LEWIS, Donald Wayne, 1936-
The Decline of the Lake Erie Commercial Fishing Industry in Ohio.
The Ohio State University, Ph.D., 1966
Geography

University Microfilms, Inc., Ann Arbor, Michigan
THE DECLINE OF THE LAKE ERIE COMMERCIAL FISHING INDUSTRY IN OHIO

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Donald Wayne Lewis, B.S., M.A.

The Ohio State University
1966

Approved by

[Signature]
Adviser
Department of Geography
ACKNOWLEDGMENTS

I wish to express my gratitude to Professors Henry L. Hunker, S. Earl Brown, and Charles A. Dambach for their assistance and encouragement in the development of this dissertation. In addition, I wish to acknowledge the financial support of The Natural Resources Institute of The Ohio State University that made this research possible.
VITA

July 26, 1936    Born - Tiffin, Ohio

1958          B.S., Bowling Green State University, Bowling Green, Ohio

1958-1960    Research Cartographer, U. S. Air Force Aeronautical Chart and Information Center, St. Louis, Missouri

1961-1963    Teaching Assistant, Department of Geography, The Ohio State University, Columbus, Ohio

1963          M.A., The Ohio State University, Columbus, Ohio

1963-1964    Research Associate, The Natural Resources Institute, The Ohio State University, Columbus, Ohio

1964-1966    Assistant Professor, Department of Geography, California State College at Long Beach, Long Beach, California

1966          Assistant Professor, Department of Geography, The University of Toledo, Toledo, Ohio

FIELDS OF STUDY

Major Field: Geography

Studies in Economic Geography. Professors S. Earl Brown and Lawrence A. Hoffman

Studies in Industrial Geography. Professor S. Earl Brown


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CHAPTER I

INTRODUCTION

Purpose, scope, and orientation

This examination of the Lake Erie commercial fishing industry in Ohio has three primary purposes. The first is to describe and explain the present condition of the industry, with major emphasis upon the severe depression which has recently gripped it. Indeed, it is this depression which precipitated the need for the study. A second objective is to identify the problems now confronting the industry and which have been casually associated with its decline. Finally, the study will suggest possible alternative courses of action which the industry might take in response to specific problems. These are aimed at making the fishing industry a more viable economic institution, as well as to provide for more efficient utilization of the fishery resources of Lake Erie.

The scope of this study is restricted to that part of the Lake Erie commercial fishing activities which are based in the state of Ohio. Commercial fishing operations in Ohio are confined to the waters of Lake Erie and its tributary streams which lie within the boundaries of the state. For purposes of this study, commercial fishermen are defined as those who capture fish for sale and are thus subject to the commercial fishing regulations of Ohio. While the processing and marketing of fish after their capture are considered to be integral operations of the fish-
ing industry, firms which perform these activities without engaging in the capture of fish have been excluded from the study. The Ohio fishing industry, as defined above, accounts for 81% of the United States commercial catch in Lake Erie, 26% of the total Lake Erie commercial catch, and 0.3% of the nation's commercial catch of fish and shellfish. Although Ohio is a decidedly minor fishing state by national standards, its industry is an important producer of Lake Erie fish.

The topics discussed in this study might be examined from a number of points of view, using a variety of approaches. While those of the biologist or the economist would be equally valid, this study has been conducted and written using the viewpoint and approach of the economic geographer interested in the decline of an industry. This investigation has touched upon a broad range of subjects, many of which both invite and deserve additional research. Generally, however, they have not been pursued beyond the stated purposes of the study. Thus, water pollution in Lake Erie, for example, is discussed only in terms of its effects upon commercial fishing and sport fishing is viewed solely as a competitor of commercial fishermen in the capture of lake fish.

Organization

The organization of the study is indicative of its problem orientation. Chapter I describes the purposes, scope, and point of view of the study, discusses its organization, and places it in the perspective of the existing literature in the field. In Chapter II the depressed condition of the fishing industry in recent years is described and an assessment of its present value is offered. In addition, the chapter contains a brief historical review of several phases of the industry's operations, to provide the reader with an historical perspective of present problems.
Chapter III is concerned with Lake Erie as a resource base for the fishing industry. The major focus of the chapter is upon the intensive human uses of the lake's waters and their effects upon the supply of commercial fish. Chapters IV and V deal with problems of an economic, social, and political nature. The harvesting operations of the Ohio fishing industry are the subject of Chapter IV, while Chapter V focuses upon the processing and marketing of fishery products. The conclusions of the study are summarized in Chapter VI and some suggested topics for further research are offered.

Commercial fisheries literature

Investigators representing a number of disciplines have been active in commercial fisheries research. In the preparation of this study, the writings of biologists, economists, and geographers have been the most pertinent.

Biological scientists have contributed a larger number of studies to the commercial fisheries literature than any other single discipline. Of the total biological literature on fisheries, only a relatively small fraction is concerned with Lake Erie and its fish stocks. It is this literature which has been most pertinent to the subject examined in this study. Early biological studies of Lake Erie's fishery resources were often short-term efforts, conducted in an atmosphere of crisis, which sought to explain the disappearance of valuable fish species. More recently, research has been more continuous and comprehensive in nature. Studies of this type have yielded the hypothesis that Lake Erie's changing aquatic environment is responsible for its changing fish populations.
Within the last decade, as Chapter III will indicate, increasing amounts of evidence have been gathered to support this conclusion.¹

Fisheries research by economists has included studies of specific regional fishing industries which have afforded the opportunity to compare approaches and findings with the present study. A recent monograph concerning the fishing industry of Ontario, Canada has been particularly useful as a source of information on this most important competitor of the Ohio fishing industry.² Within the past few years, economists have become interested in various theoretical aspects of the commercial fishing industries. In general, writing of this type are more useful to the economic geographer than the regional studies mentioned above since they often contain generalizations which are applicable within a number of regional frames of reference. An example can be found in the theory of the

¹Early biological research often blamed overfishing by commercial operators for observed changes in the Lake Erie fish stocks (see, for example, John Van Oosten, "The Extent of the Depletion of the Great Lakes Fisheries," Proceedings of the Great Lakes Fisheries Conference, Detroit, Michigan, February 25-26, 1938). Thomas H. Langlois, who might be considered the "father" of modern biological research into the fishery resources of Lake Erie, has long advocated systematic, comprehensive, and continuous research efforts. He took vigorous exception to the findings of the early researchers and championed the theory that the lake's altered aquatic environment was the most important factor in its changing fishery resource base. Although more than a decade old, his book The Western End of Lake Erie and Its Ecology (Ann Arbor: J.W. Edwards, Inc., 1951) remains the most comprehensive statement on the biology of Lake Erie fishery resources.

common property resource, which suggests that the tendency to overproduce and the low economic returns to labor, capital, and management which often characterize commercial fishing as an economic activity may be inherent in the common property nature of the fishery resources it exploits.  

Food technologists and nutritional scientists have made valuable contributions to the commercial fishing literature with their writings about the processing and marketing operations of fishing industries. Studies of this type have helped to give the writer a better understanding of the processes and problems involved in the preparation and sale of fishery products.  

Geographic research on commercial fishing has been relatively sparse and sporadic, when compared to most other economic activities. Although some geographers have been interested in the resource management aspects of fishing, the greatest share of studies have consisted of descriptive, 

^3Discussions of this and other theoretical work by economists are contained in Ralph Turvey and Jack Wiseman (eds.), The Economics of Fisheries (Rome: Food and Agriculture Organization of the United Nations, 1957) and Francis T. Christy, Jr., and Anthony Scott, The Commonwealth in Ocean Fisheries (Baltimore: Johns Hopkins Press for Resources for the Future, Inc., 1965).  


^5Five years ago, Padgett noted the relative paucity of geographic research on commercial fisheries (Herbert R. Padgett, "Sea Industries: A Neglected Field of Geography," The Professional Geographer, Vol. 13, No. 6 (November, 1961), pp. 26-28). Since then, research interest has remained quite limited, as evidenced by the use of only one paragraph to describe fishing studies in a recent 260 page survey of the field of economic geography (Harold H. McCarty and James B. Lindberg, A Preface to Economic Geography), (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966).
regional examinations of fishing industries. Due to the few studies which have been done and the relative lack of interregional comparisons, geographers have not, as yet, provided a clear understanding of the nation's or the world's commercial fishing. Lacking as well, has been research of a theoretical nature.

