

a. The Lake Winnebago Pool
b. Municipal Treatment Plants
c. Industrial Wastes
d. Tributaries Draining Agricultural Land
e. Urban Runoff

To accomplish the above goals, a regular sampling program has been established to ascertain contributions from the Lake Winnebago Pool, Municipal Treatment plants, and tributaries of the lower Fox River. The following parameters are being estimated: conductivity, pH, total phosphate, dissolved phosphate, orthophosphate, ammonia nitrogen, nitrate nitrogen, dissolved oxygen, biological oxygen demand, chemical oxygen demand, temperature, chlorophyll a, secchi disc turbidity and suspended solids. Established sampling locations and frequency are summarized below.

I. Lower Fox River

Ten sampling stations have been established on the lower Fox River. The stations are distributed such that a close evaluation of water quality change can be made as the water leaves the Winnebago pool, moves through the municipal-industrial complex, and enters Green Bay. Samples were taken at weekly intervals since June 1970 (biweekly intervals, fall through winter) throughout the year.

Preliminary observations indicate that the river system displays a wide spectrum of water quality problems, many of which would likely be more severe were it not for the interacting effects of other factors. For example, it appears that the high nutrient load in the river accelerates algal growth that, by photosynthesis, produces oxygen. The dissolved oxygen, thus produced, is in turn utilized in the process of biological degradation of organic matter that in large part originates from industrial sources. That the assimilative capacity of the river (in terms of the oxidation of organic loading) is exceeded, in spite of the intensive photosynthetic activity, is reflected

in portions of the river between Kaukauna and DePere, where for several miles, near anoxic conditions prevail for extended periods. Seasonal variations, flow variations and organic loading will be analyzed further.

The assimilation of nutrients by the river system is also of interest in light of the heavy loadings originating from municipalities and other sources. Closer examination of the nutrient inputs and subsequent discharge to the Bay is being made.

II. Tributary Streams of the Lower Fox River

Three tributary streams draining agricultural lands have been sampled since June 1970. Recently, five other streams have been added to the biweekly sampling schedules.

III. Sewage Treatment Plants

In an attempt to estimate the nutrient loading on the Fox River from treatment facilities, the final treated effluent from 11 municipal sewage treatment plants is sampled on a biweekly basis. The cooperating treatment plants are in the communities of Green Bay, DePere, Village of Wrightstown, Kaukauna, Little Chute, Kimberly, Appleton, Town of Menasha, Nennah-Menasha, Town of Grand Chute, and Town of Holland.

Discussions with several operators of treatment plants has revealed that sewage is bypassed because of inadequate treatment capacity. This condition has increased the difficulty of determining the amounts of nutrients originating from the source.

IV. Lower Green Bay

An attempt to determine the dispersal and fate of the nutrient load entering the Bay has been made by sampling 24 stations located throughout the lower Bay. These stations were sampled on a biweekly basis during the summer months and on a monthly basis during the fall months.

A summary of the measured parameters and ranges of these parameters is found in Table I.

Table I - Samples of Parameters and Ranges

	Fox River		Tributaries	Sewage Tr. Plants	Green Bay
	Source	Mouth			
Nitrate-Nitrogen mg/l	0.00- 1.45	0.00- 1.26	0.00- 8.84	0.00- 8.50	0.01- 0.29
Ammonia-Nitrogen mg/l	0.00- 0.38	0.09- 1.22	0.00- 0.93	0.39-22.8	0.03- 6.72
Orthophosphate-P mg/l	0.011-0.611	0.00-0.217	0.30- 6.35	0.053-47.22	0.00- 1.41
Diss. Phosphate-P mg/l	0.22- 6.25	0.014-0.307	0.014- 4.66	0.028-35.85	0.00- 0.264
Total Phosphate-P mg/l	0.188-0.893	0.312- 1.08	0.124- 5.15	5.343-126.025	0.044- 1.065
Diss. Oxygen mg/l	6.10-13.65	0.00- 9.94	-	-	-
B.O.D. mg/l	2.10-16.4	8.37-18.00	-	6.00-486.0	-
C.O.D. mg/l	11.49-51.0	43.48-184.7	-	31.85-1891.3	9.88-90.90
Conductivity µmhos	257-359	348-525	510-3180	705-6200	240-555
pH	7.90- 9.39	6.85- 7.70	7.90- 8.65	6.80- 8.40	7.75- 9.05
Chlorophyll	in process of computation		-	-	-
Secchi Disk meter	.25- 1.6m	.30- .70m	-	-	-
Suspended Solids mg/l	8.50-40.0	14.0-36.0	25-446	-	-

THE ECONOMICS OF GREEN BAY

Eric Schenker

The study of the impact of the Port of Green Bay on the Economy of the community conducted by Eric Schenker, Professor of Economics; Center for Great Lakes Studies, University of Wisconsin-Milwaukee has resulted in the paper, "An Estimation of the Quantitative Impact of the St. Lawrence Seaway on the Hinterland's Economy". This has been published in the Proceedings of the International Association for Great Lakes Research Conference. The referee of the paper considered it "an exceptionally good piece of work". His comments are appended. The Wisconsin results can be used for the regional multiplier.

This study of the Great Lakes Region includes the States of Minnesota, Wisconsin, Illinois, Michigan and Ohio. It considers the regional economic growth process by attempting to estimate the impact of the Seaway on regional income and employment.

The study will now concentrate on estimating the income and employment generated by the Port of Green Bay.

The project is now in the data gathering stage and several field trips have been made. We plan to use 1970 census data when it is available. This research program is being coordinated with other studies in the area.

Review of "An Estimation of the Quantitative Impact of The St. Lawrence Seaway on the Hinterland's Economy", by Eric Schenker, et. al. Referee's Comments Mr. Ian Butters, Ontario Economic Council.

Much has been said about the importance of the Seaway as a transportation route and especially about the benefits provided to areas adjacent to it. Yet little has been done to quantitatively estimate the magnitude of these benefits and its spatial impacts. Studies in Ontario to date[1] have generally concentrated on commodity flows at ports especially in terms of origins and destinations, changes in composition and volume of cargoes, and more recently, Foley looked at approximate changes in the level of investment in each port and how these affected the St. Lawrence system.

What is significant about the Schenker approach is that it looked at the regional economic growth process by attempting to estimate the impact of the Seaway on regional income and employment. Prior to assessing the merits of this study approach, a brief review of the methodology and data employed is instructive.

The Study Area: The Great Lakes Region defined by this Study included the States of Minnesota, Wisconsin, Illinois, Michigan and Ohio.

Methodology: The author recognized three types of economic benefits stimulated by the Seaway: (a) reducing transportation costs for mid-American foreign commerce; (b) generating increased economic activity of Lake ports; and (c) extending the range of mid-American manufacturers' marketing possibilities.

As was pointed out before, much work has been done on the first two benefits. It was in response to the third that this Study was attempted. The procedure adopted was couched within the export base theory of regional economic growth utilizing as working hypothesis that an increase in the "basic" or export sector will generate increased "non basic" or localized employment by an amount greater than the initial increase. The problems faced can be classified and solved as follows:

Problem: To isolate the basic sector of the economy of the Great Lakes Region and separate total employment into basic and non-basic components.

Location quotients were first calculated using both the Great Lakes region and the U.S.A. as a whole as benchmark economies. The results showed that on the whole, the primary market orientation of each of the States was national in scope.

---

[1] The latest study available is by K.W. Foley, "St Lawrence Seaway - Impact on Ontario," Ontario Economic Review, 1970, pp. 3-12.

A specialization ratio was calculated in the next step. This can be stated as:

Specialization ratio =

$$\frac{ns - \frac{nB + ns}{nB + Ns} \quad (Ns)}{ns}$$

where Ns and NB refer to total employment in each State and benchmark economy (U.S.) respectively, and ns and nB refer to industry employment in the State and benchment economy. This ratio separated employment into two categories (1) employment sustained by external receipts (basic) and (2) employment expected in that industry if it were self sufficient relative to the national economy(non-basic). Estimates derived were used to analyze changes in basic and non-basic employment over a nine year period (1958-66).

Problem: To estimate the influence of basic employment on non-basic employment, i.e. to derive an income-employment multiplier which relates changes in export income to the derivative change in the locality's income and employment.

This was effected by classical linear regression which states that non-basic employment is some function of basic employment, with the regression coefficient,i.e. the b value, giving the derivative change. In this case the coefficient was 1.57, meaning for every non-basic employment of 100, the change in basic employment was 157. Total employment becomes 257, and the multiplier is 2.57, which is the rate of change from the non-basic employment of 100 to the total employment of 257. The significance of this relationship is verified by the high degree of explanation which is derived from the model r^2=76% for Wisconsin and Minnesota, 90% for Illinois and Ohio, 89% for Michigan and 98% for Indiana.

The multipliers derived ranged from 1.899 for Minnesota to 2.63 for Illinois. The regional development implications of these multipliers are apparent since areas with large multipliers tend to be less stable economically because small changes in exports produce large swings in total regional income and employment. Smaller multipliers characterize more stable regions.

Problem: To estimate the income and employment generated by cargo on the Seaway.

These estimates were possible by applying the regional multipliers to Seaway traffic data. Direct income relates to Lake ports activities e.g. wharfage, terminal changes, auxillary port services etc. Using $5 for bulk cargo and $24 for general cargo as the average direct income generated at Great Lakes Ports, total direct income generated by Seaway traffic for each state was derived. Applying the regional multipliers to these incomes allowed the calculation of total dollar impact of the Seaway. The results showed that $643 million or 1 percent of the total income of the Great Lake States was generated from the Seaway.

Further, the employment generated by Seaway traffic was calculated by using a median family income figure of $7,500 (1968) and relating this to total dollar income derived from Seaway traffic. The results showed that the cargo on the Seaway directly provided income for 37,770 families and in an indirect way (using the regional multipliers) for over 85,000 families.

Conclusion

This unique study of income and employment impact of the St. Lawrence Seaway can be rated as quite good. A modification of the location quotient approach separated the basic from the non-basic component of the regional economies under consideration, consistently a traditional problem in the field of regional analysis. The derivation of the multipliers was sound and the results were readily comparable to other multipliers derived for other regions. Since the Study was probably a first of its kind, it may be necessary to test its final estimates through a similar application for Ontario. This point can be reemphasized since several studies have demonstrated that the potential impact of the Seaway on Canada (and especially on Ontario) has not been as great as the effect on the U.S.A.

In the light of what is known in the field of modern regional development theory and techniques of analysis, this Study was sound, utilized up-to-date techniques, provided original impact estimates and finally, is inspiring for further research.

CLADOPHORA PRODUCTIVITY IN GREEN BAY

Michael Adams

Three preliminary studies were made in the Green Bay area between August 4th and September 19th, 1970. Plexiglass chambers and glass bottles were used as incubation containers for measurement of C^{14} uptake by *Cladophora*. The plants were exposed for intervals of one to two hours to 5 microcuries of $NaHC^{14}O_3$ in 800 ml of water. During incubation, we monitored total radiation, temperature, and depth. Water samples were also taken for measurement of total alkalinity and pH. After the experiments, samples were immediately frozen under dry ice.

Laboratory analyses were accomplished by oven drying the *Cladophora*, extracting in 95% ethanol, and suspending 0.2 ml of the extract in a p-dioxane fluor for liquid scintillation counting. The solid plant material was ground in liquid N_2, dissolved in a tissue solvent, and suspended in a toluene fluor for liquid scintillation counting.

The range of total carbon uptake was 0.169 to 5.380 mg C per gram dry weight per hour (mean = 1.7 mg/g dry wt/hr). Three sites were chosen for sampling, and were ranked according to their association with highly eutrophic Fox River currents. Future plans include an intensive study of productivity of *Cladophora* at the three sites.

EUTROPHICATION OF GREEN BAY

A. M. Beeton

This study concentrated this past summer on a synoptic survey conducted throughout the entire area of Green Bay to determine the influence of Fox River water on the diatom populations. In addition to sampling for diatoms, water samples were collected for determination of total phosphorus, silica, and conductivity. Species identification and counts are underway on the diatoms.

One manuscript near completion is "Some Mathematical Models Useful in Exploited Fish Populations". This manuscript by Gilbert Walter and Walter Hogman is based on commercial catch records for Green Bay.

Two publications resulting from the Green Bay benthos are currently in press. One compares the composition of the benthic fauna of the lower and middle Bay in 1952 and 1969.

During the intervening 17 years, pollution tolerant midge larvae and especially oligochaete worms have increased in abundance. Other groups of benthic invertebrates have decreased. The observed changes are interpreted as indicative of increased pollution and eutrophication of the lower and middle Bay. If present trends continue future use of the benthos for assessment of environmental quality will have to be based on studies of the species composition of the oligochaete and midge populations.

The second report now in press is a description of the oligochaete fauna of the Bay. The study is based on samples from 103 stations between the Fox River mouth and Washington Island. The worm fauna consists of 29 species in three families. Distribution maps for most species are included in the report. Distribution of some species appears to be correlated with measured environmental parameters, especially those related to the path of Fox River water, viz. particle size, organic content and oxygen demand of the sediments.

An incidental contribution of the Green Bay benthos studies has been a statistical comparison of the effectiveness of Ekman and Ponar grabs, based on paired samples taken at 26 stations in the lower and middle Bay. It was concluded that the Ekman is in general a more effective tool for benthic studies in Green Bay and environments with similar sediments. However, the Ponar was more effective in capturing midge larvae on the harder sediments near the western shore of the middle Bay.

Work presently in progress includes identification of *Chironomidae* larvae from samples already taken. This will provide a detailed picture of distributional patterns of chironomid species comparable to the study of the oligochaete fauna.

Samples will be taken at eight selected stations in the lower and middle Bay at regular intervals during the coming year. This will provide knowledge of the seasonal population dynamics of chironomid and oligochaete species and may make possible an estimate of secondary production in these areas of the Bay.

Apparatus has been acquired and initial experiments begun for a study of the effects of oxygen tension on the burrowing behavior of several species of oligochaete worms. Hopefully this will contribute to our knowledge of the factors controlling their distributions in the Bay and a better understanding of the reasons for species differences in tolerance of organic pollution.

BATHYMETRIC AND HIGH RESOLUTION SHALLOW SUB-BOTTOM STUDIES OF GREEN BAY

R. P. Meyer

The bathymetric and high resolution shallow sub-bottom studies of Green Bay have been completed. As proposed, high resolution, sub-bottom acoustic program in Green Bay was finished during July and August, 1970, using the shallow draft, 40 ft. USCG buoy tender. The ship's position was electronically determined using a long wavelength, range-range Raydist system. This system, typical of what must be employed in the Great Lakes proper, provides over the horizon navigation and was highly satisfactory in this application. It required only one relocation of the two land transmitters, as compared with six land station relocations the year before while using a line of sight radar transponder system. There are now 89 complete transits across Green Bay.

The navigation has been reduced to plots of ships track on the same scale and projection as U. S. Lake Survey Charts 701, 702, and 703.

Several technical advances are significant. We have found that the high resolution system will operate in very shallow water if transmitter power is limited to low values. Evidently reverberation is not linearly related to transmitted power. Second, we have eliminated about 90% of the transducer vertical motion, which appears on high sea state days as a false rough bottom, by measuring the hydrostatic pressure at the transducer, transforming this pressure reading into time equivalent, and properly removing this datum shift from the records, which now start at a derived water surface. Third, because of the poor sea-keeping ability of the 40 ft. open-bowed tender, we designed and had built a temporary bow which was of key importance in the open waters of the Bay. Finally, we discovered that the streamlining bottom plate covering the transducer and reflector cone to be a detriment when towing in the fish in the wake of the small ship, due to bubbles streaming across this plate. Its removal and disuse corrected the problem and made possible survey with another unexpected improvement--a gain of 20 db in received signals with the same input power.

A pre-Green Bay program shakedown cruise in southern Lake Michigan with the Illinois Geological Survey was partially supported under this program. Here, in addition to developing and testing the pressure sensor system, we found from the extensive coring of the Illinois Survey team that glacial and interglacial sediments are differentiable on the basis of profiler data, and that acoustic horizons are fully correlatable with core character changes.

PESTICIDE-SEDIMENT INTERACTIONS IN GREEN BAY

David Armstrong

This area of study was initiated due to concern over the use of pesticides in the Green Bay area. Upon entrance into lake waters, rapid transport of many pesticides (e.g., the organochlorine compounds) to the lake sediments occur due to their low water solubility and high tendency for sorption by sediments and suspended particles. Within sediments, pesticides may be degraded, held in place, physically transported or may enter the food chain through bottom feeding organisms. Because extensive transport to bottom sediments occurs, an understanding of the factors controlling the fate of pesticides in sediments is of particular importance.

Organochlorine pesticides are widespread and generally persistent in the environment. In the Green Bay area, organochlorine pesticides were used extensively in the regions' orchards. Although the general persistence of the organochlorine pesticides is well documented, little is known of their ultimate fate. Of particular importance to their longevity in lakes is the recent evidence that degradation of DDT is enhanced under the anaerobic conditions that often exist in lake sediments.

The overall objective of this project is to determine the role of chemical and biochemical processes in sediments on the degradation of pesticides in Green Bay. Initial emphasis is on the effect of sediment oxygen status and chemical properties on the degradation of organochlorine pesticides, particularly p,p'-DDT.

Background

Due to a history of heavy use of organochlorine pesticides in the area, their entrance in substantial amounts into Green Bay seems likely. Analyses of samples from the Bay indicate that organochlorine pesticide levels were relatively high (4) and may have decreased somewhat in the past few years (10). However, moderately high levels ($\geq$ 0.1 ppm) were reported in some recent sediment, plankton and fish samples (10).

In spite of the well known persistence of the organochlorine pesticides, recent evidence that anaerobic conditions enhance DDT degradation suggest that DDT may degrade in anaerobic Green Bay sediments. Although degradation of DDT in lake sediments has not been substantiated, enhanced p,p'-DDT degradation has been reported in anaerobic soil (1,5,6,7,13) and

sludge (2) systems. In addition, degradation by numerous anaerobic microorganisms in pure culture has been shown (3). Whether anaerobic conditions increase degradation of other organochlorine pesticides is unknown. Rates of anaerobic p,p'-DDT degradation vary considerably but significant degradation occurred in a matter of hours for microbial pure cultures (3,11) and in a few weeks in the case of soil (1).

The concept of DDT degradation can be misleading in that the products are often closely related and potentially as toxic as the parent compound. The initial degradation product in anaerobic systems is generally thought to be p,p'-DDD (1,3, 8,11,12). Further degradation to DDMU, DDNU and DDA has been reported (1,12) but the environmental effects of these compounds and the ultimate fate of the parent p,p'-DDT remains uncertain.

Research Approach and Results

The general approach involves collection of sediments from selected locations in Green Bay, incubation of these sediments under controlled laboratory conditions after adding ^{14}C-labeled organochlorine pesticide, and following the rates and products of degradation with time. Effects of oxygen status, sediment properties and temperature on degradation will be evaluated.

Organochlorine pesticide measurements involve Soxhlet extraction with a hexane-acetone mixture (9), clean-up by adsorption chromatography, detection by electron capture gas-liquid chromatography and spectral and chemical confirmation. Degradation products will be characterized by chromatographic and spectrophotometric techniques combined with ^{14}C measurements. Labeled (^{14}C) compounds are used to evaluate analytical procedures, quantify degradation rates and to facilitate isolation and characterization of degradation products. Measurements of ^{14}C activity are made by liquid scintillation spectrometry.

Sediment samples have been collected from several locations in lower Green Bay. These locations were chosen to obtain a range of sediment composition and perhaps exposure to organochlorine pesticides. Simulated lake systems have been designed to provide control of oxygen status, temperature, uniform sampling and collection of possible volatile degradation products.

Experiments with p,p'-DDT are in progress. Results obtained indicate significant degradation of p,p'-DDT to p,p'-DDD after three weeks in anaerobic systems.

References

1. Guenzi, W.D. and Beard, W.E. "Anaerobic Conversion of DDT to DDD and Aerobic Stability of DDT in Soil". Proc. Soil Sci Soc Amer. 32:522 (1968).

2. Hill, D.W. and McCarty, P.L. "Anaerobic Degradation of Selected Chlorinated Hydrocarbon Pesticides". J. Water Poll. Control Fed. 39:1259 (1957).

3. Johnson, B.T., Goodman, R.N. and Goldberg, H.S. "Conversion of DDT to DDD by Pathogenic and Saprophytic Bacteria Associated with Plants". Science 157:560 (1967).

4. Johnson, W.D., Fuller, F.D., and Scarce, L.E. "Pesticides in the Green Bay Area". Proc. Tenth Conf. on Great Lakes Res., 363-374.

5. Kearney, P.C., Woolson, E.A., Plimmer, J.R., and Isensee, A.R. "Decontamination of Pesticides in Soils". Residue Rev. 29:137-49 (1969).

6. Ko, W.H. and Lockwood, J.D. "Conversion of DDT to DDD in Soil and the Effect of these Compounds on Soil Microorganisms". Can. J. Microbial 14:1069 (1968).

7. Parr, J.F., Willis, G.H., Smith, S. "Soil Anaerobiosis: II. Effect of Selected Environments and Energy Sources on the Degradation of DDT". Soil Sci. 110:306-312 (1970)

8. Peterson, J.E. and Robison, W.H. "Metabolic Products of p,p'-DDT in the Rat" Toxic. & Appl. Pharmacol. 6:321 (1964)

9. Pionke, H.B., Chesters, G. and Armstrong, D.E. "Extraction of Chlorinated Hydrocarbon Insecticides from Soils" Agron. J. 60:289-92 (1968)

10. Wisconsin Alumni Research Foundation. Lake Michigan Pesticide Investigations. (Unpublished Report) (1970).

11. Wedemeyer, G. "Dechlorination of DDT by Aerobacter Aerogener" Science 152:647 (1966)

12. Wedemeyer, G. "Dechlorination of 1,1,1-Trichloro-2,2-bis-(p-chlorophenyl) ethane by Aerobacter Aerogenes" Appl. Microbiol. 15:569 (1967)

13. Yoshida, T. IRRI, Los Baños, Philippines. Personal Communication (1970)

ENVIRONMENTAL CHEMISTRY OF THE CHLOROBIPHENYLS (PCBs) LAKE MICHIGAN-GREEN BAY

Gilman D. Veith

The objectives of the initial phase of this study are to determine which river systems are the major sources of chlorobiphenyls (PCBs) in Green Bay and the extent to which the chlorobiphenyls are incorporated into the littoral sediments of the Bay. The study has refined the procedures for the analysis of chlorobiphenyl mixtures in water and sediments and has initiated the environmental sampling phase. Following is a brief review of the PCB literature which is pertinent to the study, the analytical procedures for the PCBs in water and sediment, and a summary of field sampling activities.

Literature Review

The PCBs are a class of chlorinated hydrocarbons which have industrial importance as plasticizers, dielectrics, lubricants, and flame retardants (1,2). They are produced commercially by Monsanto Company under the trade name, Aroclor, and exist as mixtures of isomers with chlorine contents of 21, 32, 42, 48, 54, 60, and 62 percent by weight. In general, the chemical stability of the mixture increases with increasing chlorine content while the volatility decreases in the more highly chlorinated mixtures

Many of the industrial applications of PCBs depend largely on the chemical stability of the mixtures. Their uses as dielectrics in transformers and capacitors and as additives to hydraulic fluids restrict the PCBs to closed systems. However, possible uses of PCBs in paints, varnishes, waxes, synthetic polymers, inks, dust-inhibitors, and pesticide formulations may lead to direct contamination of natural waters through industrial and sanitary waste discharges. The stability of the more highly chlorinated mixtures to low temperature flames may also result in aerial transport of the PCBs from industrial and municipal solid waste incinerators to natural waters.

The presence of PCBs in the environment has been detected only recently (3-11). In general PCBs have been found in organisms associated with natural waters which receive wastes from urban centers. Concentrations of PCBs (as Aroclor 1254) in excess of 250 µg/l have been reported (11) in industrial discharges while those in municipal sewage treatment plant effluents and receiving streams typically range from the low ng/l to the low µg/l levels where detectable (10). The PCBs are similar to many chlorinated pesticides in that higher concentrations are found in organisms representative of the higher trophic levels.

Concentrations of the PCBs in the predator food chain range from at or near the determinable limit in water to 75 to 100 µg/gm in fish-eating birds. Consequently, the chronic effects of the PCBs in higher organisms is a concern and requires evaluation.

Because of the recent disclosures of PCBs in the environment, current knowledge regarding the acute and chronic effects of the PCBs in biological systems is insufficient to directly determine permissible limits for these chemicals in drinking water supplies. Inhalation tests on animals indicate that maximum concentrations of PCBs as vapor which are "safe" are 1.0 mg/m^3 for the lesser chlorinated mixtures and 0.5 mg/m^3 for the more highly chlorinated mixtures (1). Continuous or repeated skin contact leads to a condition called "chloracne" which has been reported by industrial workers handling products containing the PCBs (12). The acute toxcity of the PCBs to house flies (D. melanogaster) decreases with increasing degree of chlorination and is approximately a factor of 1,000 less than that of dieldrin (13).

Two-year feeding studies with rats and dogs using Aroclor 1242 at dietary levels of 1, 10, and 100 µg/gm failed to produce clinical effects or changes in blood and urine chemistry (14). Aroclor 1254 produced depressed weight gains as well as increased liver weights at the 100 µg/gm level. Aroclor 1260 produced increased liver weights at the 10 and 100 µg/gm levels although body weight gain was unaffected. The data indicated that the Aroclors have the same order of toxicity as that of DDT. The induction of hepatic microsomal enzymes in rats is minimal with the lesser chlorinated biphenyls but are significantly greater with mixtures containing greater than 60 percent chlorine (15). Induction by the PCBs is greater than that of DDT but less than that of heptaclor epoxide.

The concern over the presence of the PCBs in Green Bay and Lake Michigan is largely based on reports that the PCBs produce high mortalities in aquatic organisms such as juvenile shrimp at the µg/l levels (16). Furthermore, Stahling (17) has reported that the PCBs caused 50 percent mortalities in bluegills, channel catfish, and trout at approximately the 10 µg/l level and adverse physiological effects after continuous exposure to 1 µg/l (18).

Analytical Procedures

The analyses of water for the PCBs are particularly valuable since the data acquired from monitoring rivers, outfalls, and effluents preclude the uncertainties introduced by the analyses

of fishes or other mobile organisms, can lead to an unequivocal disclosure of contaminant sources and allow estimates of mass transport to be made. However, to determine PCBs below the µg/l level in water, large volumes of water must be extracted and the extracts concentrated to give concentration factors on the order of 20,000.

Unfiltered water samples (20 liters) are extracted twice with hexane in 1500 ml batches (10), and the hexane fractions are reduced to 15 to 20 ml for cleanup. The extract is placed on an 8 gm (9 mm I.D.) column of Florisil and eluted with hexane. The first fraction collected from the column contains the PCBs and DDE while dieldrin, DDT, and DDD are obtained by successive elution with 6 percent ether in hexane. The PCB fraction is reduced to a suitable volume for gas chromatographic (GLC) analysis using electron capture detection techniques (10). Alternate procedures using silicic acid for the isolation of the PCBs from fish extracts and other chlorinated pesticides have been developed (19, 20) and will be used with samples for which the Florisil cleanup is not satisfactory. It is likely the silicic acid columm will be utilized for the cleanup of sediment extracts.

The accuracy and precision of the analysis of PCBs in natural waters has been evaluated using Aroclor 1260. Briefly, 6 replicates of unfiltered Lake Mendota (Madison) water (4.0 liter) were "spiked" with 4.0 µg of Aroclor 1260 as a 50 ml acetone solution. The recovery was found to be 79.1 $\pm$ 8.6 percent for the earlier-eluting GLC components and 82.3 $\pm$ 6.3 percent for the later-eluting GLC components of Aroclor 1260.

The cleanup of sediments from rivers and Green Bay near industrial centers presents a complex analytical problem in organochlorine research. Thus far it has been impossible to remove the interferences from sediment extracts with separation techniques above. When the sediment extracts are cleaned up by the method used for water analysis, 5 major interfering GLC components are evident and only crude estimates of the PCBs can be obtained. However, if the crude extracts are passed through a 1:1 H_2SO_4, fuming H_2SO_4 column (impregnated on Celite 545) prior to Florisil cleanup, the interferences are significantly reduced. The disadvantage of the acid-Celite column is that many organochlorine compounds are degraded on the column, and the elution of the PCBs from the column must be carried out rapidly. Current studies are aimed at refining the procedures for sediments.

Green Bay Field Studies

The attempt to disclose the major sources of PCBs in the Green Bay area of Lake Michigan began by sampling the water near the mouths of the rivers which receive industrial and/or

municipal waste waters. From the results of these preliminary studies, the water of the rivers found to be major sources of PCBs for Green Bay will be sampled in detail. Special emphasis will be placed on transport estimates from outfalls into the rivers and the Bay. Detailed sampling will be conducted in February, 1971. Also, sediment cores will be collected for analysis and for the laboratory studies regarding biodegradation of PCBs in sediments in the next phase of the study.

The following tributaries to Green Bay have been sampled: Menominee River (Marinette-Menominee), Peshtigo River (Peshtigo), Oconto River (Oconto), Pensaukee River (Pensaukee), Suamico River (Suamico), Fox River (Green Bay), and Sturgeon Bay (Sturgeon Bay). Other tributaries will be sampled when the ice-cover permits. The data from this sampling of Green Bay tributaries are of a preliminary nature at this time and will be presented in the next report.

References

1. Hubbard, H. L. (1964) Kirk-Othmer Encyclopedia of Chemical Technology, 2nd ed. Wiley Interscience, New York, Vol. 5 289-297.

2. Monsanto Company (undated) Technical Bulletin O/PL-306, St. Louis, 20 p.

3. Jensen, S. and Widmark, G. (1967) OECD preliminary study, Stockholm, mimeo.

4. Holden, A.V. and Marsden, K. (1967) Nature 216, 1274-76.

5. Holmes, D.C., Simmons, J.H. and Tatton, J. (1967) Nature 216, 227-229.

6. Risebrough, R.W., Rieche, P., Herman, S.G., Beakall, D.C. and Kirvin, M.N. (1968) Nature 220, 1098-1102.

7. Anderson, D.W., Hickey, J.J., Risebrough, R.W., Hughes, D.L. and Christensen, R.W. (1969) Canadian Field-Naturalist 83, 91-112.

8. Koeman, I.H., De Brauw, M.C. and De Vos, R.H. (1969) Nature 222, 1126-29.

9. Bagley, G.E., Reichel, W.L. and Cromartie, E. (1970) JAOAC 53, 251-61.

10. Veith, G.D. (1970) PhD thesis (Water Chemistry) Univ. of Wisconsin-Madison, 180 p.

11. Duke, T.W., Lowe, J.I. and Wilson, A.J. (1970) Bull. Environ. Contam. Toxicol. 5, 171-80.

12. Meigs, J.W., Albom, J.J. and Kortin, B.L. (1952) JAMA 154, 1417-18.

13. Lichtenstein, E.P., Schulz, K.R., Fuhremann, T.W. and Liang, T.T. (1969) J. Econ. Ent. 62, 761-65.

14. Monsanto Company (1970) unpublished data, St. Louis, Mo.

15. Street, J.C. (1970) unpublished data, Utah State Univ., Logan.

16. Duke, T.W. (1970) unpublished data, U.S. Fish and Wildlife Service, Gulf Breeze, Florida.

17. Stalling, D. L. (1970) data presented in the PCB Newsletter, December.

18. Stalling, D. L. (1970) unpublished data, U.S. Fish and Wildlife Service, Columbia, Mo.

19. Reinert, R.E. (1970) unpublished data, U.S. Fish and Wildlife Service Ann Arbor, Michigan.

20. Armour, J.A. and Burke, J.A. (1970) JAOAC 53, 761-68.

GREEN BAY PROGRAM - PERSONNEL

Michael Adams, principal investigator (Cladophora)
David Armstrong, post-doctorate (Pesticide - Sediment Interaction)
A. M. Beeton, principal investigator (Eutrophication)
R. H. Burris, principal investigator (Blue - Green Algae)
R. B. Ditton, principal investigator (recreation)
Thomas Goodale, princpal investigator (recreation)
R. P. Meyer, post-doctorate (Bathymetry Studies)
Paul E. Sager, program coordinator (Nutrient inputs)
Eric Schenker, principal investigator (Economics of Green Bay)
Larry Vanderhoef, principal investigator (Blue - Green Algae)
Gilman D. Veith, post-doctorate (PCB's)
James Wiersma, principal investigator (Nutrient inputs)

DISPERSAL OF FOX RIVER WATER IN GREEN BAY, LAKE MICHIGAN.
Richard F. Modlin and A. M. Beeton, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53201. Contribution No. 40, Center for Great Lakes Studies, Presented, Great Lakes Research Conf. April, 1970 (Buffalo).

ABSTRACT

Two synoptic surveys were made of the southern half of Green Bay, July, 1968, and August, 1969, to determine the distribution, flushing rates, and importance of Fox River water in the bay. Circulation in the southern end of the bay was counter-clock-wise, with river water extending northward for almost 40km along the east shore. Lake Michigan water occupied the western part of the bay. A progressive decrease in conductivity from the river mouth lakeward reflected the dilution of the river water as it moved through the bay. The August, 1969, flushing time was 160 days in the southern end and 36 days in the northern part of the study area. Lakeward transport was 199 m/day and 1130 m/day respectively. Transport rates and flushing rates in the southern end were a function of the volume of river discharge while in the northern end they appeared to be determined by the magnitude of inflowing lake current.

BIOLOGICAL EVALUATION OF ENVIRONMENTAL QUALITY, GREEN BAY, LAKE MICHIGAN. R. P. Howmiller and A. M. Beeton, University of Wisconsin-Milwaukee, Wisconsin. Jour. Water Poll. Control Fed., 43,123,1 (1971)

ABSTRACT

A comparison of the benthic invertebrates found in samples from Green Bay, Lake Michigan, taken at the same stations in May 1952 and May 1969, showed marked changes. The eutrophic and pollution-tolerant groups Oligochaeta and Chironomidae increased in abundance over most of the Bay. Most other benthic invertebrates were less abundant in 1969 than in 1952, suggesting that deterioration of the bay environment had increased. The major pollution source is the Fox River. An abiotic area exists around the river mouth.

Keywords: animals, benthos, (Green Bay, Lake Michigan), invertebrates, (Lake Michigan), lakes, pollution, water pollution.

FLUCTUATIONS IN THE POPULATIONS OF LAKE HERRING (LEUCICHTHYS ARTEDII LE SUEUR) AND AMERICAN SMELT (OSMERUS MORDAX MITCHELL) IN THE COMMERCIAL FISHERY OF NORTHERN GREEN BAY, LAKE MICHIGAN, 1929-1970. Walter J. Hogman, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53201.

ABSTRACT

Commercial fishing statistics for the Michigan waters of Green Bay, Lake Michigan, were analyzed for the period 1929-1970. Estimates of abundance and intensity were computed by a method new to Great Lakes fisheries and compared with the former methods. The long term decline of the lake herring and its fluctuations in relation to the fluctuations of American smelt and alewife are discussed in detail for the period of record.

The lake herring and American smelt have exhibited non-random fluctuations in relation to each other in northern Green Bay. After the establishment of the smelt, every increase in herring abundance was followed by an increase in smelt abundance several years later. The herring abundance would then begin decreasing and the smelt would decrease several years later. The time lag between the fluctuations suggest strongly that high smelt abundance prevents successive recruitment of herring through the mechanism of predation on larval and juvenile herring. Coefficients of correlation, with and without time adjustments, between herring abundance and smelt abundance consistently gave significantly negative values.

A review of all factors of the two species' life histories establishes their nearly homogeneous environmental requirements. Overexploitation or change in water quality could not be found primarily causative for the recent near extinction of the lake herring. With the rise of abundance of the alewife, the long term smelt decrease reversed itself. The lake herring continued to decline to near extinction. The alewife has now replaced the lake herring as the dominant planktivore and the smelt now appears to be following, if not controlling in some way, the alewife abundance.

The long term fluctuations of smelt abundance in northern Green Bay in relation to herring and alewife, appear based in a density dependent manner on the prominant pelagic

planktivore. The build-up in smelt abundance in turn appears to then control the abundance of its primary prey. As the prey decreases the smelt is then controlled by it. This circumstance is common in very simple systems but has never been demonstrated in the Great Lakes. The change in species abundance over the last 20 years in other waters of the Great Lakes where major changes in open water stocks have occurred, suggest that the relationships found to exist in northern Green Bay may not be unique.

AN ESTIMATION OF THE QUANTITATIVE IMPACT OF THE ST. LAWRENCE SEAWAY ON THE HINTERLAND'S ECONOMY. Eric Schenker, Seow Tee Koh, James Kochan and Michael Bunamo, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin. Published in the Proc. 13th Conf. Great Lakes Res. 1970: 168-186. Internat. Assoc. Great Lakes Res.

ABSTRACT

Economists are in agreement that the opening of the St. Lawrence Seaway for commercial navigation has benefited the region's economy. In terms of total population and employment, the region has experienced growth since 1958. This study analyzes the Seaway's contribution to the regional economic growth process.

The approach used in the study relies on total employment data, with a view to isolating factors responsible for producing changes in total employment. The analysis takes as a working hypothesis that an increase in "non-localized" or export employment will increase localized employment by an amount greater than the initial increase. First, one must classify industries as localized (i.e., those serving the area under investigation) or non-localized, and then separate their total employment into localized and non-localized sectors. Secondly, a linear regression is done in order to estimate the influence of non-localized on localized employment. From this estimate the income-employment multiplier is derived.

The investigation showed that the employment-income multipliers of the six states in the Great Lakes region covered by this study ranged between 1.8756 and 2.6380. The revenue earned at the lake ports from Seaway cargo is non-localized income which generates secondary income and employment. Applying the income multipliers to this primary income yields an estimate of nearly $643 million for the total Seaway-cargo generated income in the Great Lakes hinterland. This is an approximation of the primary income earned at the ports plus secondary income derived therefrom, but only a part of the total economic impact of the Seaway. The size of this partial impact lends support to the thesis that the Seaway has had an important positive effect upon the economy of the Great Lakes region. (Key words: Economy; Seaway.)

THE OLIGOCHAETE FAUNA OF GREEN BAY, LAKE MICHIGAN.

Richard P. Howmiller and A. M. Beeton, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53201. Contribution No. 38, Center for Great Lakes Studies. Published in the Proc. of the 13th Conf. on Great. Lakes Research, April, 1970, (Buffalo).

ABSTRACT

Bottom samples were taken at 103 stations in Green Bay, between the City of Green Bay and the latitude of Washington Island. Oligochaeta accounted for 60% of the benthic macroinvertebrates in the southern ten miles of the Bay and about 50% of the fauna further north. Polution density of oligochaete worms ranged from 0 to 20,000/m^2. Collections in October and May at 28 stations in the lower Bay suggest a great reduction in population density and a change in species composition during the intervening months. The oligochaete fauna of Green Bay consists of one species of Lumbriculidae, nine Naididae and nineteen Tubificidae. Species distribution patterns, with respect to known environmental parameters, are similar to those found in other investigations in the Great Lakes with *Stylodrilus heringianus* at the oligotrophic northern end of the Bay, *Limnodrilus hoffmeisteri* dominant in the polluted southern end, and *Aulodrilus, Peloscolex* and *Potamothrix* species reaching their greatest relative abundance in between.

SOME CHANGES IN THE BOTTOM FAUNA OF GREEN BAY, LAKE MICHIGAN, FROM 1952 TO 1969. Richard P. Howmiller and A. M. Beeton, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53201. Submitted to the American Society of Limnology and Oceanography, Inc., 33rd Annual Meeting, University of Rhode Island, August 25-28, 1970.

ABSTRACT

The pollution and eutrophication of Green Bay, a freshwater estuary of Lake Michigan, are being studied intensively under the University of Wisconsin Sea Grant Program. To biologically assess recent changes in the bay, we took bottom samples in the lower and middle bay in May 1969 on the same date, at the same 27 stations, and using the same methods as a 1952 survey. This study thus eliminates the variables of seasonal variations in animal abundance, and selectivity of sampling gear which are inherent in many similar comparative studies.

In 1969 there were fewer Oligochaeta and Chironomidae near the mouth of the Fox River, a large, grossly polluted tributary. Elsewhere in the lower and middle Bay oligochaetes and midge larvae were more abundant but amphipods, leeches, snails and fingernail clams were less abundant than in 1952. The burrowing mayfly, *Hexagenia,* once present in nuisance proportions and still present in 1952, appears to have disappeared from the Bay.

Some of the changes in Green Bay benthos in the years 1952-1969 are similar to those known to have occurred in western Lake Erie. These changes are indicative of greater pollution and increased eutrophication in the intervening 17 years.

A COMPARISON OF THE EFFECTIVENESS OF EKMAN AND PONAR GRABS,

Richard P. Howmiller, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53201.
Contribution No. 44.

ABSTRACT

The messenger-triggered modification (Birge 1922) of the benthic grab designed by Ekman (1911) has probably been the most widely used sampler for studies of the benthos of lakes. It is "so preeminently successful and so widely used for soft bottoms that it has become the standard instrument" (Welch 1948).

Because of the light weight and weak springs on the jaws of the Ekman grab it will not bite well into hard sand or gravel bottoms and sticks or stones may hold the jaws apart so that much of the sample is lost. Thus many investigators have used other samplers for hard bottoms. The Foerst Company's modification of the Petersen grab (Petersen 1911) has frequently been employed. Its greater weight, and the level system which forces the jaws together, make it much more effective than the Ekman grab in obtaining samples of sand or gravel bottoms. However, the Petersen grab has several deficiencies. Since the tops of its jaws are solid a hydraulic disturbance (shock wave) will form below the grab as it descends. Such a shock wave may frighten off motile benthic organisms and blow away fine surficial sediments with the resident animals (Wigley 1957). Furthermore the Petersen grab may frequently lose some material by pushing it out the sides as the jaws come together (Orton 1925).

Powers and Robertson (1967) designed a grab, called the Ponar, incorporating a closing mechanism similar to that of the Foerst-Petersen and the jaw design of the Aberdeen or Smith-McIntyre grab (Smith and McIntyre 1954). These jaws have screened tops to reduce the shock wave and end plates to prevent loss of sediment and organisms as the jaws come together. Wigley (1957) provides a convincing illustration of the benefits of screen tops in the jaws of benthic grabs. In preliminary trials the Ponar seemed to be a more effective tool than the Petersen (Powers and Robertson 1967) and the Ponar may replace the Petersen for sampling hard bottoms.

Powers and Robertson (1967) compared the Ponar with the Ekman grab in several inland lakes, however the samples were too few to draw any firm conclusions. Nevertheless, it was stated elsewhere that the Ponar is as efficient as the Ekman for sampling soft bottoms.

BIOLOGICAL EVALUATION OF ENVIRONMENTAL QUALITY, GREEN BAY, LAKE MICHIGAN, R. P. Howmiller and A. M. Beeton, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53201. Published in the Journal of Water Pollution Control Fed., January, 1971 (43: 123-133).

ABSTRACT

Green Bay is a relatively shallow and fertile arm of Lake Michigan (Figure 1). The bay has long been important for recreational uses, shipping, and commercial fishing. As early as the 1880's undesirable changes in the bay were recognized. Smiley (1) reported in 1882 that sawdust pollution was important factor in the decline of the white-fish population in the 1870's.

Pollution in Green Bay, and concomitant concern, have increased in recent years. The major tributary of the bay, the Fox River, contributes an average of 125 cu m/sec of grossly polluted water. The dissolved oxygen (DO) content of the river water approaches 0 mg/l in summer months (2). Even pollution-tolerant benthic invertebrates are rarely found in the sediments of the lower reaches (2) (3).

Water from the Fox River spreads out over the lower 15 to 20 km of the lower bay (4), and dominates the character of the environment. The middle bay, from the Green Bay harbor entrance light north to Sturgeon Bay, is affected by Fox River water mainly in the eastern half where river water may account for as much as 80 percent of the northward current (5). In this region the major influence of the polluted water appears during the months of ice cover (2) (6) (7) when large areas suffer oxygen deficiency.

Various public agencies have conducted chemical and biological surveys on the bay to assess the severity and extent of pollution (2) (3) (6) (8). Bottom sampling for analysis of benthic invertebrate animals was a part of each of these studies. Surber and Cooley (8) compared numbers of organisms at nine of their stations in the lower bay in May 1952 with data from nine comparably located stations sampled during the period November 1938 to February 1939. The increased number of pollution-tolerant midges and oligochaetes led them to conclude that there was an increase in pollution during the intervening 13 yr.

SOCIAL GOALS, PROBLEM PERCEPTION, AND PUBLIC INTERVENTION: THE FISHERY, Victor L. Arnold and Daniel W. Bromley, San Diego Law Review--Law of the Seas, Vol. 7, No. 3, July, 1970, A Sea Grant Reprint, Wis.-SG-71-302.

ABSTRACT

No general criteria exists by which we can determine whether or not a certain social or economic configuration leads us to an "optimum social state." The nonexistence of a social welfare function--a unique ordering of individual preferences summed over all people--precludes the precise definition of this "optimum."

We are of the opinion, however, that a rudimentary social decision model can be conceived to aid in the above process. Such a model should possess specific attributes.

To relate this concept to the fishery, we must recognize the various components in the chain from ocean to consumer, elucidate the ramifications of alternative social policy, and enlighten affected persons of these ramifications. Examples of components are natural wealth (fish stocks), physical yield, fishermen's incomes, incomes of fishing supplies firms, processors' incomes, retailers' incomes, incomes of all laborers engaged in the above activities, and consumer preferences.

An example of a specific type of action, that of a legislated institutional change concerning the nine-mile contiguous zone, was discussed in detail. With this example we did two things: 1) related the objectives of the legislation to the possible goals for fishing management; and 2) discussed the entire process of change in the context of our social decision model.

The type of action we consider here would be better conceived and implemented if it were accompanied by a social decision model similar to the one we developed. This model should present the best practicable information about alternatives and their consequences; should afford affected groups and individuals an opportunity to be made aware of these likely impacts; should offer these parties some opportunity of participation in the decision process; and should permit the feedback of information so that initial decisions can be modified. We traced through the many

components of the system from ocean to consumer and argued that many of these are important enough to warrant access to information concerning impacts from many institutional changes. Upon tracing through the actual creation of the new legislation we saw how little thought was given to the likely impact upon these various components.

WATER QUALITY PROGRAM

With significant changes occurring in the water quality and in the biota of the Great Lakes, this program takes a critical look at the adverse effects that have resulted from conflicting use. Studies within the Water Quality Program have been concerned with two aspects, biological and chemical. The progress report that follows is divided along these lines, although it must be emphasized that both sections are equally involved with the assessment and improvement of the quality of Great Lakes water.

Within the biological section of the Water Quality Program, led by A. M. Beeton, University of Wisconsin, Milwaukee, are several segments of study which have been under examination. The following paragraphs detail the work done over the past year in the various subject areas.

Factors affecting energy fixation in Lake Michigan.

A laboratory was set up on board the C & O railroad ferry "Badger" in early summer to determine the spatial and temporal changes in primary productivity as measured by C-14 uptake. Sampling is conducted at 5 points between Milwaukee, Wisconsin and Ludington, Michigan. In addition, an *in situ* station has been established to measure C-14 uptake and ambient irradiance at depth. Water samples are collected for species identification and counts of phytoplankton, determination of pH, alkalinity, total phosphorus, soluble phosphorus, nitrate, silica, chlorophyll a, chlorophyll c, and cartenoid pigments. Sampling has been conducted 16 times from the ferry at approximately 10 day intervals. A special incubator with a gradient of light intensities and revolving discs for holding the C-14 bottles was constructed and placed aboard the ferry. A recording thermograph was installed on the water intake of the ferry. Total solar irradiance is being measured by instruments installed at Milwaukee and Ludington.

A paper "Spatial and temporal changes in primary production and related parameters in the central section of Lake Michigan" by Everett Fee, D. C. Rousar, and U. Zimmerman, is being prepared for the Conference on Great Lakes Research in Toronto, April 1971.

