Abstract
Lake effect snowfalls contribute a significant proportion of the total winter snowfall in areas to the lee of the Great Lakes. In Michigan during the seasons 1957–58 through 1961–62 at least 30% of the seasonal snowfall in lee areas was derived from lake-atmosphere interactions. Evidence suggests that lake effect snowfall has significantly increased during the past several decades, particularly in southwestern Michigan and northern Indiana. While the observed changes cannot be definitely ascribed to any single factor, it seems likely that a general cooling of winter temperatures may be partially responsible for this climatic change.

Introduction
The effects of the Great Lakes as climatic modifiers have long been recognized, and the controls over temperature and continentality imposed regionally by these water bodies have been described by Leighly (1941), Kopec (1965, 1967) and other investigators. A salient aspect of this marine effect, and also one which is difficult to measure, is the modification of precipitation along the shores of the Lakes. Throughout fall and winter, the Lakes are heat sources. Moisture transfer and sensible heat flux into overpassing cold air creates instability with a general increase in cloudiness and precipitation. Conversely, in spring and summer, the Lakes are heat sinks, restricting the development of convective cloudiness and precipitation along the shoreline. The effect of the Lakes on total precipitation depends on the balance between summer curtailment and winter augmentation (Changnon, 1968a).

Probably the most prominent example of winter precipitation modification is the marked increase of snowfall along the lee shores of the Lakes. These snowfalls (lake effect) are frequently heavy and cause major snow removal problems. They are mesoscale phenomena involving bands of snowfall from one to 50 miles wide and from 25 to 100 miles long (McVehil and Peace, 1965). These occur in the absence of macroscale fronts and cyclones, although temperature, wind, and pressure discontinuities may develop from the lake-atmosphere interactions themselves. Such snowfalls account for a considerable proportion of the snow to the lee of the Great Lakes, and evidence to be presented here suggests that the frequency and intensity of these snowfalls have recently increased significantly in some areas.

Although the meteorological mechanics of lake effect snowfalls have come under closer investigation recently (McVehil and Peace, 1965; Peace and Sykes, 1966) and additional insights have been gained as to the atmospheric mechanisms responsible for the snowfall (mesoscale pressure troughs, wind and temperature discontinuities, and convergence zones), the climatological aspects have been more difficult to assess, and as yet we have only incomplete quantitative appraisals of the effect of these mechanisms within the regional climatic complex (Eichenlaub, 1964; Changnon, 1968b). It will be the purpose here to discuss the role of lake effect snowfall as a factor in the winter precipitation climatology of the Great Lakes, to provide a quantitative estimate of the impact of lake-induced snowfalls in Michigan, where these phenomena have a profound effect on seasonal snowfall, and to report on the nature and possible causes of the marked increase in lake effect snowfall which has occurred in Michigan and other parts of the Great Lakes.

Lake effect snowfall in the Great Lakes region
The uniqueness of these weather phenomena to the Great Lakes Region of North America is often not fully appreciated. Snowfalls resulting when cold air passes over warmer water occur significantly on a world-wide basis only where a propitious juxtaposition of geographic and atmospheric factors is present. Latitudinal requirements must be met which insure the lowering of winter temperatures to the point where the resulting precipitation will occur in the form of snow rather than rain. Land masses of continental dimensions functioning as source regions for polar continental and arctic air must be located upwind and poleward. A body of water of sufficient areal dimensions to actively modify this cold air must lie athwart the prevailing tracks of the cold air masses. This water body must remain ice free, at least during the early months of the winter season.
effect snowfalls in the snowbelts are not necessarily predicted on similar mesoscale meteorological conditions, although the basic requirements of open water, overpassing cold air, and cyclonic vorticity (which may be induced by the water-air interaction) are always present. For example, the west-east alignments of Lakes Erie and Ontario (in general, parallel to prevailing air movement under a westerly flow of arctic air, although minor contrasts in long-axis orientation are of considerable importance) can create significantly different mesoscale features than those developing over Lakes Michigan, Superior, and Huron, where west-east alignment is lacking. Topographic contrasts to the lee of each lake and variations in normal extent of ice cover on the lakes also affect the intensity and spatial distribution of lake effect snowfall. Consequently, research findings concerning lake effect snowfall occurring to the lee of Lakes Ontario and Erie should be extrapolated to the other lakes with caution and due consideration of the geographic differences which exist.