In relation to this study, the resource management work by geographers has tended to show that, due to the relatively low value of its products, commercial fishing industries have difficulty competing with other users of water resources if conventional benefit-cost analysis is used to resolve conflicts. Regional studies by geographers, as well as economists, suggest the hypothesis that problems of technological obsolescence and foreign competition may be very widespread, if not universal, among the fishing industries of the United States. These factors may be very important in explaining the relative decline of the country as a world fishing power.

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CHAPTER II

THE PRESENT CONDITION AND HISTORICAL DEVELOPMENT
OF THE OHIO FISHING INDUSTRY

This chapter describes the presently depressed condition of the Ohio fishing industry. Additionally, the chapter reviews some selected aspects of the industry's historical development. It is intended that this review will provide an historical perspective of the problems which presently confront the fishing industry.

The recent depression

The Lake Erie commercial fishing industry in Ohio is in the grip of a severe depression, the worst in its history. Its condition has attracted the attention of agencies of the State of Ohio and the Federal Government, and a report concerning the industry's plight has reached the Governor of Ohio. The decline of the fishing industry to its present low level of activity may be described through various characteristics of the industry, including: volume and value of catch, employment, sales, and capital investment.

Volume of catch

The total commercial catch of the Ohio fishing industry has declined more or less steadily, since before the turn of the century. In 1890, a record catch of over 14,000,000 pounds was landed (Table 1). By

---

1964 the catch had fallen to slightly more than 11,000,000 pounds. This represents a decline of 75% between the highest and lowest years. The catch has dropped most sharply since 1957 (Figure 1).

Significantly, as the volume of the catch has declined, the fish species which make up the catch have changed. In general, the dominant species have shifted from top quality, highly prized varieties to fish of lower quality, which are less highly esteemed as food fish. The changing species composition of the commercial catch is discussed in more detail in the following chapter.

Value or catch

Perhaps the best indicator of the industry's economic condition, for which data are available over a span of years, is the value of its catch. The value of the industry's catch from 1879 to 1964 is shown in Table 2. The values shown are the amount which would have been received, each year, if all members of the industry had sold their fish immediately upon landing them, with no processing, preservation, or packaging. The amounts shown are termed the landed value of the catch. Since much of the industry's catch undergoes some form of processing prior to sale, the landed value is considerably less than the value actually received. Unfortunately, however, gross sales figures for the industry are available only for two recent years and cannot be used to depict long term trends. The weight of the catch, as shown in Table 1, is an unreliable indicator of the industry's health, since it has little bearing on the industry's earnings.

The size of the catch has declined steadily since 1890, but due to rising fish prices, the value of the catch increased until about 1950. During this period, the industry received a progressively larger amount of dollars for smaller and smaller catches.
<table>
<thead>
<tr>
<th>Years</th>
<th>Amount of Catch (pounds)</th>
<th>Years</th>
<th>Amount of Catch (pounds)</th>
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<tr>
<td>1879</td>
<td>23,500,000</td>
<td>1938</td>
<td>21,711,939</td>
</tr>
<tr>
<td>1885</td>
<td>32,763,720</td>
<td>1939</td>
<td>23,511,989</td>
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<tr>
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<td>44,882,764</td>
<td>1940</td>
<td>18,996,461</td>
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<td>1914</td>
<td>33,880,803</td>
<td>1941</td>
<td>18,581,326</td>
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<td>1915</td>
<td>36,336,733</td>
<td>1942</td>
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<td>21,871,721</td>
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<td>1917</td>
<td>31,050,572</td>
<td>1944</td>
<td>23,370,758</td>
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<td>1918</td>
<td>22,373,479</td>
<td>1945</td>
<td>22,171,855</td>
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<td>21,133,567</td>
<td>1946</td>
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<td>1920</td>
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<td>29,957,481</td>
<td>1948</td>
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<td>1922</td>
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<td>1949</td>
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<td>1923</td>
<td>18,583,836</td>
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<td>11,670,924</td>
<td>1951</td>
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<td>1925</td>
<td>15,121,773</td>
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<td>1926</td>
<td>15,933,966</td>
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<td>1928</td>
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<td>1929</td>
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<td>1930</td>
<td>23,524,188</td>
<td>1957</td>
<td>25,964,200</td>
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<td>1931</td>
<td>25,211,767</td>
<td>1958</td>
<td>19,418,900</td>
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<td>1932</td>
<td>28,163,537</td>
<td>1959</td>
<td>19,518,100</td>
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<td>1933</td>
<td>19,619,765</td>
<td>1960</td>
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<td>1934</td>
<td>26,556,770</td>
<td>1961</td>
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<td>1935</td>
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<td>1936</td>
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<td>1937</td>
<td>21,087,701</td>
<td>1964</td>
<td>11,230,383</td>
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1885-1956: Ohio Department of Natural Resources, Division of Wildlife, Summary of Ohio Lake Erie Commercial Fish Catch, 1885-1956 (Columbus, Ohio Division of Wildlife, 1957).


CATCH OF THE
OHIO COMMERCIAL FISHING INDUSTRY
1879 - 1964

Figure 1.
TABLE 2

LANDED VALUE OF CATCH, OHIO COMMERCIAL FISHING INDUSTRY,
SELECTED YEARS, 1890-1961a

<table>
<thead>
<tr>
<th>Years</th>
<th>Value of Catch (dollars)</th>
<th>Years</th>
<th>Value of Catch (dollars)</th>
</tr>
</thead>
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<tr>
<td>1890</td>
<td>618,673</td>
<td>1945</td>
<td>3,270,692</td>
</tr>
<tr>
<td>1897</td>
<td>389,712</td>
<td>1946</td>
<td>3,538,633</td>
</tr>
<tr>
<td>1899</td>
<td>677,305</td>
<td>1947</td>
<td>3,179,303</td>
</tr>
<tr>
<td>1903</td>
<td>436,017</td>
<td>1948</td>
<td>3,339,813</td>
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<tr>
<td>1917</td>
<td>1,570,230</td>
<td>1949</td>
<td>3,164,034</td>
</tr>
<tr>
<td>1926</td>
<td>1,516,713</td>
<td>1950</td>
<td>3,793,000</td>
</tr>
<tr>
<td>1927</td>
<td>1,064,883</td>
<td>1951</td>
<td>3,951,000</td>
</tr>
<tr>
<td>1928</td>
<td>1,131,770</td>
<td>1952</td>
<td>3,423,000</td>
</tr>
<tr>
<td>1929</td>
<td>980,703</td>
<td>1953</td>
<td>3,010,000</td>
</tr>
<tr>
<td>1930</td>
<td>1,252,164</td>
<td>1954</td>
<td>3,244,000</td>
</tr>
<tr>
<td>1931</td>
<td>1,213,137</td>
<td>1955</td>
<td>2,995,000</td>
</tr>
<tr>
<td>1932</td>
<td>1,160,584</td>
<td>1956</td>
<td>3,518,000</td>
</tr>
<tr>
<td>1933</td>
<td>751,883</td>
<td>1957</td>
<td>3,112,000</td>
</tr>
<tr>
<td>1934</td>
<td>1,156,754</td>
<td>1958</td>
<td>2,680,000</td>
</tr>
<tr>
<td>1939</td>
<td>1,767,274</td>
<td>1959</td>
<td>1,733,000</td>
</tr>
<tr>
<td>1940</td>
<td>1,349,218</td>
<td>1960</td>
<td>1,632,160</td>
</tr>
<tr>
<td>1941</td>
<td>1,483,264</td>
<td>1961</td>
<td>1,398,323</td>
</tr>
<tr>
<td>1942</td>
<td>2,348,511</td>
<td>1962</td>
<td>1,138,911</td>
</tr>
<tr>
<td>1943</td>
<td>3,475,700</td>
<td>1963</td>
<td>1,080,000</td>
</tr>
<tr>
<td>1944</td>
<td>2,752,804</td>
<td>1964</td>
<td>867,000</td>
</tr>
</tbody>
</table>

aSources:


Figure 2.