Inshore and offshore differences in nutrients and planktonic diatoms and their significance to eutrophication of Lake Michigan.

Detailed sampling of inshore (less than 10 miles) and offshore waters has been carried out in southern Lake Michigan

off Chicago, Illinois, Gary, Indiana, and St. Joseph, Michigan. In addition, sampling from the railroad ferry in conjunction with the above project has supplied detailed information on seasonal changes in inshore and offshore waters.

In general, total phosphorus concentrations and C-14 uptake were higher in inshore waters. Silica concentrations were usually lower inshore than offshore. Identification and counting of diatoms have not been completed for all sampling dates. Nevertheless, available data show pronounced inshore-offshore differences in the abudance and species distribution of diatoms.

A paper "The relevance of spatial differences in nutrients and biota to the eutrophication problem" was presented at the AAAS meeting in Chicago by A. M. Beeton on December 28, 1970.

The role of cyclopoid copepods in the trophic ecology of Lake Michigan.

During 1970, field studies on zooplankton were expanded to include Green Bay. The drastic changes in zooplankton species composition that have occurred in the main portion of Lake Michigan in the last few years have not occurred in Green Bay, even though this major embayment supports a large alewife population. By examining alewife stomach contents and zooplankton samples from both Green Bay and Lake Michigan proper, we have been able to directly study the effects of (1) size-selective predation by alewife and (2) accelerated eutrophication on changes in zooplankton species composition in the Lake Michigan basin.

At this time, all field sampling programs are completed. Laboratory analyses of the fish stomach data has been completed except for statistical treatment of the information, Identification and enumeration of all zooplankton samples should be finished by spring 1971. Laboratory studies on cyclopoid copepod food habits will be conducted during 1971.

Planktonic Hydra in Western Lake Michigan: their role as an indicator organism for the trophic conditions of the lake.

Sampling in the Milwaukee water intake has shown that the Hydra obtained in the Milwaukee intake are a local population living in the tunnel. The fluctuations in the population sampled in 1968 were a result of changes in the pumpage that is determined by the demand from the city. This is not a valid station for sampling Hydra.

Procedures for sampling, identifying and culturing Hydra have been worked out and are presently in operation. A paper

is in progress on sampling techniques to be submitted for publication. Monthly sampling is being done in Lake Michigan at selected semi-permanent stations. Sampling also is being conducted in the Milwaukee Harbor and at the Point Beach Power Plant site.

Questionnaires have been prepared and sent to licensed shoal fishermen in Wisconsin and Indiana who fish in the Great Lakes to attempt to isolate for analysis, the phenomenon of accumulations of Hydra on nets.

Neuston of Lake Michigan and selected inland waters.

A literature search and resume have been completed. A design of a suitable sampler has been selected and the Center for Great Lakes Studies shop will build the sampler this winter.

Investigation of winter physical and chemical characteristics of Little Bay de Noc.

The approach to the study consists of two parts: (1) a mapping of the summer currents using the distribution of 8 chemicals from the 1960 synoptic survey and (2) the actual winter sampling.

(1) From the 1970 synoptic study, an upwelling not previously mentioned is in evidence between Escanaba and Gladstone in the center of the bay. In addition, there were unusually high sulfate levels (at or below 20 ft) opposite both cities water intake plants. Both of these features would merit further study to determine their importance on the bay's circulation. The sulfates in particular could effect the water intake quality, so their source should be investigated.

(2) The winter study is to be carried out in March, when water samples are to be taken through the ice. Dissolved oxygen will be sampled at selected stations. Other chemical tests (color, turbudity, conductivity, sulfates) will be performed on each sample. A set of additional sampling stations is being decided upon to explain the upwelling characteristics in winter, if present, as well as the sulfate concentrations, and their origins.

Additional sampling trips are planned for a warming period, thaw, in the winter to estimate the influence of runoff, and just before the ice breaks up to determine the extent and influence of winter on water quality.

Water Quality-Chemistry

The Water Chemistry studies on the Great Lakes headed by G. Fred Lee, University of Wisconsin-Madison, consist of three projects concerned with determining the aqueous environmental chemistry of an element or compound in Great Lakes waters. The compounds under investigation during the past and next year are phosphorus in lower Green Bay, zinc in the upper Great Lakes and TFM (sea lamprey larvacide) in the upper Great Lakes. The objectives and approaches of each project are explained in the following.

The aqueous environmental chemistry of zinc in upper Great Lakes waters.

The overall objectives of the project are threefold: (1) to determine the existing concentrations of zinc in selected waters, (2) to determine the form of zinc in the waters, whether free ion, complexed or sorbed and (3) to develop a predictive model for the aqueous environmental chemistry of zinc in these waters with particular attention to the activities of man in influencing the amounts of zinc in the water.

An analytical procedure involving complexation, concentration through extraction, and subsequent analysis with atomic absorption spectroscopy, was found to be reliable, reproducible and sensitive to the one µg/l zinc level.

Eastern Lake Superior was the first body of water selected for study. Previous work done on zinc in the sediments showed an increase in zinc concentrations from west to east and a five year trace metal survey published by FWPCA showed anomalously high zinc concentrations at the St. Mary's River water intake for Sault Ste. Marie water supply.

To fulfill the first objective of the study, a sampling trip using Coast Guard facilities was scheduled in July. Due to a malfunction of the Coast Guard ship, however, smaller craft had to be employed, drastically curtailing original sampling plans.

Table 1 contains results for acid soluble zinc from the Soo area. Station 1 was in Whitefish Bay; Station 2 in the beginning of the St. Mary's River, Station 3 at the water intake above the locks; Station 4 in the St. Mary's River below the locks and the cities, Station 5 at the Munising Pier several hundred miles west of the Soo, and Station 6 on the Waiska River which flows into the St. Mary's River just above the water intake.

These values compare favorably with those reported by Reserve Mining Company for western Lake Superior waters, 2-5 µg/l zinc. The high value of 25 µg/l reported at Station 2 was due to contamination, but it is not known whether the higher values at the Waiska River are real or contiminants. On the other hand, the FWQA study previously mentioned reported zinc from 2-406 µg/l with a mean value of 41 µg/l for 18 samples at the same location as Station 3. Indications point to a strong possibility that the samples were contaminated in handling because this work has shown that zinc contamination at these low levels from such sources as rubber, plastic, paper and others is a serious problem.

In November a sampling trip to the waters of Green Bay and the Fox River was undertaken. Figure 1 shows a sketch with approximate station locations, and Table 2 shows the acid soluble zinc levels found. Conductance and alkalinity are also supplied providing additional parameters.

The waters of the Fox River definitely show higher zinc concentrations than the Bay, reflecting industrial discharge. It is interesting to note that alkalinity and conductance values at Stations 6 and 4 show that the waters of the Fox are moving up the eastern side of Green Bay, but the zinc levels at the two sites are not appreciably different. After entering the Bay, the zinc levels of the Fox River water appear to be quickly reduced. The apparent higher value at the 20 foot depth at Station 6 may well have been due to disturbance of the sediments while sampling.

The second phase of the project, now beginning, will develop procedures to determine the form of zinc in the water.

An additional sampling trip to Lake Superior and to Green Bay to verify zinc concentrations found and secure sediment for analysis will hopefully supply enough, data along with literature sources, for model development for zinc cycling in these environments. See Green Bay Program for projects relating to this study.

Aqueous environmental chemistry of 3-trifluoromethyl-4-nitrophenol (TFM) in upper Great Lakes waters.

This study was designed to develop a sensitive analytical procedure for TFM; to conduct laboratory studies on TFM degradation and sorption; and to determine, or test for, residual TFM in Great Lakes' water, sediments and selected organisms such as plankton and fish.

Development of analytical method.

To achieve the objectives of this proposal, more sensitive and precise analytical procedures than those which were available were developed.

At the present time the analytical procedures and techniques that are being used in this laboratory (Water Chemistry Program) involve silylating TFM with a dimethylsily group, $-Si(CH_3)_2$ designated DMS and analyzing the silylated compound on gas-liquid chromatography (GLC). Numerous experiments have shown that some form of TFM derivative was necessary as the compound TFM is not amenable to GLC analysis directly.

The dimethylsily group, $-Si(CH_3)_2$ replaced the labile hydrogen of the hydroxyl group (phenol) and forms an ether linkage, to wit:

$$TFM - OH + H - Si(CH_3)_2 \rightarrow TFM - O - Si(CH_3)_2 + 2H^+$$

The primary purpose in silylation is to depolarize and, hense, increase the volatility of the TFM molecule which can then be analyzed readily on GLC.

There are many forms of TMS, and at the present time Di-Sil-Prep™ (The Anspec Co.) (9:3:1, pyridine, tetramenthuldisilazane (TMDS), dimethylmonochlorasilane (DMMCS)) and BSA (Bis (trimethylsily) acetamide) are being used to silylate TFM. It is anticipated that other reagents will be tried; however, Di-Sil-Prep is showing the greatest promise at this time in making derivatives.

Silylation, extraction from water samples, and preliminary results.

Solutions of TFM in benzene were used in developing basic silylation procedures and TFM-derivative standards. This stock solution was made directly by adding 250 milligrams of washed and recrystallized TFM to one liter of redistilled (glass) benzene (250 mg/l final concentration). Substocks of 25, 5 and 1 mg/l were made from this stock solution.

Several different silylating reagents have been tried under a variety of conditions. Using different organic solvents in the stock solutions, varying the operating temperature of the GLC, using different types of column packing and loading, etc. are among those tried. The various silyl reagents tried were Di-Sil-Prep, BSA, BSA in pyridine, Bis-trifluorosilylacetamide (BSTFA), and BSTFA with one percent trimethylchlorosilane (a catalyst). Di-Sil-Prep was found to be the most effective and consistent silylating reagent investigated. Figures I, II and III show three different TFM solutions silylated with Di-Sil- Prep.

Silylating the TFM has given consistent results with good sensitivity. Figure III shows a chromatogram of a 2 nanogram sample; Figure II, a 0.4 nanogram sample; and Figure I, a 0.2 nanogram sample. In these "runs", the sample size is 0.4 µl, and the maximum sensitivity of the GLC is attenuated 64 times. Greater sensitivity can be achieved by injecting a larger sample size and using less attenuation. An example of less attenuation used is Figure IV which shows a chromatogram of a 0.2 µl injection of a 1 mg/l sample (from the same sample as in Figure II in which the GLC is attentuated 32X).

A variety of GLC conditions have been studied in an effort to obtain the most satisfactory sensitivity and resolution. The greatest sensitivity has been obtained by using GLC coupled with a tritium foil electron-capture detector (ECD). A flame ionization detector (FID) was evaluated in a number of experiments and was found to be too insensitive at the concentrations (nanogram, picogram range) this study requires.

Resolution of peaks depends primarily upon column length, packing, loading (percent liquid phase), type of loading, temperature and carrier gas flow rate. Evaluation of these variables will be on a continuous basis. Various liquid phases and solid supports have been tried, and non-polar liquid phases such as DC 200, SE 30 and OV 101 (all methylated silicon oils) have given good preliminary results. Choice of a solid phase apparently presents few problems, and thus far, diatomaceous earth (Gas-Chrom Q from Applied Science Laboratories, Inc.) and etched glass beads, 80/100, 100/120 mesh, work well.

As reported in the literature and eventually proven to be true , polar liquid phases do not work well with silylated compounds. In one experiment a column of two percent FFAP liquid phase (ester derivative of Carbowax 20M and 2-nitroterephthalic acid) was tried, and the results were negative.

Nitrogen gas as a carrier with flow rates of between 20 and 30 ml/min seems to be satisfactory in all experiments tried. The injection, column and detector temperatures are usually held at 175°C, 150°C, and 175°C respectively.

Batch extraction procedures were used to extract TFM from water. In this procedure the TFM sample is acidified to pH 2-3 and extracted into benzene-hexane (1/1 v/v) solvent. Figures V and VI show two results where TFM was extracted from water, dried and silylated. Figure V is the result of extracting a 0.25 mg/l TFM-Lake Mendota water solution. The solvent phase was concentrated five times prior to silylation. No problem arose with natural organics in the lake water interferring in any of the analyses performed. Figure IV shows the results of extracting a 0.5 mg/l TFM-distilled water solution.

After a period of several weeks the experiments described above were reperformed in an attempt to duplicate the results as given in this report. New columns were made which were packed as the columns used in the experiments described, and the GLC was adjusted to the operating conditions as described herein. New standards were made and run, and the results were comparable in all cases. All glass columns were used, 6 foot by 1/8 inch O.D. The packing support is Gas-Chrom Q, 100/120 mesh and coated with three percent OV-101.

Present experiments.

The objective of the present experiment is to remove very small concentrations of TFM from water, about 50 µg/l and less, by using an anion exchange column and to determine the efficiency of this method.

Batch extraction procedures appear to be too tedius, time consuming and variable for removing small concentrations of TFM from water. Therefore, an anion exchange column of Dowex™, 200/400 mesh in the hydroxide form is being used to remove TFM quantitatively. The TFM is eluted from the column with a solution of amyl acetate and 10 percent acetic acid. This solution is then back extracted into basic water to separate the TFM from the eluant. Next the basic solution is acidified, and the TFM is extracted into hexane in preparation for the silylation step.

Because of the fine mesh of the anion resin, gravimetric flow during separation and eluting steps is too slow, and aspiration techniques are being investigated. A 5-3/4 inch disposable pipette is loaded with the anion resin and connected by tubing to a vacuum pump. The loaded pipette is then placed in the TFM-water sample, and the sample is aspirated through the column. The experiment is not complete at the present time, and no data has been tabulated.

In addition to the present experiment, preparations are underway to do some mass-spectral analysis of silylated-TFM samples. Also, silylated TFM samples will be injected into GLC, and the alleged TFM peak will be trapped and analyzed by mass-spectral analysis. If the peak is indeed the TFM peak, the mass spectral data will be used to confirm TFM peaks in future experiments. Other peaks of the chromatogram (termed garbage peaks) will be checked to ascertain their possible identity.

Future Experiments and Plans.

In the next few months, degradation and sorption tests will be started. When the ice leaves northern Wisconsin and when the Bureau of Sports Fishery begins to treat streams with TFM, water and specimen samples will be collected.

Aqueous environmental chemistry of phosphorus in Green Bay.

The study on aqueous environmental chemistry of phosphorus in lower Green Bay, Wisconsin, has continued as planned. The objectives, currently, are to complete the leaching studies on Green Bay sediments and to estimate the nutrient budget for lower Green Bay to develop a crude predictive model for the chemistry of phosphorus in lower Green Bay. The following report describes the results obtained from experiments evaluating the exchange of phsophorus present in the sediments with Green Bay water. For related results see the preceding Green Bay Research Program.

The leaching experiments were carried out in the laboratory in five gallon pyrex glass jars. The sediment was mixed in 20 liter distilled water and kept in suspension with a magnetic stirrer in anaerobic jars and by mixing with a glass rod twice a day in aerobic jars. Water samples, at an interval of 24-48 hours, were taken over a period of three to four weeks for analysis of phosphate, calcium, magnesium, alkalinity and measurements of pH and conductance.

a. Oxic phosphorus release

1. P release versus time

With sediments from stations 4, 5, and 5a (south of Long Tail Point) and station 9 (near Long Tail Point) approximately 0.1 and 0.25 mg/l of soluble ortho phosphate (reported as P) was released from 50 g wet sediment in a period of a few days. Additional periods of leaching up to one month did not result in increased amounts of P release. Along with the increase in phosphorus release, an increase in calcium, magnesium, alkalinity, specific conductance and pH were observed. This trend occurred in all the oxic phosphorus release experiments carried out in the laboratory in a distilled water system. It is likely that phosphorus in association with calcium and magnesium is released under the conditions stated above.

2. Effect of Location

In order to find the effect of location of stations on the amount of phosphorus released, sediments from station 5a (near the mouht of Fox River) and station 11 (northwest of Long Tail Point) were used in one set of experiments. Higher phosphorus release from the sediment was associated with the proximity of station to Fox River. With station 5a, the release of soluble ortho P was 0.25 mg/l in 20 days while with station 11 there was only 0.01 mg/l of soluble ortho P release.

3. Sediment water ratio

Various amounts of wet sediment from station 9 (near Long Tail Point) were mixed with 20 liter distilled water, and release of P from the sediment was monitored over a period of three weeks to evaluate the effect of increase in sediment water ratio on P release. With 25 g wet sediment, total soluble ortho P release was 1.8 mg in 20 days, while with 50 g wet sediment total soluble ortho P release increased to 2.4 mg in 20 days. An increase of wet sediment weight to 200 g increased soluble ortho P release to 3.6 mg. Thus, it was evident that with an increase in sediment water ratio there was an increase in total soluble ortho P release, although mg P released per g wet sediment showed a definite decrease.

4. Effect of presence of P in solution

A set of experiments was carried out to find the effect of the presence of ortho phosphate in various concentrations in the leaching solution. The results are presented in Table 1 below.

Table 1

Phosphorus Release From Sediment of Station 5a in the Presence of Ortho Phosphate in Leaching Solution

Weight of wet sediment	*Volume of water in jar*	*Initial P conc. mg/l*	*Total mgP (initial)*	*Total mgP on 24th day*
50g	*20l*	*0.0*	*0.0*	*5.0*
50g	*20l*	*0.01*	*0.2*	*5.2*
50g	*20l*	*0.10*	*2.0*	*6.0*
50g	*20l*	*0.20*	*4.0*	*7.2*
50g	*20l*	*0.50*	*10.0*	*11.8*
50g	*20l*	*1.00*	*20.0*	*20.0*

There was a significant increase in P release when the initial P concentration in water decreased. On the other hand, when initial P concentration in water was low, total P present after 24 days of leaching was also found to be low.

Under natural environment the sediments of lower Green Bay are saturated with P and are likely to release P to the overlying water under oxic condition. At the same time, it

is possible that when the initial P concentration in water gets lower than what is present now, total P in overlying water will decrease.

5. P release versus depth

Oxic P release experiments were also extended to different sections of a core taken south of Long Tail Point. Fifty g of sediment from top 0-5 cm section of the core released 0.10 mg/l soluble ortho P in 20 liter distilled water within 25 days while the 35-40 cm section of the same core released 0.03 mg/l soluble ortho P under similar conditions. It is likely that most of the P present at 35-40 cm depth in the sediment are in the form of tightly bound P and may not be released under aerobic conditions.

6. P release in synthetic water

Synthetic water similar to lower Green Bay water was prepared using water soluble sodium, calcium, magnesium and potasium salts. The prepared water had comparable concentrations of Ca, Mg, Na, $CO_3^{=}$, Cl^- and silica to Green Bay water and a specific conductance of 360 μmhos/cm at room temperature. Leaching experiments were carried out with stations 5a and 5 sediments and synthetic water. Figure 1 shows the plots between P in water versus time for station 5 with synthetic and distilled water. No significant difference was found in P release between synthetic and distilled water systems.

B. Anoxic phosphorus release

Phosphorus leaching experiments were also carried out in nitrogen atmosphere. With 50 g sediment from station 5, the soluble ortho phosphorus release was as high as 0.38 mg/l. The relative value for oxic release was 0.12 mg/l. The difference in concentrations of P release under oxic and anoxic conditions is due likely to the presence of two different P release mechanisms. In addition to the release of loosely bound P from the sediment, P bound to elements having different oxidation states may be released in anoxic conditions. In the case of iron, Fe (III), compounds are insoluble and are precipitated in the sediment. Under anoxic conditions, Fe (II) compounds are soluble in water within the pH range of natural water systems. Along with the solubilisation of Fe (II) compounds, phosphorus bound to iron is also released into the overlying water. Thus, total soluble phosphorus released under anoxic conditions is more than that released under oxic conditions.

In addition to completion of the leaching experiments on Green Bay sediments, data are being collected from different sources to estimate the nutrient budget for lower Green Bay to develop a crude model for the chemistry of phosphorus in lower Green Bay.

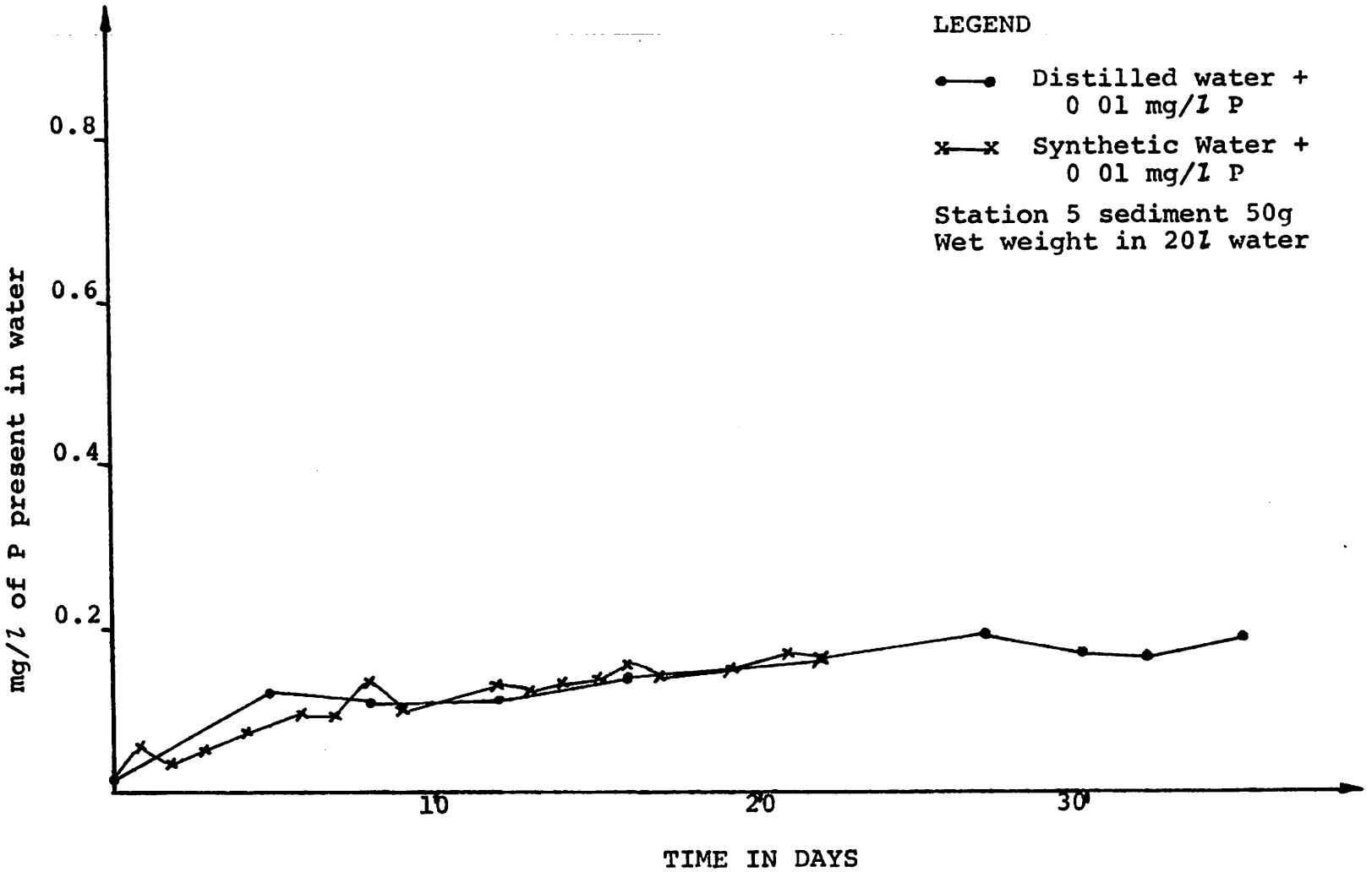


Figure 1: Comparison of leaching of P in distilled water and synthetic water

Chromatogram of Silylated TFM

TFM standard.
0.5 mg/l concentration.
0.4 µl sample volume.
(0.2 nanograms).
64x attenuation.

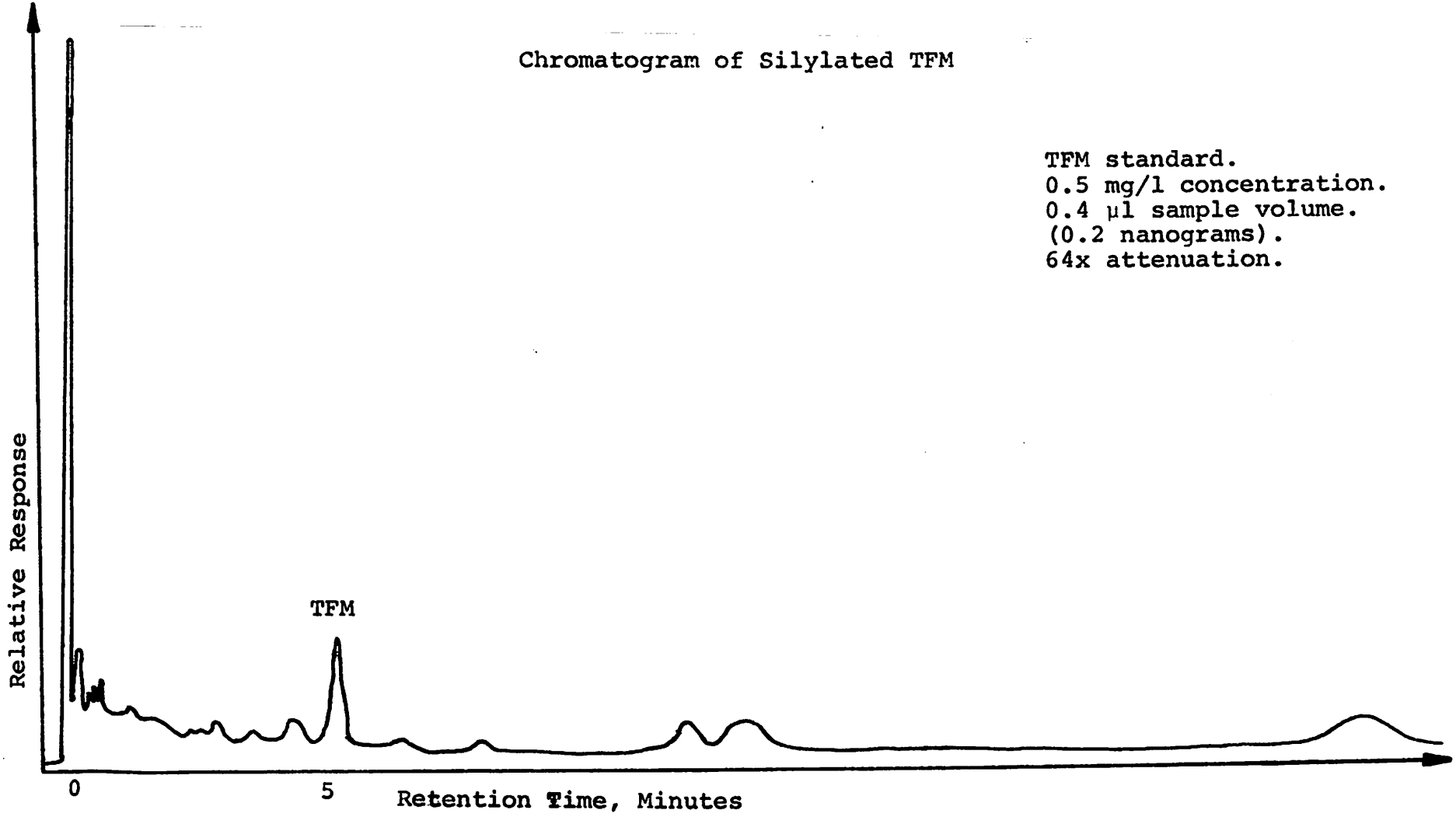


FIGURE I

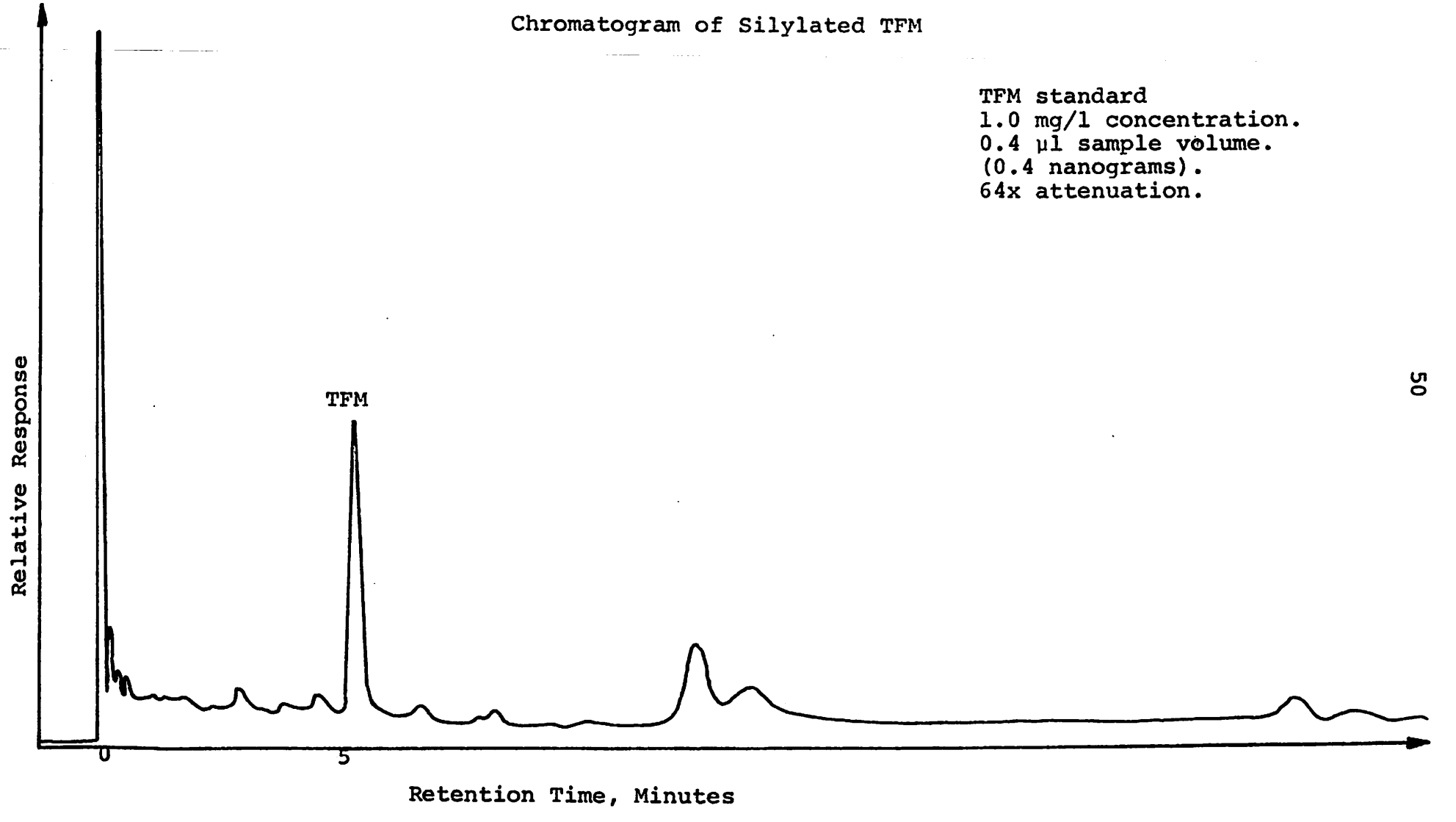

Chromatogram of Silylated TFM
TFM standard
1.0 mg/l concentration.
0.4 µl sample volume.
(0.4 nanograms).
64x attenuation.
TFM
Relative Response
0
5
Retention Time, Minutes

FIGURE II

Chromatogram of Silylated TFM

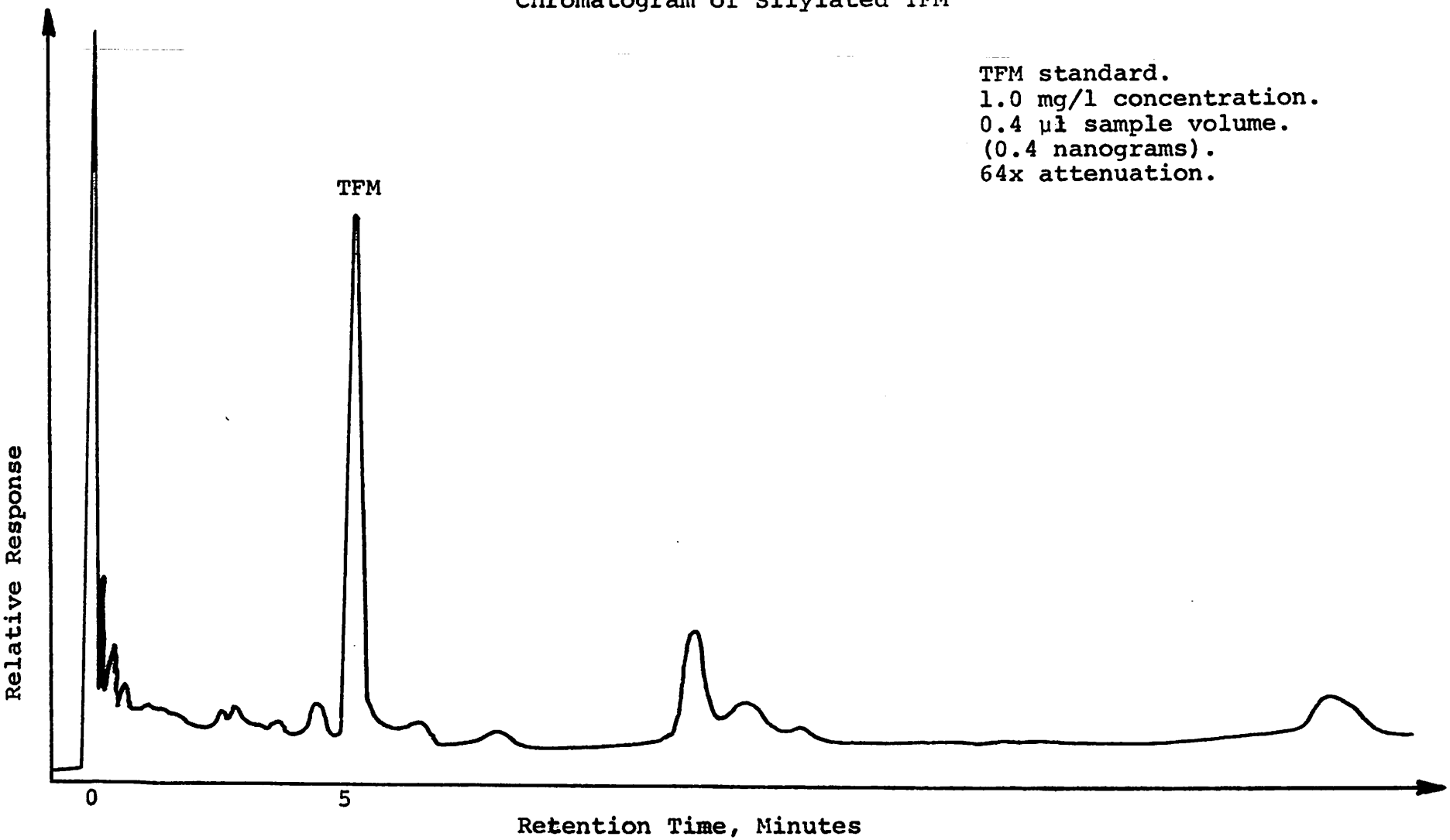


FIGURE III

Chromatogram of Silylated TFM

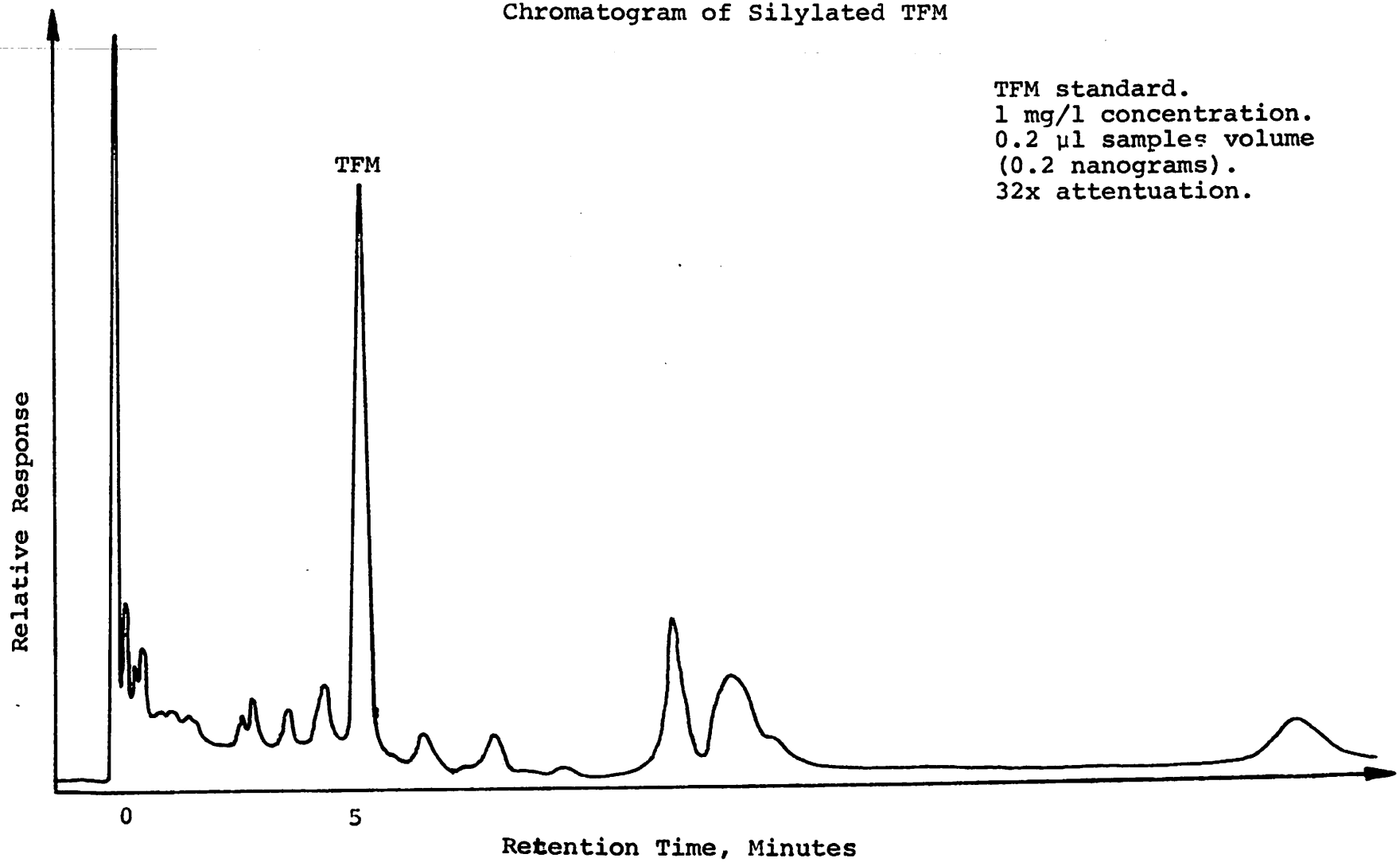


FIGURE IV

Chromatogram of Silylated TFM

TFM extracted from distilled water.
Initial concentration, 0.5 mg/l
0.4 µl sample volume (1.0 nanograms).
64x attentuation.
Derivative concentrated 5x.

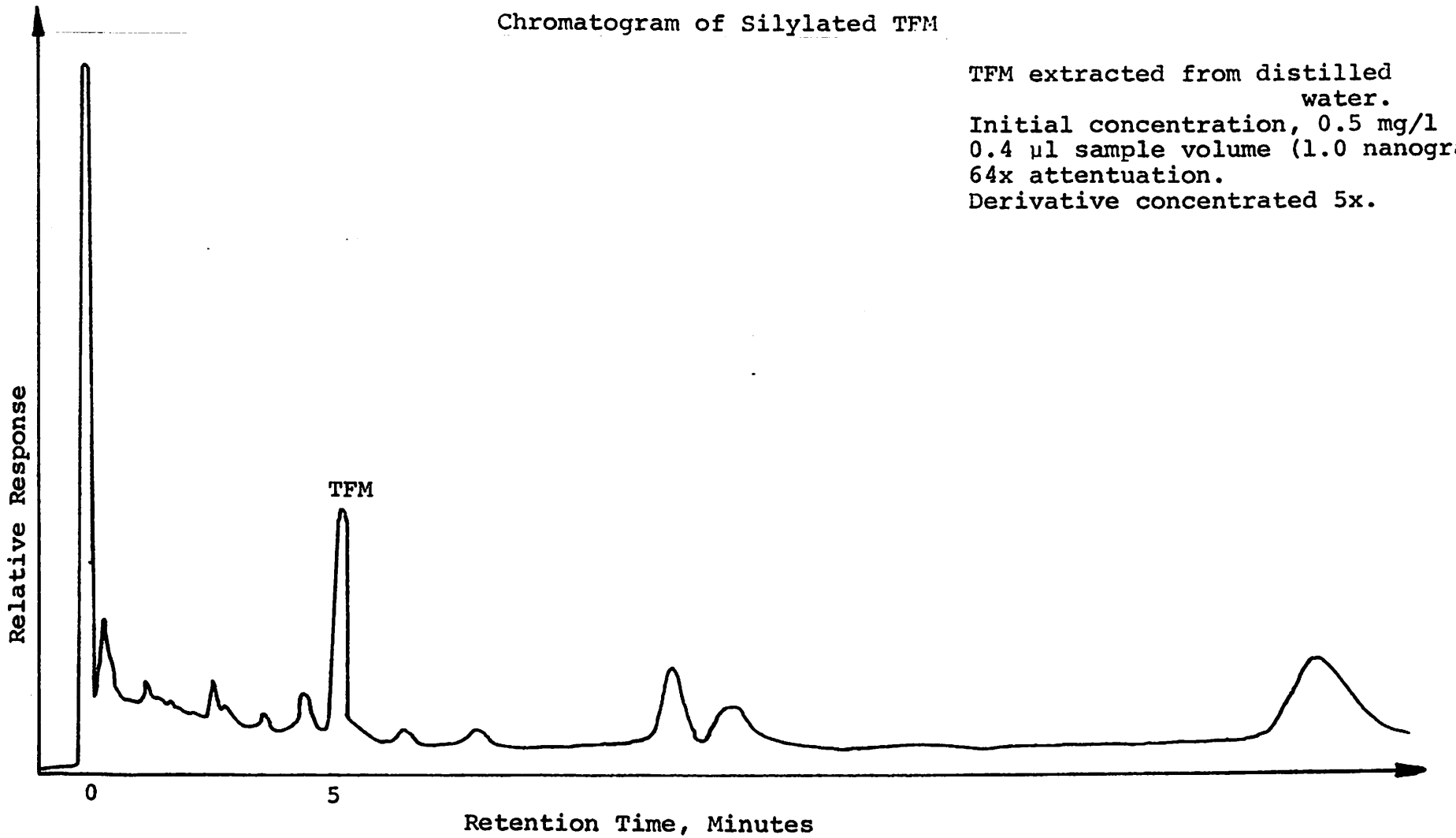


FIGURE V

Chromatogram of Silylated TFM

TFM extracted from Lake Mendota water.
Initial concentration, 0.25 mg/l
0.4 µl sample volume (0.5 nanograms).
64x attenuation.
Derivative concentrated 5x.