Lake effect snowfall in Michigan—an estimate of its significance

Although investigations regarding the meteorological mechanics of lake effect snowfall have been mostly confined to the lee shores of Lakes Ontario and Erie in New York State, the climatological impact would appear to be greatest in Michigan. Snowbelts are nearly continuous along the lee shores of Lakes Michigan and Superior in the State (Fig. 2) and snowfall patterns strongly reflect lake proximity. Snowfall amounts are, in general, least in southeast Lower Michigan, and greatest in the northwest portion of the Upper Peninsula. The increase from southeast to northwest is not uniform, however, as secondary high accumulation zones occur to the lee of Lake Michigan (Fig. 3). A rough idea of the relative importance of latitude, lake proximity, and altitude in Lower Michigan may be gained from a multiple correlation with mean seasonal snowfall as the dependent variable. The multiple correlation coefficient is .77, partial coefficients for altitude, lake proximity, and latitude are .24, .46, and .66, respectively.
In attempting to ascertain how much of the snowfall is caused by the Lakes, the problem of determining which snowfalls are purely lake-induced and which would have occurred in the absence of the Lakes, as a result of cyclones, is of course critical. Such a clear-cut dichotomy, although discernible on occasion (Sykes, 1966), is not always realistic, as in many cases lake proximity enhances snowfall amounts occurring under cyclonic conditions. Snowfalls confined to areas immediately downwind from the Lakes do, however, occur with certain recognizable synoptic associations and these lee-shore snowfalls indicate causation primarily by lake effect processes. It is thus possible to isolate the synoptic patterns under which the required lake-atmosphere interactions most typically occur, and plot the distributional patterns associated with them.

One synoptic weather type has been recognized as being highly contributory to lake effect snowfall in the Lake Superior and Lake Michigan basins (Eichenlaub, 1964). Such a situation is shown in Fig. 4. A strong flow of arctic air across the Lakes occurs with a cyclone to the east of the Lakes and an anticyclone to the west and north of the region. Although no macroscale fronts or disturbances are present, cyclonic curvature is induced within a trough extending to the rear of the cyclone westward over the Lakes area. This trough is caused by the heat flux from the Lakes into the overpassing air. Computations of vorticity induced by heat exchange from the Lakes were made by Petterssen and Calabrese (1959) for a seven-day cold spell in February 1958, and precipitation amounts were plotted for the Great Lakes Region. Lake proximity was a strong control with areas over 40 miles inland from the Lakes generally receiving less than an inch of snowfall while lake snowbelts received much heavier amounts. Evidence of interior displacement of maximum snowfall areas was also present with the heaviest snowfall occurring 10 to 15 miles inland, according to theoretical considerations outlined by Petterssen and Calabrese.

In order to obtain some assessment of the climatological impact of such snowfalls in Michigan, the above described synoptic situation was tabulated for five snowfall seasons, 1957–58 through 1961–62. Using a data network of ESSA Weather Bureau stations with near uniform reporting times, supplemented by Michigan State Highway Department snowgages located within snowbelt areas, the amounts of snowfall occurring during the periods when the designated synoptic condition existed were totaled and averaged for the five season period. The distributional patterns were then plotted, and comparisons made to the total snowfall. The mean seasonal snowfall in Michigan occurring with these causative situations is shown in Fig. 5. Amounts averaged over 30 inches seasonally in lake snowbelts, and less than five inches in interior regions. The relative contribution is shown in Fig. 6 where the types accounted for over 35% of the seasonal snowfall in the western Lower Michigan snowbelts and over 20%, in the Upper Peninsula snowbelts. The smaller per cent in the Upper Peninsula is due to the larger number of weather situations which will result in snowfall in that area where a greater proportion of winter precipitation is received as snow instead of rain. In interior areas, away from the lakes, less than 10% of the mean seasonal snowfall occurred with this synoptic type in the Lower Peninsula, and less than 5% in the Upper Peninsula.