VALUE OF CATCH
OF THE OHIO COMMERCIAL FISHING INDUSTRY
1890 - 1964

MILLIONS OF DOLLARS

SEMilog SCALE
Table 2 and Figure 2 show that the amount of actual dollars which the industry received for its catch began to decline after 1951, rose somewhat between 1955 and 1958, and then fell off sharply. This is the trend cited by most observers, both inside and outside the industry, when discussing the recent decline.

Table 3 and Figure 3 show the landed value of the Ohio commercial catch, in constant dollars, between the years 1890 and 1964. These values have been computed from the actual landed values, using the U. S. Bureau of Labor Statistics Wholesale Price Indices. Constant dollar values of the industry's catch are more useful as an indicator of its health than are actual values, since they express the value of the catch in terms of its purchasing power to the industry.

A comparison between the two trends shown in the value of the catch reveals some significant variations. In terms of the industry's purchasing power, the value of its catch began to decline as early as 1943, and has continued to fall, with minor interruptions, until the present. The World War II period is shown to be a profitable one for the Ohio fishing industry. The demand for fish as food was strong during this era. Prices were generally high, although they were controlled by the Federal Government after 1943. The costs of fishing, such as fishermen's wages, were, however, also controlled, in most cases at pre-war levels. The war-time years were especially profitable for the larger fishing establishments, since the small, part-time operators who usually enter the fishery during periods of prosperity were prevented from doing so by shortages of labor, boats, gasoline, nets, and other equipment.

The post-war period of the late 1940's and most of the decade of the 1950's saw large catches of such high value fish as blue and yellow
<table>
<thead>
<tr>
<th>Years</th>
<th>Value of Catch (dollars)</th>
<th>Years</th>
<th>Value of Catch (dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890</td>
<td>1,688,661</td>
<td>1945</td>
<td>5,648,863</td>
</tr>
<tr>
<td>1897</td>
<td>1,528,282</td>
<td>1946</td>
<td>5,353,453</td>
</tr>
<tr>
<td>1899</td>
<td>2,376,509</td>
<td>1947</td>
<td>3,915,397</td>
</tr>
<tr>
<td>1903</td>
<td>1,337,475</td>
<td>1948</td>
<td>3,799,559</td>
</tr>
<tr>
<td>1917</td>
<td>2,442,037</td>
<td>1949</td>
<td>3,148,543</td>
</tr>
<tr>
<td>1926</td>
<td>2,767,779</td>
<td>1950</td>
<td>4,369,815</td>
</tr>
<tr>
<td>1927</td>
<td>2,036,105</td>
<td>1951</td>
<td>4,089,968</td>
</tr>
<tr>
<td>1928</td>
<td>2,141,075</td>
<td>1952</td>
<td>3,641,489</td>
</tr>
<tr>
<td>1929</td>
<td>1,882,317</td>
<td>1953</td>
<td>3,247,033</td>
</tr>
<tr>
<td>1930</td>
<td>2,617,915</td>
<td>1954</td>
<td>3,191,926</td>
</tr>
<tr>
<td>1931</td>
<td>3,011,195</td>
<td>1955</td>
<td>3,213,519</td>
</tr>
<tr>
<td>1932</td>
<td>3,260,067</td>
<td>1956</td>
<td>3,656,964</td>
</tr>
<tr>
<td>1933</td>
<td>2,091,088</td>
<td>1957</td>
<td>3,476,767</td>
</tr>
<tr>
<td>1934</td>
<td>2,821,351</td>
<td>1958</td>
<td>2,669,322</td>
</tr>
<tr>
<td>1939</td>
<td>4,187,853</td>
<td>1959</td>
<td>1,722,664</td>
</tr>
<tr>
<td>1940</td>
<td>3,137,716</td>
<td>1960</td>
<td>1,620,814</td>
</tr>
<tr>
<td>1941</td>
<td>3,103,063</td>
<td>1961</td>
<td>1,394,110</td>
</tr>
<tr>
<td>1942</td>
<td>4,318,983</td>
<td>1962</td>
<td>1,135,534</td>
</tr>
<tr>
<td>1943</td>
<td>6,151,681</td>
<td>1963</td>
<td>1,078,921</td>
</tr>
<tr>
<td>1944</td>
<td>4,837,968</td>
<td>1964</td>
<td>866,134</td>
</tr>
</tbody>
</table>

*Calculated from Table 2, using the U. S. Bureau of Labor Statistics Wholesale Price Indices for 1890-1964, on a 1957-59 base.
VALUE OF CATCH
OF THE OHIO COMMERCIAL FISHING INDUSTRY
- CONSTANT DOLLARS -
1879 - 1964

MILLIONS OF DOLLARS

1890 1900 1910 1920 1930 1940 1950 1960

Figure 3.
pike by the Ohio fishing industry. The real value of the industry's catch, however, continued to decrease. The failure of the large harvests of highly prized fish to reverse, or forestall, the industry's slide toward depression suggests that the reasons for decline are not exclusively associated with Lake Erie's changing aquatic environment and fish populations. Although these biological factors are important in explaining the industry's decline, it is necessary also to consider economic, social and political problems, the focus of Chapter IV and Chapter V.

### TABLE 4

EMPLOYEES OF THE OHIO FISHING INDUSTRY, 1940 AND 1963

<table>
<thead>
<tr>
<th>Item</th>
<th>1940</th>
<th>1963</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Employees</td>
<td>699</td>
<td>544</td>
</tr>
<tr>
<td>Casual Employees (those receiving less than one-half their annual income from the fishing industry)</td>
<td>149</td>
<td>521</td>
</tr>
<tr>
<td>Percent of Total Employees classified as casual</td>
<td>21.3%</td>
<td>95.4%</td>
</tr>
</tbody>
</table>


Employment and wages

The number of people employed in the various operations of the Ohio fishing industry has declined modestly in recent years (Table 4). A progressively larger segment of the work force, moreover, has been made up of part time workers who have additional sources of income. Such workers, called casual employees by the U. S. Fish and Wildlife Service, made up
21.3% of the work force in 1940. In 1963, the latest year of record, 95.4% were so classified. Casual workers receive more than one-half of their income from outside the fishing industry.

The Ohio fisherman is not highly paid, and his wages have declined steadily, both in absolute and relative terms, in recent years (Table 5). Earnings of fishermen are available only for those covered by unemployment compensation. Covered employees make up about 27% of the total work force at present, and in the past have made up almost one-half. While the wages paid these employees are somewhat higher than the average for the industry, due primarily to a greater number of hours worked, the trends shown in Table 5 may be assumed to be characteristic of wages paid to all employees.

In 1956, the average covered employee in the fishing industry earned about $80 per week, or slightly more than 90% of the all-industry average. As recently as 1952, however, wages in the fishing industry were above the state industrial average. In 1964, fishery earnings were about $75 per week, representing the equivalent of 65% of the level of wages paid in other Ohio industries. In contrast, the average commercial fisherman in California, the nation's leading fishing state, earned $8,476 in 1962 as compared with an average wage level in that state of $5,891. The average earnings of Ohio fishermen in the same year was $3,693, while the state's industrial average was $5,592.

The relatively low wages and lack of full-time employment which now characterize the Ohio fishing industry have made it difficult to attract and retain adequate labor supplies. This is especially true for those jobs which require a high level of skill. Since it is located in

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the midst of a highly competitive labor market, the industry would likely face a labor shortage if it were restored to full economic health.