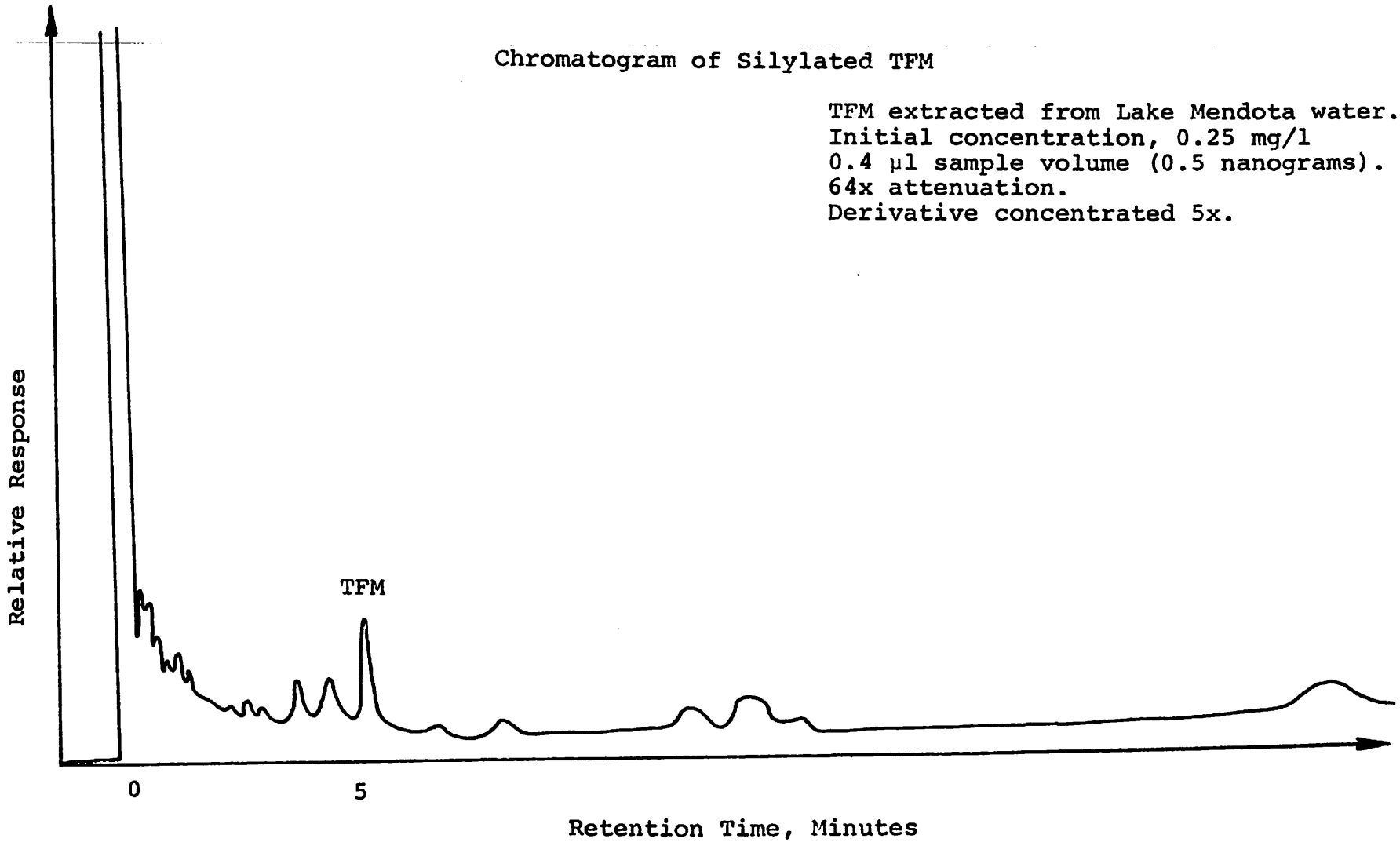


FIGURE VI

Figure I Sampling Station Locations - Green Bay

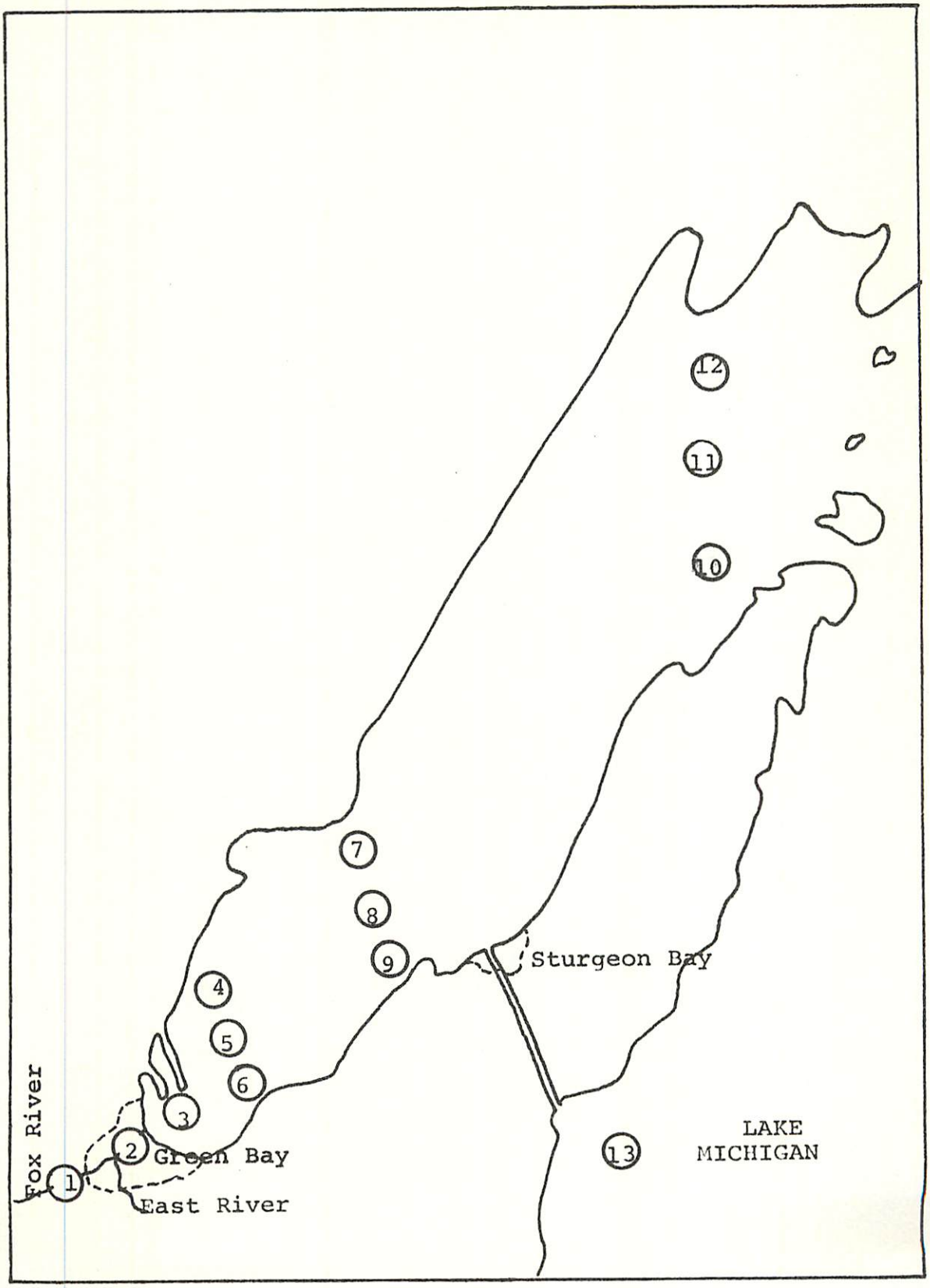


Table 1 Zinc Levels - St. Mary's River Area

Station	Depth (ft.)	pH	Conductance (µmhos/cm)	Zinc (µg/l)
1	0	7.0	96	3.4
	30	7.2	97	4.7
	60	—	—	8.6
	90	7.1	97	3.8
2	0	—	—	5.0
	15	7.2	98	2.5
	30	—	—	5.0
	50	7.1	89	8.2
	75	7.2	88	3.3
3	0	—	—	5.5
	20	7.2	92	5.8
	40	7.2	92	5.0
4	0	7.6	94	5.3
	12	6.8	97	5.4
	22	6.0	106	8.0
5	0	7.1	114	1.8
	6	7.2	—	3.7
6	West	6.4	120	30
	East	6.8	122	28

Table 2 Zinc Levels - Green Bay Area

Station	Depth (ft.)	Conductance (μmhos/cm)	Alkalinity (mg/l $CaCO_3$)	Zinc (μg/l)
1	Middle	250	165	5.7
	East	250	165	9.9
	West	-	-	9.4
2	Middle	268	161	9.2
	East	260	162	15.2
3	0	270	159	7.0
	9	260	161	3.8
4	0	210	124	1.7
	9	200	122	6.2
	18	200	124	5.8
5	0	200	126	4.6
	9	225	126	2.7
	18	210	124	4.0
6	0	235	138	3.4
	10	235	159	3.4
	20	235	138	10.3
7	0	200	136	3.1
	18	-	-	4.8
	40	-	-	1.6
	60	200	126	2.7
8	0	196	122	2.9
	18	-	-	2.2
	40	-	-	1.7
	60	195	122	8.0
9	0	189	-	4.2
	25	-	-	1.5
	50	-	-	2.3
	75	193	122	4.0
10	0	185	117	6.7
	45	195	115	4.4
	90	190	120	4.2
	150	195	117	4.4
11	0	185	117	6.2
	45	185	122	4.3
	90	190	117	5.0
	144	191	120	5.6
12	0	185	120	5.1
	40	190	117	5.2
	80	190	117	4.3
	120	185	122	6.9
13	0	195	120	4.5
	18	191	120	2.8
	36	195	115	2.3
	54	195	115	-

PERSONNEL-WATER QUALITY

Center for Great Lakes Studies

John Batha, graduate assistant (Hydra)
James Barker, graduate assistant
A.M. Beeton, program coordinator
R. E. H. Beeton, Algologist
L. Claflin, graduate assistant (algae)
Everett Fee, graduate assistant (productivity)
John Gannon, graduate assistant (zooplankton)
Ed Mayhew, graduate assistant (Little Bay de Noc)
Don Mraz, administrative assistant (Little Bay de Noc)
Don Rousar, chemist
B. Torke,graduate assistant (Inshore-offshore study)

Water Chemistry Laboratory

G. Fred Lee, principal investigator
Gerald E. Nienke, grad assistant (zinc)
N. Sridharan, grad assistant (phosphorus)
Daryl Thingvold, grad assistant (TFM)

PRIMARY PRODUCTION AND RELATED CHEMICAL VARIABLES IN LAKE MICHIGAN-SPATIAL DISTIRBUTION AND SEASONAL CHANGE ALONG A CROSS-SECTION. E.J. Fee, D. Rousar and U. Zimmermann, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Wisconsin 53201.

Abstract

The water quality of the Great Lakes is a matter of local and national concern. Unfortunately much of what we presently know about the biology and chemistry of these Lakes is based on sampling schemes inadequate both in space and time. The present study, therefore, makes use of a railroad ferry, on a year-round basis, on its scheduled cross-Lake run between Milwaukee, Wis. and Ludington, Mich. to investigate detailed relationships of light intensity, nutrient concentration and temperature to photosynthetic uptake in inshore and offshore waters. At 8 to 14 day intervals during the period 27 May - 16 November 1970, samples were taken from 4 m depths at 5 stations along the section. Stations 1 and 5 are respectively 4.8 km from the Milwaukee and Ludington breakwaters; station 2 and 4 are at the western and eastern quarter points and station 3 is at the mid-point of the section. In addition, an anchor station 15 km east of Milwaukee has been occupied by the Center's research vessel at monthly intervals, beginning 22 September, to determine the depth variation of the parameters measured on the ferry.

During the warming phase in the Lake which ended in early August, temperatures (4m) at the 2 inshore stations were consistently warmer than those offshore. Station 5 (inshore Mich.) was always slightly warmer than station 1 (inshore Wis.). By contrast, during the cooling phase, the offshore stations were warmer than station 1 but cooler than station 5.

Pronounced seasonal and quantitative differences in the optimum rate of photosynthetic carbon uptake were found between the various stations. Station 1 had sharp peaks in late June and early October and except for the first date was always greater than the other stations, usually by at least a factor of 2. The 3 offshore stations showed little seasonal change in carbon fixation. Station 5 was only slightly higher than the offshore values and also showed little change with time.

The picture for total phosphorus was similar. Station 1, with values usually double those at other stations, showed a pronounced bimodality in seasonal distribution with peak values of 21 and 22 ppb P precisely corresponding with the peaks in carbon uptake. There was a mid-summer low of 8 ppb. Again, concentrations at station 5 were generally similar to those offshore. Plant pigment concentrations, determined

from July onward, showed a similar picture with highest values of chlorophyll a at station 1 and generally higher values of chrysophyte carotenoids also. The autumnal peak in primary production at that station corresponded to peak values of 10.3 ppb chlorophyll a and 11.7 ppb carotenoids. In respect of total P and pigments, station 5 was generally similar to the offshore stations.

No consistent differences in soluble phosphorus between the stations were detectable. In general, there was a decrease in all stations from about 3 ppb P in the spring to 1 ppb in the fall.

Nitrates again clearly isolate station 1 from the others. The open lake and inshore Michigan data were again very similar, showing a bimodal curve, with peak values of 220 and 200 and a midsummer low of 130 ppb N, which corresponds closely to the seasonal changes in total P. Station 1, showing lower values during the first peak in production and after midsummer, suddenly increased to values much higher than at the other stations. The pattern for station 1 corresponded closely to rainfall at Milwaukee and probably reflects surface drainage.

In contrast to the above chemical variables, silica showed no consistent ranking between stations. Station 5 showed little seasonal deviation from a mean of 0.5 ppm SiO_2; at the offshore stations, the concentration dropped from 1.4 to 0.4 ppm SiO_2 in early summer and then changed little. At both station 1 and the offshore stations, silica dropped sharply in early summer (1.4 to 0.4 and 1.0 to 0.2, respectively). Subsequently there was little change offshore and an irregular increase at station 1 followed by a fall coinciding with the autumnal peak in carbon uptake.

The most obvious result of these data is the persistent difference between station 1 and all others. The changes in primary production, total phosphorus, nitrates and plant pigments all indicate seasonal and quantitative differences from the other 4 stations. It is likely that this reflects enrichment by Milwaukee and other population centers to the south since the other inshore stations which is further to the north east very similar in these properties to offshore stations. The absence of seasonal variations in optimum carbon uptake in the open lake was unexpected.

The data strongly indicate that observations isolated in time may have little or even incorrect significance. All parameters except offshore primary production are highly seasonal in their distribution, and data from different parts of the lake separated in time by only 10 days can be remarkably misleading. Generalization about donditions in the lake as a

whole from observations at a single fixed point are also to be avoided, since some regions are more enriched than others.

While general seasonal trends are clear, it is obvious that details cannot be resolved even with a sampling interval of 10 days. Most of the peaks, especially those in the primary productivity data, are based on single points. To determine precisely the nature of these peaks, sampling must be more frequent.

A COMPARISON OF ZOOPLANKTON CRUSTACEA POPULATIONS IN LAKE MICHIGAN AND GREEN BAY. John E. Gannon, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Wisconsin. Presented at the 13th Conference for Great Lakes Research, Buffalo, 1970.

Abstract

The zooplankton crustacea populations in northern Green Bay and Lake Michigan are very similar. However, many differences in species composition and abudance of zooplankton crustacea exist between Lake Michigan and southern Green Bay. The copepods, Macrocyclops albidus and Diaptomus siciloides, are found only in southern Green Bay. The copepods, Cyclops vernalis, Mesocyclops edax, and Tropocyclops prasinus, and the cladocerans, Daphnia schodleri, Chydrous sphaericus, Eurycercus lamellatus, Leptodora kindtii, and Daphanosoma leuchtenbergianum, are more abundant in southern Green Bay than in Lake Michigan and northern Green Bay. The cladocerans, Daphnia longiremis and Polyphemus pediculus, and the copepods, Limnolocalanus macrurus, and Senecella calanoides, are more abundant in Lake Michigan than in Green Bay. The observed differences in species composition and abundance in Green Bay and Lake Michigan will be discussed in terms of the following possible causative factors: (1) lack of sufficient cold water in Green Bay for cold stenothermous species; (2) influx of species into Green Bay through the Fox River system; (3) change in species composition due to size-selective predation by planktivorous fishes, such as the alewife; and (4) accelerated eutrophication by human influences, especially noticeable in southern Green Bay, which may be changing the nutritional aspects of the environment. Certain species of zooplankton may be increasing in abundance due to the increase in food (bacteria, detritus, algae, and rotifers) under accelerating eutrophic conditions.

SIGNIFICANCE TO THE EUTROPHICATION PROBLEM OF INSHORE-OFFSHORE DIFFERENCES IN NUTRIENTS AND THE PLANKTONIC DIATOMS OF LAKE MICHIGAN. Ruth H. Beeton and A. M. Beeton, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Wisconsin. Presented at the American Society of Limnology and Oceanography Meeting, Rhode Island, August, 1970.

Abstract

Many engineering studies dealing with water supply, disposal of sewage, waste heat, and industrial waste have been based upon the assumption that the entire volume of Lake Michigan was available for dispersion and dilution of the pollutants. Recent studies have indicated, however, that inshore waters in most areas of the lake proper have different concentrations of phosphorus, nitrogen and silica from offshore areas. These inshore and offshore differences in the distribution and concentration of nutrients are reflected in the distribution and abundance of planktonic diatoms and in the species composition of the Melosiras. The present study was undertaken to further document inshore-offshore differences. Samples were obtained by car ferry on a transect which ran across Lake Michigan and Green Bay from Frankfort, Michigan to Menominee, Wisconsin. The new data substantiated earlier findings, and indicated in addition that there were differences between inshore and offshore waters in Green Bay.

FISHERIES RESOURCES PROGRAM

Major disruptions of fish communities in the Great Lakes have occurred as a result of such factors as invasions of exotic species such as the lamprey and alewife, overfishing, and deterioration of the water quality. Man's introduction of exotic species such as salmon to attempt to restore the present species imbalance and provide sports fishing has met with some success. Although efforts are being made to restock the lakes with native species such as the lake trout, it appears likely that continued stocking of exotic species such as salmon and non-native trout will be demanded by the public on the basis of immediate recreational or economic benefits.

The ultimate success or failure of these management practices may take years to determine. However, information is needed now on which to base policy decisions regarding species to be introduced, stocking site locations, and harvesting regulations. Information is also needed to evaluate the different introductions with regard to their biological impact on the community and the assessment of the harvest benefits. For example, although the coho salmon in Lake Michigan now grow phenomenonally and return to their stocking sites in surprisingly large numbers, little is known of their distribution and movements in the lake or the characteristics of their homing migrations. Such information is needed before a complete evaluation of this species can be made, and in addition provides information which can lead to maximizing the sports harvest.

The progress reports that follow discuss the contributions being made by the Wisconsin Sea Grant Fisheries Program toward understanding and assessing the multiple interactions of populations of exotic fishes and a changing lake environment.

Special attention is being given to the effects of large electric power plants sited on Lake Michigan on the behavior of the migratory as well as the local resident fishes (see second section of Volume II).

Biochemical and microbiological studies of the uses of trash fish have resulted in further progress and have been addressed to the problem of functionality of fish protein concentrate and the removal of mercury from the protein product.

LESIONS PRODUCED BY PESTICIDES AND HERBICIDES IN FISH

William E. Ribelin

Large scale fish kills are common in both fresh and oceanic waters. Because of the dearth of knowledge regarding the lesions of fish diseases, such deaths are often attributed to environmental toxicants, frequently pesticides or herbicides. Studies by various laboratories determining the lethal concentrations of pesticides and herbicides have resulted in numerous publications with occasionally the description of some lesion. These tissue changes are rarely verified by other agencies so the significance of lesions as a means of diagnosing pesticide or herbicide poisoning is unclear.

Young 6 to 8 inch coho salmon (*Onchorhynchus kisutch*) and lake trout (*Salvelinus namaycush*) have been exposed to one-quarter LC_{50} concentrations of Sevin, DDT, Malathion and currently to Thiodan for several months. Examination of fish dying or killed in-extremis has resulted in the detection of no lesions unqualifiedly due to these agents.

Microscopy has similarly yielded no lesions of diagnostic value. Affected fish are stunted, anemic, listless, anoretic, lack body fat, and appear essentially as starved organisms. Next, Dieldrin, Atrazine and 2, 4D will be similarly studied.

Although the use of evident lesions to diagnose pesticide and herbicide poisoning would be preferable to the presently used tissue residue analysis, it is becoming evident that the response of fish to these agents is essentially a metabolic one and the range of structural changes to such exposure is very limited.

PESTICIDE LEVELS IN BIRDS WINTERING ON LAKE MICHIGAN

Robert S. Ellarson

Collection and preparation of birds wintering on Lake Michigan continued throughout the spring and fall of 1970 as they became available from commercial fishermen. These birds were cataloged and stored in a freezer at the University for later preparation and analysis. All specimens were fluoro-

scoped to detect the presence of lead shot. Whole specimens were prepared for pesticide analysis by: (1) severing wings, head and feet from the body; (2) shaving all feathers and down from the body to within one-eighth inch of the skin; (3) removing the digestive and genital tracts. When the birds were prepared in this manner, additional measurements on plumage and internal organs were made, and a wing, oviduct (from adult females), and gullet sample were saved from each specimen.

During the first half of September, a trip was made around Lake Michigan to increase fishermen contacts, and to assess gill net mortality in birds wintering on the lake as compared to that found in the early 1950's.

Results

Between the middle of March and the first of May, 47 specimens were obtained. These included 44 Old-squaw Ducks (*Clangula hyemalis*), 1 Common Loon (*Gavia immer*), 1 White-winged Scoter (*Melanetta deglandi*), and 1 Red-necked Grebe (*Podiceps grisegena holbolli*). Between the last week in October 1970 and the first of January, 1971, 193 Old-squaw Ducks and 1 White-winged Scoter were collected. With the 254 birds collected during the first fall of the project, we have cataloged a total of 495 specimens.

From the 254 birds collected in the fall of 1969, all birds other than Old-squaw Ducks (4) and a random sample of the Old-squaws (37) were prepared and sent to the WARF (Wisconsin Alumni Research Foundation) Laboratory for pesticide analysis. All birds collected in the spring of 1970 (47) were prepared and sent to WARF for analysis. As of this date, none of the birds collected in the fall of 1970 have been prepared for analysis.

Residue analysis from the fall and spring 1969-70 samples have been received. These data have not been examined in detail or submitted to statistical analysis, but a partial summary of the material is presented in Tables 1 and 2. Even though only the most tentative conclusions can be drawn at this time, a few trends are apparent in these data.

Eggshell measurements of Old-squaw Duck eggs were obtained from museum collections at Chicago, Ill. and Berkeley, Cal. These measurements will be used in comparing eggshell data to be collected this summer on the breeding grounds.

Data summarized in Table 1 will not be commented upon at this time because the sample sizes are so small, but the material is presented as a matter of record for comparison with the Old-squaw data. Data in Table 2 indicate several anomalies in the fat and DDE residues for the five sex and age classes delineated. Females arrived on the lake in the fall with a higher lipid content than males, but males left the lake in the spring with a higher fat content than females. Immature females lost the most fat (16% -4.7%) while immature males lost the least (9.5% - 9.2%) during the winter. All sex and age classes lost some fat throughout the winter.

Old-squaw Ducks collected in December had relatively low DDE values, whereas specimens of this species collected in March and April had relatively high values. Since these birds begin arriving on the lake in the last week of October, the pesticide burdens contained in them in December may or may not have come from the lake ecosystem. However, Old-squaws older than one year, arrive on the lake in the fall with a higher DDE burden (7 - 14 ppm) than birds of the year (4.9 ppm). A build-up of DDE while the birds remain on the lake is evident. Adult females (those females that presumably bred the past summer) arrived on the lake in the fall with lower DDE burdens (7.0 ppm) than subadults (10.0 ppm; those females that presumably did not breed the past summer).

Gullet samples were saved for pesticide analysis from specimens found to contain more than 1.0 ml of material. Items found in these gullets are presented in Table 3. These data are very similar to the evidence collected in the early 1950's and point out that the Old-squaw is primarily feeding on Amphipods (*Pontoporeia affinis*) while on the lake. The next most important food items are clams, snails and opossum shrimp in that order. We will use these data to select samples for pesticide analysis.

Work Planned for Spring 1971

(1) We will continue to collect specimens throughout the winter and spring of 1971;
(2) We will prepare and submit for pesticide analysis, a random sample from each sex and age class of specimens collected;
(3) We will prepare and submit food samples for pesticide analysis;
(4) All data collected to date will be transferred to punch cards for statistical analysis.

(5) We will be preparing for the arctic collecting trip to be carried out during the summer months.

Table 1. Percent Fat and DDE Residues (ppm) in Birds Other Than Old-squaws Wintering on Lake Michigan 1969-70

Species	% Fat Fall	% Fat Spring	Fall DDE (Wet Basis)	Spring DDE (Wet Basis)	Fall DDE (Lipid Basis)	Spring DDE (Lipid Basis)
Common Loon	1♀-21.1	-	1♀-1.13	-	1♀-5.35	-
	1♂-19.4	1♂-15.3	1♂-0.74	1♂-38.1	1♂-0.74	1♂-249.02
White-winged Scoter	1♀- 7.27	1♂- 0.84	1♀-0.24	1♂- 4.25	1♀-3.30	1♂-505.95
Horned Grebe	1♂-25.6	-	1♂-1.83	-	1♂-7.15	-
Red-necked Grebe	-	1♂-28.5	-	1♂-105.7	-	1♂-370.88

Table 2. Percent Fat and DDE Residues (ppm) in Old-squaws Wintering on Lake Michigan 1969-70: Means, Stand. Errors and 95% Conf. Limits

Sex and Age Class	Fall % Fat	Spring % Fat	Fall DDE (Wet-Basis)	Spring DDE (Wet-Basis)	Fall DDE (Lipid-Basis)	Spring DDE (Lipid-Basis)
Immature Males	9.5 */8	9.2 /9	4.9 /8	35 /9	54 /8	482 /9
	±1.5	±1.8	±0.9	±4.5	±9.7	±99
	(6.1-12.9)	(5.0-13.4)	(2.8-7.1)	(24-45)	(31-77)	(253-710)
Immature Females	16 /7	4.7 /4	4.9 /7	19 /4	30 /7	581 /4
	±1.7	±1.5	±0.7	±2.6	±5.2	±207
	(12-20)	(0.1-9.4)	(3.1-6.6)	(10-27)	(18-43)	(0-1240)
Adult Males	10 /8	7.7 /13	14 /8	42 /13	148 /8	640 /13
	±1.2	±1.2	±1.9	±5.9	±27	±107
	(7.6-13.1)	(5.1-10.4)	(9.4-18.2)	(29-55)	(84-213)	(407-873)
Adult Females	13 /10	7.2 /14	7.0 /10	31 /14	53 /10	473 /14
	±1.3	±0.6	±1.1	±4.0	±9.2	±70
	(10-16)	(5.8-8.5)	(4.4-9.6)	(23-40)	(32-73)	(323-623)
Subadult Females**	11 /4	6.4 /4	10 /4	28 /4	94 /4	434 /4
	±1.7	±0.9	±0.4	±8.8	±9.8	±130
	(5.9-16.6)	(3.4-9.3)	(8.9-11.4)	(0.3-56.1)	(63-125)	(21-848)

* Sample size - ** Absolute identification of this sex and age class has not been confirmed.

Table 3. Old-squaw Gullet Samples Containing More Than 1.0 ml. of Material.

Item	No.	% Occurrence	No.	% Occurrence
Amphipoda (scuds)	123	100	25	96
Pelecypoda (clams)	110	89	24	92
Gastropoda (snails)	32	26	3	11
Mysidaceae (opossum shrimp)	14	11	4	15
Skeletal Remains (fish)	0	0	7	27
Eggs (fish)	17	14	1	4
Detritus (decayed veg. matter)	43	35	6	23
Oolites	123	100	25	96
Sand (<2.0mm)	120	97	26	100
Gravel (>2.0mm)	79	64	14	54
Decapoda (crayfish)	0	0	1	4
Cottidae (sculpin)	2	2	2	8
Fish Eyelens	3	2	0	0
Clupeidae (alewife)	0	0	1	4
Gadidae (lawyer)	0	0	1	4
Trichoptera (caddis fly)	8	7	0	0
Unident. Insects	18	15	7	27
Unident. Worms	3	2	10	38
Total	123		26	

EFFECTS OF COHO SALMON IN A SMALL LAKE

John J. Magnuson

Over the past year, seasonal changes in vertical and horizontal distribution, daily activity, and food habits of coho salmon, cisco, and perch were studied in Pallette Lake using gill-nets, fyke-nets, electro-fishing gear, and echo-sounders.

Coho salmon were found inshore in the spring. Between May and June coho moved into the epilimnion and abandoned the littoral region. In July they descended into the metalimnion and remained there until October when they returned to the littoral region.

Cisco were also found inshore in the spring and fall. Perch, however, were very abundant in the littoral region throughout the year. In the pelagic region, cisco and perch were widely distributed in the spring, fall, and winter. In summer, cisco were found in the metalimnion, while perch were captured in the epilimnion.

During the year coho and perch had no evident daily changes in vertical distribution, whereas cisco rose vertically after sunset in spring and fall.

During summer perch moved horizontally onshore at sunset and offshore at sunrise. Cisco exhibited a reverse movement. At sunrise, cisco moved shoreward and remained during the day near the bottom in water 9 to 12 m deep. At sunset, part of the cisco population migrated offshore, while the remaining population remained active near shore.

Coho ate mainly terrestrial insects in the epilimnion and aquatic insects, zooplankton, and some fishes in the metalimnion. They increased in total length from 130 mm to 175 mm between April and October, 1969. Little growth occurred during winter of 1969-70.

Background

Pallette Lake is a clear, seepage lake of low fertility. It has a surface area of 69 ha (170 acres) and a maximum depth of 18.3 m. Cisco and perch are abundant in the pelagic region, while perch, common shiners, white suckers, and

small-mouth bass are numerous inshore.

Gill-netting and echosounding on Pallette Lake in 1968 provided information on the distribution and movements of cisco and perch before coho were introduced. Physical-chemical data and plankton samples were also taken in 1968. A total of 5,000 coho were then stocked in the lake in October, 1968 and April, 1969 by the Wisconsin Department of Natural Resources. The adipose fin of spring-stocked coho was removed to distinguish them from fall-stocked coho.

The objectives of this study are to 1) compare the distribution, daily activity and food habits of coho with that of cisco and perch; 2) relate the distribution, daily activity and food habits of the three species to the distribution and abundance of their food and the vertical gradient of temperature and dissolved oxygen; and 3) evaluate these data to determine the effect of coho salmon on cisco and perch.

Procedures

Sampling the Littoral Region

Horizontal gill-nets, 15 m long and 2 m deep, were set in 2 m of water. Vertical gill-nets, 5.5 m long and 18 m deep, were set in water 5 m deep. All nets were made of nylon. The stretched mesh size of the gill-nets ranged from 17 mm (3/4 in) to 64 mm (2 1/2 in).

The gill-nets were set from August to October, 1969 every 2-3 weeks and lifted daily for 48-hour sampling periods. The captured fish were measured, weighed and saved for stomach analysis. Catch per unit of effort was determined to give a daily and seasonal record of activity.

Fyke-netting and electro-fishing was done by the Department of Natural Resources to sample coho in April and October, 1969. Fyke-nets were also set in May and from October to December, 1969. Each fyke-net had a frame 1.2 m in diameter, a lead 12-15 m long, and a stretched mesh size of 9.5 mm (3/8 in). The nets were set in water 2-3 m deep.

Sampling the Pelagic Region

In 1969 six, vertical gill-nets were set from floating

rollers at two stations in the pelagic region (Fig. 1). Station A was 14 m deep and station B was 18 m deep. The two stations were 250 m apart and oriented in the same compass direction.

The nets were the same as used inshore. Duplicate gill-nets of 19 mm (3/4 in), 32 mm (1 1/4 in) and 38 mm (1 (1 1/2 in) stretched mesh were used at both stations. The nets were lifted from a barge 6.5 m long and 1.5 m wide. In 1970 three additional gill-nets of 45 mm (1 3/4 in), 51 mm (2 in), and 64 mm (2 1/2 in) were used at station B to sample larger fishes. The nets were set for 24 hours every 3-4 weeks from April to December, 1969. They were set and lifted for 4-5 hours during the morning, in the afternoon, from two hours before to two hours after sunrise and sunset, and during the night.

The order in which the nets were set and lifted was randomized. The sampling periods were spread over several days to reduce the bias caused in one period by overfishing in the previous period. Also, to avoid recruitment of fish into the nets as they were being raised, all nets were lifted rapidly in succession and the fish removed by unrolling the nets onto the deck of the barge.

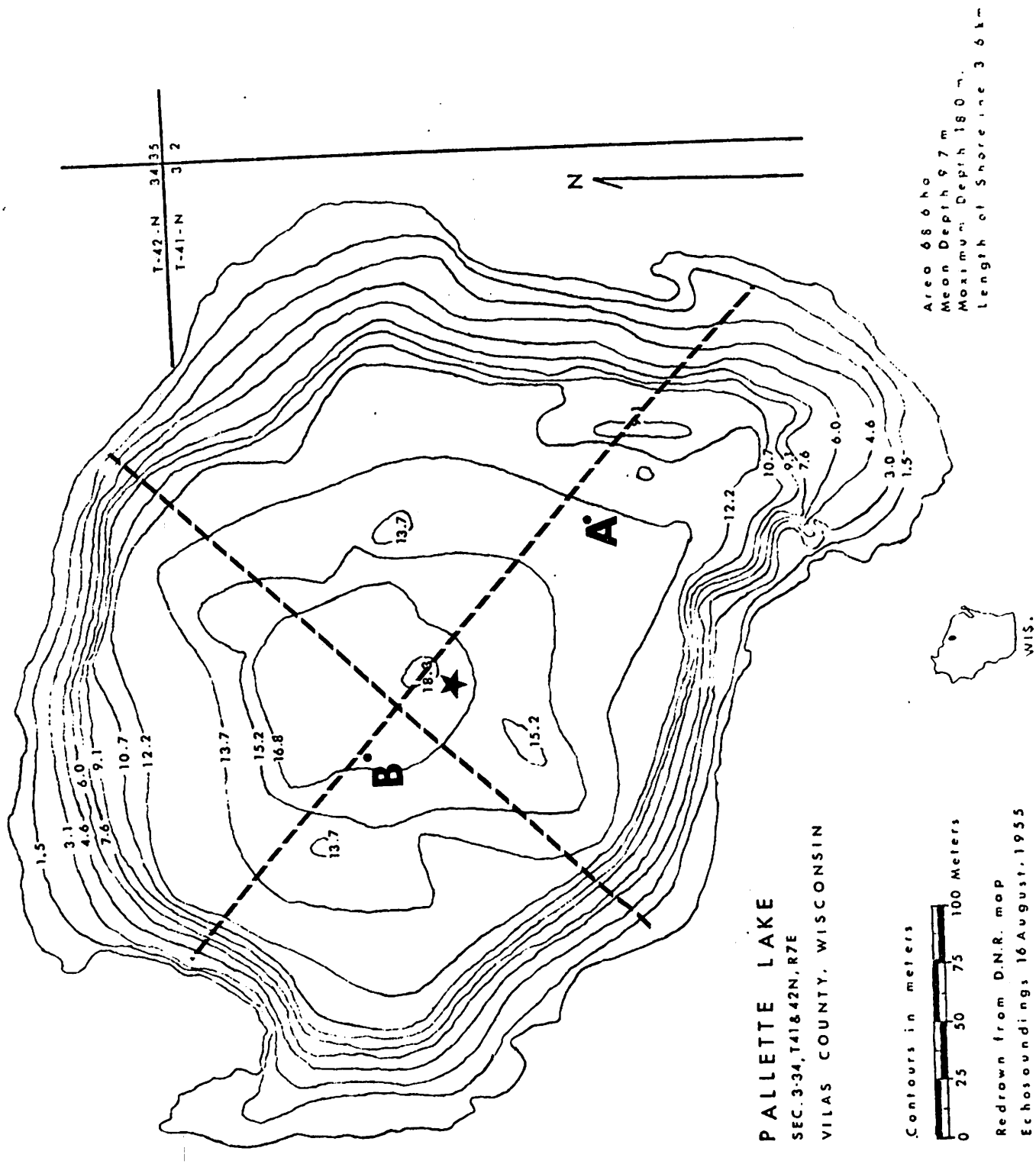
The depth, time of capture, total length and weight of each fish were recorded. All fishes were saved for stomach analysis. Temperature and oxygen profiles were taken during each gill-net series. Plankton samples were also taken with a Clark-Bumpus at various depths during the middle of each sampling period.

Two Bendix DR-9 echosounders, with a frequency of 50 kHz, supplemented gill-net data on vertical and horizontal distribution. They were also used to determine whether the fishes avoided the gill-nets during the day. One echosounder was stationed on the barge near station B and continuous, 24-hour recordings were made. The second echosounder was mounted on a boat and 24-hour transects were made across the lake.

Food Studies

The stomach and intestine of 187 coho were preserved in 5% formalin. Stomachs of 129 coho were taken in gill-nets set for 4-5 hours in the pelagic region from 26 May to 18 October, 1969. Stomachs were analyzed from 61 coho

Figure 1. Map of Pallette Lake showing location of gill-netting stations (A & B), barge (*) and paths of echosounding transects (broken lines).



captured by fyke-netting inshore in April and May, 1969 and from October to December, 1969.

The total volume of the stomach contents and the volume of each food item was measured by water displacement. The food items were sorted, identified and counted under dissecting and compound microscopes.

Findings

Distribution of coho, cisco and perch in the littoral region.

Fyke-netting and electro-fishing inshore captured 468 coho in April and May and 254 coho from October to December, 1969. Gill-nets were set inshore from August to October, but captured only a few coho in October.

Schools of coho were observed during the day inshore from April to June, but were not found inshore from July to September. SCUBA diving inshore in August also failed to find coho. Coho apparently moved offshore between May and June and returned to the littoral region in October.

Cisco were found in fyke-nets and gill-nets inshore from April to May and from late October to early December,1969. In contrast, perch less than 120 mm in total length were abundant in the littoral region throughout the year.

Distribution of coho, cisco and perch in the pelagic region.

In pelagic gill-nets, 154 coho, 2,081 cisco and 2,139 perch were captured from April to December, 1969, with 85% of coho and 64% of cisco captured in gill-nets of 32 mm (1 1/4 in) stretched mesh. The remaining coho and cisco were taken in gill-nets of 38 mm (1 1/2 in) stretched mesh. The coho averaged 164 mm in total length, whereas the cisco had a bimodal frequency-distribution with modes at 168 mm and 235 mm (Fig. 2). Ninety-three per cent of perch were captured in gill-nets of 19 mm (3/4 in) stretched mesh and ranged in size from 60 to 120 mm.

The seasonal changes in vertical distribution of coho, cisco, and perch at stations A and B are shown in Figures 3 and 4 respectively.

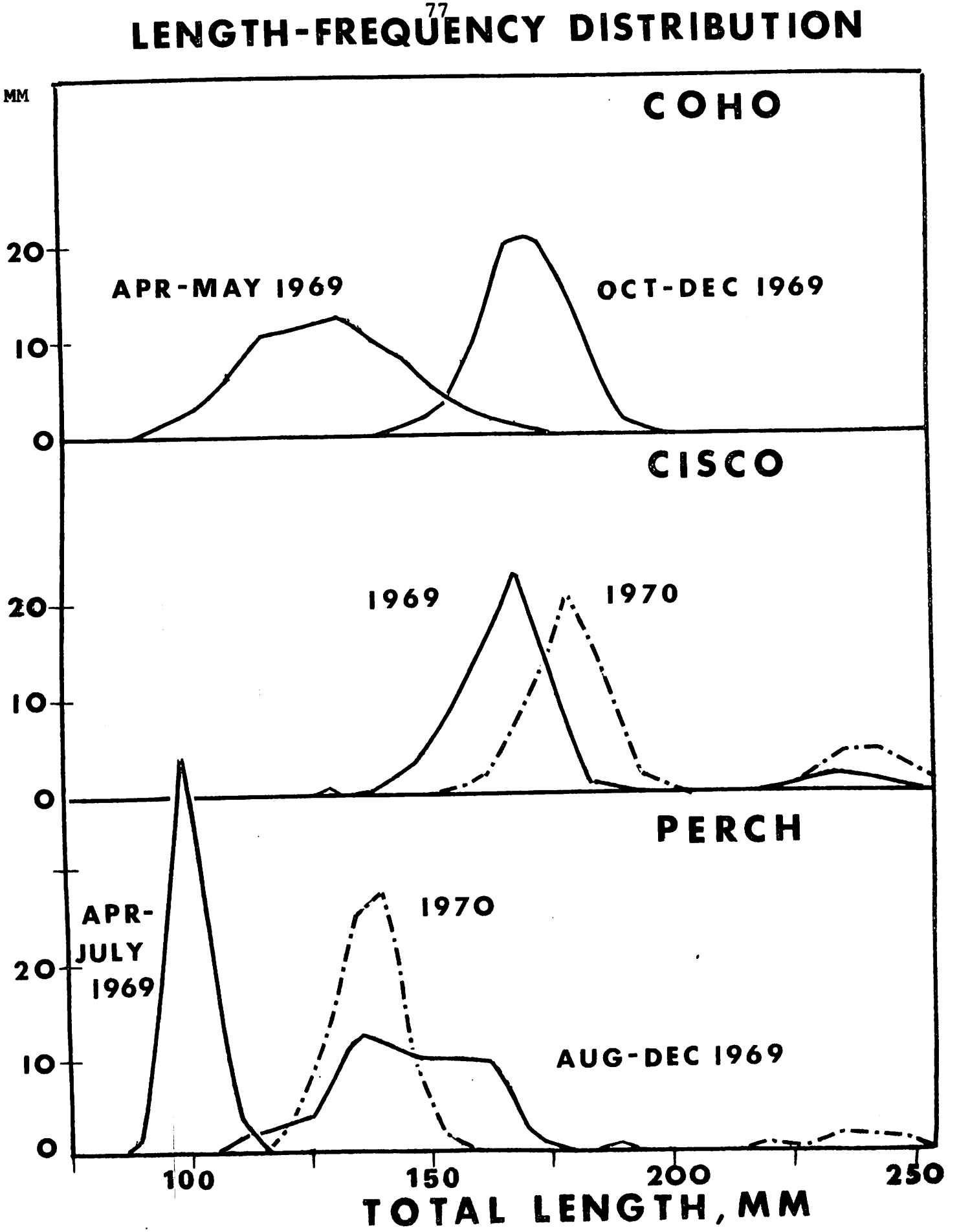


FIGURE 2. Length-frequency distribution of coho, cisco and perch. Coho captured inshore in fyke-nets and by electro-fishing. Cisco and perch captured in pelagic gill-nets.

Figure 3.

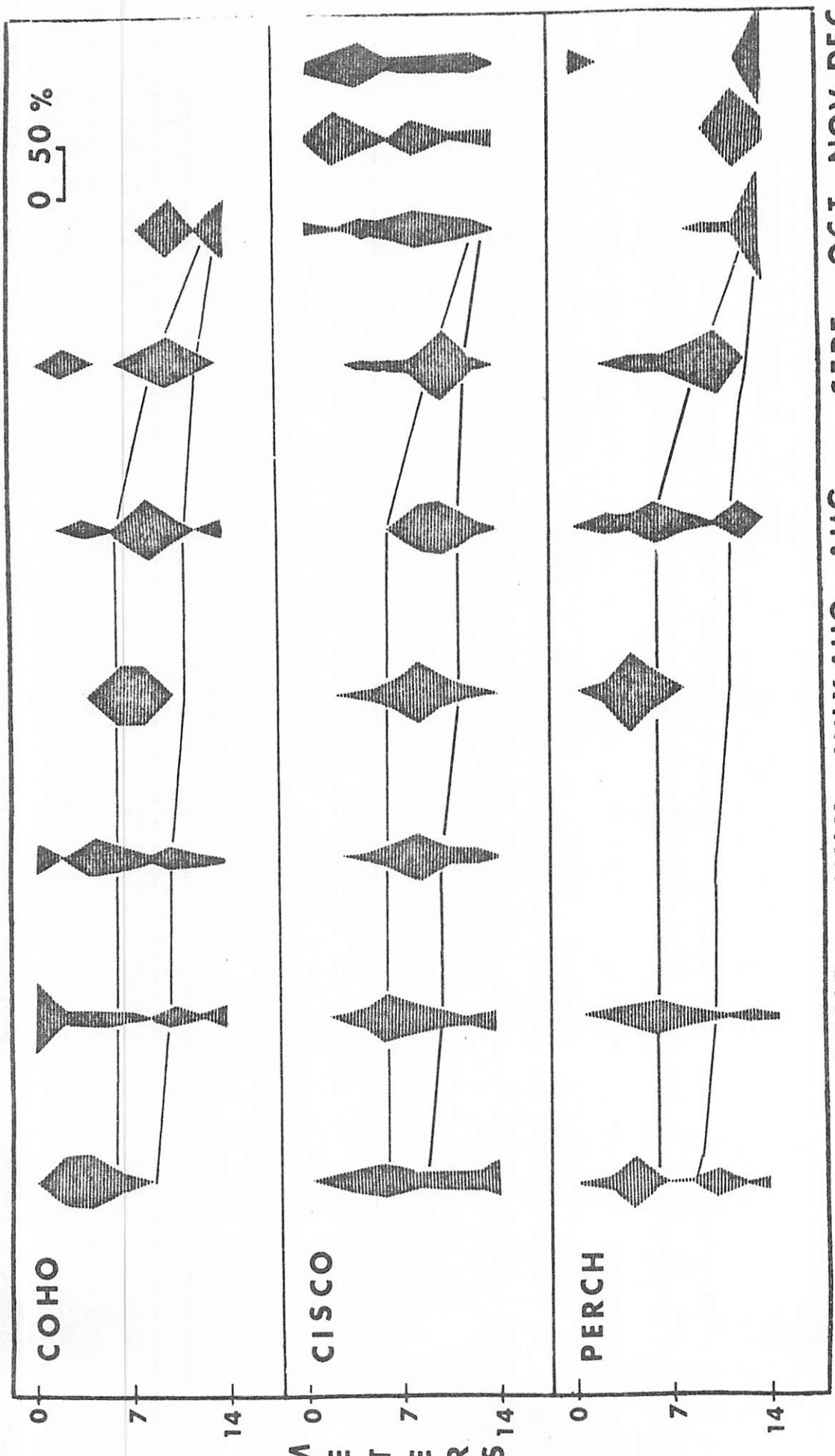
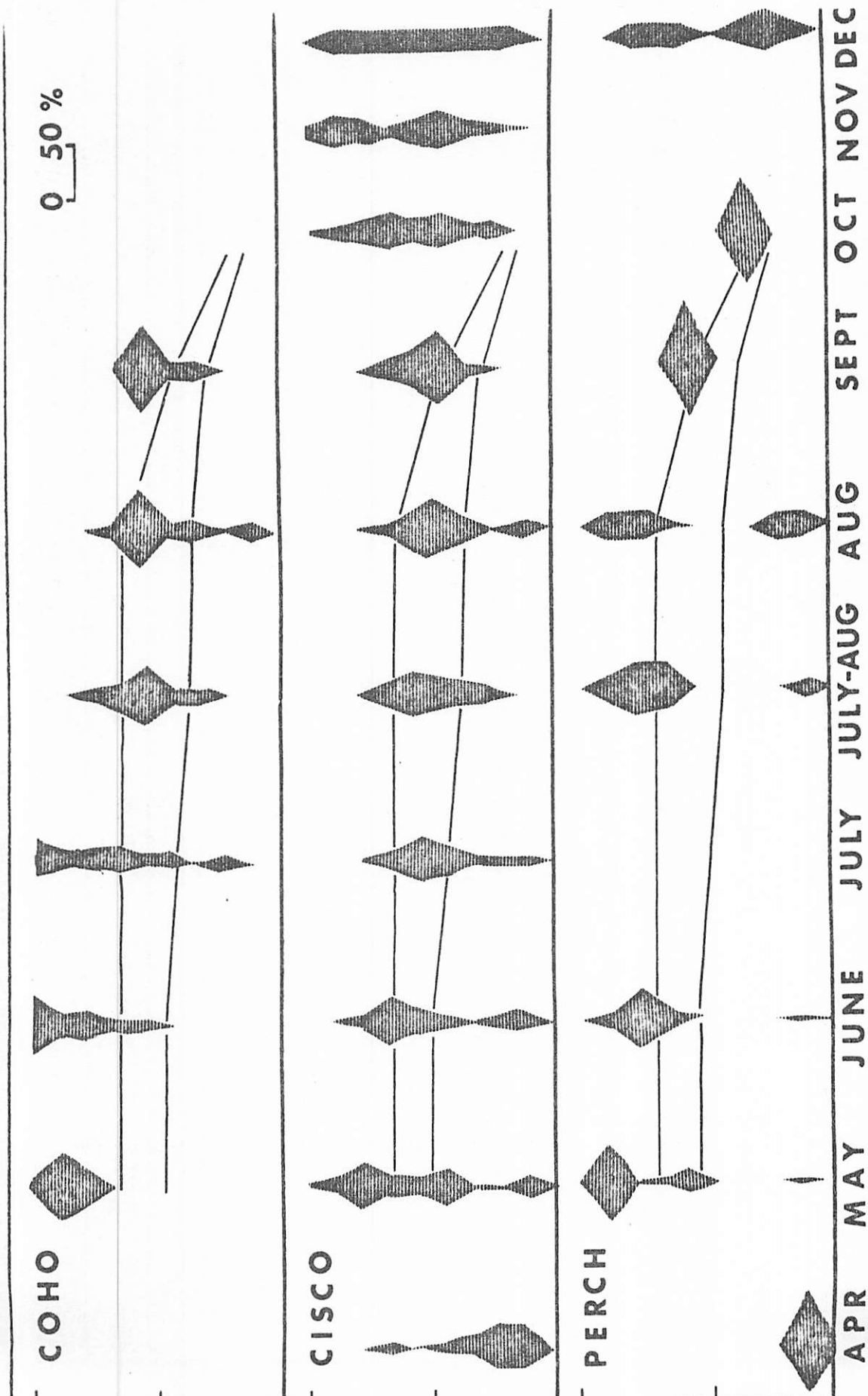

SEASONAL CHANGES IN VERTICAL DISTRIBUTION AT STATION A
0 50 %
COHO
CISCO
PERCH
0
7
14
METERS
APR MAY JUNE JULY JULY-AUG AUG SEPT OCT NOV DEC
1969

Figure 4.


SEASONAL CHANGES IN VERTICAL DISTRIBUTION AT STATION B
0 50 %
COHO
CISCO
PERCH
METERS
0
9
18
APR MAY JUNE JULY JULY-AUG AUG SEPT OCT NOV DEC
1969

On 26-27 April, four days after the ice melted, 87% of cisco were found below 11 m. Coho were first captured in the pelagic region in late May and were found only in the epilimnion. At this time cisco and perch were nearly equally distributed at all depths.

In June, 97% of coho were still found in the epilimnion, while 48% of cisco had entered the metalimnion (7-10 m). Perch were predominantly found in the upper 6 m. By early July, with the surface water temperature at 17° C., 35% of coho and 91% of cisco were found in the metalimnion.

Between late July and September nearly all coho and cisco were found below 6 m, while 81% of perch remained above 6 m. Epilimnion temperatures above 18° C. appeared to restrict coho and cisco to deeper water and perch to upper water.

During July and August the dissolved oxygen concentration at station A was above 5 mg/l at all depths, while at station B oxygen was less than 2 mg/l in the lower four meters. Low dissolved oxygen, rather than avoidance of the lake bottom, prevented coho and cisco from descending below the metalimnion and upper hypolimnion at station B. However, other factors may be important.

In October, during fall overturn, cisco had a wide vertical distribution, whereas only two coho were captured in the pelagic region. In contrast, 91% of perch were found near the bottom in 14 m. Although coho were not captured in pelagic gill-nets during the period of ice-cover, cisco and perch were taken at nearly all depths.