Snowfall associated with this synoptic pattern accounted for a significant proportion of the heavy snowfall.
falls in the Michigan snowbelts (a heavy snow is defined here as four inches or more within a 24-hour period). Along the east shore of Lake Michigan these snowfalls contributed over 40% of all the heavy snows during the five-year period (Fig. 7). However, no heavy snowfalls occurred with the synoptic type at a distance of more than about 50 miles downwind from Lakes Michigan and Superior.

Thus, although it is impossible to always make a precise distinction between lake effect and cyclonic snowfall, some indication of the role of the Lakes may be obtained by investigating snowfall distribution during periods when the prime causative synoptic type occurs. This analysis indicated that over one-third of the snowfall in lake shore areas in the southern part of Michigan may occur as a result primarily of lake-atmosphere interactions associated with this synoptic type. This is undoubtedly an underestimate of the total contribution by Lake Michigan during the five year period, as the effect of lake proximity is also apparent when the distributional patterns occurring with many other synoptic types are examined. The above value, however, compares favorably with Wiggins' (1950) and Lansing's (1962) estimates of the significance of Lake snowfalls to the lee of Lakes Erie and Ontario. On the other hand, this report will show that in recent decades the lake effect mechanisms have been hyperactive, and one should use caution in projecting the figures of the five-year investigative period as long-term means.
Seasonal variability of lake effect snowfall and relation to subnormal temperatures

To experienced weather observers in the Great Lakes Region it is apparent that during some seasons the lake effect mechanisms are overly active, while they appear repressed, occurring with lessened frequencies and intensities, during others. In the lake snowbelts, particularly in the southern snowbelts where snowfall totals from year to year are more directly related to the amount of lake effect activity, the on-off again nature of this activity leads to an unusually large variation in year-to-year snowfall. As an example, Table 1 indicates the variability of snowfall at a number of Michigan stations for the seasons 1904–05 through 1960–61. The standard deviations, as expected, are largest at stations where the mean seasonal snowfall is greatest. However, a measure of variability which is amenable to comparison, the relative variability (Conrad, 1950, computed as $V_r = \frac{AV}{P}$, where $AV = \frac{1}{N\sum|P_r - \bar{p}|}$) shows highest values at southwest Michigan snowbelt stations, Bloomingdale and Muskegon. (Locations are shown in Fig. 1.)

Table 2 shows the coefficients of correlation between mean January temperatures and January snowfall amounts during the years 1931–61 at Alpena, Detroit, and Escanaba, where lake effect snowfall is not important, and lake stations, Bloomingdale, Muskegon, and Houghton. High negative correlations exist at the lake stations, indicating that heavy snowfall amounts in snowbelt areas are related to lower than normal temperatures, while no such relation exists at the other stations. Subnormal monthly mean temperatures may (although they need not necessarily) indicate a greater frequency of arctic air movement over the area. Thus the dynamic interactions between warm lake water and cold arctic air are heightened with more snowfall occurring in the lee shore areas. At the same time, although subnormal mean monthly temperatures may increase the possibility of precipitation in the solid form at interior areas at least in southern Michigan where a significant proportion of the winter precipitation occurs as rain, the dominance of arctic air may decrease the frequency of cyclonic and frontal action, giving drier than normal winters with little precipitation.