### TABLE 5

**AVERAGE WEEKLY EARNINGS OF EMPLOYEES OF THE OHIO FISHING INDUSTRY, AND ALL OHIO INDUSTRIES, COVERED BY THE OHIO UNEMPLOYMENT COMPENSATION LAW, 1956-1961**

<table>
<thead>
<tr>
<th>Year</th>
<th>Fishing Industry</th>
<th>Average, All Industries</th>
<th>Fishing Earnings as Percent of All Industries Earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1956</td>
<td>$80.01</td>
<td>$88.25</td>
<td>90.7%</td>
</tr>
<tr>
<td>1957</td>
<td>81.90</td>
<td>92.15</td>
<td>88.9</td>
</tr>
<tr>
<td>1958</td>
<td>80.85</td>
<td>93.77</td>
<td>86.2</td>
</tr>
<tr>
<td>1959</td>
<td>75.45</td>
<td>99.61</td>
<td>75.6</td>
</tr>
<tr>
<td>1960</td>
<td>76.65</td>
<td>101.67</td>
<td>75.4</td>
</tr>
<tr>
<td>1961</td>
<td>72.32</td>
<td>103.57</td>
<td>69.8</td>
</tr>
<tr>
<td>1962</td>
<td>69.99</td>
<td>107.35</td>
<td>65.2</td>
</tr>
<tr>
<td>1963</td>
<td>67.27</td>
<td>110.44</td>
<td>60.9</td>
</tr>
<tr>
<td>1964</td>
<td>75.81</td>
<td>115.63</td>
<td>65.5</td>
</tr>
</tbody>
</table>


**Sales**

Data concerning the value of the Ohio fishing industry's sales are not generally available. A survey conducted by the Ohio Commercial Fisherman's Association revealed that the industry's sales in 1962 amounted to $20,136,700 (Table 6). This is a gross sales figure representing the landed value of the fish, plus value added in processing, transporting,
merchandising, etc. The 1962 sales figure is the only reliable one in existence, but for purposes of comparison, a figure has been estimated for 1954. Assuming the same ratio between landed value and gross sales as in 1962, the sales in 1954 are estimated to have been about $57,420,000. The decline in sales between 1954 and 1962 was almost 65% in actual dollars and nearly 68% in constant dollars. While the value of the industry's sales have declined drastically in recent years, its operating costs have risen steadily. No cost data are available for the Ohio industry, but it has been estimated that costs for commercial fishermen in the United States increased 16% between 1953 and 1963.9

Capital equipment

Estimates of the value of capital equipment employed in the operations of the Ohio fishing industry are available for only two years, 1954 and 1962 (Table 6). Capital equipment is composed chiefly of fishing boats and nets, storage and repair facilities for boats and nets, packing plants for processing the catch, and trucks for transporting fishery products.

The value of capital equipment in the industry decreased by more than 66% between 1954 and 1962. A decline of almost 69% was indicated after conversion to constant dollars. This is due both to an exodus of fishing operators from the industry between those two years, and the growing age of its equipment. The ratio of gross sales to value of capital equipment, a crude index of return on invested capital, did not change significantly between the two years cited. Unfortunately, the data upon which these calculations are based are not precise enough to

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draw any valid conclusions concerning trends in the profitability of fishing operations.

TABLE 6

GROSS SALES, VALUE OF CAPITAL EQUIPMENT, AND RATIO OF GROSS SALES TO VALUE OF EQUIPMENT IN ACTUAL AND CONSTANT (1957-1959=100) DOLLARSd, OHIO FISHING INDUSTRY, 1954 AND 1962

<table>
<thead>
<tr>
<th>Year</th>
<th>Value of Capital Equipment</th>
<th>Gross Sales</th>
<th>Ratio of Gross Sales to Value of Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(actual dollars) $19,000,000a</td>
<td>$57,420,000b</td>
<td>3.02</td>
</tr>
<tr>
<td></td>
<td>(constant dollars) $20,152,000</td>
<td>$61,808,000</td>
<td>3.02</td>
</tr>
<tr>
<td>1954</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1962</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(actual dollars) $6,417,100</td>
<td>$20,136,700</td>
<td>3.14</td>
</tr>
<tr>
<td></td>
<td>(constant dollars) $6,378,800</td>
<td>$20,016,600</td>
<td>3.14</td>
</tr>
<tr>
<td>Percent Change, 1954–62</td>
<td>(actual dollars)</td>
<td>(constant dollars)</td>
<td></td>
</tr>
<tr>
<td>66.2%</td>
<td>-68.6%</td>
<td>54.0%</td>
<td></td>
</tr>
<tr>
<td>-6.9%</td>
<td>-7.6%</td>
<td>4.0%</td>
<td></td>
</tr>
</tbody>
</table>

Sources:

a Data from an address by Hayden Olds, Chief, Ohio Division of Wildlife, to an Annual Meeting of The Ohio Commercial Fishermen's Association, Cleveland, Ohio, January 9, 1956.

b Estimated from the landed value of the Ohio catch, 1954 (Table 3).

c Data from a survey conducted by the Ohio Commercial Fishermen's Association, December, 1963.

d Constant dollar values were calculated, using the U. S. Bureau of Labor Statistics Wholesale Price Indices for 1954 and 1962, both on a 1957-59 base.
The amount of fishing gear licensed may be used as an indicator of the amount of fishing equipment in operation. In 1954, almost 4000 trap nets were licensed for use in the Ohio industry. By 1962, however, only about 1500 were licensed; in 1963 the number dropped to slightly more than 1000.

Most Lake Erie fishermen have been unwilling, or unable, to invest in modern equipment to replace that still in use. A common procedure has been to make necessary repairs to the older equipment in order to keep it in operating condition. Often, the fishing gear and boats of fishermen who go out of business are purchased by those still in operation to be used for repair parts. As a result, most operating fishermen have a stock of fishing gear, and sometimes boats, far in excess of the amount that is actually used. Much of the excess capacity represented by the old equipment is the result of the industry's expansion after World War II. During this period good catches and relatively high prices encouraged the purchase of large amounts of equipment, some of which is still in use. One fisherman stated that none of his trap nets were less than ten years old.

Most of the boats in use by the fishing industry are old. This condition is not unique to the Ohio industry, but is characteristic of the entire Great Lakes fishery. The median age of the fishing vessels employed in the United States fishing operations on the Great Lakes is twenty years. As a result, many of the boats in use are underpowered and inefficient.

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The public value of the Ohio fishing industry

The sum of the contributions which the Ohio fishing industry makes to the economic and social well-being of the state and nation may be termed its public value. The fishing industry's public value may be thought of as the reasons why the industry is worth having and saving. The recent near-collapse of the fishing industry has interested both the state and federal governments in various programs aimed at its rehabilitation. Such programs are justifiable only if the benefits which would accrue to the public from a prosperous fishing industry are substantially greater than the costs of the programs. Although a benefit-cost analysis of this type is beyond the scope of this study, such research might well be undertaken in advance of rehabilitation efforts. 11

The value of a fishing industry is difficult to assess, since it occupies both tangible and intangible forms. The following is not a complete valuation, but rather an attempt to point out some of the industry's contributions. 12

In 1962, the latest year for which data are available, the Ohio fishing industry employed 772 persons on a full time and part time basis. These persons were paid $2,231,000 in wages and salaries, and $18,258 as the employers' contributions to unemployment compensation payments. Real estate taxes were paid on almost $4,000,000 worth of shore installations,


and taxes were paid on $2,538,740 worth of other capital equipment. License fees and gasoline taxes were paid for more than 200 trucks. More than $20,136,000 worth of fish was sold for consumption, much of it in Ohio.\textsuperscript{13} Ohio fishermen paid more than $25,300 to the Ohio Division of Wildlife in fishing gear license fees in fiscal year 1961.\textsuperscript{14}

In addition to economic contributions, certain esthetic values accrue to Ohio as the result of commercial fishing. They are difficult to express in quantitative terms, but should be included in an assessment of the public value of the industry. Commercial fishing establishments and their operations have traditionally been a part of the cultural landscape of the Lake Erie shoreline. Their observation offers an interesting and educational diversion for many of the millions of people who visit this area each year. The commercial fisheries are listed as one of the area's attractions by organizations which promote tourism. Thousands of pounds of fish are purchased annually by residents and visitors in local restaurants and markets.

Sport fishing is a popular recreational activity along the Lake Erie shoreline and is an important contributor to the economy of the area. Sport fishing is directed toward a relatively few species of high quality game fish. There is some evidence that the removal of many kinds of less desirable fish by commercial fishing may improve sport fishing by making available more of the productive capacity of a water body for the growth of game fish.\textsuperscript{15} It should be noted that the evidence, thus far, has been

\textsuperscript{13}Survey conducted by the Ohio Commercial Fisherman's Association, 1963.


confined to small lakes and reservoirs and that the hypothesis has neither been proven nor disproven for lakes the size of Lake Erie. 16

Although presently depressed, the Ohio fishing industry makes significant tangible and intangible contributions to the economic and social well-being of the state and nation. Its contributions are not, however, evenly distributed, but rather are concentrated along the Lake Erie shoreline, especially in the major fishing ports.