The seasonal changes in vertical distribution of cisco and perch in 1968 and 1970, before and after coho were stocked, were similar to that found in 1969. Echosoundings taken in all years agreed closely with gill-net data.

Daily activity of coho, cisco and perch.

Coho and cisco were captured in vertical gill-nets in the pelagic region primarily at sunset, during the night, and at sunrise (Table 1). The majority of perch, however, were captured during the day. Because of low gill-net catches during the morning and afternoon periods, data were combined into one "daytime" period of 8010 hours.

Table 1. Total number and percentage of coho, cisco and perch captured per hour in pelagic gill-nets in 1969.

Time	Coho	Cisco	Perch
Total no.	154	2,127	2,300
Day	5	1	32
Sunset	28	33	19
Night	39	41	14
Sunrise	29	25	35

Low gill-net catches of coho during the day were due to reduced activity, gill-net avoidance, or movement away from the sampling stations. However, coho appeared to be active during the day inshore in the spring and fall. Experiments on 52 coho in a circular aquarium, 3 m in diameter and 1.8 m deep, revealed that the coho were active during the day but were captured in gill-nets only during the night. There was also no evidence that coho underwent daily onshore and offshore movements in summer or changed their vertical distribution during the day. This suggests that few coho were captured during the day because they avoided the gill-nets.

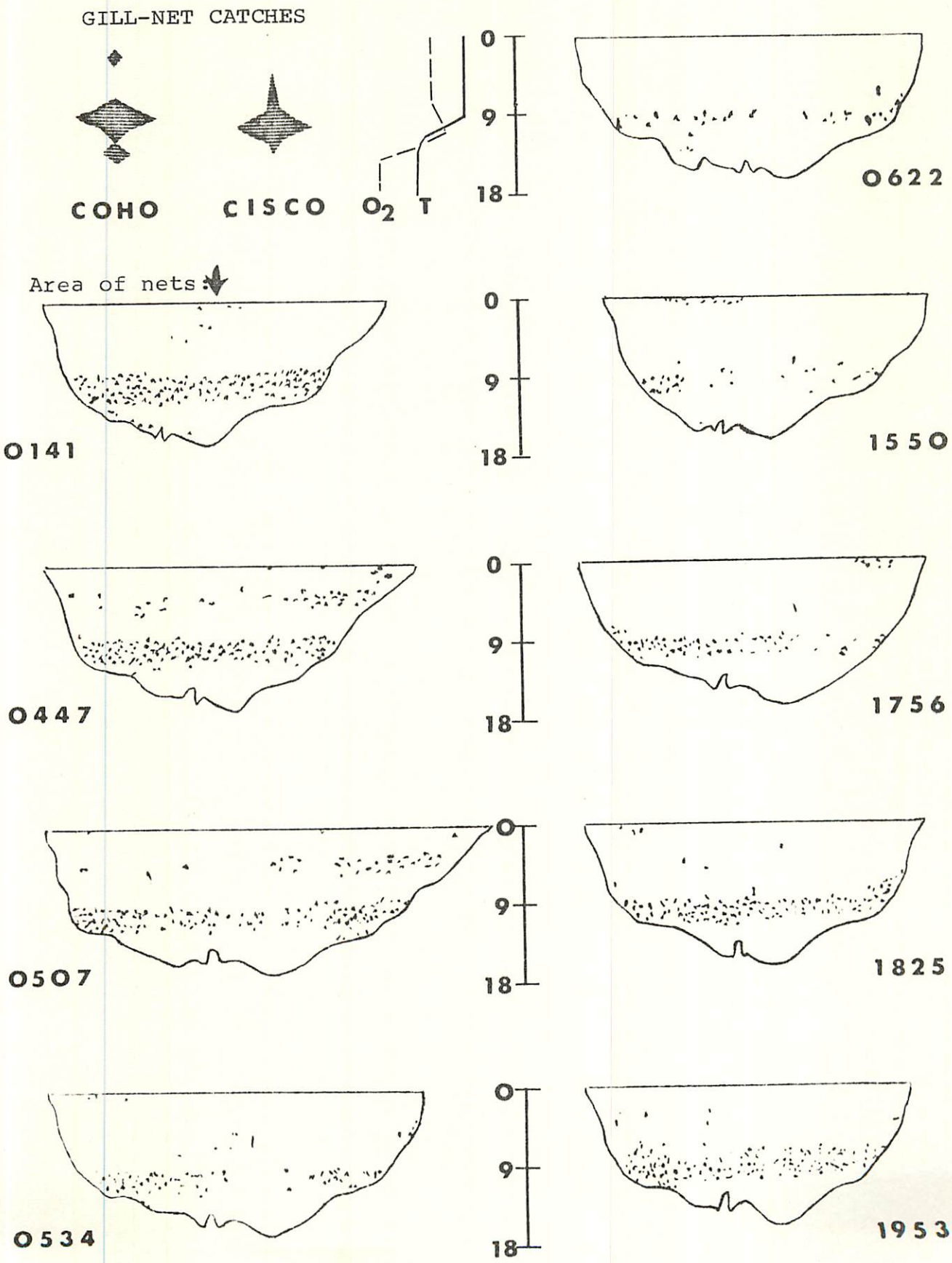
The small percentage of cisco captured during the day was due to movement of the population out of the pelagic region around sunrise. Fig. 5 shows portions of two, 24-hour echosoundings taken in September across the lake. Gill-netting was used to identify the fish traces.

Cisco moved shoreward in the metalimnion at sunrise and remained during the day near the bottom in 9-12 m. Few fish traces were found in the pelagic region during the day. Fish traces at night near shore suggest that part of the cisco population moved offshore and that the remaining population was active at night near shore. In November and December this pattern of movement was reversed and cisco moved onshore only at night to spawn.

Perch underwent a reverse movement. Echosoundings taken in the pelagic region in summer showed many fish traces at sunset and sunrise between 0 and 6 m (Fig. 5). Few coho and cisco were captured at these depths in summer, while 81% of perch were found there. Echosounding transects taken across the lake in 1968 and 1970, showed a similar pattern of movement for both cisco and perch.

Figure 5.

DIEL CHANGES IN ECHOSOUNDING TRACES
SEPT., 1969



The distribution and movements of coho, cisco and perch are summarized schematically in Figs. 6-8.

Food Habits of Coho.

Stomachs of 129 coho were analyzed from 154 coho captured in pelagic gill-nets set for 4-5 hours between 26 May and 18 October, 1969. The coho ranged in total length from 144 mm to 184 mm and averaged 165 mm. The mean body weight of the coho was 32 g. They increased in size from 159 mm in May to 172 mm in September, 1969.

Stomach contents of 61 coho salmon were analyzed from fyke-net catches inshore in 30 April-22 May and 16-17 November, 1969. The length and weight of these coho were similar to those captured in the pelagic region.

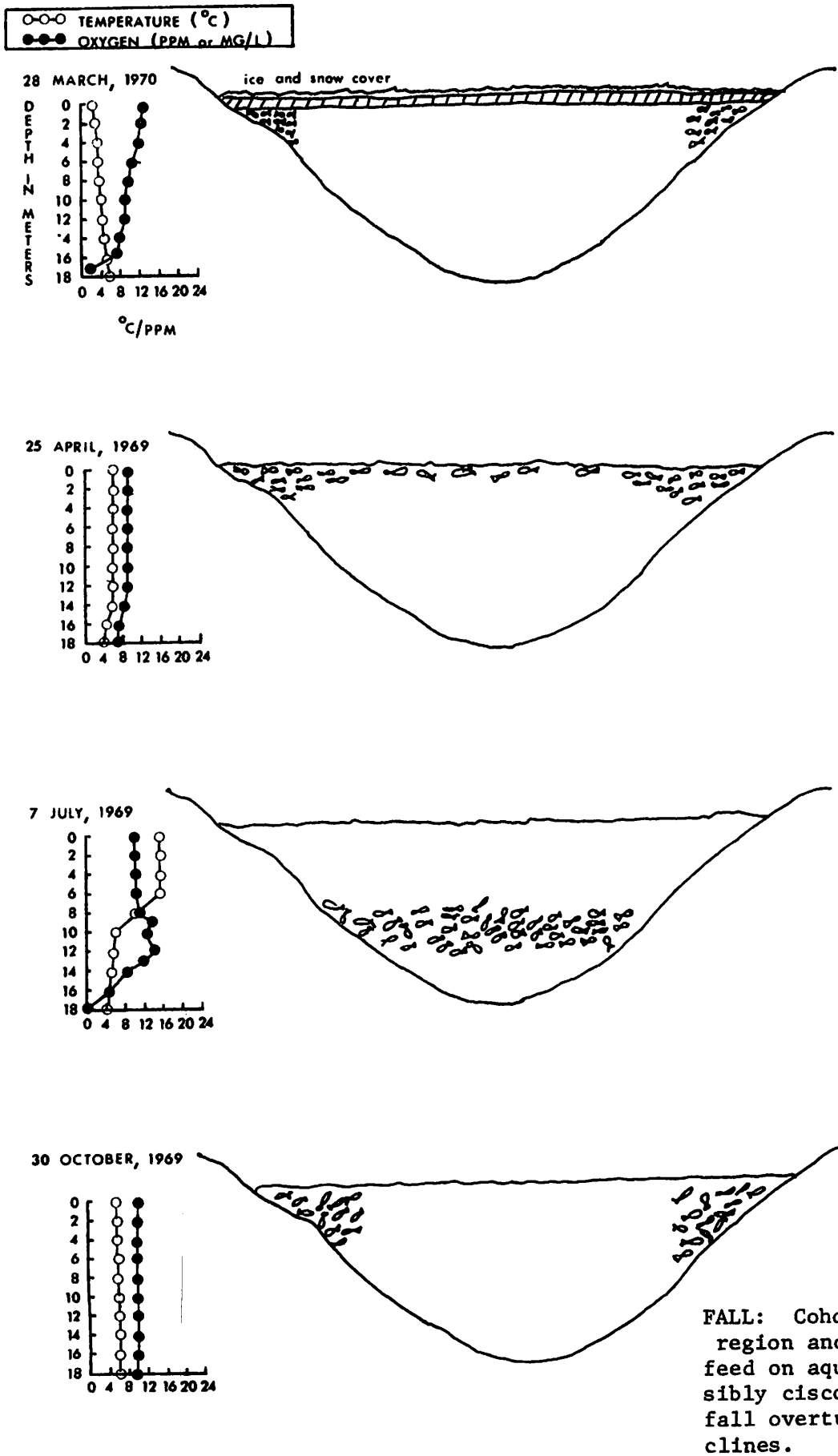
Two (1.6%) of the pelagic samples were empty and the average volume of food in the remaining stomachs (0.3 ml) varied little from May to October, 1969. There was also little difference in the average volume of food eaten at different periods of the day.

The diet of the coho changed significantly as they moved from the epilimnion, which they occupied between late May and early July, to the metalimnion, where they were found between late July and October, 1969. While inshore in spring and in the pelagic region from late May to early July, 1969, 99-100% of the coho ate insects (Table 2). Moreover, insects comprised 99% of the total number of food items and 95% of the total food volume (Table 3). Terrestrial insects accounted for 69% of the number and 59% of the volume of insects eaten at this time.

Present in coho stomachs from the pelagic region were large numbers of adult flies (*Empididae*), ants (*Formicidae*), and beetles (*Pselaphidae, Curculionidae,* and *Carabidae*). This suggests that many of these coho had moved out of the littoral region shortly before being captured.

From late July to October, 1969, insects were still found in 68% of all stomachs with food (Table 2). However, terrestrial insects now comprised only 9% of the total number and 22% of the total volume of all insects in the stomachs. The dominant aquatic insects were late instars and pupae of *Chaoborus punctipennis* (Say) and adult In addition, planktonic crustaceans (chiefly cladocerans) appeared in 58% of the total number of food items (Table 3). Few of the plankton exceeded 1 mm in length and, consequently, contributed to only 13% of the total food volume.

FIGURE 6. SCHEMATIZED VIEW OF THE SEASONAL CHANGES IN HORIZONTAL DISTRIBUTION OF YEARLING COHO SALMON DURING FIRST YEAR OF LAKE RESIDENCE. PALLETTE LAKE, 1969-70



WINTER: Coho inshore, relatively inactive, and feeding little. Lake homoiothermal, and well saturated with oxygen except the bottom in deep water.

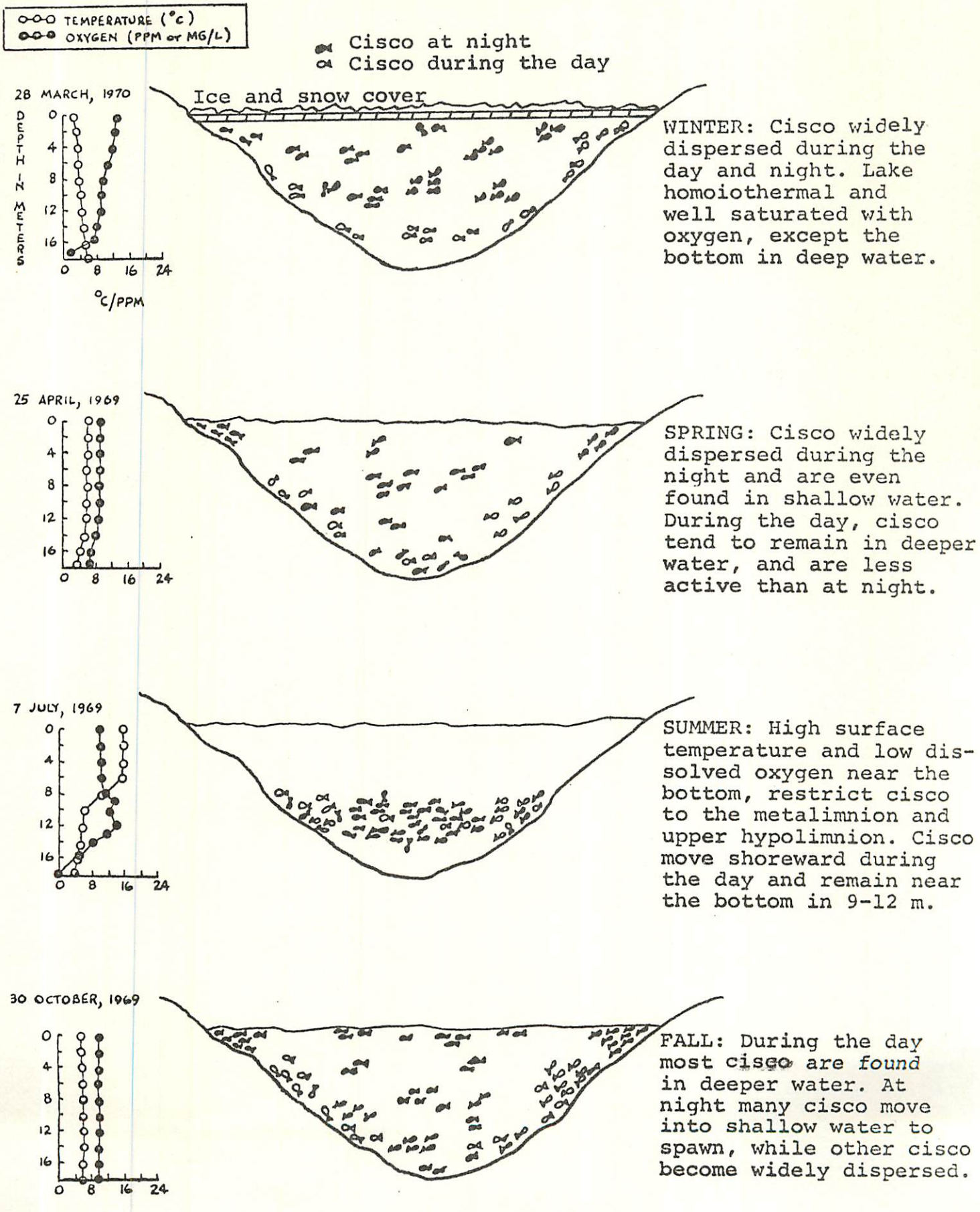
SPRING: Coho moving offshore, but mainly cruising along shore, feeding actively on aquatic insects. Lake during spring overturn.

SUMMER: During early thermal summer stratification coho leave the shore and move into the epilimnion. Later, coho descend into the thermocline. Oxygen depletion prevents their further descent into the hypolimnion, while rising surface temperatures force them into deeper water. Still feed on aquatic insects.

FALL: Coho leave the pelagic region and move onshore to feed on aquatic insects and possibly cisco eggs. Lake during fall overturn. Activity declines.

FIGURE 7. SCHEMATIZED VIEW OF THE SEASONAL AND DAILY CHANGES IN HORIZONTAL AND VERTICAL DISTRIBUTION OF CISCO.

PALLETTE LAKE, 1969-70



WINTER: Cisco widely dispersed during the day and night. Lake homoiothermal and well saturated with oxygen, except the bottom in deep water.

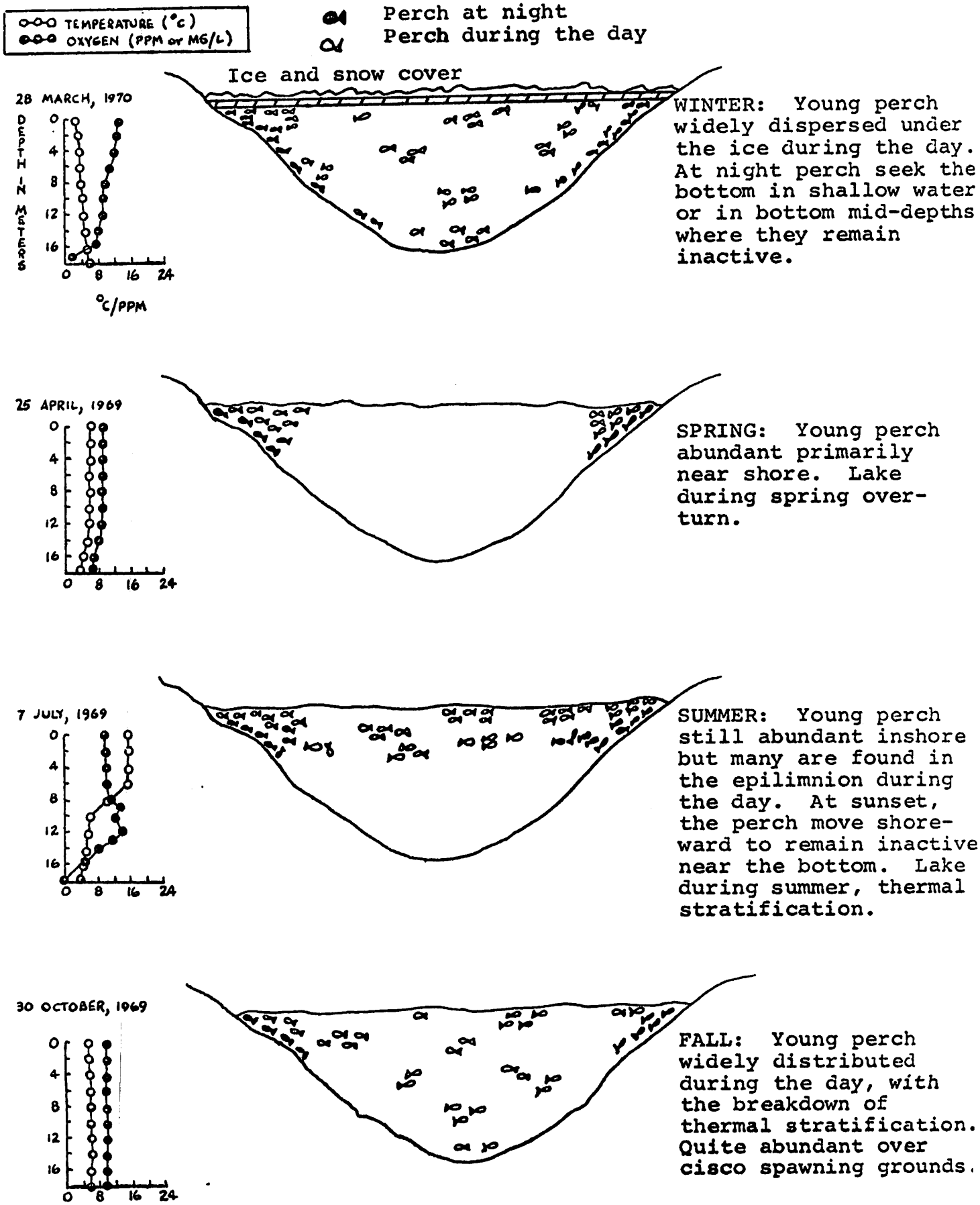
SPRING: Cisco widely dispersed during the night and are even found in shallow water. During the day, cisco tend to remain in deeper water, and are less active than at night.

SUMMER: High surface temperature and low dissolved oxygen near the bottom, restrict cisco to the metalimnion and upper hypolimnion. Cisco move shoreward during the day and remain near the bottom in 9-12 m.

FALL: During the day most cisco are found in deeper water. At night many cisco move into shallow water to spawn, while other cisco become widely dispersed.

FIGURE 8. SCHEMATIZED VIEW OF THE SEASONAL AND DAILY CHANGES IN HORIZONTAL DISTRIBUTION OF YEARLING PERCH.

PALLETTE LAKE, 1969-70



WINTER: Young perch widely dispersed under the ice during the day. At night perch seek the bottom in shallow water or in bottom mid-depths where they remain inactive.

SPRING: Young perch abundant primarily near shore. Lake during spring overturn.

SUMMER: Young perch still abundant inshore but many are found in the epilimnion during the day. At sunset, the perch move shoreward to remain inactive near the bottom. Lake during summer, thermal stratification.

FALL: Young perch widely distributed during the day, with the breakdown of thermal stratification. Quite abundant over cisco spawning grounds.

Surprisingly, no fish were found in coho stomachs in spring and only 2% of the coho ate fish from May to early July. Fish remains increased in importance later in the year. They were found in 22% of the stomachs of coho captured from late July to October and in 19% of fall-captured coho.

In a 7,000 gallon aquarium 52 coho, averaging 152 mm in total length, ate in four weeks about 1,000 bluntnose minnows, brook sticklebacks, common shiners, yellow perch, and white suckers. The fishes ranged from 40 to 80 mm and were eaten primarily during the day, although ample food was available at night.

Table 2. Frequency of occurrence of major food items found in coho salmon stomachs in Pallette Lake, Coho salmon were captured inshore in fyke-nets and in gill-nets in pelagic region. Percentages in parentheses.*

Area	Inshore		Pelagic				Inshore	
Sampling dates	30 Apr-22 May		26 May-12 July		28 July-18 Oct.		16-17 Nov.	
Number of stomachs	33		70		59		28	
Number with food	31		69		58		27	
Food categories:								
Insects	31	(100)	68	(99)	40	(68)	12	(44)
Zooplankton	0	(0)	0	(0)	21	(36)	4	(15)
Arachnida	0	(0)	8	(12)	8	(14)	1	(4)
Fishes	1	(3)	1	(2)	13	(22)	5	(19)
Other	22	(71)	3	(4)	6	(10)	19	(70)

*The table does not include insects and larval acari that were parasites on other insects in the stomachs.

Table 3. Percentage composition of food by number and volume in coho salmon stomachs in Pallette Lake.*

Area	Inshore	Pelagic		Inshore
Sampling dates	30 Apr-22 May	26 May-12 July	28 July-18 Oct.	16-17 Nov.
Number of stomachs	33	70	59	28
Number with food	31	69	58	27
Total food number	77	2,176	3,887	308
Total food volume (ml)	0.5	13.6	13.8	3.2
Percentage by number (volume)				
Insects	97 (99)	99 (95)	39 (80)	16 (35)
Zooplankton	0 (0)	0 (0)	60 (39)	80 (8)
Arachnida	0 (0)	1 (3)	1 (2)	1 (1)
Fishes	0 (0)	1 (2)	1 (4)	1 (55)
Other	3 (1)	1 (1)	1 (1)	3 (1)

*See footnote to Table 2.

Growth of Coho

At the time of stocking, fall-stocked coho averaged 117 mm and spring-stocked coho averaged 140 mm in total length. In April, fall and spring-stocked coho captured in fyke-nets and by electro-fishing averaged 121 mm and 137 mm, respectively (Fig. 2).

Since both groups of coho were from the same hatchery stock, the difference in mean size between fall and spring-stocked coho was due either to greater growth of spring-stocked coho in the hatchery over winter or to selection for larger fish at the time of spring stocking.

There was little difference in mean size of coho captured in fyke-nets and by electro-fishing. The average size of coho at the time of stocking and when taken in April by fyke-netting and electro-fishing was about the same. Hence, fyke-netting and electro-fishing gave relatively unbiased estimates of the mean sizes of the populations.

In October, both groups of coho captured in fyke-nets and by electro-fishing averaged about 175 mm (Fig. 2). Thus, holding coho over winter in the hatchery had little advantage.

The small increase in mean size from 130 mm to 175 mm, between April and October, 1969 was due to (1) actual growth; (2) higher, natural mortality of smaller coho during the year; or, (3) failure of smaller coho to migrate inshore at the time of fall sampling.

Vertical gill-nets were biased in favor of larger coho. The mean size of coho captured in gill-nets (164 mm) changed little from 26 May to 18 October, 1969. Gill-nets were not useful in estimating growth, partly because the mesh size of the nets varied over a small range.

Coho matured little during the year and many coho retained their parr markings. Gonads were also immature. Ovaries averaged 18 mm in length and 0.1 ml in volume, while testes were even smaller. Jacks were not found in the fall.

BACTERIA IN GREAT LAKES FISHES: INTESTINAL DISEASE AND POLLUTION BACTERIA

E. McCoy and W. B. Sarles

In studies with alewives, coho salmon, and other fish, our objectives have been to determine whether exposure to bacterial pollution is detrimental to the fish and whether the fish might function as carriers of bacteria of public health significance or of those potentially pathogenic for fish to otherwise clean waters.

Continuing from a study by T. Frostman, which indicated that coliforms and fecal streptococci were prevalent in the intestinal tracts of alewives spawning in the polluted Sheboygan River, we have investigated the bacterial flora of alewives from several locations in Lake Michigan. Most of these fish were collected during the summer of 1970 by cooperative commercial fishermen, while others were collected by seining along the shore. They were frozen in dry ice until tested, usually within the day.

Samples from various parts of the fish were plated on a number of bacteriological media. Although the characterization of the cultures is not yet complete, some general observations can be discussed. Typically, the floras of the gills, digestive tracts, and slime were quite similar and usually two or three dominant groups of bacteria were present, including a relatively large proportion of yellow and orange pigmented bacteria. Consistent with the fact that these fish were collected from relatively unpolluted water, the numbers of coliforms, fecal streptococci, and pseudomonads were very low. The numbers of bacteria in the guts were definitely correlated with the amount of food present. From a supply of frozen fish from some of the localities sampled during the summer, we are continuing to work on the microflora of alewives throughout the winter.

We have initiated experiments in which fish of several taxonomic and ecological groups are used as experimental animals. Experiments with bullheads, bluegill sunfish, trout, and alewives have been done. In these studies, fish in aquaria are exposed to marker bacteria, such as *Serratia marcescens*, *Escherichia coli* and *Staphylococcus saprophyticus*, and changes in the populations of the bacteria in the fish and in the water are followed by plating on appropriate media. Fish are sacrificed at timed intervals and their intestinal tract contents are examined. Among the variables manipulated are

temperature, and feeding vs. fasting. Growth of bacteria in dead fish and their release to the water will also be observed in similar experiments.

Another aspect of our investigation involves the metabolism by heterotrophic microorganisms of dissolved organic matter in polluted and nonpolluted aquatic environments. The waters of Green Bay were studied first because of the striking pollution gradient between the lower and upper bay. This work on Green Bay is being continued, and is being expanded to include the water of Lake Wingra in Madison, because of ease of access throughout the year and because the two environments are comparable in many respects.

The procedure first incubates water samples in the presence of various amounts of C^{14}-labelled and unlabelled organic compounds at *in situ* temperatures. The uptake in the plankton and the production of CO_2 is measured. By analyzing the results kinetically, the uptake velocity and turnover time attributable to active transport and to diffusion uptake can be obtained. Ideally, bacterial and algal activity can be distinguished in this way. In our present experiments, the turnover of glucose and acetate is being studied; ultimately additional carbon compounds will be investigated.

To evaluate the results, the natural substrate concentration is determined. At present, a kinetic bioassay for glucose, sensitive in the µg/l range is being developed. The uptake and oxidation data are being correlated with bacterial plate counts, chlorophyll measurements, and a variety of hydrographic measurements in conjunction with Dr. Paul Sager and Dr. James Wiersma of the University of Wisconsin-Green Bay. A cooperative study with Dr. Alice Goldsby in which aerobic and anaerobic activity are being compared, is underway.

Initial results on Green Bay indicate that glucose uptake by active transport greatly exceeds diffusion uptake, especially at sampling sites relatively far from the mouth of the Fox River. The natural substrate level decreases much more dramatically than would be expected from dilution of Fox River water alone. There is a nonlinear relationship between plate counts and uptake velocity, indicating that while plate counts may be a good index of numbers of heterotrophic bacteria, they are a poor index of metabolic activity of the bacteria. One of the most striking results was the unusual Michaelis-Menton curve for glucose uptake at the mouth of the Fox River - not predictable on the basis of current theory. Similar curves have been observed by other workers in recently upwelled Pacific Ocean water. Hopefully, studies of pure and mixed culture model systems will clarify such results.

Publication

A manuscript is in preparation covering the intestinal flora of alewives in polluted waters for *Applied Microbiology*. Additional data will be published by the Sea Grant Program Office.

AN INVESTIGATION OF ENVIRONMENTAL AND PHYSIOLOGICAL FACTORS AFFECTING THE MORTALITY OF THE ALEWIFE IN LAKE MICHIGAN

C. R. Norden, E. Warner, and J. G. Stanley

The alewife is the most abundant commercial fish in Lakes Michigan and Huron. They serve as an important forage species for piscivorous fish such as coho salmon and are thus an important resource. The alewife, however, is also a nuisance because of massive die-offs that occur in certain years. Millions of dead fish pollute beaches and water intakes. The studies on the physiology and endocrinology of the alewife will increase our understanding of why this species has been successful in invading the Great Lakes and perhaps why they periodically suffer mass mortalities. Clarification of such physiological aspects of the alewife's life history could aid in more efficient harvesting of the alewife resource and in predicting mortalities, thereby minimizing pollution problems. Several aspects of the biology of the alewife have been studied and some of these investigations are being continued.

Temperature has long been implicated as the primary environmental factor which has triggered the massive mortalities of the alewife in Lake Michigan as well as in other freshwater lakes (Graham, 1956; Brown, 1968). The principal objectives of these various studies has been to investigate the effects of temperature on osmoregulation, endocrine function, oxygen consumption, lactic acid levels and the behavior of the alewife both in nature and in the laboratory. The physiological implication is that temperature may initiate a chain reation which could result in alewife mortality.

One of the factors being investigated is the relationship between muscle lactic acid levels, temperature and season. Large accumulations of lactic acid have resulted in severe disturbances of the acid-base balance in fishes and this impairs the carbon dioxide-oxygen carrying capacity of the blood. Healthy fish were collected from Lake Michigan in April, May, June, July and August of 1970. Other alewives were held in the laboratory in three large,

circular tanks under experimental conditions. These simulated the temperature and photoperiod of Lake Michigan (Tank 1), increasing temperature and photoperiod (Tank 2), and with temperature and photoperiod decreased (Tank 3). Muscle lactic acid levels of the fish from the field collections plotted against water temperature gave a parabolic curve.

The lowest levels of muscle lactate occurred between 14° to 16° C; with either an increase or a decrease in temperature, muscle lactic acid increased. The graph for the fish held in the laboratory showed the same general slope. The lowest level of muscle lactic acid occurred at a water temperature of 15° C. It has been noted that alewife mortalities occur during periods of extreme winter temperatures and in the summer when water temperatures are near the maximum. Two small collections of dying fish, however, showed lactic acid levels slightly lower than the healthy fish.

Temperature is not the only factor contributing to the level of lactic acid in the tissues. Fish in warmer water are more active than those in colder. Laboratory experiments to determine whether the increase of lactic acid is due to temperature or, secondarily, to increased activity are being conducted. In addition, other factors which may affect lactic acid levels in fishes are the state of health, its thermal history, and season. Further research in these variables will be conducted during the spring and summer.

The effects of temperature shock on the oxygen consumption of the alewife in the laboratory is being investigated in order to determine the oxygen requirements of the alewife under various temperature regimes and to determine whether the alewife is capable of adjusting its metabolism to abrupt changes in temperature. Alewives were brought into the laboratory and acclimated at two temperatures, 14° and 22° C. After an acclimation period of at least two weeks, specimens were transferred to respirometer chambers and oxygen recordings were made at four-hour intervals using a YSI self-stirring oxygen probe. After a four-day period, in which an average metabolic rate was determined, the water temperature was abruptly raised to 22° C. or lowered to 14° C. After the initial temperature change, oxygen consumption leveled off at a lower rate in the cold water and at a higher rate in the warmer water. Temperature shock in either direction produced a change in oxygen consumption of approximately 100 to 150 ml/kgm/hr.

Although alewives were able to make some adjustment in oxygen consumption, they were unable to completely compensate for an eight-degree temperature change. A stock of alewives is being maintained at the Shedd Aquarium, Chicago, Illinois at an acclimation temperature of 24° C. Oxygen consumption measurements will be made on these animals during the next three months. During the summer (1971) and next winter, alewives will be acclimated in salt water tanks and the relationship of salinity to temperature shock and oxygen consumption will be investigated.

Experiments have been designed to determine the extreme temperature tolerances of the alewife as well as the temperatures preferred by these fishes under laboratory conditions. Two basic designs were used; (1) acclimated fish were subjected to a gradual increase or decrease in temperature and (2) acclimated fish were transferred into water baths of varying temperatures and thus subjected to temperature shock. In both cases, the results were based on an L-50 among the experimental fish. The results have indicated that an 11° C. increase in temperature over 540 min. (9hr.) time interval resulted in alewife mortality whereas lower lethals were obtained after a decrease of 10° C. over a time interval of 900 min. (15 hrs.). The data thus far collected have shown that the alewife was more tolerant of decreases in temperature than to corresponding increases.

A 90-gallon tank has been constructed with a glass window on one of the sides which is being used for temperature preference determinations. A vertical gradient is set up in the tank in a relatively short time(7 min.) and the range is 11° C. from top to bottom. The gradient is set up by flowing hot water into a large metal coil which spirals down the inside of the tank, heating the water in layers. The tank is marked in 10 equal segments and temperature probes are placed at the mid-point of each segment. These temperature preference experiments are now being conducted but the results are incomplete.

Also studied was the osmoregulation of the alewife held in fresh water and sea water and subjected to temperature stress. Alewives in fresh water maintained internal electrolyte levels identical to alewives held in sea water. We conclude that alewives in the Great Lakes do not experience osmoregulatory difficulties caused solely to living in a dilute environment. Temperature was found to influence salt balance. Cold temperatures caused osmoregulatory failure and shifts of sodium out of the cell into the extra-cellular compartment. Warm temperature exposure does not cause a loss of salts to the environment but does produce a shift

of sodium into the cells during the warmer months. Because warm temperatures do not cause reduced plasma electrolytes in the laboratory we conclude that decreased plasma sodium in Lake Michigan populations must be caused by factors other than temperature.

Other factors have been shown to affect plasma sodium levels. For several weeks after bringing adult alewives into the laboratory they have elevated plasma sodium levels. Fish held at 8°C for several weeks have high plasma sodium. Fish as they first migrate into shallow water in spring have increased pituitary-adrenal activity and elevated plasma sodium. We conclude that mild stresses activate the pituitary-adrenal axis (see below) and this results in an elevated plasma sodium.

Fish that are sick or roughly handled have reduced plasma sodium. Although further investigation is needed, it appears that shock or severe stress causes massive loss of sodium from the animal.

Dying fish have low plasma sodium levels. It is difficult to decide, however, whether the reduced plasma sodium caused morbidity or is caused by it. Lowered plasma sodium in apparently healthy fish captured at the same time as dying fish suggests a severe environmental stress which decreases plasma sodium in all fish, but to a greater degree in some than others.

The pituitary gland of the alewife resembles that of its close relative, the Atlantic herring. A hypophysial duct and a follicular type rostral pars distalis are present. The adenohypophysial cell types have been identified by selective staining techniques in light microscopy and also by electron microscopy. Detailed studies of gonadotrophs, thyrotrophs and corticotrophs reveal maximal secretory activity of these cells in early spring just prior to the spawning migration. Minimal activity occurs during late fall and early winter. The spring maxima in thyrotroph and corticotroph activity may be related to stresses encountered by the alewife during its shoreward movement.

Impairment of osmoregulation may be a factor in the

mortality of alewives in the Great Lakes. A prolactin-like pituitary hormone associated with a specific type of rostral pars distalis cell promotes sodium retention in several teleost species. Prolactin cells of alewives from Lake Michigan are being studied on a seasonal basis and compared with prolactin cells from Atlantic coast and Cayuga Lake specimens where drastic mortalities usually do not occur. Prolactin cells of Lake Michigan alewives maintained in fresh water in the Shedd Aquarium for 6 months show much greater secretory activity than prolactin cells from Shedd Aquarium specimens maintained in sea water over the same period.

Pituitary glands were collected from spawning Lake Michigan and Atlantic coast alewives for a comparative prolactin assay. Alterations in plasma sodium levels in hypophysectomized *Poecilia latipinna* will form the basis for the assays (Ensor and Ball, Gen. and Comp. Endocrinology 11: 104, 1968). Glands from prespawning and post-spawning fresh water and marine fish are being collected.

Several papers have been published, submitted for publication, or presented at conferences during the year. (See abstracts)

INVESTIGATIONS ON THE MIGRATION AND ORIENTATION OF FRESHWATER AND MARINE FISHES

A. D. Hasler and R. M. Horrall

Major disruptions of fish communities in the Great Lakes have occurred as a result of such factors as invasions of exotic species such as the lamprey and alewife, overfishing and deterioration of the water quality. Man's introduction of exotic species such as salmon to attempt to restore the present species imbalance and provide sports fishing has met with some success. Although efforts are being made to restock the lakes with native species such as the lake trout, it appears likely that continued stocking of exotic species such as salmon and non-native trout will be demanded by the public on the basis of immediate recreational or economic benefits.

The ultimate success or failure of these management practices may take years to determine. However, information is needed now on which to base policy decisions regarding species to be introduced, stocking site locations, and harvesting regulations. Information is also needed to

evaluate the different introductions with regard to their biological impact on the community and the assessment of the harvest benefits. For example, although the coho salmon in Lake Michigan now grow phenomenally and return to their stocking sites in surprisingly large numbers, little is known of their distribution and movements in the lake or the characteristics of their homing migrations. Such information is needed before a complete evaluation of this species can be made, and in addition provides information which can lead to maximizing the sports harvest.

This project started work on the coho salmon in Lake Michigan in the fall of 1969. The work was centered on the coho stocking site at Algoma, Wisconsin. The research although aimed at understanding several phases of the life history of the coho salmon in Lake Michigan, has perfected techniques and experimental procedures which could be usefully employed in many other Great Lakes fishery problems. The methods for tracking fish, for example with ultrasonic telemetry, can be used for investigating fish behavior in polluted regions and in regions of thermal discharges (see below). The techniques used in the olfaction studies provide a means to study homing behavior and reactions of fish to pollutants, and to characterize odors which may be indicators of changing water quality.

In view of the large number of fossil fuel and nuclear power plants being built or proposed for the Great Lakes, it becomes especially important to initiate studies to investigate the biological consequences to organisms exposed to the thermal discharges from these plants. Since fish are known to be strongly influenced by temperature changes, a study, started in 1969, attempted to determine the movement pathways of coho salmon past the sites of two nuclear power plants under construction on Lake Michigan (Point Beach and Kewaunee). These tracking experiments were continued in 1970 and a baseline of characteristic movements of the coho is now established. These are to be compared with the movements obtained now that one of the plants has become operational and is discharging hot cooling water into Lake Michigan.

In 1969 four coho salmon were captured at Algoma and displaced 58 km to the south. The fish received ultrasonic transmitters and were then tracked with directional hydrophones and ultrasonic receiving gear mounted on the research vessel. The tracks showed rapid northward movements past the nuclear power plants. All four salmon had returned to the Algoma site within 52 hours. In 1970 six coho were displaced 48 km southward from Algoma and tracked ultrasonically. Five

pulsed 70 kHz transmitters and one pulsed 50 kHz transmitter were used in the tracking experiments.

The R/V AQUARIUS was used to transport and track the fish. Three were tracked past both the Point Beach and Kewaunee plants and one fish past only the Point Beach plant. The remaining two fish were tracked for shorter distances. The tracks showed initial westerly movements toward the shoreline. This moved northward taking the fish past the power plants. The swimming speeds of the fish ranged from to 27 to 98 cm/sec. (1/2 to 2 knots).

These tracks represent more consistent movements than we have encountered in any of our Pacific Ocean work. This consistency is important to the investigation of the cues used by fish for open-water orientation and for meaningful comparisons with the tracks we plan to obtain in the summer and fall of 1971 when at least one and possibly two reactors will be operational at the Point Beach plant. At this time it should be possible to determine any changes in movements and/or behavior of fish that might occur in the region of the thermal plume.

In addition to the long displacement experiments described above, open-water tracking experiments were conducted from release stations 1 km and 6 km from the mouth of the Ahnapee River to 1) compare the movement pathways with fish released and tracked below the power plants, 2) obtain information on open-water orientation under different environmental and experimental conditions, and 3) increase our information on salmon movements in an area where sports fishing is concentrated.

At the 6 km release station the fish were tracked by following the movements of surface float boats attached to the fish by a 20 m length of fishing line. In experiments designed to disrupt the possible use of the earth's magnetic force field as a directional cue, half of the fish had bar magnets inserted into the stomach and the other half had brass metal segments which served as controls. Of the 25 fish tracked, thirteen were continuously tracked for more than 2 km from the release point, and 9, for more than 4 km. Six fish were followed on sustained tracks. All of these reached the shore area (4 north and 2 south of Algoma) in an average of 7 hours (5 to 11 hr), and 5 of the 6 changed their orientation to a northward course along shore after swimming into a depth between 17 and 22 m. Eighteen of the float boats were subsequently recovered, 14 from the mouth of the Ahnapee River. The results from the tracking experiments indicate that coho salmon have a good homing ability under these experimental conditions, and that orientation

toward home is manifest without necessity of familiar topographical cues or the earth's magnetic field. The study also indicates that the transport of magnet and brass segments in the stomach has little effect on homing orientation, a fact of importance since ultrasonic transmitters are also carried in the stomach and often have magnetic devices for turning them on and off.

Eleven coho captured in the homestream were displaced to a release site in open water 1 km from the mouth of the Ahnapee River. Ten fish were tracked using float boats and one fish was tracked ultrasonically. The results indicated a well-directed orientation toward the river mouth. The fish moved into the river only when the currents were moving out (ebb seiche currents); when the currents were reversed (flood seiche currents) the fish moved back out into the lake. The swimming depth of the fish tracked with the transmitter was monitored by a special hydrophone, approximately 1 m long. This consists of a linear array of ceramic transducers. The hydrophone is lowered until a maximum signal is received from the transmitter in the fish--the depth is then read on the calibrated line on the hydrophone. During the 4 1/2 hour tracking experiment the fish moved from a water depth of 30 m into waters of 3 m depth by swimming continuously along the bottom.

The tracking experiments in the Ahnapee River started in 1969 demonstrated several interesting characteristics of the migratory behavior of coho salmon in the home river and home stream. These experiments, continued in 1970, allow examination of problems of homing behavior and "home" site recognition, reactions to water currents, and blockage of movements due to temperature or pollution conditions.

During the 1970 coho run, ultrasonic tracking and float tracking methods were used to follow the movement pathways of 25 coho salmon in the Ahnapee River. During the tracks environmental variables such as sun and cloud conditions, water temperature, conductivity of the water and water currents were monitored. The following results were obtained.

(1) The behavior of fish tracked with floats (21 tracks) and fish tracked with ultrasonic transmitters (4 tracks) was similar. Floats were used in an attempt to obtain a very detailed picture of fish movements in the river.

(2) The tracks made during 1970 closely resembled the 16 ultrasonic tracks made during the 1969 season. Movements during both years were typically along the north shore of the

river until the home stream was reached. No clear association with either shore was found in movements above the homestream. The tendency to move along a particular shore may be associated with the difference in water chemistry (as measured by conductivity) observed on opposite sides of the river. Factors such as the influence of the home-stream water along the north shore or depth preferences may also be involved.

(3) The Ahnapee River is affected by the Lake Michigan seiche so that sometimes the current is reversed and flows upstream in the river. It was found that the fish moved upstream only when the currents moved downstream. When the current was reversed the fish milled around. Since fish did not actively move downstream against an upstream current, it may be assumed that the fish are responding rheotactically only to downstream water currents. This behavior also suggests the possibility of chemotactic responses to home-stream odors which would be "stronger" during the downstream phase of the flow.

(4) Two blind fish behaved in the same matter as two "normal" fish released at the same time. This suggests that vision may not be important in river migrations of salmon. This is in sharp contrast to experiments conducted in 1969 when it was found that anosmic fish behaved very differently from "normal" fish suggesting the importance of olfaction in the river phase of homing migrations.

(5) When water was released at an upstream dam on the Ahnapee River insuring a strong downstream current, but held back in the home stream by daming the flow out of the smolting pond creating strong downstream currents in the home stream and a large discharge of home-stream water into the main channel, fish moved into the home stream. This may explain why fewer fish enter the home stream during periods of low flow, whereas more and move into it during periods of rain and associated higher flows.

(6) Fish tracked on rainy, totally overcast days exhibited similar behavior to those tracked on bright, sunny days.

Experiments designed to investigate the role and importance of olfaction in the final stages of homing migrations of fish were started in 1969 and continued in 1970. Sexually mature coho salmon were examined electroencephalographically (EEG) to test their olfactory responses to various natural waters collected both on and off their migratory pathway. The electroencephalographic technique consists of measuring

the changes of electrical activity at the surface of the olfactory bulb evoked by the various natural waters perfused into the external nares. It is thought that any olfactory memory of the odors associated with the home-stream phase of the juvenile fish should result in a characteristic high intensity response to these same odors when measured on returning sexually mature fish.

The majority of the 60 fish tested in 1970 had homed either to the home stream at Algoma or to the Kewaunee home stream 16 km south of Algoma. Four different groups of experiments were performed.

(1) One group of Algoma fish was tested with waters collected along the migration route. These fish consistently "ranked" home-stream water higher than other waters tested. That is, home-stream water evoked the strongest responses. These results were comparable to those obtained in 1969 when 23 fish were tested with waters collected at similar locations.

(2) Fish collected from Algoma and Kewaunee ranked their own home-stream water highest although both groups responded most strongly to Algoma water. This can probably be attributed to a change in the source of the water supplying the smolting pond between the time of imprinting of the fry and the return of the adults to the Kewaunee site.

(3) Fish collected by gill net off the mouth of the Ahnapee River (Algoma) were tested to determine their responses to Algoma home-stream water before actually arriving there. Preliminary examination of the data shows no discernible differences between these fish and fish captured in the home stream.

(4) Six fish were tested with home-stream waters chemically manipulated to bracket the active fraction. Although the results for many of the analyses were inconclusive because of the small sample size, several suggestive results were found concerning response to pH, the size of active molecules, and the effect of the concentration method.

It is known that coho salmon fry taken from a hatchery and stocked into a smolting pond tributary to Lake Michigan become effectively imprinted to this new environment in a short period of time--usually a month or less. The success of the returning runs of adults has indicated the effectiveness of the imprinting process although some straying does occur.

The working hypothesis is that the fish become imprinted to specific odors or odor combinations in the waters they reside in before and during smolting. The returning adults, through olfactory memory of the imprinted odors, recognize and select the same waters, then used for spawning. Experiments designed to test this hypothesis used synthetic odors introduced into water containing coho fry. Success of the synthetic odors as effective imprinting agents will be determined by homing success to the "decoy" area and/or EEG responses. These experiments are made possible because the stocking and recapture practices in Lake Michigan allow almost virtual control over all phases of the coho life cycle except for the open-lake phase.