Recent snowfall increases in southwestern Michigan and northern Indiana

Since the mid-1950's, winters in the southwestern Michigan snowbelt have become noticeably snowier and new seasonal and monthly snowfall records have been set at a number of stations in the area. Time-series analyses for stations with at least 50 years of available data indicate some rather surprising trends. Fig. 8 compares time-series curves for lake stations in southwestern Michigan and northern Indiana (Muskegon, Bloomingdale, La Porte, and South Bend) with stations at approximately the same latitude but removed from the influence of the lakes (Lansing, Battle Creek, and Fort Wayne). In each case, decadal averages shown by ten-year moving means have nearly doubled at the lake stations with large increases occurring during the past twenty years. At the same time, amounts at the interior stations have shown little variation, indicating that the source of these recent increases at the lake stations must undoubtedly lie with lake effect snowfall.

One must always be suspect of snowfall records as lack of uniform measurement techniques from observer to observer and even seemingly inconsequential site changes can seriously affect the homogeneity of the record. For example, a site change at Muskegon in 1989 from the lake shore to the airport several miles inland has undoubtedly been a factor in the snowfall increase there.

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| Table 3. Cross correlations between time series. |
|-----------------------------------------------|-------------|-------------|
| Stations                  | Number of years of record | Correlation coefficient |
| Stations within snowbelt   |                          |                          |
| Muskegon, Mich.—Allegan, Mich. | 14             | +0.864       |
| Bloomingdale, Mich.—Holland, Mich. | 19             | +0.849       |
| Muskegon, Mich.—Holland, Mich. | 19             | +0.839       |
| La Porte, Ind.—S. Bend, Ind. | 49             | +0.837       |
| Bloomingdale, Mich.—Muskegon, Mich. | 19             | +0.828       |
| La Porte, Ind.—Bloomingdale, Mich. | 12             | +0.800       |
| S. Bend, Ind.—Holland, Mich. | 48             | +0.788       |
| La Porte, Ind.—Paw Paw, Mich. | 38             | +0.736       |
| Snowbelt stations and nearby interior stations |                          |                          |
| La Porte, Ind.—Ft. Wayne, Ind. | 49             | +0.330       |
| Muskegon, Mich.—Lansing, Mich. | 19             | +0.380       |
although the upward trend has continued and has been most prominent during the past two decades, when no site change has occurred. A recent change in measuring technique at Muskegon may have also contributed to the much larger snowfall totals noted at that station. However, further examination of available records in southwestern Michigan showed large increases for all snowbelt stations, both first order and cooperative. These increases seem to have occurred in phase within the region. Table 3 shows cross-correlations between time-series curves for stations both within and just outside the snowbelt. High correlations exist between stations within the snowbelt, even when a considerable distance separates them. Low correlation coefficients exist between the snowbelt stations and interior stations although the distance involved may be small. A composite time-series curve (Fig. 9) further confirms the regional trend existing in the area.

Consequently, in spite of the fact that at Muskegon, a site change and the introduction of a new measuring technique may be partially responsible for the rather spectacular increase observed there, investigation of records for other stations where site and measuring changes have not occurred, and the overall correspondence of time-series curves for stations in the snowbelt, suggest that the larger snowfall amounts in recent years are indicative of a realistic climatic change.

In order to determine whether other portions of the Great Lakes have experienced similar snowfall increases, time-series curves for an additional 75 stations were ana...
lyzed for the seasons 1920–21 through 1962–63. Smoothing was accomplished in these cases by using a binomial filter. Regression equations were then computed for each curve and the slopes of the regressions plotted (Fig. 10). With the time-series curves obviously not in phase at all stations within the region, nor the trends unidirectional during all decades of the period examined, the slopes of the regressions can give only a rough approximation of the regional trends, but may be useful in determining the overall tendency during the period. Although most lake snowbelt stations showed positive slope values, highest values occurred in southwestern Michigan and northern Indiana, and in the snowbelt to the lee of Lake Erie. Time-series curves for Erie, Pa., and Buffalo, N. Y. (Fig. 11) indicate the nature of the snowfall increase in that area. On the other hand, snowfall appears to have decreased within a large area in southeastern Michigan removed from the effects of the lakes and remained fairly constant in other non-lake sections.