**Historical development**

The history of the Lake Erie commercial fishing industry in Ohio is interesting and colorful. In this study, however, no attempt is made to provide a comprehensive history of the industry. Instead, certain aspects of the industry's historical development will be described briefly in an attempt to provide a background for the later discussion of problems associated with the industry's present condition.

**Markets and the demand for fish**

There is evidence that Lake Erie fish have been included in human diets from very early times. First, Indians and, later, white settlers harvested fish from its waters on a subsistence basis. The War of 1812 and the stationing of both British and American garrisons at the western end of Lake Erie provided a concentrated demand for food fish of sufficient magnitude to make a commercial fishing operation feasible. After the War, the rapid influx of immigrants into the Lake Erie port cities of Detroit, Toledo, and Cleveland (Map I) provided a sustained demand for fish

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Map I
and these cities became the first permanent markets for lake fish. By this time, land settlement in the inland region to the south of the lake had progressed to the point where sizable towns existed. These inland towns became an important secondary market. Information about the markets for lake fish prior to 1880 is fragmentary, but it is noted that in 1816, Lake Erie white bass were wholesaled in Chillicothe for $2.00 per barrel and retailed at $1.00 per dozen.

In 1826 the Ohio fishing industry made its first contact with the large fish markets of the Eastern Seaboard cities when salted whitefish and lake trout were shipped there in barrels. This trade, which was to become important to the industry, grew rapidly and by 1832 seven vessels were engaged in shipping fish eastward on Lake Erie. The Civil War and the post-war period increased the market for fish and further stimulated production in the industry.

The first official survey of the Lake Erie commercial fishing industry, and unfortunately the last of a comprehensive nature, was made by Goode in 1879. By this time, many of the markets and marketing channels which became traditional for the industry were already well established, and the total output of fish and fish by-products had reached a level which has been surpassed but rarely since then (Table 7).

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19 Hatcher, loc. cit.
Detroit and Cleveland had become important centers for the collection, processing, packaging, and distribution of the Lake Erie catch. Sandusky and Toledo were important secondary centers. The latter were also important primary fishing ports. Processing functions consisted of cleaning the fish, freezing, and salting. An important by-product industry had grown up in Sandusky and Toledo based on the sturgeon. The eggs of the sturgeon were made into caviar, its flesh smoked, and its bladder made into isinglass. Fish oil used in the leather tanning industry was also produced.

**TABLE 7**

**SHIPMENTS OF THE OHIO FISHING INDUSTRY, 1879**

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Fish</td>
<td>17,654,670</td>
</tr>
<tr>
<td>Salted Fish</td>
<td>6,712,500</td>
</tr>
<tr>
<td>Frozen Fish</td>
<td>1,406,650</td>
</tr>
<tr>
<td>Smoked Fish</td>
<td>933,180</td>
</tr>
<tr>
<td>Caviar</td>
<td>178,580</td>
</tr>
<tr>
<td>Isinglass</td>
<td>3,344</td>
</tr>
<tr>
<td>Fish Oil</td>
<td>4,880</td>
</tr>
</tbody>
</table>


Fish landed at the many small fishing ports along the southern shore of the lake and in the island region were sent to collection centers where shipments large enough to be sent economically to distant markets were assembled. These centers also packaged fish in smaller quantities for shipment to markets in nearby towns.
Lake Erie fish were shipped in large quantities over most of the eastern United States, with the exception of the deep South. Boston, Philadelphia, and especially New York City were important markets on the east coast, while in the interior, cities and towns in Ohio, Pennsylvania, West Virginia, and Kentucky regularly received shipments. The Lake Erie port cities of Toledo, Detroit, and Cleveland remained large consumers of fish. Unlike the markets for fish, fish by-products were sold in singular markets. Isinglass was sold in New York City, fish oil was sent to tanneries in Buffalo, and caviar was exported to Hamburg, Germany.

The spectacular disappearance of the sturgeon in Lake Erie, after 1900, caused the collapse of the by-product industry which had been based on this fish. The markets that had been established for caviar, isinglass, and fish oil could no longer be served by the Ohio industry. Like the disappearance of other high value fish in Lake Erie, the collapse of the sturgeon fishery has not been adequately explained.

As Chicago grew in population and became an important distribution center in the Midwest for food products, it became an important market for Lake Erie fish. Chicago grew to rival and surpass New York as a destination for shipments from Ohio fishing ports.

As has been shown, the demand for fish from Lake Erie was at first local in scope. As soon as supplies exceeded local demands, markets farther away from the lake were sought and established. These distant markets became important ones for the industry. In more recent times, there has been a trend toward less dependence on distant markets and more on markets closer to the points of production. A number of factors, which will be discussed at greater length later, have contributed to this condition. The Midwest has grown steadily in population and thus represents,
in an absolute sense, a continuingly larger market for freshwater fish. The catch of the Lake Erie fishing industry in Ohio has been declining in volume rather steadily in recent years (Table 1). There has been an especially sharp decline in the catch of the higher priced, more preferred species which can most readily absorb the costs of long-distance transportation. The cost of shipping so perishable a product as fresh fish has always been expensive, but in recent years transportation rates on fishery products have risen sharply, especially for small shipments which are characteristic of the Ohio industry. Thus, it has become more profitable to sell preferred species in nearby markets which can now absorb most of the reduced catch. An additional factor which has affected the position of Ohio-caught fish in the New York and Chicago markets has been the increased sales of Canadian fish in these cities. The presence of large quantities of Canadian fish in these markets has tended to keep prices below the point where it would be profitable to ship Ohio fish there, except during periods of peak production when local markets cannot absorb the entire catch.

In recent years, the availability of low value, less desirable species of fish in Lake Erie has increased, while preferred species have declined (Chapter III). Although limited markets presently exist for low value fish, only a small fraction of their number is being harvested. The development of saleable products and the establishment of adequate markets for these fish represent major problems for the fishing industry (Chapter V).

The technology of production and processing

Since its establishment, the Lake Erie fishing industry in Ohio has witnessed a succession of technological inventions and innovations.
Those which have been most important in the development of the industry involve fishing gear, fishing boats and equipment, and processing and preservation of the catch. An examination of the types of fishing gear used by the Ohio fishing industry since its establishment reveals a general trend toward more efficient gear and more intensive fishing operations.

In the early Ohio industry, crude brush weirs, which diverted migrating fish into holding ponds, were used along with small hand seines and hooks and lines in the tributary streams and embayments of Lake Erie. The fishermen of the early 1800's usually engaged in farming, lumbering, and other occupations in addition to fishing. Nets were originally made by hand, an industry which helped to pass the long winter evenings.21

The old fishing methods were very inefficient and expensive in terms of human labor. By 1850 they had been replaced by the pound net and the gill net, which were introduced from Europe. The new methods extended fishing into the open lake. The pound net is a funnel-like system of netting supported by poles which are driven into the lake bottom. The fish are guided into the net by a long, fence-like wall of netting, and once inside, find it difficult to escape. The gill net closely resembles the net on a tennis court. It is held upright in the water by a system of floats and weights, and is woven of a very fine thread which makes the net almost invisible when placed in the water. The gill net is placed across known fish migration routes, and fish which are too large to pass through the mesh of the net are caught by the gills. In the period following the Civil War, when the demand for food fish was accelerated, gill nets produced large catches of cisco and whitefish in the deeper waters off the eastern Ohio shore.

The widespread use of pound nets and gill nets greatly expanded the catch of Lake Erie fish, since fishing was no longer dependent upon the migration of fish up tributary streams. This had the effect of increasing the volume of the catch and making possible a fish harvest throughout the ice-free months of the year.

In 1885 the trap net was introduced to Lake Erie. It is similar in design to the pound net, except that it is entirely submerged in the water and is supported by a system of anchors, weights, and floats rather than poles driven into the lake bottom. The trap net proved superior to, and has gradually replaced, the pound net since it can be operated by fewer men and can be fished in water of any depth. Trap nets are more mobile than pound nets and can be moved about the lake in response to changing fishing conditions. In addition, trap nets can be fished on parts of the lake bottom which are too hard to permit the driving of pound net poles. The trap net is considered one of the most effective types of gear in widespread use by the Ohio industry and has accounted for about 75% of the state's fish catch, by weight, during the past two decades.