Three sets of experiments were started in the spring of 1970 in cooperation with the Wisconsin Department of Natural Resources. The first experiment was designed to test the feasibility of imprinting salmon fry to synthetic odors. Five cement tanks in a pumping station were used to hold the fry and the synthetic odors were added to the Lake Michigan water which supplied the tanks. Twenty-thousand fry were "imprinted" with morpholine and 20,000 with rose oil. Ten-thousand fry acted as controls and were not exposed to any synthetic odor. The fish were exposed for 30 days until smoltification was well along and then trucked to Lake Michigan and released.

In the fall of 1970 the synthetic "imprinting" odors were dripped into a small creek with a wier to attempt to decoy the artificially imprinted fish to this area. The results to date are inconclusive due to the small jack run; final results will be obtained in the fall of 1971 when the adults will be returning. The second experiment was designed to develop a new "run" at Algoma in a tributary of the Ahnapee River using caged fish rather than expensive excavated ponds. Twenty-five hundred cold-branded coho fry were held in hardware cloth cages and were released when they showed signs of smolting (after 18 days). The tributary will be monitored in the fall of 1971 when the adults are due to return.

The third experiment designed specifically to use the EEG technique, sought whether we could demonstrate an olfactory memory extending from the period of smolting, analogous to the natural situation. Twenty-five hundred fry were allowed to smolt in a hatchery raceway into which morpholine was added. Twenty-five hundred fry, not exposed to morpholine, were used as controls. After smoltification was well underway, the fish were trucked to the Algoma smolting pond and released. Results will be available when the adults return in the fall of 1971.

Work to improve ultrasonic transmitters, receivers and hydrophones used in fish tracking continues with special emphasis placed on developing methods for telemetering information on water temperature and swimming depth of fish. The special depth hydrophone constructed at our laboratory was described earlier in this report.

A paper by Andrew Dizon and Ross Horrall, "The Homing Salmon and EEG Responses to Homestream Water" was presented at The New York Academy of Sciences Conference on Orientation: Sensory Basis (8-10 February, 1971) in New York City.

FERMENTATION OF FISH (UTILIZATION OF TRASH FISH)

T. Richardson, D. A. Stuiber, C. H. Amundson

In the utilization of fatty fish, a great deal of attention is paid to the protein component; however, to economically produce the protein we must find ways to utilize the entire fish. Currently, fatty trash fish, such as the alewife and menhaden, are processed to yield fish meal, fish oil and stick-water, water which remains after the fish are processed, is often a pollutant. Recently a process was developed to prepare a high grade fish protein concentrate by solvent extraction of fatty trash fish. The purpose of this project is to find means to upgrade fish oil and stick-water to yield useful products to modify fish protein concentrate so that it is more functional in foods and to attempt to remove mercury from contaminated fish protein concentrate.

Essentially, we have been fermenting fish lipids and stick-water with various strains of *Candida lipolytica* and *Geotrichum candidum* to determine the extent to which useful products might be derived. Products from these fermentations might include yeast protein, nucleic acids, amino acids, organic acids and enzymes. Also, we are initiating studies on modification of fish protein concentrate and on removal of mercury from fish protein concentrate.

FERMENTATION OF FISH OIL

Utilization of glycerol by C. Lipolytica and G. candidum

Media containing 2 or 4% glycerol, ammonium sulfate and salts were inoculated with *Candida lipolytica* strains Y-1094 or Y-1095, or *Geotrichum candidum*. Growth was followed by

measuring the turbidity at 600 nm and by following utilization of the ammonium sulfate.

Turbidity values and nitrogen data indicated that both *C. lipolytica* Y-1094 and Y-1095 grew poorly in the 2 and 4% glycerol media. This might mean that in the fermenation of fish oil by *C. lipolytica,* glycerol might be obtained as a byproduct.

On the other hand, *Geotrichum candidum* showed rapid growth in the above media and excellent utilization of nitrogen. This microorganism is capable of utilizing glycerol as a carbon source.

To further clarify the nutrient requirements of the above microorganisms, particularly *Candida lipolytica,* we subsequently added yeast extract or cornsteep liquor to the medium containing 4% glycerol as the carbon source. The cultures were grown at 30° in shake flasks; samples of the fermentations were taken periodically and examined for:

1. Optical Density
2. Nonprotein Nitrogen in the Supernatant
3. pH
4. Morphology as observed microscopically

With the addition of 0.2% yeast extract, the *Candida lipolytica* reached a growth optical density of 2.0 within 40 hours whereas *Geotrichum candidum* reached this growth density on *supplement free* media containing glycerol within 30 hours. The addition of only 0.02% yeast extract to *Candida lipolytica* cultures resulted in decreased growth compared to the 0.2% level and the growth optical density was reached after about 55 hours.

In the above experiments the nitrogen source was used to about 30% as compared to about 75% by *Geotrichum candidum* on the basic glycerol medium.

The addition of 0.2% cornsteep liquor to cultures of *Candida lipolytica* in a 4% glycerol medium resulted in a growth optical density of 2.0 in 60 hours. The growth of *Candida* was markedly poorer compared to that where yeast extract was added. On the other hand more nitrogen was consumed and the available nitrogen level was reduced by about 50%. The addition of only 0.2% cornsteep liquor to the medium resulted in a marked reduction of growth compared to 0.2% cornsteep liquor. After 30 hours of fermentation of growth optical density of only 0.8 and after 60 hours only 1.2 was recorded.

In summary, the addition of cornsteep liquor and especially yeast extract make it possible for *Candida lipolytica* to use glycerol as the sole carbon source. This growth, however, is not as good as the growth shown by *Geotrichum candidum* on basic glycerol media.

Further research will be directed toward maximizing the growth of the microorganisms and to use fish stick water as a nitrogen source in the fermentation of fish oil thus allowing the combined fermentation of fish oil and stick water.

Lipase Production by C. lipolytica

Lipase enzymes are commonly used in the food and dairy industries to produce flavors and aromas. During the fermentation of fish oil by *C. lipolytica*, lipase enzymes must be produced by the organism to break down the oil so that it can be utilized. Consequently, we have been studying lipase production by *C. lipolytica* grown on fish oil with a view toward purifying the enzyme.

It was anticipated that lipase production should be stimulated if *Candida* were forced to grow in a medium containing triglycerides (fish oil) as the sole carbon source.

In the preliminary experiments, *Candida* was grown at 25.C with rapid aeration in a phosphate buffered medium (pH 6.0) containing 1% fish oil, $(NH_4)_2SO_4$, trace elements and a small amount of vitamin supplement. Lipase activity in cultures or growth liquor was monitored (1) fluorimetrically using the fluorescin dibutyrate assay of Guilbault and Kramer (1964), (2) by the pH stat method using a polyvinyl alcohol-olive oil emulsion containing NaCl and $CaCl_2$ and employing a Radiometer pH stat or (3) by titrating after 2 hr incubation using the unemulsified system of Tomizuka et al. (1966). Rapid estimation of cellular growth was complicated by the association of the yeast with the lipid phase of the medium. A method was devised which is based on splitting the cell-oil interaction with the neutral detergent Triton X100 so that routine turbidometric measurements could be utilized. This procedure is rapid, quantitative and generated reproducible growth curves.

After a single subculture under the conditions provided (15 hr), *Candida* grows rapidly (approximately 1.5 hr per doubling), causing considerable emulsification of the oil but no detectable alteration in the pH of the medium. Cells become buoyant and float. Lipase activity is detectable in the culture, but accurate quantification is impaired by the distribution of the activity between (1) the emulsified oil, (2) the oil layer and (3) the buoyant lipid coated cells.

Cell free, lipase enriched preparations are not easily obtainable (to date) since (1) cells are too buoyant to be sedimented by centrifugation, (2) skimming of the cells after centrifugation reduces lipase content of the medium, (3) filtration removes lipase associated with micelles as well as cells and (4) mild treatments of the total culture with solvents, detergents, emulsifying agents or salts appear to significantly decrease lipase activity or are insufficient to separate the cells. Reducing the oil content to as low as 0.25% did not improve the cultural characteristics significantly.

Fermentation of Stick-Water by Candida lipolytica 1094

The growth of *Candida* on several defined media with complex additives such as peptone, nutrient broth, whey, etc., suggested that this organism would grow very well on a proteinaceous medium. Lipase production by *Candida* was tested using fish stick-water as the medium.

Further experiments indicated that when the growth rate was reduced by minimally aerating the cultures, higher yields of lipase were obtained. With certain media, static growth conditions were preferable. Cultures grown in stick-water medium (pH 6) at 70 rpm on a reciprocating shaker (25C) produced optimum lipase yields in 3 to 4 days. Proteolysis occurred causing solubilization of the solids and an elevation of the pH. Cells and any remaining debris were easily removed by centrifugation. Attempts to stimulate additional lipase production by the inclusion of 0.1 to 0.5% fish or olive oil were frustrated since the oil removes the lipase from solution in the form of micelles and accurate quantitation becomes difficult.

The growth of *Candida lipolytica* on stick-water appears to have potential for production of lipase. First, a cell-free preparation enriched in lipase is technically easy to obtain. A minor purification or clarification process may be required to produce an edible product. Second, extracellular proteinases appear to be produced during growth. These may have some commercial value either in conjunction with or separated from the lipase. Third, growth of *Candida* causes clarification of stick-water. This might be useful in decreasing the pollution potential for stick-water.

Original attempts to ferment alewife stick-water were designed to optimize lipase production by the organism. Although lipase production was significant, considerable proteolysis of the growth liquor was also apparent. There

was, for example, dramatic reduction in cold TCA precipitable material concomitant with an elevation in pH of the stick-water. Assays for proteinase activity suggested that *C. lipolytica* was excreting from 10 to 40 times more proteinase than some bacterial strains used for commercial enzyme production. Subsequent experiments have been concerned with obtaining and characterizing the yeast proteinase.

Characteristics of Growth and Proteinase Production

Alewife stick-water is not available from Wisconsin fisheries during the winter months. Consequently, 5 to 10 gallon batches of stick-water were prepared in a pilot plant from frozen alewife. This material was either sterilized immediately or lyophilized and reconstituted (based on the dry weight content of the original) when required.

Growth on laboratory prepared stick-water was characterized by 1 of 3 pH and proteinase production profiles depending on the oil content of the medium. First, when relatively large quantities of oil were present, e.g. 1%, the pH dropped from an ititial 6.8 to 6.1-6.2 within 24 hours with no subsequent change in up to 144 hours. Little proteolytic activity was detectable. It was not possible to induce proteinase activity by initially subculturing the organism in a medium such as Difco peptone. Second, if less than 0.25% oil was present, the pH declined as in (1) but elevated to approximately 8.8 within 48 hours. Proteinase levels were high at 48 hours. Cell yeilds were significantly better in these cultures. Third, when care was taken to further reduce the oil content of the stick-water, there was no initial decline in pH and large quantities of protease were detectable after 15 hr with maximum production by 40 hr. Stick-water prepared from herring yielded similar results.

Type (3) alewife stick-water is presently being used to obtain *C. lipolytica* proteinase(s) for characterization. Cells are grown in 500 ml/2 l flask batches with moderate aeration for 48 hr. When the medium reaches pH 8.0 or higher, the yeast is removed and the growth liquor stored at 5 C. Proteinase activity is stable in these crude preparations for at least 2 weeks.

C. lipolytica Proteinase: Preliminary Characterization

Proteinase activity is currently being measured by a modification of the assay of Charney and Tomarelli (1948) which estimates the hydrolysis of azocasein.

Crude preparations of proteinase are very stable at room temperature (24 hr; 25-27 C) in a pH range from 4.5 to

9.5. All activity is eliminated by a 20 min. incubation at pH 10.1 The pH versus activity profile of the enzyme in crude material is complex and vaguely suggests that 2 proteolytic enzymes are present, one with an activity optimum at pH 8 and another with an optimum at pH 9.8. The metal chelators orthophenanthroline and nitrilotriacetic acid at 1mM do not affect the total activity of the preparation although 10^{-4} M EDTA totally eliminates it.

Further and more accurate characterization of the enzymatic properties must await at least partial purification of the enzyme(s).

C. lipolytica Proteinase: Preliminary Purification

An initial step in purification must be the concentration of the enzyme(s) from large volumes of growth liquor. Attempts to trap the enzyme activity by passage through either CM cellulose (pH 5.0) or DEAE cellulose (pH 7.5 or 9.5) were unsuccessful. Salting out with $(NH_4)_2SO_4$ was similarly ineffective. The enzyme activity can, however, be precipitated at pH 8.0 by the addition of between 1 and 3 volumes of either cold (0-5C) acetone or ethanol. The characteristics of the precipitate obtained depend on the solvent used. With acetone, 95% of the activity is collected in the form of a brown gum. Ethanol yields approximately 80% of the activity in a cream colored particulate form. Purification resulting from this concentration step is 3 fold for acetone and 17 fold for ethanol fractionation. Pigment remaining in the resuspended acetone gum can be removed by passage through DEAE cellulose (pH 6.4) in 0.1% calcium acetate. Ethanol precipitated material does not require further clarification. $MnCl_2$ (1M) at 6.7 ml/100 ml of enzyme solution has been useful in precipitating inert material from the partially purified preparations. Further purification and characterization are in progress.

References

1. Tomizuka, N.,O. Yasuhide and K. Yamada. 1966. Agr. Biol. Chem. 30:576-584.

2. Guilbault, G., and D. N. Kramer. 1964. Anal. Chem. 36:409-412.

Modifying the Functionality of Fish Protein Concentrate

A major drawback to the use of fish protein concentrate in food systems is its lack of functionality. By functionality, it is meant the ability of FPC to: form stable colloidal dispersion, bind water, bind fat, be heat coagulable, be acid coagulable, be an effective emulsifying agent, gel under appropriate conditions, etc. These are just a few of the properties that make a protein valuable in food systems. We are currently working on ways to introduce functionality into FPC. This might be accomplished by enzymatic modification of FPC, by chemical attachment of appropriate functional groups to the protein, by physical adsorption of appropriate reagents. Furthermore, convenient solubilization of FPC might allow us to reduce the fluoride content of FPC which is currently a stumbling block to its greater utilization.

Removal of Mercury from Fish Protein Concentrate

Presumably most of the mercury, probably as methyl mercury, is bound to the fish protein. Reduction of the fish protein to fish protein concentrate might allow us at least the opportunity to try and remove the mercury. *Assuming* we can get the protein concentrate into suitable solution, we may be able to selectively remove the mercury by passing the solution through a resin bed affixed with sulfhydryl and other groups which bind mercury. We are in the process of synthesizing the necessary resins and, hopefully, will be in a position to try this concept in the near future.

PERSONNEL-FISH

Wm. E. Ribelin, principal investigator (pesticides in fish)
Robert S. Ellarson, principal investigator (pesticides in birds)
Steven R. Peterson, grad assistant (pesticides in birds)
John J. Magnuson, program coordinator (coho salmon)
Sanford Engel, grad assistant (coho salmon)
E. McCoy, principal investigator (bacteria in fish)
W. B. Sarles, principal investigator (bacteria in fish)
Linda Vogen, research assistant (bacteria in fish)
Frank Barvenik, post-doctorate (bacteria in fish)
C. R. Norden, principal investigator (alewives)
E. D. Warner, principal investigator (alewives)
J. G. Stanley, principal investigator (alewives)
T. Richardson, principal investigator (fermentation of fish)
D. A. Stuiber, principal investigator (fermentation of fish)
C. H. Amundson, principal investigator (fermentation of fish)
A. M. Hasler, principal investigator (migration and orientation)
R. M. Horrall, program coordinator (migration and orientation)
A. Dizon, grad assistant (migration and orientation)
A. H. Walsh, assoc. investigator (pesticides in fish)

ELECTROLYTE METABOLISM OF MORIBUND ALEWIVES FROM LAKE MICHIGAN.
Jon G. Stanley and James A. Holzer, University of Wisconsin-Milwaukee. Paper to be presented at the 14th Conference of the International Association for Great Lakes Research. Toronto, Canada, April, 19-21, 1971.

Abstract

Alosa pseudoharengus, an anadromous species native to the Atlantic Ocean, has immigrated into the Great Lakes. When alewives became abundant in this freshwater environment they frequently experienced massive die-offs. The causes of these mortalities are as yet unclear. Some investigators have suggested that massive mortalities are caused by failure to maintain internal salt concentrations. We present data here showing that low salt concentrations in body fluids are associated with the moribund state.

Adult alewives were captured by lift net from Lake Michigan at Milwaukee, Wisconsin during 1970. Blood and muscle samples were taken from healthy and dying alewives immediately following capture. Other alewives were kept alive and held in 1730 liter circular tanks containing fresh water. Induction of mortality was attempted using temperature shocks by heating or cooling the water at rates of approximately 2.5°C per hour. A temperature change from 16°C to 6°C or from 16°C to 26°C did not cause death. However, cold exposure increased susceptibility to fungal infections, which caused mortality. A small number of control fish were similarly affected. Diseased fish were killed for samples of blood and muscle. Further experiments revealed that alewives can withstand temperatures of about 30°C. Fish acclimated to 16.9°C had an average acute upper lethal of 29.8°C. Those acclimated to 24.5°C had an average upper lethal of 32.8°C. The alewife appears to tolerate temperatures well above those normally encountered in the Great Lakes.

Sodium and potassium concentrations were determined by flame photometry and are reported in Table 1 and Fig. 1. Dying fish in Lake Michigan had low sodium in plasma and muscle. Fish infected with fungus in the laboratory also had low sodium. We conclude that dying or sick fish characteristically lose sodium, although it is not clear whether sodium loss causes death or is a consequence of it. Morbidity resulting from high temperature exposure is associated with somewhat lowered plasma sodium and elevated plasma potassium. We believe high temperature produces a loss of potassium from cells and that the resulting high plasma potassium may be primarily responsible for heat death.

Adult alewives held in the laboratory developed high plasma sodium levels (Fig. 1). Although the cause of this hypernatremia is not known, it is possible that these fish were under stress. High plasma sodium had previously been reported for alewives during their spring migration into shallow water.

The causes of mass mortality in the alewife inhabiting fresh water remains unknown. The data reported here suggest that temperature alone is probably not a significant factor. The possibility of osmoregulatory failure due to a loss of sodium cannot be excluded as a cause of mass mortality in this species.

ELECTROLYTE METABOLISM IN THE ALEWIFE IN LAKE MICHIGAN.
Jon G. Stanley, University of Wisconsin-Milwaukee. Paper presented at the American Association for the Advancement of Science. Chicago, Illinois, December, 1970. Published in the American Zoologist, 10:520.

Abstract

The alewife (*Alosa pseudoharengus*), an anadromous species native to the Atlantic Ocean, has recently become established in the Great Lakes. These populations, in fresh water, experience seasonal die-offs which are of economic, recreational and public health concern. Such mortalities may be caused by thermal conditions in the Great Lakes, unstable compared to those in the Atlantic Ocean. Laboratory data suggest that temperature of alewives collected from Lake Michigan revealed little correlation between environmental temperature and body fluid composition. Relatively constant concentrations of potassium in plasma were observed over a temperature range of 3° to 24°C. Plasma sodium concentrations appeared to be elevated by prolonged exposure to cold, and reduced, during mid-summer, by factors other than temperature. Dying fish are characterized by low sodium and potassium in plasma. While muscle sodium remained constant, muscle potassium showed significant fluctuations in early spring, as fish migrate, from water with a temperature of 3°C, to water of 10° to 14°C. In July and August, muscle sodium increased and muscle potassium remained relatively unchanged. These alterations in plasma and muscle ions in Lake Michigan alewives do not follow patterns established for laboratory populations subjected to thermal stress, suggesting that factors other than temperature cause these changes. Although the cause of mass mortality in this species remains unknown, one possibility is that death results when thermal stress is experienced simultaneously with the action of some unknown factor.

THE HOMING SALMON AND EEG RESPONSES TO HOMESTREAM WATER.
A. E. Dizon, R. M. Horrall and A. D. Hasler, University of Wisconsin, Madison. Paper presented at the New York Academy of Sciences Conference on Orientation: Sensory Basis. New York City, February 8-10, 1971.

Abstract

Results from past studies indicate that an EEG (electroencephalograph) recorded from the olfactory bulb of an adult salmon which has homed can demonstrate that the fish recognizes and responds to the specific olfactory quality of its own home stream. Previous workers have concluded that the electric response is specific in the sense that it cannot be evoked by water from spawning terminii of other homing populations. A closer look at this work, however, reveals some contradictions, and our own results on coho salmon from Lake Michigan streams suggest that there are other non-specific stimulatory factors. Still unresolved is how much of the response to home stream water is a function of: i) past olfactory experiences (imprinting) of the juvenile fish, ii) recent experiences of the adult in the home stream after the return, or iii) simply inherently high concentrations of odor producing products in the home stream, i.e. from spawning adults.

Sensitization because of recent residence in the home stream or imprinting as juveniles could provide the specificity of the responses found by previous workers. The effectiveness of recent residence in producing intense responses can be demonstrated and furthermore products produced by spawning adults have a strong effect on the stimulatory ability of various water samples.

We feel that before the evoked bulbar EEG can be used as a routine tool for examination of the homing process and a bioassay for home stream more work must be done on the basic process of excitation of this response.

EFFECTS OF TEMPERATURE ON ELECTROLYTE BALANCE AND OSMOREGULATION IN THE ALEWIFE (ALOSA PSEUDOHARENGUS) IN FRESH AND SEA WATER. Jon G. Stanley, University of Wisconsin-Milwaukee, and Peter J. Colby, Great Lakes Fishery Laboratory. Paper submitted for publication in Transactions of the American Fisheries Society.

Abstract

A study of temperature and salinity on osmoregulation in the alewife, *Alosa pseudoharengus*, revealed that concentrations of sodium, potassium, and calcium in plasma and muscle were similar in fish adapted to fresh water and those adapted to sea water. The non-stressed alewife is apparently an excellent osmoregulator in both environments.

Exposure to acute cold caused a shift in the concentrations of sodium and calcium in the plasma toward environmental concentrations, i.e., these ions decreased in fresh water and increased in sea water. (Potassium also increased in sea water, but not significantly in fresh water.) An osmoregulatory failure due to cold is suggested. In fresh water, acute exposure to warm water had little effect on plasma electrolyte levels, whereas in sea water it elevated the concentrations of sodium, potassium, and calcium. It was concluded that mortalities of the alewife in the Great Lakes may be caused by osmoregulatory failure induced by acute exposure to cold, but cannot be attributed to osmoregulatory collapse induced by exposure to elevated temperatures. Fish thermally acclimated in the laboratory or in Lake Michigan had essentially normal concentrations of blood electrolytes.

In muscle, sodium was reduced and potassium and calcium levels were changed during exposure to acute cold in both fresh water and sea water. The effect of warm water on ion levels in muscle was, in general, opposite that of cold. These data suggest shifts of ions and water or both between cellular and extracellular fluids of muscle, and such shifts are known to affect the function of excitable tissue. The behavior of dying alewives during summer mortalities suggests upset in excitable tissue; such upsets might be brought about when sudden temperature changes (e.g., as a result of upwellings) induce disturbances in cellular or extracellular concentrations of ions. In the laboratory, alewife mortalities were about equal in sea water and fresh water when temperatures were increased or decreased at the rate of 2.5°C/day for 4 days. These findings suggest that salinity in the seawater environment does not increase the capacity of alewives to tolerate acute temperature stress.

EFFECTS OF TEMPERATURE SHOCK ON OXYGEN CONSUMPTION OF THE ALEWIFE, ALOSA PSEUDOHARENGUS. Carroll R. Norden and Fred Binkowski, Department of Zoology, University of Wisconsin-Milwaukee. Paper to be presented at the 14th Conference of the International Association for Great Lakes Research. Toronto, Canada, April, 1971.

Abstract

The objective of this study was to measure the effect of temperature shock on the oxygen consumption of the alewife in the laboratory in order to determine whether the alewife is capable of adjusting its metabolism to abrupt changes in temperature. At times, during the months of June, July and August water temperatures measured in Lake Michigan off Milwaukee, Wisconsin have varied from one to nine degrees C. between the surface and a depth of 10 meters. Alewives, therefore, moving in and out of the harbor and the inshore waters of Lake Michigan may encounter fluctuating temperatures between various depths.

Alewives were collected from the inshore waters of Lake Michigan during the months of July and August, brought into the laboratory and acclimated at temperatures of 14° and 22°C for periods of twenty days or longer. The fish were starved for 24 hours prior to being transferred to respirometers which consisted of flowing water chambers. Oxygen concentrations were monitored with an oxygen electrode and meter.

The alewives were held in the respirometer chambers for four days before the water temperature was increased or decreased eight degrees (to 22° or 14°C) at a rate of about one degree per 15 minutes. After this temperature shock, oxygen consumption was monitored for another four days.

After the initial temperature change, oxygen consumption leveled off at a lower rate in the cold water and at a higher rate in the warmer water. Temperature shock in either direction produced a change in oxygen consumption of approximately 100 to 150 ml/kgm/hr. Although alewives were able to make some adjustment in oxygen consumption they were unable to completely compensate for an eight degree temperature change during the four day period.

This research was supported in part by the National Science Foundation and the State of Wisconsin under the University of Wisconsin Sea Grant Program.

ECOLOGICAL INTERACTIONS AMONG COHO SALMON AND NATIVE FISHES IN A SMALL LAKE. Sandy Engel and John J. Magnuson, Laboratory of Limnology, University of Wisconsin, Madison. Paper to be presented at the 14th Conference of the International Association for Great Lakes Research. Toronto, Canada, April, 1971.

Abstract

Recent introductions of coho salmon (*Oncorhynchus kisutch*) into the Great Lakes have prompted concern for understanding how coho salmon interact with native fishes in the Great Lakes. However, the vast size of the Great Lakes makes it difficult to study fish interactions in detail.

Pallette Lake, in northern Wisconsin, was selected as a smaller lake where interactions among coho salmon, cisco (*Coregonus artedii*) and yellow perch (*Perca flavescens*) could be studied. The lake has a surface area of 69 ha and a maximum depth of 18m. In the fall of 1968 and spring of 1969, the Wisconsin Department of Natural Resources stocked the lake with 5,000 coho salmon, averaging 130 mm total length.

Gill-nets, 5.5 m long and 18 m deep, were suspended from floating rollers in the pelagic region to capture fishes and study their daily and seasonal changes in vertical distribution. The nets were lifted at 4-hour intervals for a 24-hour period every 3-4 weeks throughout the year. For capturing fishes inshore, gill-nets, fyke-nets and electrofishing gear were used.

Temperature and oxygen profiles were obtained during each sampling period. Zooplankton were collected with a Clark-Bumpus sampler at different times of the day and at various depths for comparison with vertical distribution and stomach contents of captured fishes.

Two Bendix DR-9 echosounders, with a frequency of 50 kHz, supplemented gill-net data on vertical distribution and were used to study horizontal movements.

Coho salmon were found inshore in the spring and fall, while cisco and yellow perch were more widely distributed. In May and June, coho salmon and yellow perch were found primarily in the epilimnion. Cisco left the epilimnion and were captured in the metalimnion beginning in June and early July when the surface temperature reached 17°C. Coho salmon

entered the metalimnion in late July when the surface temperature was 23°C. Yellow perch remained inshore and in the epilimnion during summer.

Throughout the year yellow perch moved toward shore at sunset and away at sunrise. Conversely, cisco moved toward shore at sunrise and away at sunset. Yellow perch were active during the day, while cisco remained near the bottom at depths of 9-12 m.

Early in the year coho salmon ate mainly terrestrial and aquatic insects. When they entered the metalimnion in summer, their diet changed to aquatic insects and zooplankton. In the fall, they ate insects, zooplankton, fishes and cisco eggs inshore. Cisco fed mainly on zooplankton throughout the year.

Coho salmon grew from 130 mm to 175 mm total length from April to October. This slow growth suggested that suitable food, such as young fishes, was not available to them.

Our study suggested that little direct interaction occurred between coho salmon and yellow perch during summer, since they were widely separated in the pelagic region. Young cisco were either too large to be eaten by coho salmon, or they were not abundant in the metalimnion. More direct interaction was found inshore in the fall when some coho salmon ate cisco eggs.

THE AQUATIC ENVIRONMENT AND ELECTRIC POWER PRODUCTION PROGRAM

STUDIES OF THE PHYSICAL ASPECTS OF THERMAL POLLUTION

Theodore Green, III

Introduction

The ejected cooling water from power plants along lake shores has important ecological effects, which have been discussed by several people (e.g., Ref. 1). There have been a number of qualitative studies of the associated "thermal plumes" (Ref. 2). These have given some information on plume size and shape at a particular instant in time, and have been used primarily to argue for or against a particular power plant site, with little regard for underlying plume dynamics. We know, of course, that these plumes are turbulent, behave randomly, and that their spatial and temporal variations are probably quite important. The precise measurements needed to describe these variations are time consuming and expensive, and the effort has not been put forth.

Soon there will be many thermal plumes, the number increasing with the nation's power requirements. We must be able to predict in advance the physical effects of pouring this hot water into our lakes, so that the ecological effects can be ascertained beforehand, and reasoned decisions made regarding the siting and size of future power plants. To produce such forecasts, much more information is needed concerning the mechanism of dispersal of the hot water, and the effect of such external parameters as ambient lake turbulence and wind stress. To get the information, we must have a very thorough description of the phenomenon. This will only come after a period of intense study. That is, a thorough study of one example is an important step in formulating a successful scheme for prediction.

An analogous problem is cloud seeding. Cloud seeders are concerned with a very practical problem: producing rain. Yet the literature is full of related attempts by the same people to understand the intricacies of a single cloud (e.g., Ref. 3). Our "cloud" is horizontal, hence more complex. Here, as in clouds, the detailed structure is crucial to understanding the entire physical mechanism.

We have studied a relatively small thermal plume on nearby Lake Monona for a number of years (Ref. 4). With the advent of the larger nuclear power plants, an extension of this work to the large-scale plumes on the Great Lakes was in order. We selected the Point Beach plant at Two Rivers, Wisconsin (on Lake Michigan) for logistical reasons. The plant did not come on line until November, 1970. This enabled us to collect nearly a year of "baseline" information on the nearshore temperature structure, with which to judge the more subtle, large-scale effects of the plume (Fig. 1).

Last summer was spent on Lake Monona. We pursued our studies of that plume, while at the same time developing and testing new techniques for determining the small-scale plume structure. Some of these techniques entailed combined plane, boat, and shore observations, thus necessitating rather elaborate coordination. At first, to avoid unnecessary complications, and to keep costly equipment dry, we worked only in fairly calm weather. Several types of measurements were tried, with varying degrees of success. These are described below. When possible, similar (but usually cruder) measurements were made at Point Beach.

WORK ON THE LAKE MONONA AND POINT BEACH THERMAL PLUMES OF SUMMER AND FALL, 1970

Surface Temperature Measurements

To measure the spatial fine structure of the surface temperature, a precision radiation thermometer (Barnes, PRT 5) was mounted ahead of the bow of an 18' outboard (Fig. 2). The boat traced a repetitive path across the plume, using precisely located moored buoys for navigation. A typical run covered most of the morning (say, from 6:30 a.m. to noon), in order to measure variations with time due to increased use of electric power as the day wore on. A typical temperature trace is shown in Fig. 3; a contoured plot of the plume, together with the boat track, is shown in Fig. 4. This work will be continued this coming summer at Point Beach, using the new 41' R/V AQUARIUS.

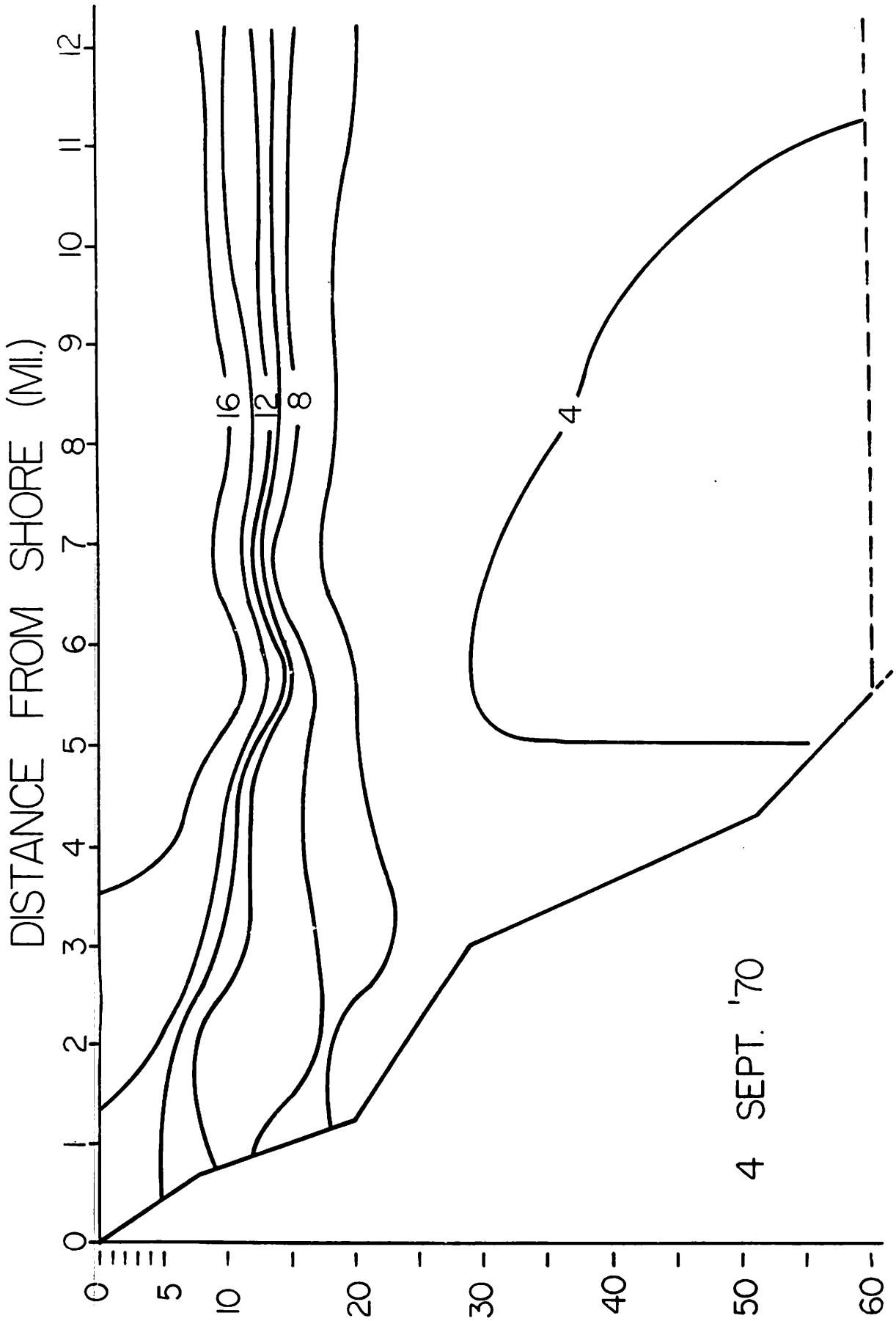


Figure 1a. Typical Bathythermograph Data on the Nearshore Temperature Structure of Lake Michigan near Point Beach, 4 September 1970.

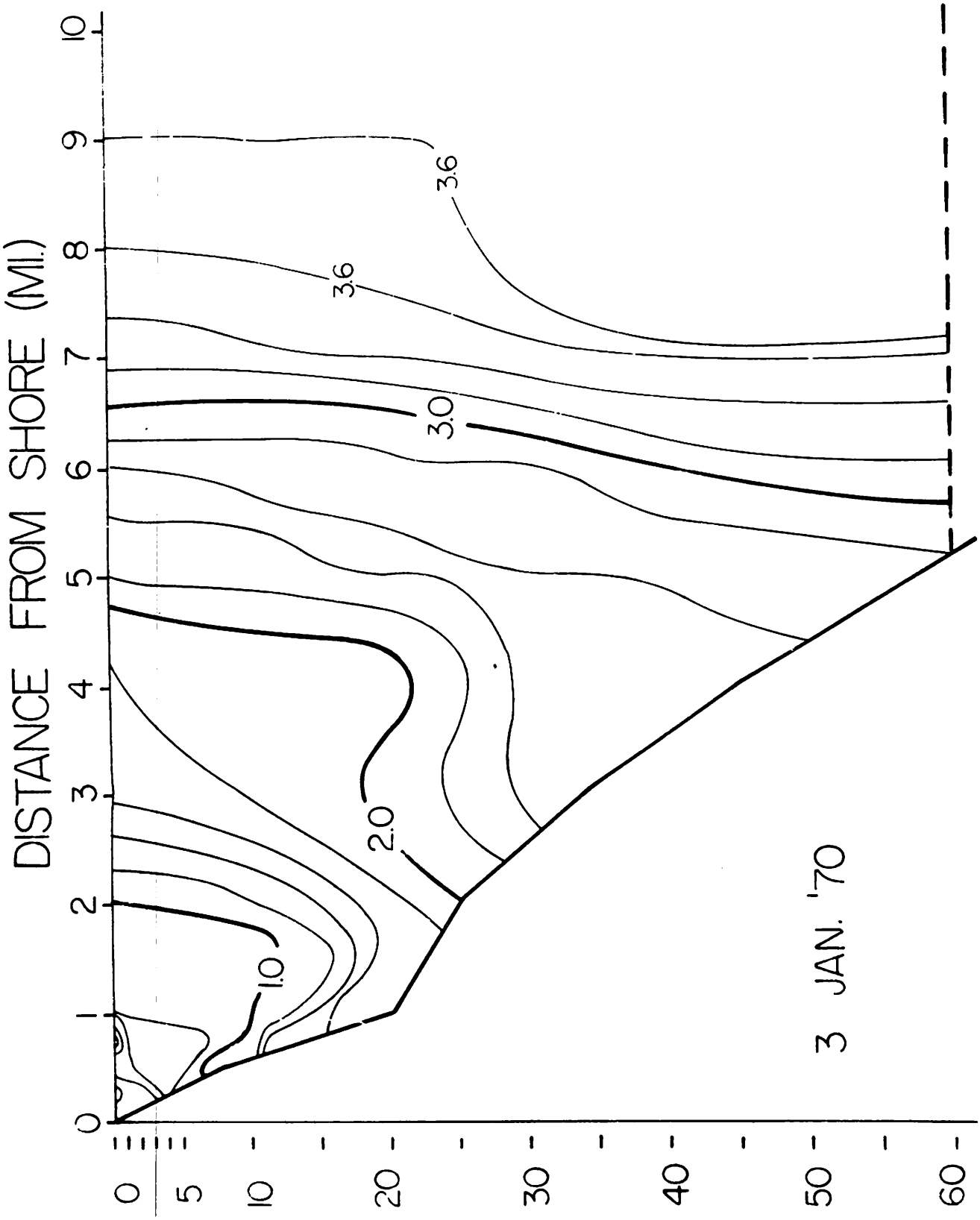


Figure 1b. Typical Bathythermograph Data on the Nearshore Temperature Structure of Lake Michigan near Point Beach, 3 January 1970.

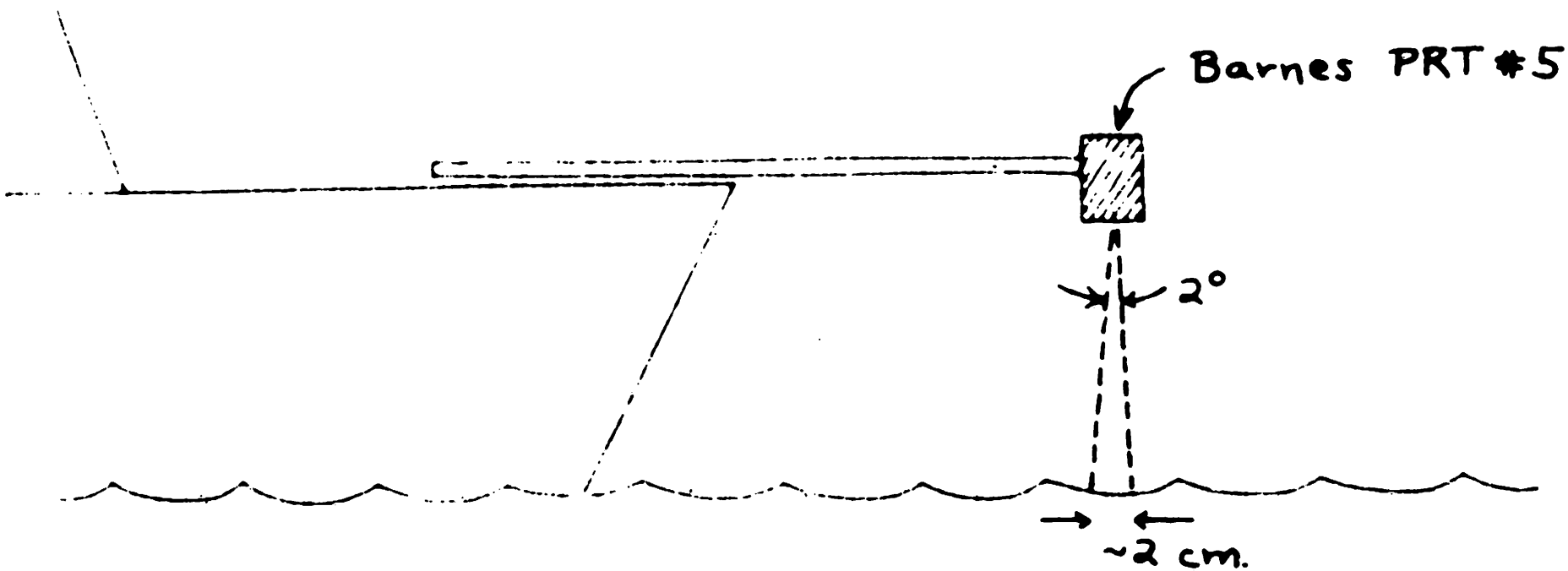
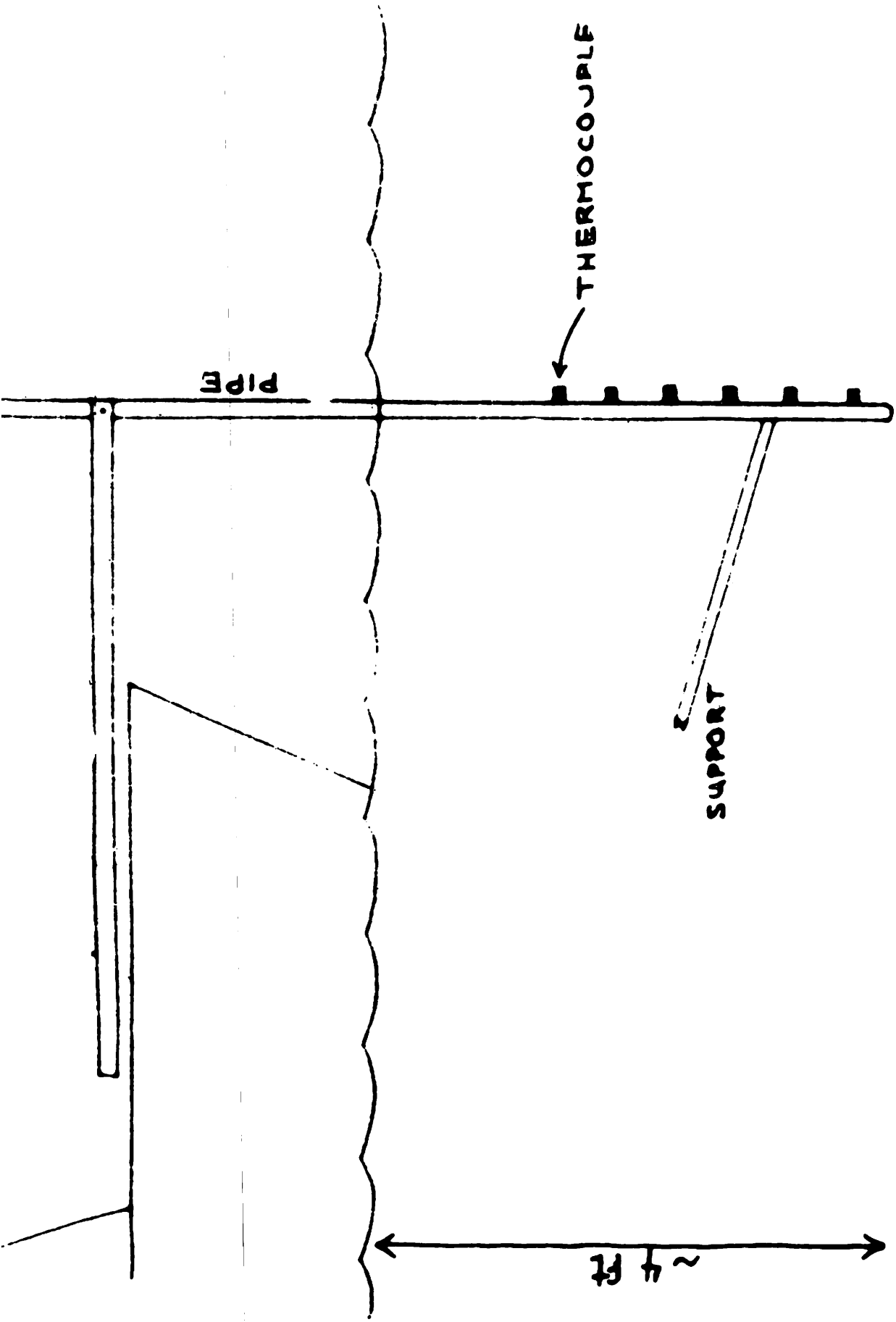


Figure 2a. Schematic Showing the Radiation Thermometer Mounted on the Boat.



THERMOCOUPLE PROBE

Figure 2b. Schematic Showing the Thermocouple Probe.

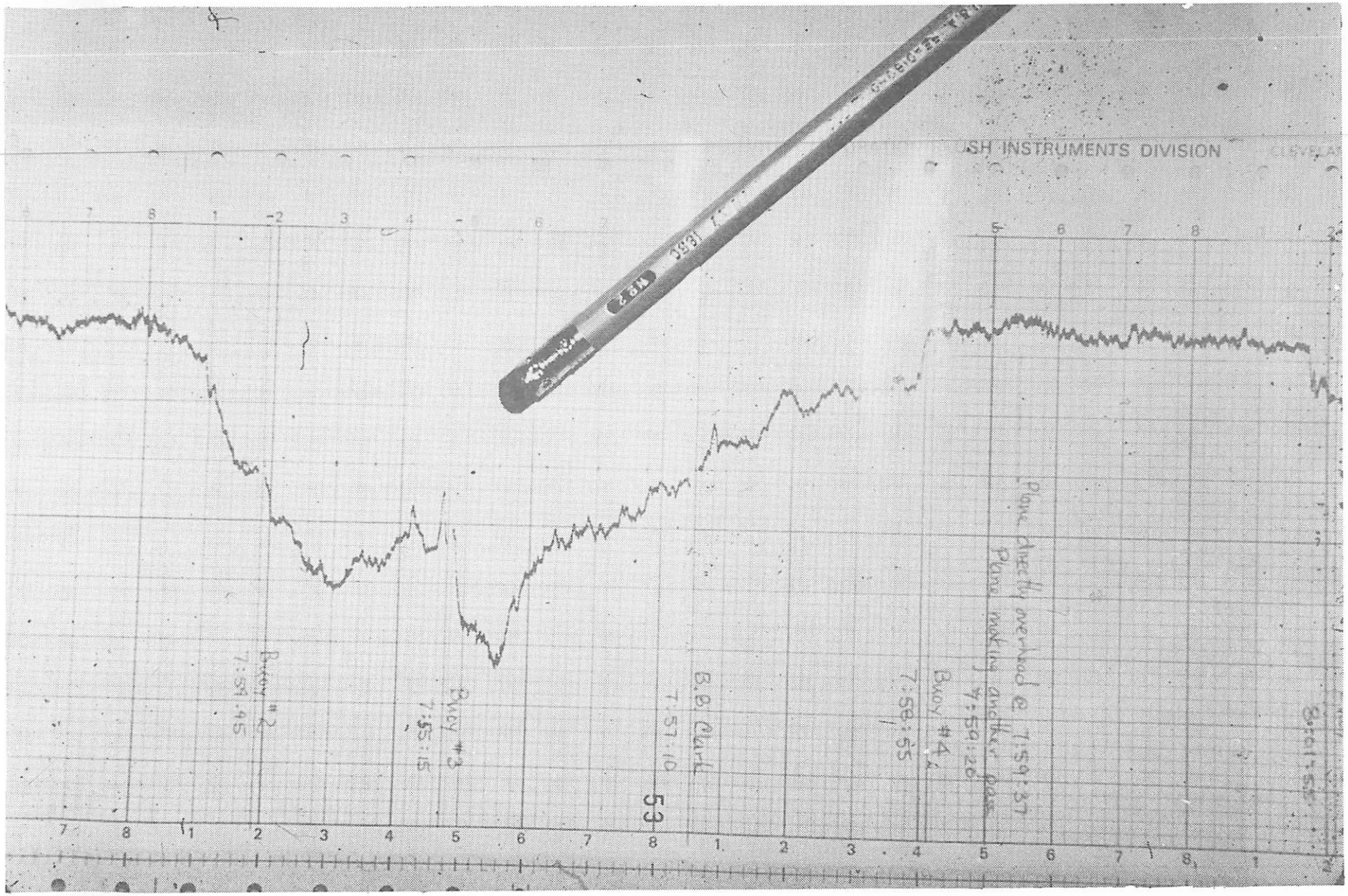


Figure 3. A Typical Surface Temperature Record Obtained with the Bow-Mounted Radiation Thermometer.