Possible causes of the observed increases

Lake effect snowfall mechanisms, therefore, or the production of snowfall from them, appear to have been less prominent during the earlier decades of this century. What explanations might account for the increased snowfall which has been observed in many lake snowbelts? The near doubling of decadal averages in southwestern Michigan and northern Indiana poses a particularly perplexing problem. While, as of yet, there is no solid evidence to suggest that the observed changes can be ascribed to a single cause or group of causes, some possible explanations of this climatic change can be indicated and the avenues of further research delineated.

Logic points first to a secular fluctuation in atmospheric parameters which may have resulted in more frequent incursions of arctic air across the lakes with enhanced lake-atmosphere interactions. Shifts in the position of the mean troughs and ridges over the eastern United States have been cited by Namias (1960) as responsible for increases in snowfall at interior eastern

![Slope of Regression 1920–1962](image)

**Fig. 10.** Slopes of regression lines for time-series curves of 75 Great Lakes stations.

![Composite Time-Series Curve](image)

**Fig. 9.** Composite time-series curve for stations in southwestern Michigan and northern Indiana. Smoothing by a binomial filter.

![Time-Series Curves](image)

**Fig. 11.** Time-series curves for Erie, Pa., and Buffalo, N. Y. Ten-year moving means of yearly snowfall.
cities. Namias correlated seasonally averaged maps at the 700-mb level with snowfall totals for a number of cities in the eastern United States. He concluded that the increase in snowfall from the eastern Great Lakes to the Appalachians in the 1950’s was associated with a shift in the position of mean troughs and ridges aloft favoring increased marine influence and warmth along the immediate east coast, but operating so as to increase snowfall well inland. Similar shifts in the mean longitudinal position or intensity of troughs and ridges might also enhance lake effect activity by increasing the frequency of the causative synoptic type and of cold air incursions across the Lakes.

Wahl (1968) has investigated the climatic change occurring in the eastern United States since the early 1800's and suggested that since the “climatic optimum” of the 1930’s a deterioration involving a return to cooler weather and the circulation patterns of the early 19th century may have developed in the midwest. In agreement with Wahl’s observation, mean January temperatures since 1930 at Eau Claire in the southwestern Michigan snowbelt are shown in Fig. 11. Eau Claire, a cooperative station in a rural setting, has had uniformity of siting and observer since the late 1920’s. Since the mid-1940’s, January temperatures have become progressively colder, particularly during the 1960’s. The relation between subnormal January temperatures and snowfall in southwestern Michigan has already been noted, and it is possible that at least some of the snowfall increase may be attributed to a progressive winter “cooling off.” In addition, many of the snowfall time-series curves for lake stations show downward trends during the 1920’s and 1930’s, at the height of the recent warm period, and the more recent snowfall increase has coincided with a general world-wide cooling which has occurred during the past several decades (Mitchell, 1961; Lamb, 1966). Recent evidence derived from O18 analysis of ice core samples on the Greenland ice cap indicates a continuance of this cooling trend for another 20 or 30 years (Dansgaard et al., 1969).

Further research is needed into possible fluctuations of various lake parameters. An increase in surface temperature of the lakes during the early winter months would probably be of greatest significance, heightening the degree of lake-atmosphere interaction. However, the causative agent for such a temperature increase would be difficult to identify, and there are no verifying data that a change has occurred. Increased cloud cover as a factor in decreasing radiative cooling; increased insolation; weaker summer and fall winds over the lakes resulting in less vertical mixing—each could be a critical link in the interplay of physical effects resulting in warmer lake waters. Much speculation, at present, centers around the possible climatic effects of the warm water effluent from a number of nuclear plants to be constructed on the shores of southern Lake Michigan (the initial plant, near South Haven, Mich., will begin operation in the spring of 1970. Two plants have also begun operation along the shores of Lake Ontario, near Nine Mile Point and along the shore between Rochester and Sodus Point). Although some preliminary studies indicate rapid dispersal of the effluent, other ecologists, biologists, and climatologists are not so sanguine and foresee significant changes in the shore and nearshore environment. An enhancement of the lake effect snowfall mechanism may be a possible prospect, although no one can predict accurately the degree to which this aspect of lake-induced modification may be altered. Current variations, changes in extent of ice cover, volume, depth, and area of the lakes may appear to be of too minor a scale for consideration, but could be critical where a small disruption of the delicate balance between lake surface and atmosphere may escalate into significant climatic effects.