The bull net, a 20-25 foot high gill net, was introduced in 1906. Unlike the common gill net, the bull net floated off the lake bottom and formed a fence midway between the surface of the water and the bottom. This method was so effective that the bull net was outlawed in 1929, after it was blamed for the extermination of the cisco, or lake herring.  

The haul seine has been used in the Ohio fishing industry since earliest times. The earliest seines were small and were operated by hand.

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Later, horses were used to pull somewhat larger seines ashore. More recently, power-operated winches have been developed which permit two men to operate a seine up to 5000 feet in length. An efficient piece of equipment in terms of labor productivity, the modern haul seine is used in shallow water near the shoreline of western Lake Erie and Sandusky Bay to harvest low value species, such as sheepshead and carp.

The last technical innovation to have widespread effect upon the Ohio industry has been the nylon gill net. Nylon was introduced into Ohio in the early 1950's and has largely replaced cotton and linen, which were previously used in the construction of gill nets. The nylon net has a number of advantages over a net made from natural fibers. Nylon is less visible under water than are cotton and linen, and fish are less likely to see and avoid the net. Because of this fact, it is estimated that nylon nets are between two and four times more effective than those made from natural fibers. Unlike natural fibers, nylon does not have to be brought back to shore to be dried and treated after each use to prevent rotting, but can be fished continuously. Due to its strength and resistance to decay, gill nets made from nylon resist tearing and generally last from two to eight times longer than those made from natural fibers.

The introduction of nylon gill nets has had the effect of increasing the efficiency of the gill net fisherman, while reducing his labor costs. The long-lasting qualities of nylon nets, however, represent a mixed blessing to the fishing industry. Traditionally, part-time fishermen have entered the Ohio gill net fishery during good times, and left it

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when catches or prices were unfavorable. When linen and cotton fibers were used, the absence of more than a year or two caused so much deterioration to the nets that new ones had to be purchased to re-enter the fishery. The purchase price of new gill nets represented almost the entire re-entry cost of the part-time fisherman. The durable nylon net, however, can be stored almost indefinitely without significant deterioration. The advent of the nylon gill net has reduced entry costs to the gill net fishery, making it easier for part-time operators to enter it in prosperous times. Part-time fishermen compete with full-time fishing establishments in the capture and sale of fish, thus reducing their catches and profits.

In the early years of the Ohio fishing industry, operations were conducted from rowboats and sailboats. Rowboats could not be used very far from shore, and sailboats, though considerably larger and possessing greater ranges, were restricted to operations during fair weather. After 1900, steam powered, and later gasoline and diesel powered, craft came into use. These were larger, more efficient boats which could handle more nets and range over the entire lake. Though large enough to be operated safely on Lake Erie during the stormy spring and fall seasons, most were under 65 feet in length, however, as boats larger than this were required to be operated by licensed pilots and engineers. While large power-boats over five registered gross tons form the backbone of the Ohio fishing fleet, many small boats are still in use. They range from rowboats to larger craft with outboard motors, most of which are used in the gill net fishery by part-time fishermen.

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The efficiency of gill net and trap net fishing was greatly increased with the introduction of mechanical net lifters on the fishing craft. The use of power gill net lifters began in 1899 and the power trap net lifter was invented in 1930. The introduction of power lifters reduced labor costs and permitted a single boat crew to greatly increase the number of nets it could tend.

In fishing gear and fishing craft, the trend has been toward the operation of larger quantities of gear with progressively small amounts of labor. Between 1890 and 1940, the amount of trap nets and pound nets fished increased by three times, while the number of men employed was reduced by about four times. This is a trend which has been shared by most other primary industries in the United States, including agriculture, mining, and forestry.

Technological changes in processing and preservation of the catch of Ohio's fishing industry resulted in an early trend toward higher quality, more convenient products which were available more regularly throughout the year. In the early years of the fishery, salting was the only method of preservation available and fish which could not be sold fresh were salted and sold as a cheap, inferior food product. The availability of fish was limited largely to the spring and fall when spawning runs occurred. A large proportion of the heavy catches made during these seasons spoiled before they could be sold and were wasted. It is estimated that only 5% of the fish caught in the early years were sold.25

Cold storage of fish came to Ohio in the 1870's when ice houses were constructed in most fishing ports and stocked with ice cut from the lake in winter. The storage of fish at near freezing temperatures resulted in a better quality product and made possible the utilization of fish which were previously wasted. In addition, fish in cold storage could be marketed during periods of low production, when prices were highest. The first artificial freezing of fish in the United States was carried on in Sandusky, Ohio in 1892, when an ammonia refrigeration device was constructed. This process achieved much lower temperatures than natural freezing and resulted in less deterioration of the fish during storage.

The catch of the Ohio fishing industry has always been sold in a relatively unprocessed condition. The greatest quantity of fish is, and has been, sold "in the round" just as they are taken from the water. A portion of the catch is eviscerated and sold as "dressed," while a very small amount of fish is smoked. The most significant innovation in processing has been filleting, which originated in the fisheries of New England in the 1920's and spread from there to Lake Erie. The filleting of fish reduces shipping costs by eliminating the 50% to 60% of total fish weight which is waste. Fish fillets are more convenient for consumers to use and thus have more appeal in the marketplace.

A review of the technological changes which have taken place within the Ohio fishing industry reveals two major generalizations which are

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28 Turvey and Wiseman, op. cit., p. 146.
significant to a study of the present condition of the industry. The first is that the industry has, since its establishment, developed more efficient methods for catching, preserving, and processing fish. Especially significant, is the timing of these more efficient methods. With the exception of the nylon gill net, the methods which are used today have been in use for at least thirty-five years. The fishing industry exhibited a high degree of inventiveness in its early years, but not in recent times. Factors responsible for the current technological stagnation include restrictive fishery regulations, under which the industry operates, which all but prohibit the introduction of new types of fishing equipment (Chapter IV). In addition, one must note the economic conservatism of the fishermen themselves, an attitude perhaps born of the declining earnings of the fishing industry since World War II. Whatever the cause, the lack of technological progress within the Ohio fishing industry has increased production costs and made it difficult to meet market competition from the freshwater fisheries of Canada and the marine fisheries of the United States (Chapter V).

Locational aspects of the industry

The locational changes which the Ohio fishing industry has undergone may be viewed both in terms of fishing grounds and fishing ports. Fishing grounds are areas of Lake Erie and its embayments which are important producers of fish, while the fishing ports are the towns along the Ohio shore of the lake where fish are landed and processed for sale.

The industry's original fishing grounds were the bays and tributary streams of Lake Erie. These areas, despite the crude gear employed, produced all the fish which could be sold in the early days of the fishery. With the introduction of fishing gear which could be used in deep water, and with the increased demand for fish, operations moved into Lake Erie proper.
Three major fishing grounds have been important to the Ohio industry. The waters of Lake Erie west of Sandusky, Ohio (Map I) have traditionally been the most productive. It is here that pound nets, and later trap nets and gill nets, have been used. The deeper waters east of Sandusky, where gill nets are the primary gear used, have at times rivaled the waters to the west in production, especially in high quality fish. Recently, however, desirable species of fish have become scarce in this area and its importance to the industry has been reduced. In addition to the open waters of Lake Erie, Sandusky Bay and the shoreline areas of the lake west of Port Clinton are important producers of fish (Map III).

Haul seining, which has been carried on in these areas since earliest times, has recently been expanded. Seining capacity increased by 40% in the decade between 1950 and 1960.

With the full development of the Ohio fishing industry in the late 1800's, almost every town along the Lake Erie shoreline which was located near the mouth of a tributary stream became a fishing port. The most important, however, have been located in the western half of the state near the richest fishing grounds. Port Clinton, Toledo, Vermilion, Sandusky and Huron are the most important of the fishing ports in terms of fish landed (Table 16). At one time, Sandusky enjoyed the title of the world's largest fresh-water fishing port.