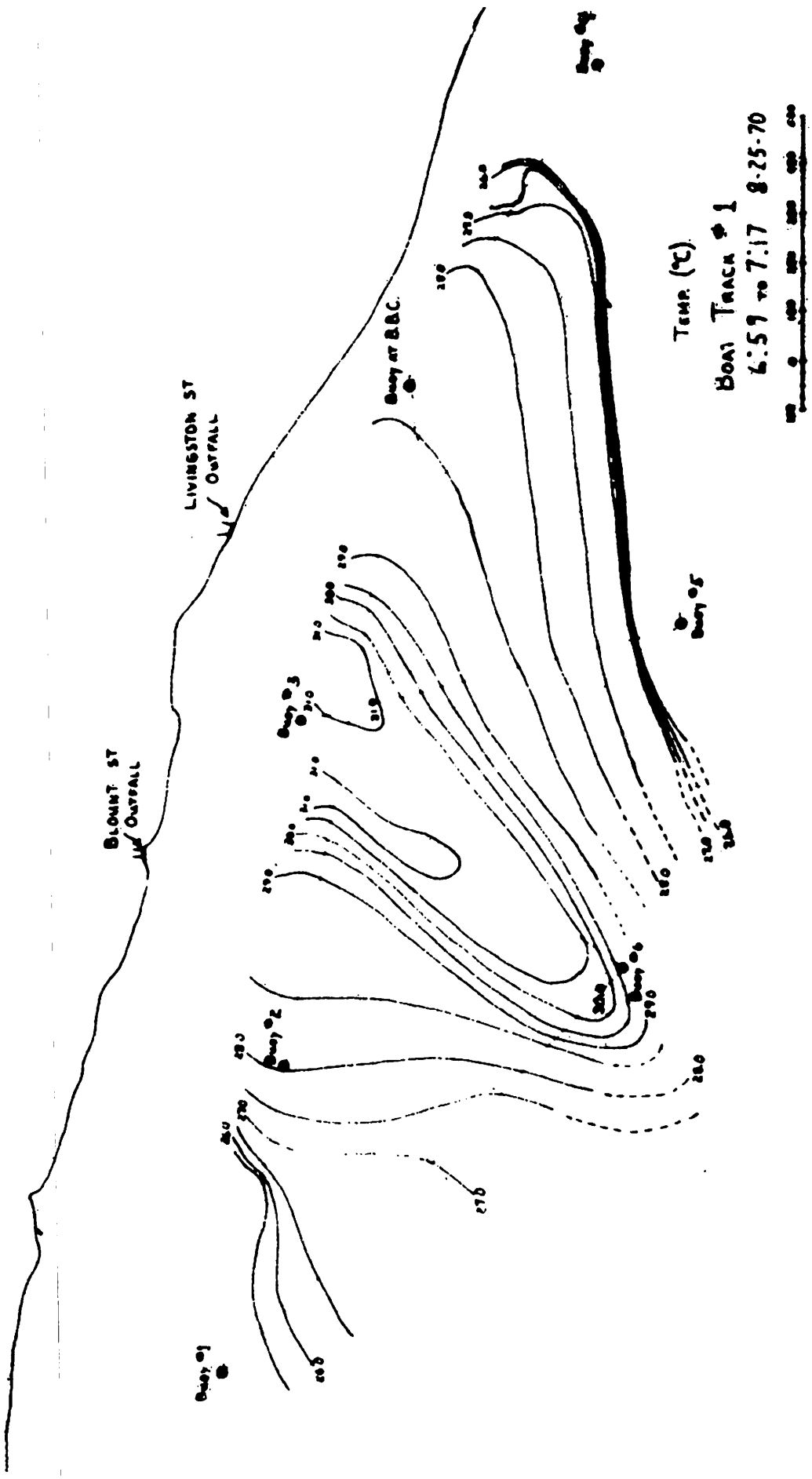


Figure 4. An Interpretation of the General Surface Outline of the Lake Monona Plume (From the Radiation Thermometer Data).

Temperature Beneath the Surface

A pole with 8 thermocouples spaced 10 cm apart was mounted vertically ahead of the boat to monitor subsurface water temperatures (Fig. 2). (The plume is only about one meter thick, with a rather sharp interface.) This device was used sparingly, as we encountered severe vibrations in the pole supports above a speed of 2 knots. What data we did get shows that the upwind edge of the plume is extremely sharp at all depths (Fig. 5). This is most likely due to wind forcing the cool lake water over the warm plume water, and the ensuing sinking. It does not occur along the down-wind edge of the plume. The details of the upwind edge will be discussed further below. We are now working on the vibration problem, and on rapid methods for analyzing the data.

Internal waves along the plume bottom were measured crudely by mooring the boat (a two-point mooring) and repeatedly lowering a thermometer with an on-deck readout. The record is shown in Fig. 6. A small-scale "isotherm follower", more suited to these measurements, is being developed.

We will never get truly synoptic (i.e., instantaneous) data on the whole three-dimensional plume. However, the type of data we are getting will allow us to predict the amount of vertical mixing, the stress on the plume bottom, and the rates of outward spread.

In a related experiment, we tried to scuttle, in a convincing manner, the lingering notion that heat transfer through the water surface is important in the warmer part of the plume. A drogue was set at the outfall to follow the mean plume current, and water temperature was measured at various depths at the drogue as it moved away from the outfall. These "water parcel" temperature measurements lead to the time variation of the total heat content of the parcel. When this is compared with a fairly accurate estimate of the heat flux through the surface, an estimate of the speed of lateral mixing results. Preliminary work on both the Point Beach and Monona plumes indicates that lateral mixing accounts for almost all heat loss in the region where the plume is ecologically significant.

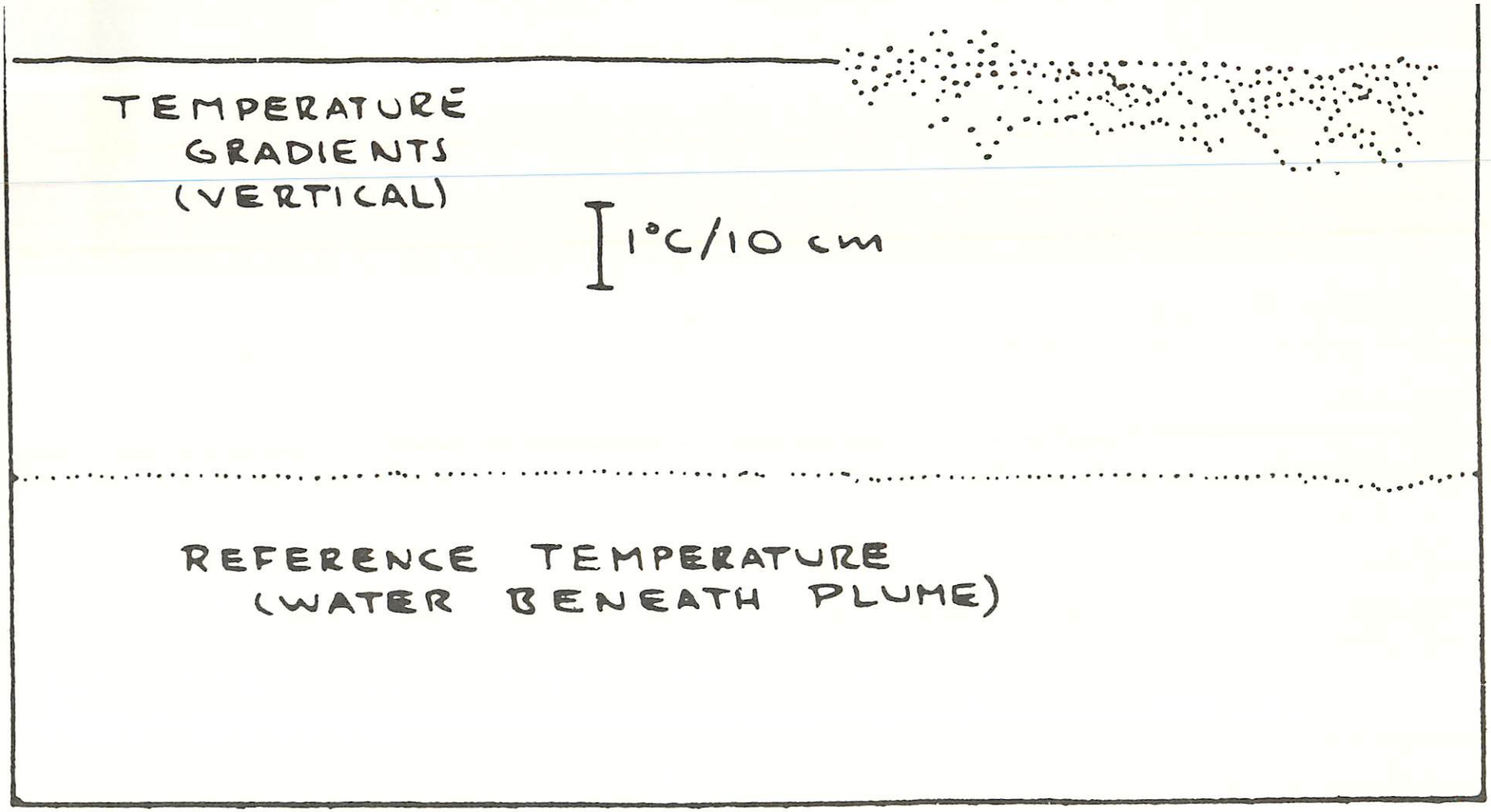


Figure 5. Vertical Temperature Gradients at the Upwind Edge of the Lake Monona Plume (The Gradients are all Zero Until the Plume is Encountered).

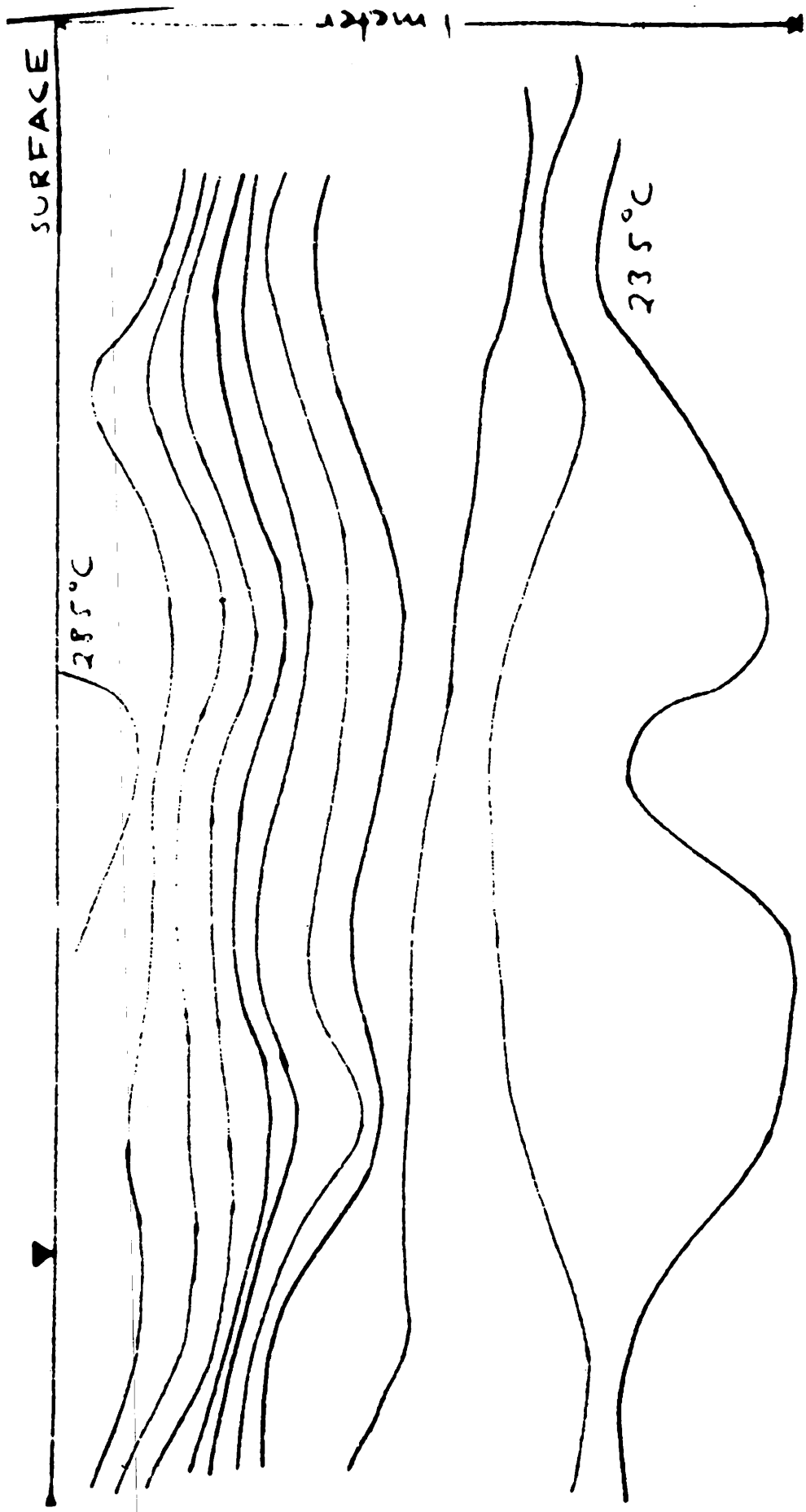


Figure 6. Internal Waves Associated With the Lake Monona Thermal Plume.

Remote Sensing of Surface Temperatures

We can get a synoptic measurement of the plume surface temperature by using an airborne "thermal scanner" (a radiation thermometer which rotates so as to scan a broad area under the plane). This was tried once last summer, over a period of three days. Several thermal images of the Monona plume were obtained. A typical image is shown in Fig. 7. Note the boat in the image; concurrent "ground truth" was obtained using the methods described above.

The imagery is being analyzed for total surface heat content and fine spatial detail. Note the series of secondary fronts along the upwind(left) edge. These also occur along oceanic thermal fronts, and suggest some sort of instability mechanism. They seem to dominate upwind spreading. These secondary fronts will be investigated more closely, both theoretically and experimentally.

This three-day series of flights (including the data collection) was done by a private firm. It should be noted that the work was shared with other (NASA and Water Resources) research projects in such a way that there was no direct cost to the Sea Grant Program.

Three similar flights are planned for the coming summer using the NCAR research aircraft (again, at small cost). Both the Monona and Point Beach plumes will be studied.

Analytical Photogrammetric Determination of Surface Currents

Detailed information on the velocity structure of both the lake water and the plume water is important in predicting their rate of mixing. This is at best difficult to obtain with conventional current meters. Too many meters are needed, and their threshold velocity responses are too high. Aerial photographs of surface floats offer a possible alternative. Here the data are obtained relatively cheaply. The data reduction, however, is a formidable task.

A first attempt to use this method was made with the NCAR aircraft in late November, at Point Beach. The results, though interesting, were rather crude. A more precise trial with an aerial mapping camera was conducted in

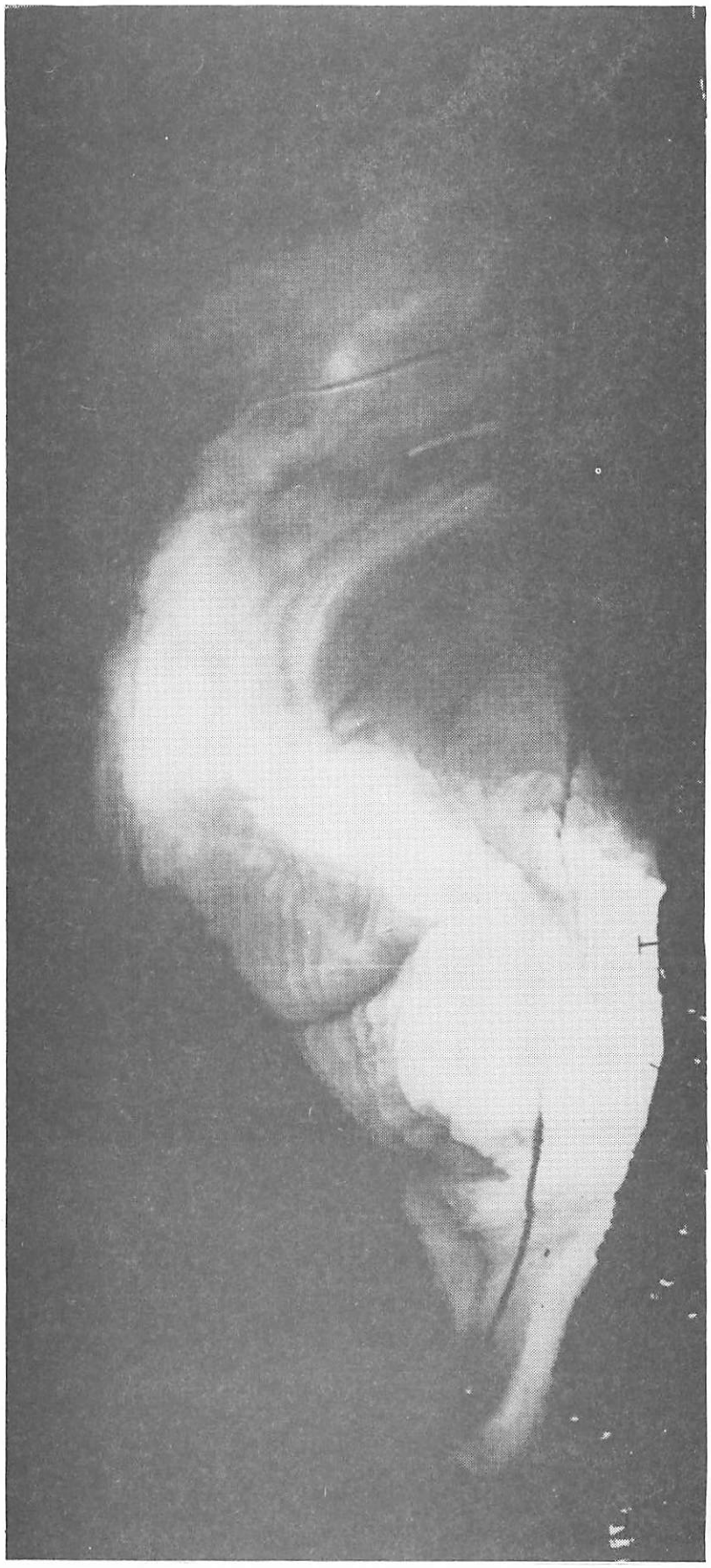


Figure 7. Thermal Imagery of the Lake Monona Plume.

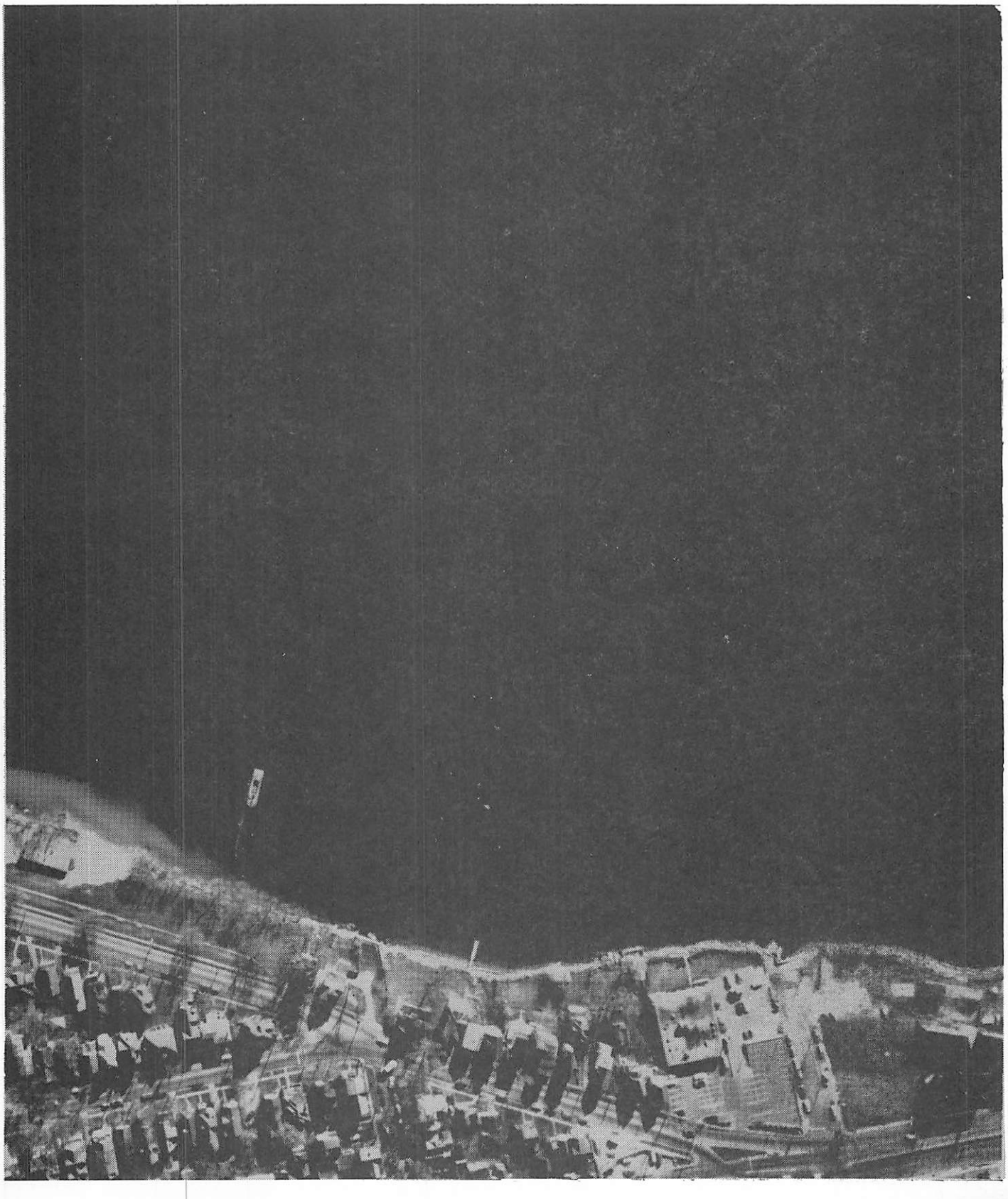


Figure 8. Aerial Photograph of Paper Floats in the Lake Monona Plume. Successive Locations of Individual Floats Give Plume Velocities.

early December on Lake Monona (see Fig. 8). We used the Wisconsin State Highway Division mapping plane (at marginal cost) and are using their facilities (at no cost) to reduce the data. Once the rough positions of the surface floats on the negatives are known, analytical photogrammetric techniques will be used to find true positions and their velocities and rates of mixing.

Similar work is planned for the coming summer, mainly at Point Beach. With luck, we will also get a thermal scan at the same time. These velocity and temperature data will be used to check the various assumptions currently employed when forecasting plumes and to develop new forecasting methods.

Monthly Monitoring of Offshore Temperature

As mentioned above, our monthly monitoring of the gross temperature structure near the Point Beach power plant continued. We now have over a year of this data and plan to continue the work indefinitely.

Theoretical Work

Nearshore currents have much bearing on shoreline pollution problems. One controversial aspect has been the "thermal bar", the longshore region of surface water of maximum density (at 4°C) which occurs in the spring and fall. Some claim the bar impedes mixing of nearshore (polluted) water with central lake water; hence, the name. Others suspect that it might increase mixing. We have formulated a numerical model of the bar and its associated current structure as a first step toward answering this question. The results will be presented this April (Ref. 4).

Related Work

A number of related research projects focusing on the Point Beach area should begin this coming summer. The effect of the plume on the littoral sediment drift will be studied. The distribution of fish in the plume will be measured. Analytical photogrammetists will aid in reducing the current data collected using aerial photography.

New Work (to be started this summer)

The details of the ambient water motion just offshore are critical to the position and extent of the plume. We have begun measuring ambient lake turbulence, using the aerial techniques discussed above. This will be continued. Information on long waves and mean currents in the vicinity of Point Beach does not exist. To get preliminary data, we plan to moor a current meter a short distance offshore and to install two long-period wave gauges with onshore readout to monitor edge-wave activity. These instruments are now on hand.

References

1. Physical and Ecological Effects of Waste Heat on Lake Michigan, U.S. Department of the Interior, September, 1970.

2. Thermal Discharge: a Model-Prototype Comparison, R.M. Miner, et al, presented at the ASCE National Water Resources Meeting, January 11-16, 1971.

3. The Microstructure of the Cumulus Cloud, J. Warner, Journal of the Atmospheric Sciences, 1970.

4. A numerical Simulation of the Thermal Bar, J. R. Bennett, to be presented at the 14th Conference on Great Lakes Research, April, 1971.

INFORMATION FLOW - ATOMIC POWER PLANT COMMUNITIES

John E. Ross

A number of communities currently, or will in the near future, face the problem of deciding whether or not they want an atomic power plant built in their community. In the past, many such major decisions have been made outside the arena of local public opinion, and communities have been presented with a fact accomplished. Rising public (and local) concern over environmental questions makes it less and less likely that this kind of decision-making will succeed in the future. In numerous current cases projects

such as atomic power plants (dams, highways, super sonic airplanes) are being delayed or rejected because of "public" response. A key question, then, is whether or not the decision-making process is analytical or emotional, i.e., whether or not there is rational consideration of alternatives, cost and benefits and environmental impact. Given a lack of processing of analytical information, what is the impact on the timing and the outcome of the decision.

This project proposes to describe as completely as possible the issues and ramifications of the establishment of a local atomic power plant. This has been done (see attached domument - coding categories). The next step is to make some assessment of the public availability of information on the issues as described. To do this we must examine the written records. The most accessible of these include the daily newspapers, transcriptions of hearings, and study commission documents. Analysis of the written record gives a measure of the availability of information. It does not necessarily indicate the transmission or understanding of that information. That is another step.

Newspaper articles relating to the construction of power plants at any of five sites on Lake Michigan and from the nearest local and metropolitan areas are being examined for the period from four months before the company announced the plant site to six months after the AEC granted a construction permit. A content analysis will present an accurate picture of the range of ideas available to citizens through this medium. It is not a complete picture of available information.

The categories chosen for scrutiny were developed after reading a variety of sources during July. The sources included material written by specific power companies, by spokesmen for the electric utility industry, by the AEC and by various conservationists. A copy of the category system is attached as initially developed. The category system enables classification of information. The authors have not been able to find a complete description of the issues in any available report on power plants.

Issues of the Manitowoc *Herald-Times* for the period November 1, 1965, to February 28, 1969, were scanned for relevant articles. The appropriate articles were duplicated and coded for the presence of the detailed categories. A similar search of the *New York Times* for the period November 1, 1965 to June 30, 1969 is now in progress. This and several other national media are being scanned as a basis for comparison for local media. Using the *New York Times* index to identify relevant articles has greatly simplified this task.

Articles from these two papers are being used to test the categories for completeness and redundancy. The categories will be revised as necessary.

When the categories are in final form, the other eleven newspapers will be scanned and coded. The complete list of newspapers to be studied in this project follows:

Plants	Papers	Dates Covered
Point Beach and Kewaunee	Manitowoc *Herald-Time*	11/1/65 - 2/28/69
	Green Bay *Press-Gazette*	1/1/66 - 2/28/69
	Milwaukee *Journal*	" "
	Milwaukee *Sentinel*	" "
Zion	Waukegan *News-Sun*	1/1/66 - 6/30/69
	Chicago *Sun-Times*	" "
	Chicago *News*	" "
	Chicago *Tribune*	" "
Donald C. Cook	Benton Harbor *News-Palladium*	4/1/67 - 9/30/69
Palisades	Kalamazoo *Gazette*	10/1/65 - 9/30/67
	Muskegon *Chronicle*	" "
	South Haven *Tribune*	" "
all	*New York Times*	11/1/65 - 9/30/69

Further reading to more clearly define the issues involved in nuclear power plant siting is underway now.

Coding Categories

There are five major areas to consider when coding an article. In coding, you must go to each of the five and *Key* out the article under consideration. For example; if the article which you are coding does not fall under the first category, (1.1) then you do not code number 13, and you do not go on to number 2.0. Instead - read across to the "If not, go to . . ." section, then go on to number 1.2 as directed. Now go on to category 1.

Categories	Code	If yes go to...	If no go to...
1. Major function of item			
1.1 The article being coded is nuclear bomb oriented, weapons or weapons testing, Plowshare, or bomb as used in research - any nuclear explosion theme	13	2	1.2
1.2 Nuclear power generation theme excluding any other power source	14	2	1.3
1.3 Any other power generation theme, excluding nuclear power of any kind. .	15	2	1.4
1.4 Both nuclear and other source of power generation	16	2	1.5
1.5 Article in question is not concerned with, and does specifically mention any of the above	N	Go on to	1.51
1.51 Articles major concern is desalination	17	2	1.52
1.52 Environmental problems	18	2	1.53

1.53	Mining and miners 19		2	1.54
1.54	Oil and coal problems 20		2	1.55
1.55	Other major theme, not mentioned above 21		2	2

2. Information source. Where did the initial information come from? Go on to 2.1

2.1	Federal government 22		3	2.2
2.2	State government 23		3	2.3
2.3	Local government 24		3	2.4
2.4	Power company 25		3	2.5
2.5	Other industry 26		3	2.6
2.6	International agency 27		3	2.7
2.7	Special interest group, (chamber of commerce, clubs, conservation groups, industrial associations 28		3	2.8
2.8	Investigative reporter (muckraker) . . .29		3	2.9
2.9	Paper staff or reporter 30		3	2.10
2.10	Letters to the editor, editorial cartoons and editorials 31		3	2.11
2.11	Wire services 32		3	2.12
2.12	Book review 33	Go on to	3	

3. This section deals with the article's approach toward ENVIRONMENTAL IMPACT ...Go on to 3.1

3.1	Environmental impact RADIATION . . . . .N		3.11	3.2
3.11	Radiation impact BAD . . . . . .N		3.111	3.12
3.111	Effects of radiation on human life and health . . .N		3.1111	3.112
3.1111	General threat - no specifics mentioned . . .34		3.112	3.1112
3.1112	Accelerated aging 35	Go on to	3.1113	
3.1113	Increased cancer occurrence 36	Go on to	3.1114	

3.1114	Human gene mutation, genetic disease 37	Go on to	3.1115	
3.1115	None of the above, but mentioned 38	Go on to	3.112	
3.112	Effects not on human population, rather to other BIOTA, ecological balance and environmental stability and concentration in the food chain 39	Go on to	3.113	
3.113	Radio active waste disposal - either by dilution or burial 40	Go on to	3.114	
3.114	Shipment or theft of radio active materials 41	Go on to	3.115	
3.115	Plant accidents mentioned in article . . . . . N		3.1151	4
3.1151	General statement without reason or details . .42		3.1154	3.1152
3.1152	Lack of quality control at all stages of manufacture and construction.43	Go on to	3.1153	
3.1153	Human error causing accident 44	Go on to	3.1154	
3.1154	Training to cope with accidents 45	Go on to	3.12	
3.12	Radiation impact GOOD . . . . . N		3.121	3.2
3.121	Medical uses of radiation .46	Go on to	3.122	
3.122	Radioisotopes used (tracers) 47	Go on to	3.123	
3.123	Physical uses of power - either from electrical power generation or from bomb explosion 48	Go on to	3.124	
3.124	Other good environmental radiation impact 49	Go on to	3.2	

3.2	Environmental impact NON - RADIATION . .N			3.21	3.3
	3.21 General statement - no particulars given 50			3.3	3.22
	3.22 Thermal pollution of air and/or water . . . . . N			3.221	3.23
	3.221 Thermal pollution of water 51	Go on to		3.222	
	3.222 Thermal pollution of air (fog and climate changes in local area) 52	Go on to		3.23	
	3.23 Non-thermal air pollution. . . . N			3.231	3.24
	3.231 Non-thermal air pollution from fossil fuel plants only 53	Go on to		3.232	
	3.232 Comparison of fossil and nuclear plants with respect to air pollution 54	Go on to		3.24	
	3.24 Solid waste disposal . . . . . .N			3.241	3.25
	3.241 Sewage treatment and/or problems 55	Go on to		3.242	
	3.242 Fossil fuel ashes 56	Go on to		3.25	
	3.25 Damage from fuel extraction - strip mining and leakage of oil . 57	Go on to		3.26	
	3.26 Aesthetics of the plant and transmission lines 58	Go on to		3.27	
	3.27 Site location as it affects the environment. 59	Go on to		3.3	
3.3	Today's technological situation . . . . N			3.31	4
	3.31 Technological advances affecting power source alternatives 60	Go on to		3.32	
	3.32 Types of reactors 61	Go on to		3.33	
	3.33 Utility corridors 62	Go on to		3.34	
	3.34 Underground transmission lines . .63	Go on to		3.35	
	3.35 Today's technology affecting power demand (more effective motors). . 64	Go on to		3.36	

3.36 Technological advances affecting what to do with thermal effluents, (cooling towers, heating homes, and irrigation). . . . . .65 Go on to 3.37

3.37 Technology affecting radiation pollution . . . . . 66 Go on to 3.4

3.4 Taking into consideration, the answers which you've coded for this section, did the article mainly stress the subjects' *costs* or its benefits? . . . . . N Go on to 3.41

3.41 Emphasis on costs only - negative side of balance sheet . .67 Go on to 3.42

3.42 Emphasis on benefits only - positive side of balance sheet . .68 Go on to 3.43

3.43 Emphasis on both costs and benefits . . . . . .69 Go on to 3.44

3.44 Emphasis on neither . . . . . 70 Go on to 4

4. Section 4 is a large one. It deals with several diverse areas. Among them are the POLICIES of government and power companies legal CONTROLS which are placed on power groups, the PLANNING which is going on concerning the nuclear plant. Section 4 also codes for the power projects' affect on the COMMUNITY and its value systems. Go on to 4.1

4.1 Policies, planning and resource use . . N 4.11 4.4

4.11 Does the article mention society's growing power and energy needs? . . . . . 71 Go on to 4.12

4.12 Using power to obtain an easier or better life . . . . . .72 Go on to 4.13

4.13 Does the article mention planning for lead times between decision to build and start up? . . . . . .73 Go on to 4.14

4.14	Planning for power needs of defense installations such as Sanguine or ABM 74	Go on to	4.15		
4.15	Integration of choice of plant sites and power line routes with normal regional land use planning process 75	Go on to	4.16		
4.16	On a national level, are there plans to encourage development of technological changes that will reduce power demand? 76	Go on to	4.17		
4.17	How are growth of the national economy and growth of demand for power and energy related? 77	Go on to	4.18		
4.18	Adding public participation and more consideration of environmental effects to present utility planning 78	Go on to	4.19		
4.19	Does the article mention resource supplies, including present levels of use and predictions regarding how long the supply will last?. . 79	Go on to	4.20		
4.20	Nuclear vs. fossil: does the article describe this competition in terms of relative costs of these fuels including transportation cost and supply reliability? 80	Go on to	4.21		
4.21	Cost of, and supply of the equipment for generating electricity . 81	Go on to	4.22		
4.22	Are there enough trained men to mine the fuel and build and operate the plants? 82	Go on to	4.3		
4.3	Present legal. . . . . .N	Go on to	4.31		4.4
4.31	Present legal limits on plant construction and operation 83	Go on to	4.32		

4.32 Standards for air quality, water quality and radiation . . . . . 84 Go on to 4.4

4.4 Regulatory problems . . . . . N Go on to 4.41 4.5

4.41 Does the article propose new control institutions? . . . . . 85 Go on to 4.42

4.42 Form of standards: discharge no more than a given amount vs. reduce discharge to limits technologically possible . . . . .86 Go on to 4.43

4.43 Should the AEC continue to both promote and to regulate nuclear power generation? . . . . . 87 Go on to 4.44

4.44 Should the federal government continue to own and operate the only enrichment facilities? . . . . . .88 Go on to 4.45

4.45 Should the federal government continue to buy uranium at guaranteed prices? . . . . . 89 Go on to 4.46

4.46 Should the government continue to own and lease all uranium products? . . . . . 90 Go on to 4.47

4.47 Should the government continue to underwrite the bulk of the insurance covering accidents?. . . .91 Go on to 4.48

4.48 Is the present pattern of power plant equipment manufacturers a monopoly? . . . . . 92 Go on to 4.49

4.49 Does the article discuss the issue of public vs. private ownership of generating facilities?. 93 Go on to 4.5

4.5 How is the community affected? . . . . .N Go on to 4.51

4.51 Does the article mention that there will be a rate change to pay for environmental protection or for a new plant to be built (while maintaining the level of profits)? . . . . . .94 Go on to 4.52

4.52 would an increase in the price of electricity encourage industrial users to look for ways to reduce their demand for electricity? . . 95 Go on to 4.53

4.53 How are utility taxes allocated - shared state-wide or a local windfall? . . . . . 96 Go on to 4.54

4.54 Is multiple use of the plant site (park, water, ponds, etc.) being planned? . . . . . .97 Go on to 4.55

4.55 Effect on the local economy and population . . . . . .98 Go on to 4.6

4.6 Values. . . . . N 4.61 4.8

4.61 Statement of different value systems as a basis for judging cost/benefit ratio . . . . . .99 Go on to 4.62

4.62 Description of different life styles of individuals as related to the power demands of society . . . . . .100 Go on to 5

5. This category deals with the actions taken by power companies, governments, publics, etc.

5.1 Reactor progress - Code articles here which deal with Lake Michigan reactors only . . . . . .N 5.11 5.2

5.11 Announcement made that plant will be built . . . . . .101 Go on to 5.12

5.12 Reactor progress report to public . . . . . 102 Go on to 5.13

5.13 Local puffrey (building town's ego - this is a great town with a lot in its future) . . . .103 Go on to 5.14

	5.14	Personnel - human interest story (Joe Brown completes training and goes on to better things) 104	Go on to	5.15	
	5.15	Reactor site researched (ecology, meteorology thermal, background radiation) 105	Go on to	5.2	
5.2		Reactor progress (other reactors) - code any article which would fit any of the above categories, but does not apply to the Lake Michigan reactor 106	Go on to	5.3	
5.3		Meetings being held: Government or special interest 107	Go on to	5.4	
5.4		Strikes affecting power industry 108	Go on to	5.5	
5.5		Legal complications . . . . . .N		5.51	END
	5.51	Legal suits being filed 109	Go on to	5.52	
	5.52	Legislation and Administrative orders 110	Go on to	5.53	
	5.53	Extra-legal demonstrations (the Fox) 111	Go on to	5.6	
	5.6	Publication of a report 112	END		

PERSONNEL - THE AQUATIC ENVIRONMENT AND ELECTRIC POWER PRODUCTION

Theodore Green, III, program coordinator (Physical Aspects)
P. L. Monkmeyer, associate investigator (Physical Aspects)
R. A. Ragotzkie, associate investigator (Physical Aspects)
J. A. Hoopes, associate investigator (Physical Aspects)
J. L. Clapp, associate investigator (Physical Aspects)
John Ross, principal investigator (Information Flow)
Sarah Jenkins, graduate assistant (Information Flow)

GEO-ENVIRONMENTAL AND MINERAL RESOURCES PROGRAM

Growth of this program during the past year has occurred notably in initiating co-operative minerals research with industry. While our most active work has been in the area of marine mineral placers, we have also continued analytical and interpretive study of the Green Bay manganese resource, as well as gathered critical permit and other regulatory information on mineral exploitation beneath the Great Lakes and selected coastal waters. Program personnel have aided industry and agencies in the form of organized technical meetings, informal discussions and liaison visits to discuss technical problems encountered in underwater mineral exploration. Moreover, some limited study of published and unpublished data regarding Lake Superior copper was made to provide us with background on this problem and how best to approach it when the opportunity arose. Highlights of these several program activities are presented below.

MARINE PLACER MINERALS PROJECT

J. R. Moore

To meet the Sea Grant objectives of this project, namely to provide exploration guides for use by industry, the research is divided into two assignment areas: (1) theoretical and model testing, incorporating both field and laboratory observations, and (2) study of actual marine placers over the specific gravity range of 3.0 to 20.00, including high-energy and low-energy placers, and both base and noble metals.

The first part of this research has centered on theoretical and laboratory investigations conducted on the Madison campus and on the monitoring of a placer environment field site in the vicinity of Oregon Inlet on the North Carolina coast. This particular area was selected because it readily met our research requirements for wave and current energy systems, sediment texture and composition, additional seasonal data were available, and it is located in a known heavy mineral province. Mr. Craig Everts, the Research Assistant assigned to this problem, conducted a detailed sampling program of all parts of the inlet, beach and offshore high energy complex, as well as measurements of currents, waves, and other environmental variables.

Subsequent to the field survey, and for all of last year, the laboratory phase of the research was undertaken at

Madison. Partition analyses on the heavy mineral fractions, by grain size and specific gravity, were subjected to controlled flume experiments in the Hydraulics Laboratory. These experiments have provided the critical flow velocity values so necessary for determining *how* the economically important placer minerals are dispersed, *why* the several minerals respond to the mechanical energy systems as they do, and *where* we might expect to locate similar, but richer, placer deposits. In the course of both laboratory and field work, we have generated over 30,000 data. This synthesis and interpretation of this large body of information is currently being undertaken, in part by computer analysis, in part by reference to basic transport theory, and lastly, by empirical comparisons. Working together, Mr. Everts and Professor Moore plan to present the initial report on this phase of the research in late 1971, concentrating on metal element, heavy mineral distribution and the applied theory aspects.

This phase of the placer project is not an isolated effort, for we have already begun using early results obtained from the model and theory phase in interpreting field data from elsewhere, although, it must be pointed out, we have been highly selective in doing so.

Figure 1, a chart of the total heavy mineral distribution in the Oregon Inlet field test area, based on 400 samples, is instructive. Noteworthy are the enrichment (4% to 7%) zones seaward of the inlet and behind Pea Island. The several enrichment zones charted in Figure 1 do not, as might be believed otherwise, show any pronounced, elongate accumulations, not even paralleling the beach, rather, isolated dispersal patterns are noted. Moreover, in comparing the enrichment areas with the charted values for critical bed velocity (Figure2), an antipathetic spatial distribution of maxima zones for the two are shown. While such empirical relations are useful in themselves, the most important findings are those relating the several variables and are not solely related to the Oregon Inlet study area. At this time, Mr. Everts and Professor Moore, using the combined field-laboratory-theory approach, are formulating an integrated placer origin model for application by industrial explorationists in similar energy/sedimentation regimes.

The part of our placer research described above has been discussed with industry personnel (Reynolds Metals, INCO, Inlet, Chicago Bridge, and Ore and Chemical Inc.), and their helpful comments are much appreciated.

Figure 1

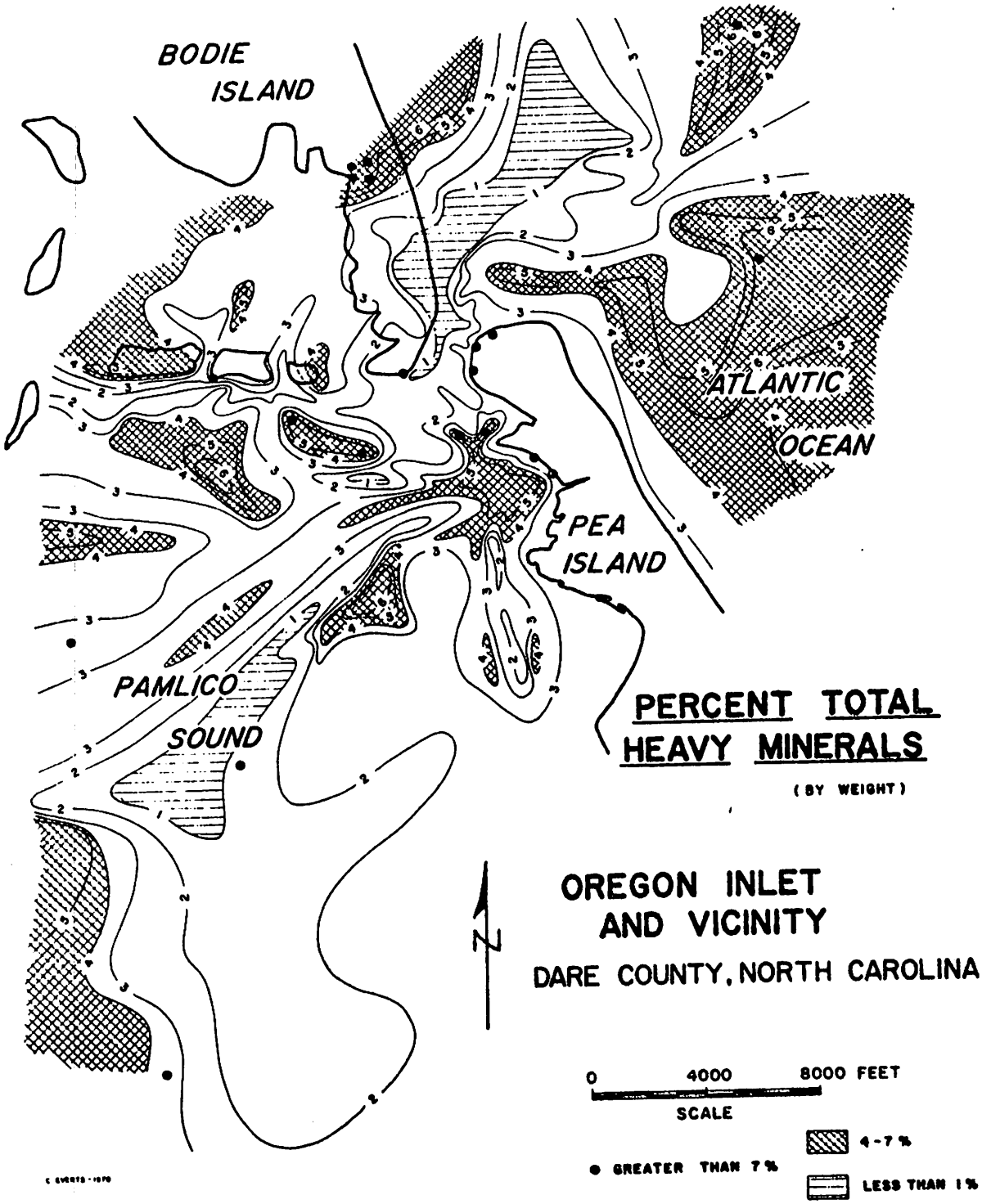


Chart of total heavy mineral distribution in North Carolina placer field test site.