Recent studies pertinent to the climate of the Great Lakes Region have described noticeable increases in air pollution downwind from southern Great Lakes metropolitan centers (Schaefer, 1969) and a marked increase in precipitation at La Porte, Ind., downwind from the Chicago-Gary industrial area (Changnon, 1968c). Schaefer has shown the presence of high concentrations of ice nuclei and crystals in the southern Great Lakes area, and indicated that juxtaposition with very moist air may be favorable for the occurrence of the optimum reaction. Although Changnon noted that increased precipitation at La Porte in recent decades was mostly due to more warm season rainfall and ascribed it to the heat effect of upwind industries rather than the high concentration of ice nuclei, the large increase in snowfall at that station which has also occurred has been cited in the present study. Given the low density of lake effect snowfall which generally prevails, the impact of the snowfall increase at La Porte on melted equivalent winter precipitation (considered by Changnon) is less emphatic.

With these studies in mind, some serious questions may be posed as to a possible link between air pollution and the observed upward trend in lake effect snowfall. No substantive evidence is available to confirm such a link. However, several observations concerning lake effect snowfall indicate that additional research into the matter may be desirable. First, the most radical increases in snowfall have occurred in the much more densely populated and industrialized southern Lakes areas. Although northern snowbelts have shown a general overall increase from 1920-1962 as shown by the slopes of re-

![Fig. 12](image-url)
gressions in Fig. 10, an examination of individual smoothed time-series curves shows that the largest increases during the past two decades, and the sharpest overall increases, have occurred in southwestern Michigan, northern Indiana, and in the Lake Erie snowbelt. Secondly, the nature and composition of industrial effluent in Muskegon, where the increase has been most pronounced, plus the persistent tendency for snowfall in the Muskegon area to be most sharply contrasted with inland locations under lake effect conditions involving southwesterly flow (thus placing the Muskegon area downwind from the Chicago-Gary industrial area) are also suggestive of the existence of a problem which could bear further investigation.

Conclusions

There can be little doubt that the Great Lakes impose strong controls over the winter climate of surrounding areas. Lake effect snowfalls comprise probably the most overt revelations of these controls. As a preliminary report, this study indicates that a significant proportion of the winter snowfall in lee areas of Lakes Michigan and Superior is due to lake processes, while previous studies have shown similar findings to the lee of Lakes Erie and Ontario. The sharp increase in lake effect snowfall to the lee of southern Lake Michigan during recent decades appears realistic and cannot be attributed to lack of homogeneity in siting or measuring techniques. Similar large increases have been noted in the snowbelt to the lee of Lake Erie, and lesser increases in the more northern lake snowbelts. While this increase in lake effect snowfall cannot, as yet, be ascribed to any single cause, a tendency toward colder winters recently in southwestern Michigan may be partially responsible for the upward trend in that area. Further evidence is needed before valid conclusions can be drawn regarding the role of air pollution in this climatic change.

Much more research and a better understanding of the meteorological mechanics of lake effect snowfalls are needed before the true climatological significance of these phenomena can be discerned. Additional observational networks similar to those supported by the Atmospheric Sciences Research Center of The State University of New York on the south and east shores of Lake Ontario, as well as coordinated research efforts such as the forthcoming International Field Year for the Great Lakes program concentrating on the Lake Ontario basin are needed to supply the data on the desired scale. In the meantime, residents of Great Lakes snowbelts will probably continue to receive the snowsqualls borne by frigid winds off the Lakes which are so much a part of the winter climate of these areas.