In recent years, the tonnage of fish received by all Ohio ports has declined. The decline has been most drastic in the eastern Ohio ports, due to the disappearance of desirable fish populations in the deeper waters of the central basin, which these ports served. The fishing industry's center of gravity, in terms of landing, began in western Lake Erie, and spread progressively eastward as the industry developed. This center has
now shifted back toward the west with the decline of the eastern Ohio gill
net fishery.

The most important problem with regard to the location of the Ohio
fishing industry is the fact that it is spread over so many small ports.
The distribution of the Ohio catch among more than ten fishing ports is
due, in large part, to the ease of landing fishing vessels in the mouths
of the numerous tributary streams along the Ohio shore of Lake Erie. This
condition has precluded the concentration of operations in which economies
of scale are possible: processing, preservation and packaging, and
transportation. The relatively small amount of fish handled by any
individual port has made it difficult for the industry to adopt efficient,
high-volume, low-cost methods.

Governmental regulations affecting
the fishing industry

The Ohio fishing industry has been profoundly affected by govern­
mental regulations for many years. The regulations imposed by government
may be grouped into three classes: those which control the harvest of fish
in Lake Erie, those which affect the importation of lake fish into the
United States from Canada, and those which are concerned with the importa­
tion of fishing equipment.

Since 1857, the Ohio legislature has assumed the authority to
regulate the commercial cropping of fish within the Ohio waters of Lake
Erie, for the purpose of protecting the fish populations of the lake.
Most of the major provisions of the present fishing legislation have been
in existence since the early 1900's and were enacted in response to pressures
from sport fishermen who believed that the initial decline of some favored
species was the result of overfishing by commercial operators.29

29Kah, op. cit., p. 13.
In most Great Lakes states, authority to regulate commercial fishing is vested in the state conservation agency, but in Ohio fishing regulations have traditionally been written into the state legal code. Although the Ohio Division of Wildlife has had the responsibility to enforce commercial fishing regulations, it has not had the authority to change them as the biological conditions of the Lake Erie fish stocks have changed. In Ohio, an act of the legislature has been required to change a regulation and, since the legislature meets only once in two years, often the reasons for change have passed before proposals can be placed before it. Hearings before legislative committees on proposed changes in fishery regulations have witnessed a constant struggle between various elements of the commercial fishing industry to gain advantage for their particular method of fishing. There was, for example, competition between operators of gill nets, trap nets, and haul seines which was reflected in the strengths they could demonstrate before the legislature. Since the recent establishment of the Ohio Commercial Fishermen's Association, there has been more unified political action on the part of the industry in the past few years.

Since September, 1963, the Ohio Division of Wildlife has had limited authority to establish commercial fishing regulations for the Ohio waters of Lake Erie. The Chief of the Division is charged with the task of initiating regulatory changes, subject to the approval of the Division's Wildlife Council. As a result of this change, it is likely that biological considerations will play a larger role in the formulation of regulations and intra-industry rivalries will play a more minor part. With the regulation of commercial fishing further removed from the power politics of the legislature, it may be possible to adopt regulations
geared to the productivity of the Lake Erie fish stocks and in concert with those established by the Province of Ontario, which has long had the authority to adjust regulations to meet both market and biological conditions.

The Ohio fishing regulations are extremely detailed and complicated, but in general the following are controlled: areas of the lake and its embayments which may be fished, times of the day and year when fishing is permitted, types of fishing gear which may be employed, and the species and sizes of fish which may be landed. Regulations have sought to reduce fishing pressure on preferred species by limiting, in various ways, the amount of fish which can be harvested. They are based on the belief, noted earlier, that the depletion of fish populations are the result of simple overfishing. This belief has now been discarded by many fishery scientists in the face of mounting evidence that Lake Erie's changing aquatic environment is influencing its fish populations.\(^{30}\) Despite scientific evidence to the contrary, regulations based upon the hypothesis of overfishing remain in effect.\(^{31}\)

Regulations on commercial fishing have not had the desired effect of restoring the declining species, but instead have increased the costs of producing fish, reduced the profits of the fishermen, and increased the cost of fish to the consumer (Chapter IV). By specifying the types of fishing gear which may be used, the invention or introduction of new


methods has been discouraged. Fishing laws are responsible, in large measure, for the technological stagnation of the Ohio fishing industry.

In Michigan, Pennsylvania, New York, and the Province of Ontario the trend in recent years has been toward the liberalization of laws dealing with commercial fishing in Lake Erie. This trend has been especially marked in Ontario, where size limits, closed seasons, and restrictions on gear have been removed. Ohio has not followed the trend toward liberalization and its fishermen are now at a disadvantage in their competition with those of other states and Canada who fish in Lake Erie.

In 1930, the importation of freshwater fish into the United States from Canada was subjected to an import tariff. Under the original tariff act, whole or dressed fish were subject to an import duty of one cent per pound, while fillets carried a duty of two and one-half cents per pound. In 1948, however, the duty on whole and dressed fish was cut to one-half cent per pound, and in 1954 the tariff on fillets was reduced to one and one-half cents per pound.\(^{32}\)

As the amount of duty per pound of fish has decreased, the value of the imported fish, per pound, has increased. In 1964 the average value of imported Canadian whole and dressed freshwater fish was approximately thirty cents per pound, while that of fillets was about forty cents.\(^{33}\) At these prices, an import duty of one-half cent for whole and dressed fish, and one and one-half cents for fillets represents a very small


\(^{33}\)U. S. Bureau of Commercial Fisheries, Imports and Exports of Fishery Products, 1963-64, pp. 3-4.
portion of the total value of the shipment. Import duties have now ceased to function as a barrier to the importation of Canadian freshwater fish.

A second tariff of concern to the Ohio fishing industry is the duty on fish nets and netting, which are imported primarily from Japan. Japanese nets can be produced cheaper than domestic ones, and a 22-1/2% ad valorem rate of duty is in effect to protect United States netmakers. The duty raises the cost of fishing equipment by 22-1/2% to Ohio fishermen. Canada has no tariff on nets, however, and fishermen there are able to buy the same equipment at considerably lower prices. The difference in price on a single trap net, for example, amounts to about $250.00.

Existing governmental regulations represent a serious problem for the Ohio fishing industry. Ohio commercial fishing regulations result in higher production costs for Ohio fishermen than those of surrounding states and Ontario, where regulations have recently been liberalized. In addition, current regulations encourage technological stagnation within the industry. Attempts to modify Ohio fishing regulations, in line with new knowledge in the fields of fishery biology and resource management, have been unsuccessful largely due to the inability of the fishing industry to maintain a united position at legislative hearings. Import tariffs on freshwater fish and fishing equipment are presently at unfavorable levels, but there is little likelihood of their being changed in the near future.

Industrial structure

The structure of an industry is important in determining its success or failure to adapt to changing conditions. Two elements of industrial structure will be emphasized: size of establishments and degree of vertical integration. The size of the establishments which make up an industry is important in a number of ways. Large companies are often able to attract
and reward full-time, well-informed, progressive managers, while small companies cannot. In addition, large companies can better afford to spend money on research to develop new methods, products, and markets. Finally, large companies are better able to raise capital for modernization than small firms.

Vertical integration is the involvement of a single firm in several phases of an entire industry. A fully integrated fishing company, therefore, would operate its own fishing fleet, process the catch in its own plant, package its products in consumer-sized packages under its own brand name, transport them to market in its own trucks, and sell them to the public in its own stores. There are economic advantages to integration, since the company has optimum control over its raw material source and its markets, and can control production and marketing costs to assure maximum profits. The dominance of an industry by integrated companies encourages an orderly flow of products from the raw materials to the final consumers.