Figure 2

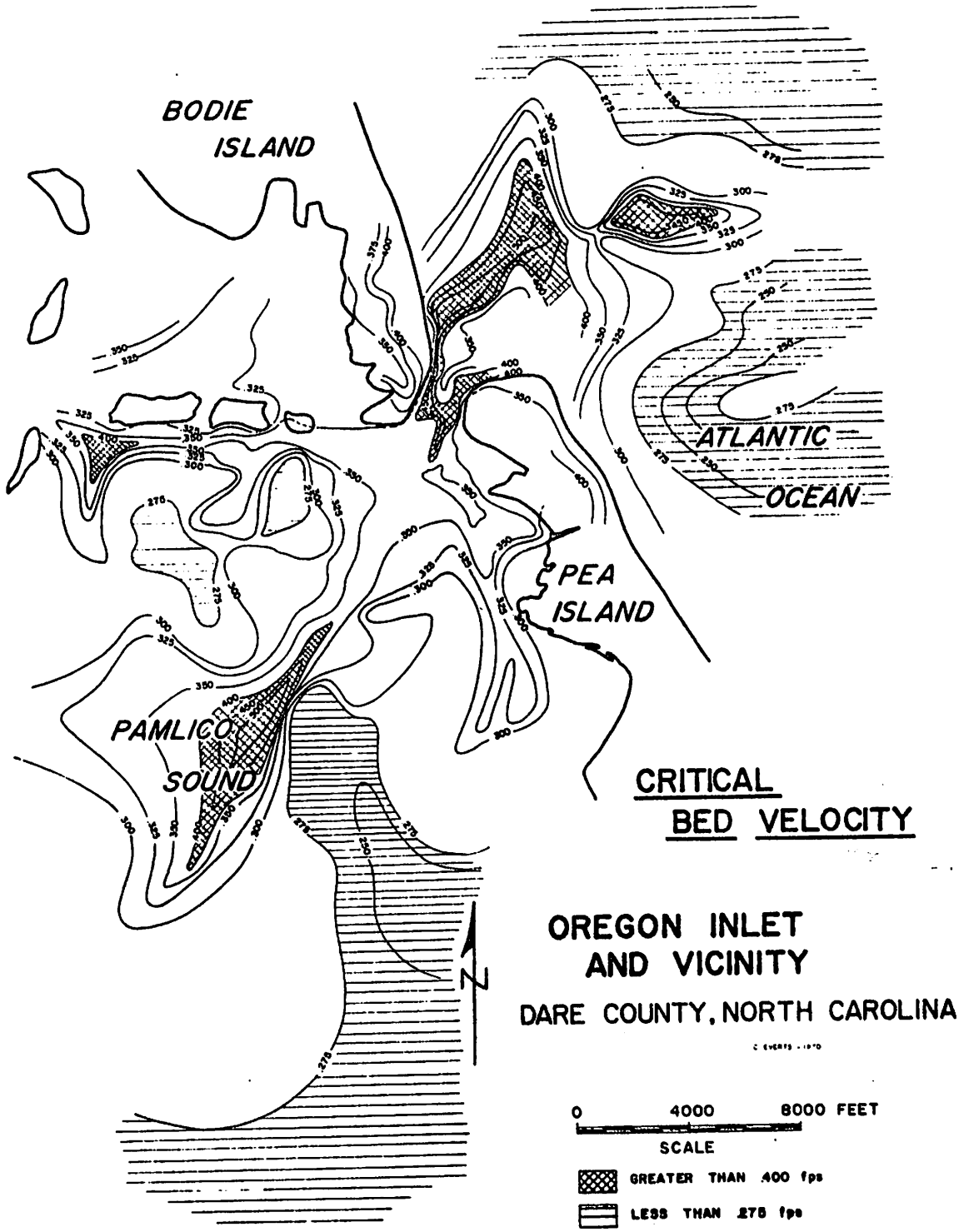


Chart of critical bed velocities for the placer test site. This is, in effect, a simplified energy map.

The second part of our placer project is directed toward detailed study of specific placers, with sufficient coverage to include examples of mineral suites in the 3.0-5.0, 5.0-10.0, and above 15.0 specific gravity range. Examples from these groupings, in order, would be rutile (titanium), cassiterite (tin), and noble metal (gold-platinum) deposits. Our purpose and objectives in this phase of the project require careful measurement of the critical depositional and environmental variables including mineral provenance, waves, currents, sediment texture, mineralogy, and spatial geometry. Moreover, we believe it important to investigate "real" placers and to do so in co-operation with ocean mineral companies. Such an approach provides for essential input from the industry, exchange of data, and usually access to cores and dredge samples. Furthermore, it is important that students have every opportunity to join the scientific and engineering teams aboard industry coring and survey vessels.

During this past year the Wisconsin team joined the Inlet Oil Corporation group operating in the inshore waters of the Bering Sea, where active coring and study of an underwater noble metals placer was being conducted (Figure 3). The management of Inlet Oil has extended many courtesies to our project personnel, including gratis berths and mess aboard ship, other company facilities, cuts of all cores, and exchange of information and data. Perhaps the most important aspect has been Inlet's concern for Sea Grant students. During the 1970 field season, Inlet employed one senior as a junior marine geologist aboard the company drilling barge. Through his employment, the student (John Murgas of Tomahawk, Wis.) gained valuable experience in placer coring, separation methods, sample analysis, and shipboard operations. Inlet supervisors were pleased enough to hire him as a full-time employee upon graduation in January, 1971, and assigned him to a new underwater minerals survey in S.E. Alaska.

In support of graduate student and project research, Inlet also permitted a Sea Grant graduate student (Wm.Rudolph) to pursue non-proprietary thesis research on a complex noble metals placer on the Bering Sea Coast.

The field study part of our placer research has benefitted much from our early initiation of co-operative research with industry. Results of the research already show that (1) important enrichment zones of very fine-grained, low-energy placer minerals are of importance in total economic considerations, (2) spatial distribution patterns are usually different for the deeper sediment horizons, requiring a careful review of the ocean/coastal history of the prospect province in order to predict economic extensions, (3) specific surface

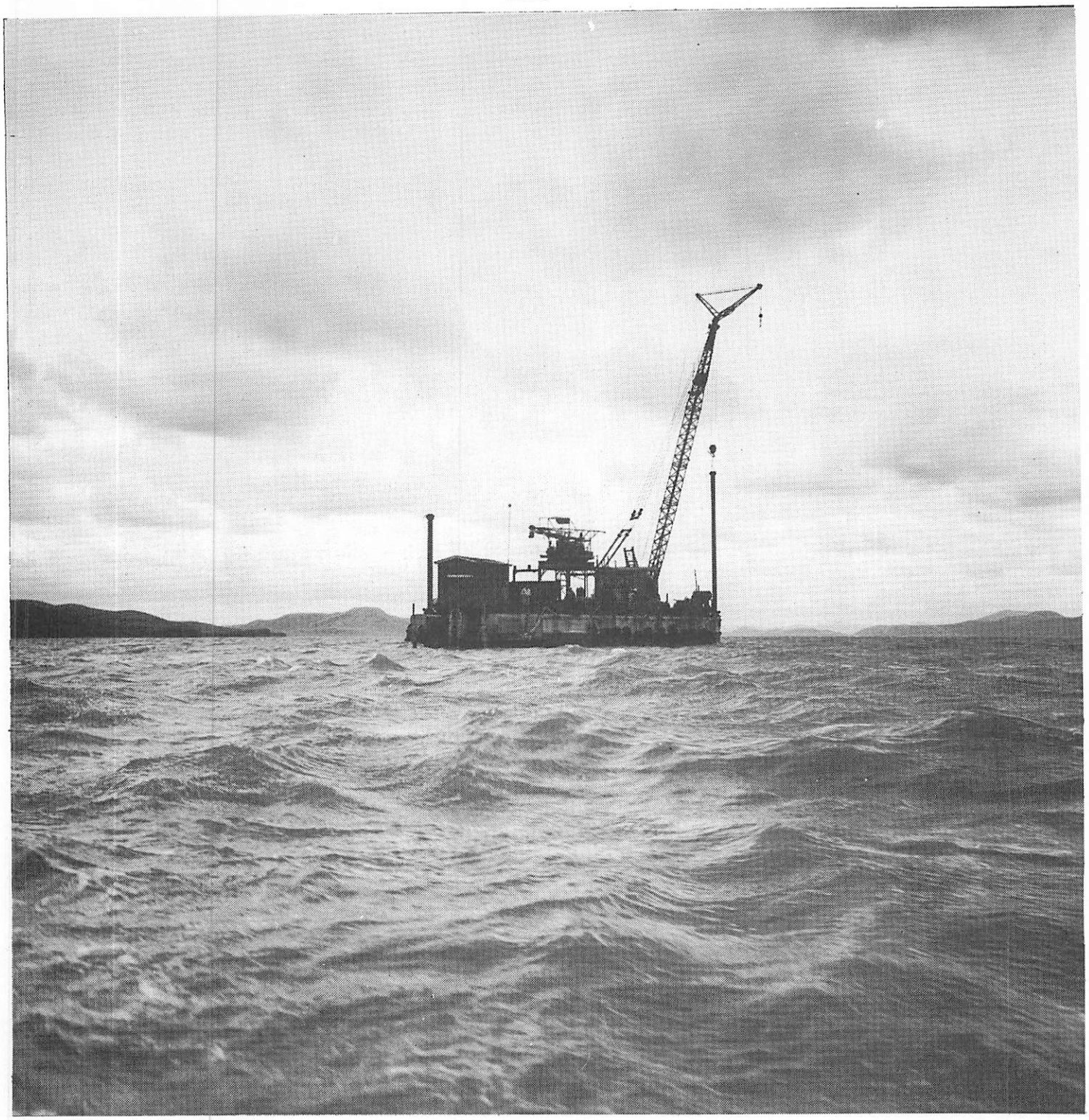


Figure 3. View of the placer coring vessel used by Inlet Oil Corporation in the Bering Sea. Wisconsin Sea Grant personnel worked aboard this ship and on the nearby shore.

area phenomena become dominant in some low-energy noble metal placers, and that (4) dredged samples do provide excellent clues to placer *province* determination, even where cores are necessary to evaluate fully the potential production at depth beneath the sea floor. Professor Moore and Mr. Rudolph will present some of their early findings in a Sea Grant Technical Report later this year.

In short, the placer project has become an increasingly important part of Wisconsin's underwater minerals program, and as such, has attracted the attention of numerous extractive companies. In addition to Inlet Oil, the following firms have expressed serious interest in our placer research: Ore and Chemical Co., Ocean Science and Engineering, Ocean Mining, Inc., Oceanonics, Inc., Chicago Bridge, Catalytic, Inc., Anoconda, International Nickel, Mobil, and others. We hope to initiate additional cooperative research, similar to our work with Inlet, with at least two of the above firms within the next twelve months.

GREEN BAY MANGANESE

J. R. Moore

This project has progressed on schedule, and we are presently completing the analytical phase of our research. With over 700 core and dredge samples to analyze, the work has essentially been confined to laboratory efforts.

Sea Grant objectives in the manganese survey remain as originally stated: (1) to chart the quality, quantity, and bay floor distribution of the Green Bay Manganese pellets in terms of local mineral resource potential, (2) to analyze and characterize the geometry and gross chemical composition of the pellets in regard to industrial beneficiation and use, (3) to determine the origin of the manganese, and (4) to determine pellet suitability in regard to non-metallurgical uses, chiefly as absorbers, catalysts, and chemical additives. We judge that these objectives will have been accomplished by the end of next year. A report, including all the data, is planned for release to the industrial community at that time. While we will continue selected non-applied research on the chemistry and petrography of the pellets beyond next year, such work will be through industrial grants. This project will have met its objectives by the end of next year, and will probably be terminated.

During the past year and a half, our research on the pellets has shown that two entirely unexpected uses of the

pellets may be forthcoming: (1) their use in catalysis and pollution control, and (2) their use as natural monitors of toxic metals in associated waters, both resulting from the high surface area nature of the pellets.

Mobil Oil has provided additional support for our manganese studies through a grant-in-aid to Professor Moore. Further, Mobil scientists have visited Madison to discuss research, to talk with students doing research, and to extend professional cooperation. We are much indebted to Mobil for their scientific interest and financial help, and particularly for their interest in the students.

Associated Program Activities

During the past year, a Sea Grant funded project assistant was assigned to gathering and reviewing information, papers, statutes, and regulatory rules on the problems of exploration, exploitation, and conservation of underwater mineral deposits. Such problems as they relate to kinds of equipment permitted, procedures for obtaining offshore prospecting permits, mining in public waters, royalties, leases, and anti-pollution measures appear to be equally important to the industrial operator, and even the public, as are the technical aspects of prospecting. We have already recognized needs for specific legislation concerning permits and pollution control which must be enacted to ensure a vigorous, yet protected, exploration/exploitation effort by the industrial sector.

Project personnel have also met with numerous industry visitors to answer questions on underwater minerals problems. This activity has not only benefitted the individual company, but it has also provided important guides to our own research planning. In public presentations, reports on our minerals program were delivered before the Sea Grant Conference in Madison, before the Sea Grant Underwater Mining Institute in Milwaukee, before smaller groups of engineers and laymen, and at the Great Lakes and Offshore Technology Conferences.

That this program should develop an interest in geo-environmental research was natural. Accordingly, such issues as ore dredging and its impact on water quality, changes in natural sediment dispersal by construction and interrelations between sediment, beach, bottom, and man's use of the fragile, delicately balanced sediment/water interface, warrant early and effective attention. Our first step in this critically important field--a study of sediment changes around power plants--has already been planned and is proposed for Sea Grant support beginning later this year. We are also studying the problems encountered in coastal

mining, and we expect to propose research on this problem shortly, and to seek industry support in doing so.

During the year, using non-Sea Grant support, we continued to compile data, logs, profiles, and published information concerning the potential copper deposits beneath Lake Superior. Our efforts have been rewarded in that Ocean Science and Engineering, Inc. has offered the Wisconsin Sea Grant group the opportunity to cooperate in the copper-test coring program off the Keweenaw Peninsula later this year, using the new coring ship SEAPROBE. (See Minerals Section, New Proposals)

In this brief review of our year's activities, we have tried to report the research and operational highlights of our geo-environmental and minerals program. Of equal importance, has been the training and specialized education which the several students in the program have acquired. Through Sea Grant support, we have already provided one junior professional to the ocean minerals business, and others are in preparation. Moreover, we have, through Sea Grant supported research, established Wisconsin as a center for education in the search for, and use of, underwater mineral resources, which is a national asset in itself.

MINERALS PERSONNEL

J. R. Moore, program coordinator (placers, Green Bay manganese)
Anne Hall, graduate assistant (manganese)
Craig Everts, graduate assistant (placers)
William Rudolph, graduate assistant (placers)
Gail M. Habermann, project assistant (statute review)

MANGANESE-RICH PELLETS IN GREEN BAY, AN EXPLOITABLE MINERAL RESOURCE OF THE GREAT LAKES. J. Robert Moore, University of Wisconsin. Offshore Technology Conference, Paper number OTC 1143. (1970).

ABSTRACT

Based on the detailed study of 600 grab samples and cores collected in Green Bay, an arm of Lake Michigan, the presence of a major underwater mineral resource of manganese has been established. The manganese occurs combined with iron in pellets, the majority of which range in size from 0.1 inch to 0.6 inch in diameter. While in some areas as much as 30% of the very fine sand fraction is composed of micro-nodules, the very small sizes are usually present in only limited amounts. Manganese content of the pellets, as determined by neutron activation, varies between 1.0% and 25%, with the average for most samples being slightly over 10%. The major areas of Mn-rich pellets are in the central part of Green Bay, principally offshore from Marinette, Wisconsin, and in the Sturgeon Bay area. Over 200 square miles of bay bottom with abundant manganese pellets have been charted in detail, and current efforts are being made to test the depth of mineralization by core drilling. While over most of the area the pellets are devoid of other metals in other than trace amounts, in two areas totaling some 25 square miles, the copper content of the pellets is noticeable high, ranging between 0.5 and 2.0% by weight. The *in situ* genesis of the manganese pellets is being studied using trace element, petrographic, and electron probe methods, as well as certain water chemistry data. Conclusions at this time suggest that a major mineral resource of manganese, and to a lesser extent copper, is available in exploitable amounts beneath Green Bay, a feature further enhanced by shallow dredging depths, easy separation, local ore loading docks, and nearby markets.

MANGANESE PELLETS IN GREEN BAY, WISCONSIN - THEIR GEOMETRY, GROSS COMPOSITION AND DISTRIBUTION. J. Robert Moore, Marine Research Laboratory, University of Wisconsin, Madison, Wisconsin. Presented at the IAGLR Conf., Buffalo, N.Y., Apr. 1970.

ABSTRACT

Research on over 600 grab samples and cores collected from the bottom of Green Bay, Wisconsin, has established that a major mineral resource of manganese, and to a lesser extent, copper, is present there. Neutron activation analyses show manganese to be present in the pellets ranging from 1% to 25%, with an average of slightly over 10%. Pellet Copper values for two areas in mid-bay range between 0.5% and 2.0%. Data for pellet texture, gross element content, pellet distribution and electron probe measurements (on single pellets) are presented in the form of facies maps and are discussed in relation to environmental variables. This report is based on field and laboratory work supported by the Sea Grant Program to the National Science Foundation.

OCEAN MECHANICS PROGRAM

The Ocean Mechanics Program, over the past year, has been substantially re-oriented. Eight new projects (Sec. 2) have been proposed, among them the hoped-for corrosion study. However, research from the several projects already in progress has brought interesting results. Those findings are presented on the following pages.

A number of these projects have reached a termination point. Those that remain will blend well with the newly proposed program, presenting a more cohesive approach to the management of the marine environment and undersea operations. Combined with the courses and educational aims of the Ocean Engineering M.S., this subprogram has been of great value in enabling students to participate in ocean research projects and to contribute to the progress of the program.

VIBRATORY CORER

Ralph J. Harker

This project is developing equipment to obtain undisturbed vertical cores in marine sediments. During the past year, shipboard tests were conducted on board the USCGC MESQUITE in July and August, 1970. The effort to satisfy an urgent need for a device to retrieve relatively undeformed bottom samples at depth, utilizes a torsional vibration of a hollow square tube to obtain penetration. The torsional vibratory approach is apparently unique, and offers a number of theoretical advantages over other methods, such as rotational drilling or vertical vibration.

A complete coring system was designed and built in the Department of Mechanical Engineering, including a support structure for bottom standing, coring tubes, retainers, core liners, exciter and oil hydraulic power supply. The complete rig, as swung from the deck, weighed approximately 1500 lbs, incorporated a 20 ft stroke, applied 600 lb. preload to the tube, and could be operated from 0-3000 C.P.M. Angular amplitude was two to three degrees. Maximum operating depth, as limited by the hydraulic lines available, was about 120 ft.

Operations in Green Bay extended from July 27 to August 7, with sampling at thirteen positions, generally north of Sturgeon Bay, including one in Lake Michigan. A total of 25 probes were attempted in water depths ranging from 32 to 96 ft.

The core retrieval experience varied considerably with the nature of the bottom, which included relatively hard, dry clay, sand, and mud. The sand proved difficult to penetrate and to retain, with a maximum penetration of about 4 ft. The maximum core was inclay, with several feet of mud overlay. Here, a penetration of 15 ft. yielded a core of 11 ft. Several sub-surface layers were identified for Professor Robert Meyer. (See Geo-environmental and Mineral Program and Green Bay Research Program for related topics.)

Performance of the entire system and of the hydraulic drive were trouble-free, and no mechanical failures occurred. Crane handling was no problem, and the horizontal attitude of the tube and rig on the deck was especially convenient for sample removal.

A Ph.D. candidate in Mechanical Engineering, Rohit M. Shah, participated in the shipboard operation for the second season. He is minoring in Ocean Engineering, (See Special Education Programs) and has been intimately involved in the design, construction, and theoretical analysis of the vibratory coring equipment. In addition to his marine-related experience, he has had an exceptional opportunity to become familiar with the engineering problems relating to mechanical equipment development.

The program will be continued until January 1972, with a study of the coring parameters in an attempt to optimize results. Vertical preload on the tube is believed to be a particularly critical variable in this vibratory system, and will be controlled using a hydraulic cylinder for vertical actuation of the probe.

STUDIES OF TEMPERATURE DISTRIBUTIONS AND INDUCED CIRCULATION IN LAKES

John A. Hoopes

The two basic objectives of this project have been: to develop models for the steady and unsteady, vertical and horizontal temperature and circulation pattern in Lake Superior, subject to prescribed wind conditions, and to test these results in a rotating model of the lake and with field observations; and (2) to determine the criteria for breaking up thermal stratification in a lake or impoundment through the introduction of heated water at or near the bottom of a lake and to test such criteria in a model and an actual lake or impoundment.

To attain the first objective numerical calculations of the steady wind-driven circulation in Lake Superior, including the vertical and horizontal geometry, is continuing. The computer program, which has been developed, had to be rewritten due to a problem encountered with the iterative numerical scheme. The new program is currently being tested in a circular basin with a parabolic depth distribution for which the analytical solution is known. The determination of the free modes of lake oscillation and the general two-dimensional unsteady circulation calculations are in progress. The free mode calculation method also had to be revised, for it required the inversion of a matrix which was too large for the computer. Currently a straightforward trial and error scheme for computing the free modes is being carried out.

In the laboratory model measurements, work is under way on seiches. As this work began, considerable vibrations in the model were noted. In order to reduce these vibrations and thereby improve the signal-to-noise ratio, the model has been resupported with respect to the rotating table and the rotating table has been resupported with respect to the floor. Measurements will be under way this month on the lake oscillations. From the earlier work, we found that the fundamental seiche period is 8.34 hours (prototype time) with a damping factor of 0.018. A simple harmonic analysis method has been developed to analyze the experimental results for the various modes of lake oscillation. During the remainder of 1970, numerical calculations of the steady and unsteady wind-driven circulation and observations of the seiche measurements for both homogeneous and two-layer conditions as well as wind-driven current patterns in the laboratory model will be carried out.

In the second objective, work on a one-dimensional model of the natural vertical temperature distribution in a lake is in progress. This model is based on the thermal energy equation in which an apparent diffusion coefficient has been introduced to account for the combined effects of turbulent diffusion and vertical convection ("penetrative convection"). From observations of the temperature distribution in several lakes, a correlation has been established for the apparent diffusion coefficient with temperature. Using this correlation, a numerical solution of the one-dimensional thermal energy equation is in progress. In the experiments on the overturning of stratified lakes and impoundments by the introduction of a warm water discharge at or near the bottom of such impoundment, the experiments in a 1 1/2 ft. diameter tank have been completed. Based on these experiments, a correlation has been obtained between the mixing time (i.e., the time to mix the stratified tank to a uniform temperature) and the following variables:

1. discharge velocity
2. temperature difference between the discharge and the bottom layer of the tank;
3. the distance between the point of discharge and the thermocline;
4. the temperature difference between the top and bottom of the tank;
5. the thickness of the top layer in the tank;
6. the diameter of the discharge; and
7. wind speed over the tank.

To answer the question of whether this correlation is applicable to lakes or impoundments having much larger lateral dimensions than the model tank, additional experiments will be carried out in a 4'x4'x4' tank and later in a 10 to 12 ft. diameter tank. During the remainder of 1970, the work on the thermocline model will be completed along with additional experimental observations of the thermally induced overturning in the 4'x4'x4' tank.

EXPLORATION AND THEORETICAL STUDY OF CIRCULATION IN LARGE BASINS, GULFS AND ESTUARIES WITH PARTICULAR REFERENCE TO GREEN BAY

C. H. Mortimer, F. R. S.
N. S. Heaps

This second report also has studied aspects of circulation in Green Bay.

Characteristics of the Models

To recapitulate (see last year's report), the principal assumptions, adopted for the construction of the mathematical models of water circulation in Green Bay, were:

(a) the water is unstratified and pressure is solely governed by hydrostatics;

(b) the following factors may be neglected--the vertical component of motion, friction in horizontal planes, the time-generating forces;

(c) with motion essentially horizontal, the equations of motion (appropriately modified and including terms for friction and for the earth's rotation) are integrated from surface to bottom, at which a quadratic law of friction is in force;

(d) actual basin topography is replaced by an array of compartments or "boxes", square in plan each with a flat bottom of depth corresponding to the local mean depth on the hydrographic chart.

Three models have been constructed and operated to date. Work on model I, with box area 2x2 km, reported on in 1968, was discontinued in 1970, largely because of computer expense and because it proved possible to obtain essentially equivalent results with models of box area 4x4 km. Of these, model II imposes the boundary condition of elevation always zero (i.e., a node) at the mouth of the Bay. Model IV imposes no such condition and includes the northern third of the Lake Michigan basin. This has proven necessary in order to describe the free responses of the Bay, which is found to be in co-oscillation with the main basin.

Model Responses to Wind Stress

The main work during the year has been to determine the response of the Bay to uniform wind fields, over the Bay alone and over the Bay plus the Lake portion. Steady (model) wind was applied for forty hours, starting from equilibrium (level surface, no flow) in one case with a SW wind blowing along the axis of the Bay and, in another case from the opposite direction. The iteration interval was 45 sec; surface elevations and the components of water transport were recorded for each "box" every 20 minutes; and the distribution of transport vectors has been plotted for every hour. This gives, we believe, a realistic picture of the large-scale features of circulation and oscillations (seiche motion) in the unstratified Bay: and the results show excellent agreement with observed oscillatory response as shown by spectra of water level fluctuations at the head of the Bay (City of Green Bay level recorder). Paper read at the 13th Conference on Great Lakes Research, Buffalo, spring 1970.

Data Collected for Model Verification

But, as outlined in last year's report, an important aspect of the study--and one in which its practical use can, we hope, be demonstrated--is a more complete verification through the use of actual winds and of observed variations in water level at the Bay's mouth as "forcing" inputs to the model. The responses of the model to these "actual" forcing functions can be displayed at any one of the 4x4 km "boxes" and in particular at those corresponding to the positions of continuously recording instruments (level gauges and current meters), with the records of which the model response can be directly compared. To this end, the water level recorder at Menominee, Michigan, has been continuously maintained (year-round), the water level recorder at Plum Island has been maintained from 8 July to 3 December, and copies of 5-min. level readings from the U.S. Lake Survey recorder at Green Bay, Wisconsin, have been obtained on IBM cards. Hourly readings of wind speed and direction have been obtained from Green Bay, Wisconsin, and Escanaba, Michigan airports as well as six-hourly readings (during the manned season only) made by the U.S. Coast Guard on Plum Island. All this data has been digitized and plotted. With the help of U.S.C.G. MESQUITE, trials of setting and recovery of current meters and a thermistor chain have been carried out at stations in the Death's Door Passage (main entrance channel to the Bay). Fluctuations in current and water temperature at one station have been plotted, but the records for the summer of 1970 have yet to be analyzed.

Forward Look

The main effort during 1971 will be the application of the above data assemblage to the verification of the model. The results will then determine the deployment of instruments at key locations during the measurement program for the summer.

References

1. N.S. Heaps, C.H. Mortimer and E. J. Fee, Development and Verification of a Numerical Model of Water Motion in Green Bay, Lake Michigan. Proceedings of the 13th Conference Great Lakes Research, Toronto, 1970.

GRAVITY WAVES

P. L. Monkmeyer, T. Green, W. E. Saul

This project contains three aspects, each of which are discussed separately below:

Non-linear Gravity Waves (P.L. Monkmeyer)

During the summer of 1970, the basic equations underlying a new theory for non-linear gravity waves were derived. These equations cover the full range of gravity waves, including Airy waves, Stokes waves, cnoidal waves and the solitary wave. Subsequently, a computer program was written to calculate the coefficients which are necessary for the practical application of the theory. The program was run on the University of Wisconsin's Univac 1108 computer, and appropriate coefficients for several representative waves (with specified wave height, wave length and water depth) were obtained.

A paper was then prepared for presentation at the Twelfth International Coastal Engineering Conference held in Washington, D.C. in the fall of 1970. The paper entitled "A Higher Order Theory for Gravity Waves" includes the basic theory and some of the initial coefficient data obtained on the computer. It is expected that the paper will be published as a part of the conference proceedings early in 1971.

Wave Damping (T. Green)

Wave oscillations in harbors are one of the main causes of ship damage. A study of damping of harbor oscillations has begun. A 3 1/2' by 12' wave tank, 1' deep, has been constructed, and fitted with a paddle wavemaker. Heated nichrome wires under a 1/2" thick slab of aluminum provide a uniform heat source over the entire tank bottom.

Calibration of the characteristics of the thermally induced turbulent convection in the tank is under way (the Rayleigh number is over 10^8). The temperature oscillations are greatest near the top and bottom, as would be expected from previous experimental studies. The maximum oscillations at a fixed point are over 1°C, with apparent (visual) periods of about 10 to 15 seconds. Tests are being conducted of the amount of insulation needed to greatly reduce the heat flux through the side walls.

Preliminary calculations and experiments have been carried out on the effect of the turbulence on oscillations. The effect seems small, for the Rayleigh numbers we can achieve (small compared to those in nature). However, we believe it to be measurable, and are now refining our measurement techniques to do this.

The analyses of the scattering effects of the turbulence is continuing.

Wave Forces on Piles (P. L. Monkmeyer and W. E. Saul)

During 1970, the theory developed by MacCamy and Fuchs for wave forces on a single pile, in the range where inertial forces dominate, was extended to include a row of piles parallel to the wave front. The theory for wave pressures was sufficiently complicated to require a computer solution. Interpretation of this solution is under way. Furthermore, a computer routine to integrate the pressures is being added to the general program, so that the total force on the pile can be determined.

Considerable progress was also made in the experimental phase of the program. Further efforts to reduce unwanted wave reflections in the flume were completed. Pressure data was then collected and analyzed preparatory to a comparison with the theoretical results.

With the addition of a new research assistant, who has a strong interest in structural dynamics, a theoretical study has been initiated to consider flexible piles.

UNDERWATER BODY DYNAMICS

Ali A. Seireg

The Underwater Body Dynamics project has been divided into two sections, theoretical and experimental work.

Theoretical Work

The mathematical model for analysis of supportive force on the human body during underwater activities (Ref. 1) was extended for the unanchored case. The findings were reported in a paper entitled "A Mathematical Model for Swimming Mechanics", which was presented in September 1970 at the First International Conference on Biomechanics in Swimming (Ref. 2). The study is to our knowledge the first comprehensive mathematical analysis on the subject.

Experimental Work

Scale model investigation of the drag forces on bodies with different configuration has been completed for the case of rotary motion. A special experimental set-up has been developed to accomplish this. Work is now in progress for the analysis of the drag forces under oscillatory motions of different forms. This information is necessary to design optimal assistive devices to enable man to move in control underwater.

References

1. A. Seireg, A. Baz and D. Patel, "Supportive Forces on the Human Body During Underwater Activities", ASME paper no. (70-BHF-6) also Journal of Biomechanics, Vol. 3, 1970.

2. "A Mathematical Model for Swimming Mechanics", to be published in the Proceedings of the First International Conference on Biomechanics in Swimming, Brussells, September 14-16, 1970.

PERSONNEL-OCEAN MECHANICS

Ralph J. Harker, Project Investigator (corer)
Rohit M. Shah, grad. assist. (corer)
John A. Hoopes, Project Investigator (Circulation Studies)
C. H. Mortimer, Project Investigator (Circulation Studies)
N. S. Heaps, Project Investigator (Circulation Studies)
E. J. Fee, NSF Predoctoral Fellow (Circulation Studies)
K. Sato, Grad. fellow (Circulation Studies)
A. Seireg, Project Investigator (Body Dynamics)
A. Baz, grad. assist. (Body Dynamics)
P. L. Monkmeyer, Project Investigator (Gravity Waves)
T. Green, program coordinator (Gravity Waves)
William E. Saul, Project Investigator (Gravity Waves)
Bradford H. Spring, grad. assist. (waves)
Dong Hee Kim, grad. assist. (waves)
San Lien, grad. assist. (Circulation Studies)
Kenneth Henkel, grad. assist. (Lake temperature distribution)

DEVELOPMENT AND VERIFICATION OF A NUMERICAL MODEL OF WATER MOTION IN GREEN BAY, LAKE MICHIGAN. N.S. Heaps, C.H. Mortimer E. J. Fee, Center for Great Lakes Studies, University of Wisconsin, Milwaukee, Wisconsin.

ABSTRACT

Based on techniques which he developed for the study of tidal and storm surge motions in marine coastal areas, Heaps devised numerical models fitted to the topography of the northern part of Lake Michigan including Green Bay. The resolution of one of these models (4 km mesh spacing) permits a fairly detailed simulation of the response of an unstratified Green Bay-Lake Michigan system to hypothetical and actual wind stresses and to forced (sinusoidal) variation of water level at the mouth of the Bay.

Model responses, illustrated as variations in current pattern and surface elevation, are compared with observed responses of the Bay to actual wind stresses and to forcing oscillations generated in the main Lake Michigan basin.

A HIGHER ORDER THEORY FOR SYMMETRICAL GRAVITY WAVES. Peter L. Monkmeyer, University of Wisconsin, Madison, Wisconsin.

ABSTRACT

A higher order theory is presented for symmetrical, non-linear gravity waves. As a consequence of the generality employed, the theory includes the full range of possible wave lengths, water depths and wave heights that may be encountered, and brings them into one unified formulation. Thus, the theory encompasses both linear and non-linear waves, including Airy waves, Stokes waves, cnoidal waves and the solitary wave.

Based on the work of Nekrasov, a complex potential in the form of an infinite series is developed to describe the flow field. The potential satisfied the bottom (horizontal) condition as well as the kinematic surface condition exactly. Furthermore, the dynamic surface condition is satisfied by numerical calculation of the series coefficients which appear in the complex potential. The calculation of these coefficients is accomplished by solving a set of non-linear algebraic equations, with the aid of a Newton-Raphson iteration procedure and matrix inversion.

Coefficients of the complex potential have been obtained for a fifth order analysis and preliminary results are presented in tabular form. A brief discussion of the characteristics of the waves, including wave speed, wave shape and the height of the highest possible wave follows.

INVESTIGATIONS OF THE CIRCULATION IN LAKE SUPERIOR. San-Lang Lien and John A. Hoopes, University of Wisconsin, Madison, Wisconsin.

ABSTRACT

The steady, wind-driven circulation in Lake Superior has been investigated using a rotating vertically-distorted, laboratory model and numerical solutions of the equations of fluid motion. In experiments with the model, surface and subsurface currents, streamline patterns, and water surface displacements have been measured for homogeneous lake conditions subject to various wind stress distributions (such as uniform and constant curl). The predominant features of the circulation patterns are: (1) strong, narrow, counterclockwise surface currents around the Lake perimeter; (2) slow, counterclockwise gyres in the eastern and western Lake basins; and (3) slow, Ekman-type subsurface currents.

Numerical computations of the free surface displacements and the vertically-integrated volume transports have been made using a finite difference form of the steady-state, two-dimensional equations of motion. These solutions, which take into account the variable horizontal and vertical geometry of the Lake, were obtained using a linearized, bottom friction term and have been carried out for various surface wind stress distributions on a 3.5 mi and a 14 mi grid. The results of these numerical computations are in agreement with experimental observations in the laboratory model and with field observations in the Lake.

A MATHEMATICAL MODEL FOR SWIMMING MECHANICS. A. Seireg, and A. Baz, University of Wisconsin, Madison, Wisconsin. Presented at the First International Conference on Biomechanics in Swimming, Brussells, September 14-16, 1970.

ABSTRACT

This paper presents a simplified mathematical model for analysis of swimming mechanics. The effect of the motions of upper and lower extremities on the swimming speed is discussed. The model is based on results from experimental data obtained by the authors from simulated tests. The model illustrates the influence of the main parameters affecting swimming.

SUPPORTIVE FORCES ON THE HUMAN BODY DURING UNDERWATER ACTIVITIES. A. Seireg, A. Baz and D. Patel, University of Wisconsin, Madison, Wisconsin. ASME paper No. (70-BHF-6) also Journal of Biomechanics, Vol. 3, 1970.

ABSTRACT

This study deals with the evaluation of the magnitude of the supportive forces and moments resulting from human activities in an underwater environment. A platform capable of monitoring all components of supporting forces and moments has been used in a water tank. Results from similar activities in air and water are presented. A mathematical model has been developed to verify the experimental results. The model can be utilized for the analysis of human body dynamics underwater.

SOCIAL AND ECONOMIC ASPECTS OF THE GREAT LAKES PROGRAM

We make a bewildering variety of demands on the water resources we find available. Our growing awareness of environmental pollution has made us realize that the impact of our technological demands threaten the continued existence, in any useful form, of the water resources we are exploiting.

At the same time, as the scope and impact of these demands and the technology itself continue to expand, the magnitude of the problem rises. It may be, as some have suggested, that man and his environment may not be able to coexist. It is in an attempt to understand and somehow manage this complex interrelationship that the Socio-Economic Program of the Wisconsin Sea Grant Program supports a series of projects which take somewhat different approaches to the same basic problem.

The work of Eric Schenker, Harry Brockel and G.M. Karadi approach the problem of commercial demand for the development and use of internal water ways. Such demand and use continues to increase even as pollution problems worsen. Elizabeth David and Delbert Smith address the problem through public response and legal recourse. William Lord and his colleagues address the water use problem in terms of direct economic exploitation in an attempt to understand the present situation and the future projections. Their integrated study is a first step to understanding the complex interrelationships between direct and indirect economic effects and the legal framework which constrains them. In a larger sense Richard Bilder, through a case study of specific new international pollution laws, tries to make explicit the present trend in abridging international understandings in favor of unilateral national activity. He clearly displays the dilemma between the desire to protect the environment of a specific nation and the erosion of international mechanisms that may thereby ensue.

Concern about water quality is intense, but frequently we must choose between experts of differing opinions in the formulation of his understanding. Elizabeth David is attempting, through the medium of survev research , to understand what aspects of water quality the public perceives and perhaps more importantly, what perceptions of water quality cause them to change their behavior for water-based activity. To the extent that these perceptions and reactions to water quality do not correspond to the technically defined water quality standards, a feeling of frustration is an inevitable result. Parallel and mutually supporting research by Ditton and Goodale (Green Bay Program) supplement this line of activity. The recently

completed work of William Strang (see abstracts, and Technical Report #204 and 205) further elaborates this line of investigation. A standard recourse for dissatisfaction by the public is in the courts. Therefore the next logical step in approaching water quality from a public point of view is to understand exactly how the legal system regards evidence regarding water quality and objections to conditions that the public may perceive as degraded. Delbert Smith is attempting this through examination of the literature and current litigation.

Of the commercial activities taking place in the water in the Great Lakes, commercial fishing is one of considerable historical importance. Decline in fisheries activities in recent years, for a variety of reasons, have raised doubts about what the future course should be for fisheries management. William Lord and his colleagues are attempting to understand for a delimited area what the current impact of fisheries both commercial and sport are upon the economy. The outcome of this program is expected to be a model for identifying economic and environmental impact of alternative fisheries management options. Such a model could be useful for the entire Great Lakes region in determining the economic and human values and hence the priorities to be placed on competing uses.

Commercial shipping is a much larger use of the Great Lakes in dollar terms. Proposals to extend the St. Lawrence Seaway shipping season have been made periodically since its inception. As yet there exists no clear-cut economic analysis of the benefits and costs accruing from such a decision, Eric Schenker is attempting to provide such an analysis and has completed a preliminary study. Such a study goes beyond the specific issue of the length of the shipping season to include the question of trends in shipping practices, port facilities and containerization.

To continue even the present level of commercial shipping, harbors and channels must still be dredged and we have come recently to understand the threat to the environment that might be inherent in the disposal of dredging spoils. Current conflict over the use to be made of dredge spoils has resulted in the suspension of open lake dumping which is currently impeding harbor dredging. Harry Brockel is studying the techniques of disposal presently in use with a special eye to the alternative to open lake dumping most commonly used, that of filling lands along the lake shores. Physical processes themselves in such filled lands are not well understood and G. M. Karadi and his colleagues are attempting to understand the physical properties and time dependence of present filling procedures using dredging spoils.

It is difficult as yet to provide a complete interrelated picture of all these activities yet these beginnings encourage us to believe that both an understanding of our problems and a sensible approach to the future is possible. In the accounts that follow brief statements of the current progress of these projects is given. The difficulties should not be underemphasized, but we believe the conceptual tools are at hand and find the results thusfar far more satisfying than the strident public allegations that we are ruining both the environment and the economy with little thought for the future.

EVIDENTIARY STANDING OF WATER QUALITY CRITERIA

Delbert D. Smith

The aim of this project is to understand the current standing of water quality evidence and criteria within the legal system as practiced in the Great Lakes states. This knowledge is a needed and an important link between the current studies of public attitude and public perception of water quality and the legal relief available to private citizens. Although a literature survey has been undertaken, the project starting date is April 1st, 1971, with a completion date of August, 1971. Assisted by a graduate student, the investigator will examine evidentiary precedents and discuss the relevance of currently acceptable evidence to both technical water quality standards and public perception of water quality standards.

INTERNATIONAL LEGAL ASPECTS OF WATER POLLUTION PROBLEMS: BILATERAL EXPERIENCE

Richard B. Bilder

The Canadian Arctic Waters Pollution Prevention Act is one of the first national acts on pollution of arctic waters and poses a whole new series of questions for both arctic ecology and international law of the sea. It may also provide the first example of the changing relationships implied by pollution problems in non-arctic ocean waters and the Great Lakes for the U.S. and Canada. This six month program is now essentially complete and the results have been published in the Michigan Law Review, November 1970 as The Canadian Arctic Waters Pollution Prevention Act: New Stresses on the Law of the Sea.

The act may have been precipitated by the journey of the ship MANHATTAN through the Northwest Passage as a giant oil tanker and the possible first step in a major oil transportation

route from the newly developing fields on the north slope of Alaska. In any case, the act is interesting in that it asserts national jurisdiction for a limited but extendable collection of purposes to a distance 100 miles seaward from the nearest Canadian line. For some purposes the jurisdiction is asserted over "arctic waters" beyond the 100 mile limit. Essentially jurisdiction is asserted over all waters within the outer fringe of the Canadian archipelago and for a hundred miles beyond. It is not quite clear what areas are included in arctic waters, and whether the west coast of Canada may be involved seasonally or otherwise. Nor is it clear how far down the east coast of Canada such an act would be interpreted to extend.

The United States promptly replied to Canada denying the extension of jurisdiction and proposing resolution by means of bilateral negotiation or by submitting the case to the international court of justice. Canada appears to be relying on extension of the "contiguous zone" in international law beyond the interpretations normally placed on it in the 1958 Geneva Convention (to which Canada is not a party) and suggests that they not only have the right to extend the jurisdiction in this way but that it is not an appropriate case for the international court of justice.

Considering past relations between the U.S. and Canada and their amicable history it is somewhat surprising that the Canadian government chose to act unilaterally rather than await international action. The United States has since called for an international conference on the subject but Canada did not wait with the enactment of the legislation until such a conference was held. A new pressure, similar in import to the actions of Peru, Chile and others in extending their national jurisdictions into the sea, has again illustrated our inability to engage in meaningful international negotiations to obtain an international law for waters near national boundaries or the seabed beneath. It is especially noteworthy that this was done with extensive citations of American practice in extending its jurisdictions under the Truman continental shelf and fisheries proclamations, customs enforcement practices, and air defense identification zones as well as other special jurisdictions established for atomic tests and the Cuban missle quarantine.

The crux of the Canadian position may be found in the statement of Prime Minister Pierre Trudeau that "we have extended our sovereignty; we are prepared to go to court. On the other hand, where we are only attempting to control pollution, we will not go to court until such time as the law catches up with technology". Some tentative conclusions might be ventured although it is too early to pass final judgement on the Canadian action. First, the act appears to be, on its face, inconsistent with existing international law of the sea.

Canada's decision to act unilaterally does not offer much hope for orderly development of international law through through multilateral negotiotion. Finally, the precedents established by the act are clearly capable of widespread abuse by others, perhaps less responsible states, with potentially harmful consequences for traditional principles of freedom of the sea.

The Pollution Prevention Act weakens international law and is another significant step in the process of erosion of the principle of freedom of the seas - a process that has been continuing since 1945. The implications for east coast and west coast arctic waters that are normally not thought of as arctic remain to be resolved through application of the act and the implication for future activities negotiation within the Great Lakes have not yet been discussed.

PUBLIC POLICIES FOR FISHERIES MANAGEMENT IN LAKE SUPERIOR

William B. Lord

The overall objective of the research program is to develop a management information system which will facilitate the policy formulation process regarding the Lake Superior lake trout fishery.

Work currently in progress includes:

1) Determination of the industry supply function for the commercial fishing industry (Wisconsin portion of Lake Superior)
2) Development of a conceptual model for identifying environmental and economic impacts.

Procedures

A preliminary survey of the Wisconsin portion of the Lake Superior commercial fishing industry was undertaken. Also, a review of approaches to estimating firm cost curves and industry supply curves was completed. Finally, a literature review was conducted, with the aim of identifying previous empirical work which might be applicable to this fishery. Both the statistical approach to supply curve estimation and the production function approach were rejected for this study because of data deficiencies and the questionable applicability of the pre-lamprey data available. An engineering-economic approach is now being taken, using a linear programming model.

Research begun earlier on the development of a general format for information display for environmental decision-making continued during this period. The aim is to analyze the information needs of the decision process, particularly as it relates to identifying and resolving resource use conflicts, present and future. Also, work continues on practical and inexpensive ways of estimating location-specific and group-specific economic impacts, both direct and indirect, of alternative policy measures.

Preliminary Findings

The Wisconsin portion of the Lake Superior commercial fishing industry consists of a very few full-time firms and a marginal fringe of small, part-time operators. Technological change has been slow and most capital equipment in use is old and inefficient. Past and present regulatory policies have discouraged the entry of new firms and capital investment by existing firms.

A preliminary version of an information display system has been developed, although more work is needed before it can be considered adequate. This system, and the considerations supporting it, are set forth in a paper prepared by W. B. Lord for delivery at the University of Florida on March 19, 1971. A copy of that paper will be available shortly.

EXTENDING THE ST. LAWRENCE SEAWAY NAVIGATION SYSTEM: THE BENEFIT-COST APPROACH

Eric Schenker

The first phase of this study is concentrating on the benefit side of the benefit-cost approach. Considerable data has been gathered on all cargo moving in and out of the Great Lakes/St. Lawrence Seaway area, all of the ports, and all of the applicable ship types. From the preliminary study it became obvious that projections about port modernization and the use of containerized shipping would play a large role in determining what benefits may be expected to accrue from lengthening the Seaway season.

To that end, a study was made of containerization growth in shipping and its applicability to the Great Lakes ports. Our findings were presented at the previously mentioned Transportation Research Forum, New Orleans, October 22, 1970.

Briefly, we concluded that lake ports as a whole will suffer nearly total diversion of their container traffic unless they provide the facilities and services necessary to handle this traffic. This claim may be exaggerated, since 42.8% of the existing container fleet is able to use the present Seaway system. The Seaway is accessible to 51.6% of the existing containership fleet if not fully loaded. The growth expected in containerization would mean a deterioration in these figures unless the Great Lakes ports are able to cope with larger sized containerized ships. By investing in specialized container handling facilities and equipment plus remodelling existing berths for limited container operations, lake ports will be able to service the present container traffic. A relatively small amount of capital investment would allow the ports to service present container traffic as well as to attract new traffic to lake ports.

In the long run, regional load centers equipped with the most modern container facilities may be required to prevent lake ports from losing their general cargo traffic and financial stability. This program of port development, coupled with proposed improvements in the Seaway system would make the lake ports into a modern, efficient sea coast able to provide complete shipping services required by a growing hinterland.