Acknowledgments. A grant from the Faculty Research Fund, Western Michigan University, supported a portion of this research.

References


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**Meetings of interest**

3–14 August: Advanced Study Institute on Aurora and Airglow will be offered in Kingston, Ont., by Lockheed Palo Alto Research Laboratory and the National Research Council of Canada. Contact: Dr. Billy M. McCormac, Lockheed Palo Alto Research Lab., 3251 Hanover, Palo Alto, Calif. 94304.

14–21 August: Upper Atmospheric Currents and Electric Fields Symposium will be conducted in Boulder, Colo. The symposium is sponsored by the International Union of Geodesy and Geophysics, the American Geophysical Union, the Office of Naval Research, and the Air Force Cambridge Research Laboratories. Deadline for the submission of abstracts is 30 June. Contact: W. H. Campbell, R. 11 Geomagnetism Laboratory, ESSA Research Laboratories, Boulder, Colo. 80302.

28 August–1 September: The first national meeting of the newly organized American Quaternary Association (AMQUA) will be held at Yellowstone National Park and Montana State University in Bozeman. The two-day session at Yellowstone will be devoted to field conferences with discussions on broad topics of general interest illustrated by the Quaternary features of the area; the next two days will feature a symposium and sessions of papers on “Climatic changes from 14,000 to 9000 years ago.” Contact: AMQUA Secretary, Margaret Davis, Great Lakes Research Division, University of Michigan, Ann Arbor, Mich. 48104.

7–11 September: Second International CODATA Conference on Numerical Data for Science and Technology will convene in St. Andrews, Scotland. The program will include reports from new data centers, computer processing and transmission of data, output of data centers, computerized and automated storage and retrieval of data and literature in data centers, industrial data, and the role of CODATA in a worldwide information network. Attendance will be limited to 100. Contact: CODATA Central Office, Westendstrasse 19, 6 Frankfurt/Main, Germany-BRD.

17–18 September: Tutorial Seminar on Low Light Level Imaging Systems, sponsored by the Society of Photographic Scientists and Engineers, will be conducted at the Airport Marina, Los Angeles, Calif. Contact: Russell P. Cook, Polaroid Corporation, 730 Main St., Cambridge, Mass. 02139, Area Code 617-864-6000, ext. 2614.

4–9 October: Forty-third Meeting of the Water Pollution Control Federation will take place in Boston, Mass. Contact: Editor, Room N-100, 3900 Wisconsin Ave., Washington, D. C. 20016.

13–15 October: International Telemetering Conference of the International Foundation for Telemetering will convene in Los Angeles, Calif. Contact: Dr. W. Hedeman, Aerospace Corporation, Box 1308, San Bernardino, Calif. 92402.

21–23 October: Playa Lake Symposium, sponsored by the International Center for Arid and Semi-Arid Studies (ICA-SALS), at Texas Tech University, Lubbock, Texas, will cover all aspects of intermittent lakes, including physical and economic elements. Contact: C. C. Reeves, Jr., Department of Geoscience, Texas Tech University, Lubbock, Tex. 79409.

21–24 October: Symposium on Color Photography will be offered by the Society of Photographic Scientists and Engineers at the Marriott Twin Bridges Motor Hotel, Washington, D. C. Contact: Russell P. Cook, Polaroid Corporation, 730 Main St., Cambridge, Mass. 02139, Area Code 617-864-6000, ext. 2614.

10–15 November: Interocean '70 at Dusseldorf, Germany, will be an international congress and exhibition for marine research and exploitation. Contact: German-American Chamber of Commerce, Inc., 666 Fifth Ave., New York, N. Y. 10019, or Dusseldorfer Messegewerkschaft mbH, 4 Dusseldorf 10, Deutschland.

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