The project using the data now gathered will attempt to estimate the future benefits to be obtained by extending the Seaway season in the light of several different assumptions about expenditures on port modernization and containerization. All available data of the Department of Commerce, the Department of Transportation and the Army Corps of Engineers is being utilized.

What changes in habits and scheduled sailings can be expected from the shippers by some extension (say, four weeks) of the Seaway system is still not known. Clearly the expected benefits depend upon an understanding of the scheduling of increased sailings. The benefits also depend upon an estimate of the time at which congestion of Seaway facilities make the extended Seaway season attractive simply to handle more cargo irregardless of season. Each of these matters is being studied with an eye to expanding or modernizing both the Seaway and port facilities.

The preliminary report on the subject of this study (Technical report #2) was published by the University of Wisconsin Sea Grant Program in the summer of 1970. In October, 1970 a paper was presented containing additional data in New Orleans and published in the proceedings of the Transportation Research Forum, 1970, the Richard B. Cross press, Oxford, Indiana.

DISPOSAL OF DREDGING SPOILS

Harry Brockel

The current prohibition against open lake dumping of dredging spoil has produced a dilemma for many port operations. Many ports on the Great Lakes are unable to keep their navigational facilities fully operational in the absence of periodic dredging. In the past, spoils from dredging have been disposed of in two ways: (1) open lake dumping and (2) employment of the dredging spoil as land fill. Open lake dumping has been suspended pending a detailed understanding of the pollution potential of open lake dumping. At the same time, concern for the haphazard filling of wet lands and other coastal areas has come under attack from conservationists, city planners and others who want a more detailed examination of the long range plans and effects of continually filling lands simply to accommodate the availability of dredging spoil.

This project has been an attempt to examine the scope and complexity of the problem, especially in relation to land fills. For example, a very large fill is underway in Toronto harbor using a technique substantially different from the methods prescribed in American waters of the Great Lakes. Data are being collected on the filled lands and those for which land fill is proposed in an effort to understand what kinds of economically feasible and environmentally acceptable solutions can be envisioned for the present dilemma.

The present data indicate a wide variety of uses to which filled lands are put and there may be additional potential uses not envisioned by present land fill proposals in the Great Lakes area. The results of this proposal together with those of Professor Karadi on the physical properties and drying of filled lands should provide new information and new options for individual ports in planning for the disposal of dredging spoils. The necessity for some kind of interim solution as well as long term plans becomes more critical every day since port maintenance and improvement on the Great Lakes are at a standstill where dredging is involved. The needs of commerce and the problems of maintaining a satisfactory environment are meeting head on in this confrontation.

MATHEMATICAL AND PHYSICAL MODEL FOR THE DRYING PROCESS IN DREDGING DISPOSAL

G. M. Karadi, G. Roderick, W. T. Painter

Dredging in Milwaukee harbor has been suspended indefinitely. Consequently, we have begun research on the U.S. Army Corp of

Engineers project underway at Green Bay harbor.

The U.S. Army Corp of Engineers is dredging a 3-1/3 mile long access channel for shipping and the dredge material is being used to reclaim swampland on the shore of Lake Michigan for the development of an industrial zone. The project is particularly suited to the research objectives of our proposal.

The site is located on the west side of the mouth of the Fox River about 1/2 mile west of the Pulliam Power Plant just north of the city of Green Bay. The area selected for industrial development is 1 mile long by 1/2 mile wide and will be raised to a height of about 10 feet above low lake level.

Dredge material consisting of clay lumps, gravel, sand, silt and clay slurry, is pumped a distance of 2 miles from the cutter dredge through 24-inch diameter pipes. The various soils are deposited in deltaic fashion from discharge points arbitrarily situated across the landfill area. The heavy clay lumps and gravel material are deposited at short distances from the discharge pipes, whereas, the finer grained silts and clays are carried in suspension for relatively large distances. This mode of deposition leads to a complex configuration of soil strata over most of the landfill area. However, at relatively large distances from the discharge points, the soil strata are relatively homogeneous and are suited to vacuum consolidation studies of the type envisaged in our research proposal.

Progress to Date

Samples of all dredge materials have been collected from various locations across the landfill area and laboratory classification tests are in progress. The results obtained to date are shown below:

Soil Description	Average Liquid Limit (3 tests)	Average Plastic Limit (9 tests)	Average Shrinkage (6 tests)	Average Specific Gravity (2 tests)
Clay lumps	35%	18%	16%	2.73
Clay lumps	27.5%	15%	13%	2.68
Clay lumps	(2 tests) 45%	30%	---	----

Future tests will include grain size analyses, mineralogical analyses and orthodox one-dimensional consolidation tests. These test results will aid us in designing apparatus

for the vacuum consolidation tests referred to in our proposal. The vacuum tests will simulate field conditions where clay slurry is deposited but will not be generally applicable to the consolidation process for the landfill area.

Additional field studies would be required to formulate procedures for accelerating the consolidation process where the deposition of dredge material is non-uniform. We intend to devote some attention to this phase of the project in the coming months.

During this period several contacts have been made with agencies involved in dredging disposal problems. On October 5 the following persons met in the Great Lakes Regional Office (Chicago) of the FWQA to discuss the broad aspects of the problem:

Clifford Risley	FWQA
Carlysle Pemberton, Jr.	FWQA
Merle W. Tellekson	FWQA
Owen R. Opine	U.S. Army Corps of Engr.
Gabor M. Karadi	UW-Milwaukee
Jorj O. Osterberg	Northwestern University
Paul L. Hummel	Northwestern University
Raymond J. Krizek	Northwestern University

Dr. Krizek reviewed the research program Northwestern University is to undertake in connection with dredging disposal (FWQA Project 15070 GCK). Mr. Opine and Mr. Pemberton summarized their experiences. Dr. Karadi gave a short review of the project to be conducted at University of Wisconsin-Milwaukee. It was agreed that a close cooperation will be developed among the parties engaged in research activity related to dredging disposal. In order to accomplish this, visits to several dredging sites in Cleveland and Detroit will be organized jointly in early December.

PUBLIC PERCEPTION OF AND REACTION TO WATER QUALITY

Elizabeth L. David

In the analysis of the data from the Wisconsin studies of participation in outdoor recreation and the perceived effects of pollution progress has been made. Two articles based on very general analyses have been prepared and submitted to journals for publication. More specific studies are in progress although it will take some time before they are ready for publication. (See abstracts).

Tentative results indicate that water pollution perceptions are identifiable and both can, and should, be integrated into the information which normally is contained in water quality indices such as BOD, coliform count, etc.

Pollution perceptions influence both the amount of participation in water-based outdoor recreation, the location thereof, and to some extent may cause substitution between different forms of such recreation.

There are of course numerous deterrents to participation in water-based recreation but it seems to be fairly conclusively documented from this study that pollution is one such deterrent. It is hoped that constructive suggestions can be indicated for the direction and types of abatement which promise the greatest return in increased participation, taking into account both some costs of alternatives and the incidence of the benefits among the various groups in the population.

There is no doubt that waste disposal is felt to be a major problem and that the resulting water pollution is something people feel should be dealt with. This is true nationally and was recently demonstrated at the state level as well. One of the ways in which the water pollution problem manifests itself is in its effect on participation in outdoor recreation.

Despite our concern for recreation and pollution, little is known about how and to what extent water pollution deters or alters participation in outdoor recreation. In Wisconsin people were asked to define pollution, to rank different types of pollution and its effect on their participation, and to say what they thought the major causes of pollution were.

Analyzing this data for its implications for the Great Lakes, we hope to answer questions such as:

(1) What sorts of pollution do people perceive as being most noxious and how much does perceived pollution deter people from recreational participation.

(2) To what extent are the sorts of pollution described by the public measurable in quantitative terms and to what extent are these dimensions measured currently by water quality monitors? How useful are the various definitions of pollution as they relate to various types of recreational use of the water? What suggestions can be made for alternative definitions?

(3) What policy implication can be drawn:

a. planning for recreation opportunities for the Great Lakes region,

b. minimum cost models for the provision of alternative kinds of public recreational opportunities,

c. alternative methods of regional organization to rationally provide for the needs of polluters as well as the needs of recreational users.

Some Tentative Conclusions

General deterrents to participation are of two kinds: those which can be relieved or removed by public or private market actions of various sorts and those which are not amendable to direct action. The latter include things such as old age and illness, bad weather, etc. These latter are outside the scope of this study.

The general deterrents about which we are concerned involve ways in which people who want to participate do not have opportunities to participate. Anything which increases chances to participate in effect shortens the distance to the opportunity. This distance can be measured in miles, time, money or a host of other ways, including pollution abatement.

Deterrents can be of a number of kinds:

1. Distance in terms of actual miles;

2. Discrete blocks of time needed for the participation experience available from other commitments such as job and family;

3. Income to "buy" access, ranging from owning property on the waterfront and buying equipment to paying entrance fees;

4. Income earning ability: Some heads of households earn enough to support the family recreational participation desires from the single income. Other families depend on both husband's and wife's earnings to have enough income to participate. Yet a working wife is not home to take or accompany the children to recreate and thus shorten the distance to the opportunity.

5. Transportation: People who live on the waterfront are at one end of a continuum; those who must drive are deterred both by the nuisance of driving and the

time it may take; those who must rely on others to transport them, notably public taansportation, may suffer even further inconveniences of various sorts. Opportunities for which there is no transportation are, of course, not open to the individuals so affected. This is the principal source of children's frustrated demand for rereation.

6. Public and private control of the waterfront: Distances to opportunities are increased or diminished depending on the access to the waterfront. Private access with no sale of access rights, such as private cottage developments with deed restrictions prohibiting owners from developing private beaches open to a fee-paying public constitute one sort of extreme. Public beaches with life guards posted to prevent people using the polluted water are at the same end of the continuum. Individuals who own private access to or who live close to public access to opportunities for water-based recreation are on the other end.

Indications of the effect of these various deterrents show up in differential participation rates and differential levels of satisfaction with existing participation rates. In the Wisconsin River Basin only 20% of the adults who frequented the area used the River for fishing, boating or swimming in contrast to the statewide participation rate of 60%.

The first possible deterrent mentioned was distance. Since most of the people in the Basin live within a mile of the River, distance to the waterfront for people living there is less there than it is on the average throughout the state. Distance, thus, does not seem likely to be part of the explanation for the lower participation rates. Time constraints are likely to average out to the same whether a person lives in the Wisconsin River Basin or in the other parts of the state so that is not likely to be a cause of different particpation patterns. The income constraint for families in and out of the Basin is readily testable from median income statistics which show that people in the Basin are quite similar to state average statistics. A transportation network does not seem to be a prime limiting factor because so many people live as close to the River.

We are left then with two related explanations: one the lack of public access and especially public beaches; the other, the quality of the water. Despite the presence of parks along the River and, hence, available public as well as private access, there are only two swimming beaches between Rhinelander

and the upper end of the Pentenwell flowage. Yet, this 180-mile reach of the River contains the bulk of the population of the Basin. It seems self-evident that in a large part, the lack of recreational activity centered around the River is directly attributable to the poor water quality. In this case, the deterrents to participation involve not the lack of water per se but lack of opportunities to use water of sufficiently good quality to be acceptable.

The appended tables give examples of other sorts of data being generated in the project. These are more directly related to the boating reference of this conference.

TABLE I

PARTICIPATION RATES: STATE AND NATION
(Percent of adult population who participated at least once during the previous year)

	National[1] B.O.R. 1964	National[2] ORRRC 1962	North Central Region ORRRC 1962	State 1963	State 1969
Swimming	48%	46%	40%	41%	38%
Boating	24*	28	34	35	26**
Fishing	30	39	38	42	37

[1]Bureau of Outdoor Recreation, "The 1965 Survey of Outdoor Recreation Activities"

[2]Outdoor Recreation Resources Review Commission, ORRRC Study Report 20, 1962.

*Primarily motor boating, as canoeing and sailing were excluded.

**Motor boating only

TABLE II

BOATING-RELATED PARTICIPATION RATES

26%	of the adults went motor boating. 65% of those who went motor boating said they owned their own boat. 35% of these moved it around by trailer or car. (4% of the adults)
25%	of the adults fished from a boat. 60% of the adult fishermen fished from a boat.
20%	of the children fished from a boat. 35% of the children who fished, fished from a boat.
20%	of the adults live in families owning an outboard motor. 50% of the fishermen own the boat they used for fishing. 40% of the boaters own the boat they used for boating.

TABLE ILI

FREQUENCY OF PARTICIPATION

50%	Of the adults who went motor boating did so one to five times.
25%	Of the adults who went motor boating did so ten or more times.

TABLE IV

DISTANCE TRAVELLED BY PARTICIPANTS

		Adults	Children
Less than 1 1/2 miles	to swim	20%	40%
	to fish	15%	20%

TABLE V

LATENT DEMAND AMONG PARTICIPANTS

(People who said they did not participate as often as they would have liked)

Reason:		Adults	Children
No place to go	to swim	32%	66%
No way to get there	to fish	15%	80%

SOCIAL AND ECONOMIC ASPECTS OF THE GREAT LAKES PROGRAM - PERSONNEL

Daniel Bromley, associate investigator (Fishery Management)
Elizabeth L. David, principal investigator (Recreation)
G. Karadi, principal investigator (Dredging Disposal)
W. B. Lord, principal investigator (Fishery Management)
James MacDonald, associate investigator (Fishery Management)
W. Painter, associate investigator (Dredging Disposal)
G. Roderick, associate investigator (Dredging Disposal)
Eric Schenker, principal investigator (Seaway Season Extension)
John S. Steinhart, program coordinator

THE GREAT LAKES CONTAINER DILEMMA. Eric Schenker and Michael Bunamo. Transportation Res. Forum, New Orleans, October, 1970, WIS-SG-71-304.

ABSTRACT

Containerization poses an immediate challenge for the Great Lakes cargo ports. Midwestern shippers are containerizing their general-cargo traffic and are expected increasingly to utilize this mode of transportation in the future. It is predicted that the Lake ports as a whole will suffer nearly total diversion of their container traffic unless they provide the facilities and services necessary to handle this traffic efficiently. This claim may be exaggerated, since 42.8 per cent of the existing container fleet is able to use economically (fully loaded) the present Seaway system. The Seaway is accessible to 51.6 per cent of the existing containership fleet if not fully loaded.

In the short run Lake ports should more effectively utilize the existing Seaway system and its facilities to halt the flow of diverted traffic. By investing in specialized container handling facilities and equipment plus remodeling existing berths for limited container operations, Lake ports will be able to service present container traffic. In light of the fact that the Seaway is accessible to a majority of the currently operating container fleet, a relatively small amount of capital investment would allow the ports to service efficiently present container Lake traffic as well as attract new traffic to Lake ports.

In the long run, regional load centers - one on Lake Michigan and the other on Lake Erie - equipped with the most modern container facilities may be required to prevent Lake ports from losing their general cargo traffic and financial stability. This program of port development, coupled with proposed improvements of the Seaway system would make the Lake ports into a modern, efficient seacoast able to provide the complete shipping services required by its growing hinterland.

BARRIERS TO PARTICIPATION IN OUTDOOR RECREATION: THE RELATIVE IMPORTANCE OF INCOME. Elizabeth David, University of Wisconsin, Madison, Agric. Econ. To be published.

ABSTRACT

Lack of family income is one of several important barriers to participation in various forms of outdoor recreation. From regression analysis of the results of a survey of Wisconsin adults, this appears to be the case for most activities except hunting and fishing. It does not occur for hunting because of the correlation between living in the countryside and lower family income: poor families in urban areas tend to have low participation rates. Although participation rates do not increase consistently with increments in income, swimming appears to be markedly income elastic, especially when education is taken into account. Overall, the results suggest that much higher participation rates might occur, especially in swimming, if opportunities were increased in urban areas where lower income people live.

PUBLIC PERCEPTION OF WATER QUALITY. Elizabeth David. University of Wisconsin, Madison, Agric. Econ. To be published in Water Resources Research, June, 1971

ABSTRACT

Water pollution is perceived by the general public to be an important problem, one of increasing concern as a major problem facing the State. From a sample of adults it was shown that the public has rather definite ideas about what constitutes a description of pollution. These include algae and murky, dark water; the public did not often mention attributes, such as chemicals or disease germs, not detected by the human sensory system. When respondents were asked to name water in the State which they felt was polluted, they named waters which in fact have the characteristics they described when defining pollution. The most widely used indicators of water pollution seem insufficient in light of the public definition of, and concern about, water pollution.

USE OF MARKET SEGMENTATION IN PLANNING FOR A RECREATION-BASED ECONOMY. William A. Strang, University of Wisconsin, Madison, School of Business Admin. Tech. Report #5, WIS-SG-71-205, February, 1971.

ABSTRACT

This research study shows the direct and indirect economic impacts of major groups of tourists on an economy that is highly dependent on tourism. Expenditure data was collected by interviewing 380 tourists. The influence of tourist economic and demographic characteristics on their level and pattern of expenditures was determined using analysis of variance.

Generally, the higher income, older age, manager, proprietor and sales worker, hotel, resort, and tourist home customers had the greatest positive economic impact on the local economy. The research indicated that persons seeking opportunities to participate in water-related activities did *not* spend significantly more than did other market segments. If additional research can relate the quality of the area's water resources to demand in the various market segments, planners and policymakers would be prepared to evaluate the economic importance of maintaining and improving the water resources of the area.

PRESENT AND FUTURE INCOME AND EMPLOYMENT GENERATED BY THE ST. LAWRENCE SEAWAY. Eric Schenker, University of Wisconsin, Milwaukee, Wisconsin, Center for Great Lakes Studies. The Seaway Review, Vol. 1, No. 3, Autumn, 1970.

ABSTRACT

The St. Lawrence Seaway's influence upon the growth of its hinterland extends beyond the port-related income it has generated. Completion of this low cost, deep water transportation route has made the agricultural and industrial products of the Midcontinent more accessible and more economical to overseas customers.

At the same time the Seaway permits the Midwestern firm and consumer the same access to foreign raw materials and consumer goods as his counterpart situated near a coastal port. Hence, through its effect upon the cost of transporting its hinterland's commerce and the port activity its traffic has generated, the St. Lawrence Seaway has made a significant and pervasive impact upon the economic growth of the Midcontinent.

The St. Lawrence Seaway produces economic benefits in two ways: by reducing the cost of transporting its hinterland's commerce, and by generating increased activity at the ports along the Seaway.

Estimation of the total income and employment effects of Seaway traffic is made possible through the application of regional multipliers. The familiar multiplier concept states, in brief, that an increase in the exports of a region will lead to an increase in regional employment and therefore to an increase in regional income. This increased income will, in turn, be spent and induce a second round of increased regional employment and income which will also be spent to induce more income, and so on, to a finite limit. The calculated regional multiplier is an estimate of that finite limit. It is an estimate of the total amount of income generated by an injection of one dollar of new income into the region.

These income effects are only part of the total impact which the Seaway has upon the economy of its hinterland. The Seaway generates even greater benefits by providing a low cost route for transporting the overseas commerce of

the midcontinent. Though the magnitude of these future benefits may be impossible to estimate, the size of the potential income effects alone would seem to be ample incentive for the residents of the midcontinent region to insist upon continued expansion and improvement of the Seaway system.

INTERNATIONAL ENVIRONMENTAL LAW AS A STUDY IN INTERNATIONAL LEGAL PROCESS. Richard B. Bilder, University of Wisconsin, Madison, School of Law. To appear in 1970 Proceedings of the American Association of Law Schools.

ABSTRACT

The emergence of environmental issues as an area of major international interest has far outpaced the present development of relevant international law and raises pressing problems as to how and what international law and lawyers can presently contribute to the solution of these problems. A principal question is whether it is useful for international law to attempt to conceptualize and attempt to deal with the many diverse types of international issues in this area under a common "environmental law" umbrella, or whether these various issues are best approached as wholly distinct problems.

Despite certain theoretical and practical difficulties, the concept of a distinct field of "international environmental law", does appear to have validity, interest and usefulness, particularly as a teaching device. First, it recognizes the fact that international organizations and public attitudes are in practice assuming the existence of such a distinct field, and focuses attention on the creative task of devising innovative international legal techniques to meet this emerging community demand. Second, it focuses attention on broad general questions as to the role of rules in an international system and, more particularly, of what we mean by subjects of "international concern" as contrasted with subjects of "domestic concern". Third, it illustrates, in a particularly interesting context, the ways in which rule-making typically involves difficult policy choices and emphasizes the role of the lawyer in the creative achievement of workable compromises as among competing means and ends. Fourth, it raises acutely the question of how the international decision-making process can be organized to cope with long-run global problems where facts are uncertain and pay-offs indeterminate. Fifth, it offers a vantage point for a study of the relations between science, technology and international law and the complex problems of formulating international legal policy regarding such issues. Finally, an "international environmental law" approach invites a realistic assessment of the various techniques available to actually make international rules effective and the

practical considerations and problems involved in decision-making in this respect. While the international community appears still somewhat skeptical and less than fully committed to far-ranging action (in contrast with rhetoric) in this area, it seems likely that "international environmental law" will rapidly assume an accepted and important role in the framework of rules and institutions concerned with the future management of the international system.

RECREATION AND THE LOCAL ECONOMY: AN INPUT -OUTPUT MODEL OF A RECREATION-ORIENTED ECONOMY. William A. Strang, University of Wisconsin, Madison, School of Business Admin. Tech. Report #4, WIS-SG-71-204, October 1970.

ABSTRACT

The purpose of this report is to broaden the scope of a marine research program conducted in Green Bay, a major bay of Lake Michigan. Specifically, this report presents the findings of the first stage of a 3-stage project to relate water quality to the economic health of an area oriented toward outdoor recreation. The 3 project stages are:

(1) identify the economic interactions in the area and trace the total impact of tourism on the economy;

(2) measure the direct and indirect economic impacts of specific groups of tourists on the local economy; and

(3) relate the several dimensions of the quality of local water resources to the number of tourists drawn to the area in these specific groups. It will then be possible to relate water quality to an important segment of the local economy.

THE CANADIAN ARCTIC WATERS POLLUTION PREVENTION ACT: NEW STRESSES ON THE LAW OF THE SEA. Richard B. Bilder, University of Wisconsin, Madison, School of Law. Michigan Law Review, Vol. 69, No. 1, November 1970. A Sea Grant Reprint, WIS-SG-71-305.

ABSTRACT

The Canadian Arctic Waters Pollution Prevention Act have been precipitated by the journey of the ship MANHATTAN may through the Northwest Passage as a giant oil tanker and the possible first step in a major oil transportation route from the newly developing fields on the north slope of Alaska. The act asserts national jurisdiction for a limited but extendable collection of purposes to a distance 100 miles seaward from the nearest Canadian line. For some purposes the jurisdiction is asserted over "arctic waters" beyond the 100 mile limit. Essentially jurisdiction is asserted over all waters within the outer fringe of the Canadian archipelago and for a hundred miles beyond. It is not quite clear what areas are meaningful for international negotiations to obtain an international law for waters near national boundaries or the seabed beneath. It is especially noteworthy that this was done with extensive citations of American practice in extending its jurisdictions under the Truman continental shelf and fisheries proclamations, customs enforcement practices, and air defense identification zones as well as other special jurisdictions established for atomic tests and the Cuban missile quarantine.

The Pollution Prevention Act weakens international law and is another significant step in the process of erosion of the principle of freedom of the seas - a process that has been continuing since 1945. The implications for east coast and west coast arctic waters that are normally not thought of as arctic remain to be resolved through application of the act and the implication for future activities negotiation within the Great Lakes have not yet been discussed.

SPECIAL EDUCATION PROGRAMS

Education is not a confinable concept. It must be, and is in the Wisconsin Sea Grant Program, closely interwoven in all segments of research and advisory services. Necessarily, all aspects of education cannot appropriately be fitted into these other sections. Therefore, to give specific and personal aid to students, we include a program of special education items.

Progress in courses and formal programs which have stimulated students in oceanography, limnology and engineering fields, to name a few, are committed to this section of the report. However, in every research program, graduate students conduct critical research and assist principal investigators in their work. Most frequently, the result of this is a master's or Ph.D. thesis. Undergraduate students are also a part of these programs as hourly assistants and receiving, in addition, training and exposure to fields in which they some day hope to participate on a higher level. Seminars and short courses within advisory services make available to the public outside the university community knowledge about Sea Grant research and the state of the art in the field of marine resources and technology.

INTERDEPARTMENTAL OCEANOGRAPHY AND LIMNOLOGY PH.D. PROGRAM

Even though up to the present no Sea Grant funds have been used to directly support the Oceanography and Limnology Ph.D. program, it has enjoyed healthy growth as a result of the stimulation of marine-related research by the Sea Grant Program. Therefore it is cited here as background evidence of the overall effect on the University of Wisconsin's Marine Studies Program.

The Oceanography and Limnology Ph.D. Program offers students who have already earned a degree in a fundamental scientific discipline an opportunity to apply this basic background to the study of the oceans. Candidates specialize in one aspect of oceanography, biological, chemical, geological, or physical, and also receive auxiliary training in related disciplines. Students majoring in other sciences may also minor in this program.

Participating departments include Bacteriology, Botany, Civil Engineering (including Water Chemistry), Geology and Geophysics, Meteorology and Zoology. Recent growth of the program is shown in the following table:

	1969	1970
Inquiries	160	207
Applicants	30	39
Accepted	7	8
Total in Program	5	10
Minors	2	7

Several graduate students, presently master's degree candidates, will transfer to the O & L Program upon completing their M.S. Seven additional students are minoring in the Ph.D. Program.

The Program is administered by the O & L Ph.D. Committee, Dr. Robert A. Ragotzkie, chairman. All inquiries concerning "oceanography" are processed through this office. A new and updated Oceanography and Limnology brochure will be available shortly.

OCEAN ENGINEERING MASTER'S DEGREE

Theodore Green, III

This program has cleared three hurdles during the past year. The College of Engineering has approved it, as has the Madison campus and Central Administration. Presently, it is before the Coordinating Council on Higher Education (CCHE) for final approval.

Courses for this program are now being given and we look forward to final official approval. Net enrollment in ocean engineering courses is rising. (See last year's proposal for course description.)

FIELD METHODS AND PROBLEMS IN GREAT LAKES RESEARCH

A. M. Beeton

The Milwaukee campus will initiate this new course in this summer, 1971. Since it has not begun as yet, it is difficult to ascertain its progress. The course will provide

graduate students with an opportunity to gain experience with limnological and oceanographic equipment and sampling methods, and to develop a knowledge of the special problems of studying large lakes.

Enrollment will be limited to 10 graduate students. The first two weeks of the course will consist of lectures and seminars with student participation, with emphasis on background information on the Great Lakes. The second two weeks will consist of field work aboard the vessel of the Center for Great Lakes Studies. A two week cruise will permit sampling in inshore to offshore areas of Lakes Huron and Michigan and sampling in the more productive waters of western Lake Erie and Saginaw Bay. During the remainder of the course, collected samples will be examined and reports prepared. Each student will work on a certain kind of data, i.e. phytoplankton, benthos, physical or chemical.

INTRODUCTION TO OCEANOGRAPHY

J. M. Pezzetta

This undergraduate course, offered during the past year on the Green Bay campus, gives students a review of the major disciplines in oceanography including the nature and extent of the marine environment, the physical and chemical properties of sea water, the mass movement of oceanic water, marine geology, and plant and animal life in the sea. Some 15 students enrolled in the course, and several field trips were taken using the new R/V AQUARIUS.

RECENT ADVANCES IN LIMNOLOGY

A. M. Beeton
C. H. Mortimer

This highly successful course which brings invited speakers to the Milwaukee campus, is offered every other year. Its progress and list of speakers was presented in the previous annual report. The course will be offered again in the coming year (September, 1971), but the list of speakers is not yet available.

DISTINGUISHED LECTURE SERIES

The Distinguished Guest Lecture Series is designed to bring marine scientists of international reputation to the campus to deliver a public lecture to a large audience and to meet with one or two smaller groups, as well, to discuss the technical aspects of their research. This year's speaker, Dr. A. Lerman of the Canada Center for Inland Waters, will appear in May, 1971. One of the truly outstanding marine chemists, his specialty is the Great Lakes studies of the thermocline, diffusion problems and the chemical relationships between water and bottom sediments. Dr. Lerman will also act as a consultant for certain aspects of Sea Grant research.

BERTHS OF OPPORTUNITY

The Berths of Opportunity Program is particularly important at Wisconsin. In order to provide our students at-sea experience it is frequently necessary to provide funds for travel to the port of embarkation. The "Berths of Opportunity" is a modest but highly effective program to accomplish this. Each request is screened by the Advisory Committee for relevancy, need, and probable cruise experience.

As an example, an undergraduate geologist, John Murgas, was employed as a junior marine mineral geologist aboard Inlet Oil Corporation's placer coring vessel in the inshore waters of the Bering Sea. He was primarily responsible for core handling and description on the night watch in a noble metals mineral placer program. (see photo)

FLEXIBLE RESEARCH ASSISTANTSHIPS

This program is designed to take full advantage of exceptionally talented students who become available subsequent to the beginning of a research program. At present only one student, Steve Roffler, is presently being supported under this program. The remaining three assistantships were not filled this year because approval and funding for the program was received too late in the year to take advantage of the graduate applications from the previous spring. We did not wish to take second rate students simply to fill the positions.

John Murgas (center), a Sea Grant Berths of Opportunity student works on board an Inlet Oil Corporation placer coring vessel in the Bering Sea.

Our Sea Grant Education and Training program has greatly stimulated efforts by faculty to broaden our curricula in marine studies. Several new courses have been initiated and others have been enriched. Visiting lecturers have added flavor and brought new ideas and recent advances in the marine field to our campuses. Students, both graduate and undergraduate, have responded with enthusiasm and have pushed the faculty to greater efforts to increase the variety and depth of oceanographic training.

EDUCATION - PERSONNEL

A. M. Beeton (Recent Advances in Limnology)
Theodore Green, III (Ocean Engineering, M.S.)
J. R. Moore (Distinguished Lecture Series, Births of Opportunity)
C. H. Mortimer (Field Methods in Limnology)
J. M. Pezzetta (Introduction to Oceanography)
Advisory Committee
Oceanography and Limnology Committee

ADVISORY SERVICES PROGRAM

Gregory D. Hedden
Coordinator

Introduction

The past months have shown that the Advisory Services Program is more and more beginning to fulfill its mission--that of reaching the using public, becoming aware of its problems and acting concretely wherever possible.

Personal contact, resulting in a two-way exchange, has been one effective method of communication. For example, the dilemma of the commercial fisherman has been recognized. To do something about it, the Department of Agricultural Economics has proposed a feasibility study of economic potential of aquaculture in Wisconsin. Meetings with planners of multiple use of Green Bay focused on several serious conditions of lake deterioration; research is now in progress to find answers.

The interchange of ideas and experiences at regular staff meetings indicates the Sea Grant Program is being made known. Staff people take part in national as well as statewide programs and participate in regional commissions and related work committees. A liaison with the Wisconsin Department of Administration is valuable in carrying the Sea Grant Program to the State government. Inquiries directed to the Sea Grant offices on problems relative to water resources and their use have increased.

The annual Wisconsin Sea Grant "Governor's Conference" was held in October. This year's major general reporting activity, held annually for public audiences, centered on "The Multiple Use Conflicts in the Great Lakes Waters" theme.

Fitting into this topic four speakers from outside of the University of Wisconsin system addressed the subject, each from his own viewpoint: the industrialist (power industry); the economist (university); the ecologist (Canadian government bureau); and the commission planner (Great Lakes Basin Commission). The session was chaired by Professor David Anderson of the Great Lakes Institute (Toronto) and the four papers were well received by most of the heterogeneous audience. Broadcast of the session (Educational Radio Network) was made to four Great Lakes states. The question period raised more questions than could be answered. Separate sessions on water-based recreation, geo-environmental and mineral resources, fisheries, the estuarine systems (Green Bay) study and ports were scheduled.

Within the scope of each session, University of Wisconsin Sea Grant research was presented by investigators. Where possible, the sessions were chaired by the research coordinators.

The first University of Wisconsin Sea Grant cinema production, "Tools for Decision", was premiered at the October meeting and has now been released to general distribution through T.V., schools, and meetings of service clubs and professional societies. Response has been enthusiastic. Understandable to school groups, it also generates comment in professional audiences. The message of the need for new research to provide the tools for decision in economic growth versus the environmental protection is clear. More importantly, the "either-or" questions are being challenged and hope is expressed for another approach.

University-Industry Research (UIR) - Norbert A. Hildebrand

The role of UIR in Sea Grant Advisory Services activities is to facilitate relationships between industry and faculty on matters of research, to assist industry in identifying research of potential economic value, and to provide industrial access to University and Sea Grant resources of technological information through available literature services.

The development of continuing relationships with specific industries is essentially the achievement of the various research faculty on an individual project basis--the mutual match of interest between research results and potential application. UIR is the starting point in identifying industrial needs pertinent to research or in determining potential industrial interests in specific research. Then it effects the introductions or methods of communication.

Having furthered such an industrial relationship, UIR continues to be a part only when it can contribute additional assistance; normally it does not remain in close contact with the principals involved. This report, then, will not cover those industrial relationships already in effect and being carried out by Sea Grant research faculty as a part of their continuing responsibility. For example, the continuing interest in the Green Bay manganese deposits are directly maintained through the personal contact between Professor J. R. Moore and his associates (in the geological projects) and those industries interested in the potential development aspects of such deposits. Other Sea Grant faculty associations and relationships with industry are similarly maintained and have already been discussed in previous reports.

Of interest this year is an arrangement with the Abbott Laboratories' Scientific Division making bottom samples from the Green Bay and Lake Superior projects available to Abbott for testing to determine evidence of microbiological activity. Specifically, Abbott is interested in finding organisms which produce antibiotics effective against gram-negative or a broad spectrum of bacteria. If such organisms are found, they may provide new sources of pharmaceuticals. While tests thus far have proven negative, testing of all samples are not yet completed and will continue as new bottom samples become available. This research relationship illustrates one way in which UIR has been able to serve as a catalyst and in this instance has provided an opportunity to investigate an area of marine resources not being otherwise studied in the Great Lakes research activities.

Another example of current industrial liaison involves a series of meetings with representatives of the outboard boating industry, which have identified a number of problems pertinent to Sea Grant interests. The proposed establishment of federal standards regarding thermal pollution from nuclear power plants planned for Great Lakes locations developed questions relative to the potential thermal and other effects resulting from outboard motors; problems of noise pollution from two-cycle engines; oil and gas leakage; boating safety and other aspects concerned with economic and environmental significance to the recreational boating industry.

At the moment, few Sea Grant projects are underway which have a direct bearing on these problems of the boating industry. Thus such discussions help provide an input for consideration in future Sea Grant research planning. Among specific needs identified by the boating industry is an economic evaluation of recreational small boat usage of the Great Lakes with projections of future demands to provide a basis for building launching and storage facilities, harbors of refuge, service facilities, improved marina design, weather communications, and other matters involved in the expanding demand for recreational boating. Marine-related recreation is an economically and socially significant aspect of Great Lakes resources which is germaine to the Sea Grant purpose, and which have only been partially approached in current projects.

These boating problems have been called to the attention of appropriate faculty and an experimental project regarding one problem has been currently introduced in a mechanical engineering design course. Students will try to design better methods of launching, loading, and storing small boats and if the results look promising, the boating industry has evidenced interest in providing financial support for further development. Though this is a modest approach to a problem, it serves to illustrate how Sea Grant activities can provide educational inputs with potential practical applications.

Many UIR industrial contacts during the year have related to water quality problems and have involved not only Sea Grant research but other University programs. For example, a number of chemical firms have discussed with faculty people the alternatives to using phosphates in soap and detergent products; the development of new or improved chemical processes of waste treatment for small industries and communities; new chemical agents for control of aquatic weeds and algae; the problems of agricultural chemicals in water pollution; and waste treatment for food processors. Other firms have been interested in water monitoring instrumentation and related equipment needs.

Liaison with governmental agencies, particularly at the state level has continued through UIR and agencies indicate an increasing desire to utilize University resources, particularly in problems associated with the natural environment. Of particular interest are the relationships developed with the Wisconsin Department of Natural Resources regarding water quality problems, the recreation industry, and marine-related commercial developments. Contacts are also active with the Attorney General's office, the Department of Industrial Development, the Governor's office, and individual members of the Wisconsin Legislature. These relationships are not exclusively Sea Grant but as with industry, involve whatever University resources are appropriate to the need.

Information Services - John Luedtke

The Directory of Marine and Marine-Related Information Resources was recently completed and published in two parts. Distribution to industry, Sea Grant institutions and others is now in progress.

Industrial usage of the Sea Grant Information Services, which utilizes the total literature resources of the University, have largely been in the area of water quality problems. Since the publication activities under Sea Grant (detailed separately in this report) provide for regular dissemination of Sea Grant research results, and the UIR/Research Newsletter provides an additional method of reporting research--industrial requests for technical information in Sea Grant subject areas have been relatively few. With the growing appreciation of industrial interest resulting from all Sea Grant activities and promotion of available information services, it is expected that this activity will increase. Government agencies (again at the state level) are also showing an interest in these services.

Since all industrial inquiries concerning literature resources are channeled through the regular UIR Information Services Division they are not always identified as originating from Sea Grant interests - except insofar as the nature of the material requested might so indicate. The recent establishment of a fee structure for some of the literature services provided appears at this point to have decreased the quantity of total requests being made although this may be too soon to make such a judgment. Thus a quantitative report of the activities level of the Sea Grant information services during the present reporting period will be evaluated in another year.

Publications - Jeanie Katzel

The publications effort has produced two Public Information Reports, four Technical Reports, six Reprints and four listed citations of University of Wisconsin related research publications this year. These have received general distribution and are available on request. Announcements of their availability are being given wide distribution. These three report areas constitute the specific report series that have been established over the past year. Requests for two of these reports, the "Annual Report of Sea Grant Activities", and "Recreation and the Local Economy" have been especially numerous.

In addition to bound reports, news releases and features are prepared and published to reach the general public. A small brochure capsulizing the aims and objectives of the Wisconsin Sea Grant Program has been distributed. Feature stories on the new marine research vessel, the AQUARIUS, and on the overall Sea Grant Program have appeared in LIMNOS, the magazine of the Great Lakes Foundation.

A half-time research assistant has prepared news releases on the Sea Grant film and on the R/V AQUARIUS. He is presently managing the distribution and record-keeping of the film and hopes to soon initiate an internal communiqué for Sea Grant communication.

A small library of Sea Grant and related publications is also now based at the Sea Grant Administrative offices in Madison. A collection of over 150 volumes is available on a two-week loan basis to all Wisconsin Sea Grant personnel and interested university members. The library is a member of the Madison Area Library Council, a new organization designed to keep libraries informed and to better direct information requests to the proper place.

Personal Contacts

Direct, personal contact with various using publics is also being carried out by the fisheries Extension agent, the water quality specialist, the Advisory Services staff member in water-based recreation, and in special information transfer programs such a short course in sanitation for fish processors and an institute program (planned in May) in underwater mining.

Regional planning commissions, state agencies, and industry groups have been identified and when requested and available University of Wisconsin Sea Grant expertise provides aid in communication and contact.

Industrial contacts in Milwaukee are made by Mr. John Gammell, Department of Engineering, University Extension. He is the liaison between the Sea Grant Program and industry, setting up meetings with the industrial community and arranging discussions with professional and service clubs. He also assists in Sea Grant institutes and seminars.

Water Quality - John Quigley

Most activity in the water quality area deals with a study of the waters of the lower Fox River, its contamination and projected remedial treatments. At the Governor's Conference this subject arose, prompting the introduction of a controversial water-use proposal. The investigator in this field, is in contact with regional planning commissions and consultants, as well as with the Corps of Engineers, harbor commissioners and local government agencies.

Among other activities, this program has identified sources of heavy metal contamination in the Fox watershed and has initiated new work on the proposed study of fish processing waste (in cooperation with Professor David Stuiber of Food Sciences).

Fisheries--Food Science and Fish Program - David A. Stuiber

The Fisheries Advisory Program has become a very busy one with demands touching on many problem areas. Professor Stuiber has built, through personal contact, a strong rapport with the commercial fisherman; and as the Bureau of Commercial Fisheries lost interest in the Great Lakes region, this group has turned to the University of Wisconsin for help with their problems.

The fish processors, in particular, have problems. An example is the case of a complaint lodged against an alewife-fish meal operation because of its fish "stick water" discharge. The Food Science Department developed a procedure to remove protein and together with Civil Engineering is working on other methods for treatment of the noxious wastes. Fishermen are anxious to learn more about sanitation in fish handling, especially with anticipated changes in regulations. Another operator has requested help in computerizing his bookkeeping system.

Professor Stuiber also attended various hearings, concerned with such subjects as a Wisconsin statute on smoking fish. At the present time, a short course is planned to cover a variety of the problems crucial to the commercial fisherman. In addition, this group has asked the University of Wisconsin to help them develop two relatively new areas of production--aquaculture and fresh fish canning.

Recreation - Robert Ditton

Professor Ditton of the University of Wisconsin-Green Bay serves as the Advisory Services specialist in water-based recreation. In the fall, the bibliographic retrieval system was put into operation for use by marine researchers. Pertinent literature continues to be gathered and disseminated to researchers and specialists within the Sea Grant Program as well as the general public. In this period, 210 requests for information have been handled. This is expected to increase as its availability is more widely known.

For the first time since the inception of the Sea Grant Program, a session of the annual conference was devoted exclusively to marine recreation. The session, "Recreation--The Future of Boating on Lake Michigan", was attended by 60 persons. Professor Ditton planned and carried out the program. The recreation session brought together industrial representatives, governmental officials, resource planners and lay people for a program focusing on pertinent policy problems as well as Sea Grant research. Published Sea Grant research reports dealing with recreation were distributed at this session. The program proceedings will be edited and published by Sea Grant for distribution to participants and others.

Professor Ditton and his counterparts formulating the Michigan State Sea Grant proposal met and discussed mutual concerns and the need for coordination among institutions in dealing with the recreation component. In addition, a relationship has been established with the Wisconsin Bureau

of Commercial Recreation, Department of Natural Resources; the Outboard Marine Corporation and the Boating Industry Association. Representatives of these three groups and Sea Grant specialists have discussed research needs and the value of the Lake Michigan sport fishery and related economic impacts. These research needs are being delineated and refined into workable problems for transmission to the Sea Grant Program so they may encourage the needed research.

Professor Ditton has continued his study of problems and policies surrounding dredging and landfill operations in lower Green Bay. A presentation on this subject with accompanying slides will be made at a staff meeting.

Annual Sea Grant Conference, October 15-16, 1971 - G.D. Hedden

Programmed annually to report Wisconsin Sea Grant Research progress, this (third) year's conferance was keyed to conflicting issues and problems of multiple-use and development of Great Lakes marine resources. Entitled, "Great Lakes--Sink? or Swim?", its discussions treated water-use patterns and projections related to the public's economic and environmental well being as affected by the policy-decision of business, industry and government.

Specific research reports dealt with recreational boating, commercial and sport fishing, geo-environmental and mineral resources, coastal water management, transportation and ports.

Attendance totaled 198, with industrial managers and government administrators primarily representing marine interests in Wisconsin, Michigan, Minnesota and Illinois. Other representatives came from California, District of Columbia, Hawaii, Maryland, Massachusetts, New Jersey, New York, Ohio, Oregon, Rhode Island, Texas, Washington, U.S. federal agencies and Canada.

A new feature for reporting the conference was a statewide radio broadcast via the educational network of the opening general session, a symposium on "Preservation and Multiple-Use Problems in the Great Lakes". This broadcast also provided listeners with an opportunity to ask questions via telephone following the panel's presentations.

Port Management Seminar - Harry Brockel

Preliminary planning as to the scope and content of this proposed seminar was assisted by Mr. Paul A. Amundsen, Executive Director, American Association of Port Authorities,

Washington, D.C./Dr. Eric Schenker, Associate Director of the Center for Great Lakes Studies, will aid Mr. Brockel in planning and executing the Seminar.

Developments in ports and in world shipping are carefully followed to keep the proposed events in tune with the realities of international trade and shipping, and with technological developments in the ports of the world.

Sea Grant Film - Jack Lund

Recently completed is a 28-minute color and sound (16mm) movie, illustrating the multi-discipline area research activities of Wisconsin's Sea Grant Program, and the problems of multiple-uses of Great Lakes marine resources. Designed to inform and educate the general public on major and conflicting issues of marine resource utilization, the film discusses the economic, social and environmental aspects of industrial pollution, agricultural chemicals, marine biota, commercial and sport fishing, shoreline development and water-based recreation. Titled, "Tools for Decision", the film illustrates the role of Sea Grant research in providing essential knowledge to enable society to deal effectively with multiple-use policies or to select the best alternatives in marine resource exploitation. Both the public and private aspects of controversial issues are presented.

Shown initially at the third annual Sea Grant Conference, the film is now available for television, to schools, service organizations and other groups. It also is available for loan or purchase by other Sea Grant institutions. Bookings are made through the Wisconsin Sea Grant office, and a record of showings and attendance is maintained.

Promotional activities concerning the film's availability are currently under way and will be reported later. Showings to date have included two television airings, in Stoughton and Green Bay, Wisconsin.

Museum Exhibit - Joseph Hutchison

Plans are in progress for an exhibit at the Manitowoc museum. This will portray a phase of Sea Grant activity. Mr. Joseph Hutchison, principal investigator, works with Sea Grant people in planning the exhibit.

Summary of Identified Problems.

One objective of the Advisory Services Program is to identify problems related to water resource utilization which might be a subject of Sea Grant research. Of a number of questions raised, the following are representative and illustrate the range and scope of problems posed.

1. Water in the Fox River coming from Lake Winnebago no longer has a favorable DO to BOD ratio for use downstream and the carrying capacity of the river has decreased in very recent times. Paper industry people would like to know why.

2. In the watershed area of the Fox systems, bog recession has posed a problem in water quality (increased algal blooms) and water level control has sometimes affected the bog. Water level is controlled by the Corps of Engineers and historically was related to navigation needs. The historical need (barge traffic) has been replaced by small pleasure craft. Questions of optimization policy are being raised.

3. In river regions, multiple jurisdictions in regional water control measures pose problems in coordination and implementation. Assistance in development of institutions to effect and implement a plan may be a need that deserves study because of the overall relation to water quality in Sea Grant objectives.

4. Economic evaluation of sport fishing in Lake Michigan, including supportive activities, would be useful to regional planners and others concerned with parks, marinas and related industries.

5. Weather phenomena related to recreational boating needs study according to comments at the last Governor's Conference. Other areas, for example, transmit continuous weather forecasts over the public service (radio) band, but this is not done in the Great Lakes' region.

6. Marinas could be designed for increased efficiency thereby increasing capacity to improve utilization in boating in the Great Lakes. As a result, costs and citing problems would be more favorable.

7. The commercial fishing industry has asked the University of Wisconsin Sea Grant for assistance in assessing the potential for aquaculture in the Great Lakes region.

8. Vegetable canneries have inquired about the potential of canning fresh fish in the off-season. The department of Food Science assistance with processing is contemplated.

9. Heavy equipment suppliers to the mining industry and to water treatment facilities have sought discussions on areas of designed economics of marine-related hardware.

The above present the broad scope of Advisory Service activities. The specifics within each area and in other smaller subject groups are plentiful and cannot be detailed here. Contact and communication on an even higher level are among the goals in this sub-program and dissemination through all media will continue to be employed.

ADVISORY SERVICES PERSONNEL

C. Amundson (Fisheries)
Harry C. Brockel (Ports)
Robert B. Ditton (Recreation)
John Gammell (Conferences)
G. D. Hedden (Program Coordinator)
Esther Herman (Administrative Assistant)
Norbert A. Hildebrand (UIR)
Joseph Hutchison (Museum)
Jeanine Katzel (Publications Editor)
Jack Lund (Films)
John Luedtke (Information Services)
John Quigley (Water Quality)
T. Richardson (Fisheries)
David A. Stuiber (Fisheries)