Historical data concerning the size and degree of integration of Ohio fishing establishments is almost totally non-existent. A history of South Bass Island, by Langlois, however, provides a glimpse of the industry during the 1920's and 1930's. Langlois mentions the existence of three large companies which had their own fishing fleets, dock facilities, processing and freezing plants, and shipping facilities. In addition, they operated their own retail market outlets in the large cities of the eastern United States. The companies' operations were directed by full-time

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Thomas H. Langlois and Marina H. Langlois, South Bass Island and Islanders, The Ohio State University, Franz Stone Laboratory, Contract No. 10, 1948.
managers with long experience in the fishing business. Although no finan-
cial data are provided, the impression is given that these large firms
represented substantial capital investments, and exercised a large degree
of control over the industry. Many small fishermen sold their catches to
the large companies for processing and shipping. In some cases, the small
fishermen were in debt to the large firms and were, in effect, controlled
by them as part of the parent organizations.35

Data concerning the present size of fishing establishments are
restricted to the number of trap nets, gill net boats, and haul seines
licensed by each fisherman.36 An indication of vertical integration is
provided by lists of producers and wholesalers of fishery products,
compiled by the U. S. Bureau of Commercial Fisheries.37

The large companies mentioned by Langlois are no longer engaged
in commercial fishing. Two are completely out of business and one operates
exclusively as a wholesale fish dealer. The remaining fishing establish­
ments are small. In 1963, 50 Ohio fishermen were licensed to fish a total
of approximately 1000 trap nets in Lake Erie. The largest had 130 nets
licensed, or about 13% of the trap net capacity. The next largest fishing
establishment had about 6% of the industry's trap net capacity. The
remaining capacity was scattered among 48 other fishermen. The gill net
capacity of the Ohio industry in 1963 consisted of 57 boats, operated by
47 establishments. The largest establishment operated only three of the


36 Special tabulation of commercial licenseholders from the records
of the Ohio Division of Wildlife, Sandusky, Ohio.

37 United States Bureau of Commercial Fisheries, Wholesale Dealers
in Fishery Products, Ohio, 1962, Publication No. SL-29, Washington, D. C.,
1962.
fifty-seven gill net boats, or approximately 5% of total capacity. Haul seine capacity was comprised of 9338 rods of seine. The largest seine operator licensed 690 rods, or about 7% of the total. The remainder was distributed rather evenly among 57 fishing establishments. Licensed gill net, trap net, and haul seine operators totaled 137 in 1963. Of them only 23 were engaged in processing fishery products. Thus, the Ohio fishing industry is presently composed of a large number of small, non-integrated establishments. Integrated firms are present, but they are neither large nor numerous. Many of the challenges facing the industry are in the realm of mechanization of operations and new product and market development (Chapter IV). Many of the fishing firms now in operation are too small to effectively undertake and conduct efforts of this type. The trend in the structure of the Ohio fishing industry has been from large, integrated companies to small firms engaged primarily in fishing operations. Ironically, the present structure of the industry is probably less favorably suited to meeting the crisis with which it is confronted than at any time in its modern history.

Summary

The fishing industry's presently depressed condition, the major focus of this study, has been described in terms of volume and value of catch, employment and wages, gross sales and value of capital equipment. The industry's volume of catch has declined by 75% since the turn of the century, with the sharpest drop occurring since 1957. Landed value of catch, the best available long-term barometer of industrial health, has declined steadily, in actual dollars received, since the mid-1950's. Conversion of landed value of catch to constant dollars reveals an industrial decline beginning in 1943, despite abundant harvests of highly
desirable fish in the 1950's. The timing of the beginning of the present depression suggests the causal association of both biological and other factors.

Employment in the Ohio fishing industry has fallen in recent years, and almost all workers are now part-time. Wage rates have declined both absolutely and relatively and now are only 65% of the Ohio all-industry average. Since it offers only part-time work and a low level of wages, the industry faces potentially serious labor supply problems. Gross sales of the industry and the value of its capital equipment were reduced by approximately 65% between 1954 and 1962. Most equipment is old; there has been little replacement or modernization since the early 1950's.

The public value of the fishing industry, which may be expressed as the contributions which it makes to the public welfare, is substantial despite its depressed condition. Tangible contributions include more than $20 million worth of fishery products, as well as wages and salaries, unemployment compensation payments, taxes and license fees paid by fishing establishments. Esthetically, commercial fisheries have traditionally been a part of the cultural landscape of the Lake Erie shoreline and may improve sport fishing in Lake Erie by the removal of non-game fish species.

The Lake Erie commercial fishing industry in Ohio traces its beginnings to the early years of the 19th century. Before that century was over, it had become the largest freshwater fishing industry in any state of the United States. Its principal port, Sandusky, enjoyed the title of the world's largest freshwater fishing port. After 1900, the industry was stimulated by the two World Wars, and a period of expansion followed each. The fishing industry has been declining since the end of World War II and is now in the depths of a severe depression.
The demand and markets for lake fish were primarily local in the early years of the fishery. Later, more distant markets were tapped, until most of the principal market centers in the northeastern United States were being served. In recent years, marketing patterns have become more localized as the Midwest expanded in population, the industry's catch declined in volume and value, and transportation costs increased. Present markets for high value food fish products are adequate to absorb the current output, but markets for low value fish are relatively underdeveloped. The establishment of profitable markets for these fish remains a major industry problem.

The Ohio fishing industry had a remarkable record of innovation and inventiveness throughout much of its early history. Efficient methods were devised to capture, process and preserve the catch. In some cases, techniques developed in Ohio spread successfully throughout the United States. The progressiveness of the early years stands in stark contrast to the stagnant technology of the present industry. Only one major technological change, the introduction of nylon nets, has occurred in the last thirty-five years. Whether caused by restrictive fishery regulations or the conservatism of fishing operators, the stagnant technology of the present industry has increased production costs, making it difficult to meet growing competition in the marketplace.

The Ohio fishing industry began in the shallow waters of western Lake Erie, with operations later shifting to the deeper waters off the eastern Ohio shore. Eastern Ohio fishing grounds and ports once rivaled those in the west, but in recent years have declined sharply. Due to the numerous tributary streams which line the Ohio shoreline of Lake Erie, and the ease of landing small fishing boats therein, the industry's establish-
ments are distributed among several small fishing ports. This has discouraged the development of large scale processing and handling methods which the industry needs to reduce its costs.

Existing regulations, imposed by both the state and federal governments, represent a major problem to the fishing industry. Regulations on commercial fishing operations were imposed as a means of restoring abundance to highly prized species of fish in Lake Erie. This objective has not been achieved; the costs of fishing have been increased and the introduction of new fishing methods has been prohibited. A tariff on the importation of Canadian lake fish, which was designed to aid the industry, has ceased to be a barrier. A duty on the importation of fishing gear into the United States makes the cost of such gear higher to the Ohio fisherman than to his Canadian competitors.

An examination of the structure of the Ohio fishing industry reveals a large number of small, non-integrated firms. Large, vertically integrated companies which once dominated the industry have now been replaced by small establishments, engaged mainly in primary fishing operations. Unfortunately, most of them are too small to effectively deal, on an individual basis, with the problems which now confront the industry.
CHAPTER III

LAKE ERIE: THE RESOURCE BASE
OF THE OHIO FISHING INDUSTRY

As the preceding chapter has indicated, the factors associated with the decline of the Ohio fishing industry are both physical and cultural in nature. This chapter will describe the physical problems associated with Lake Erie as the resource base for the fishing industry. Although the changing supply of commercial fish is of most immediate concern to the industry, other related aspects of the lake will be discussed in an effort to provide a background for the understanding of this problem. These include, initially, the physical characteristics of the lake which makes its aquatic environment unique among the Great Lakes. The waters of Lake Erie are intensively used by man for a variety of purposes, with significant effects upon the lake's aquatic environment and the operations of the Ohio fishing industry. The intensive human use of Lake Erie has accelerated its natural aging processes, causing dramatic changes to occur in the aquatic environment for fish. All of these factors are related to the lake's changing populations of fish which are available for capture by the fishing industry.

The physical characteristics of Lake Erie

Lake Erie lies in the drainage basin of the St. Lawrence River and is part of the Great Lakes drainage system. Although it is next to the smallest of the Great Lakes, its 9,940 square miles of area rank it
as the tenth largest lake in the world. The greatest length of the lake is 241 miles and its greatest width is 57 miles. It is divided almost equally in half by the international boundary between the United States and Canada. Lake Erie is the shallowest of the five Great Lakes and the only one whose entire water mass is above sea level. The deepest point in the lake is 210 feet compared with Lake Superior's greatest depth of 1,290 feet and Lake Michigan's 923 feet. Lake Erie receives the outflow of the upper Great Lakes through Lake St. Clair and the Detroit River, as well as the surface drainage from its own 34,680 square mile drainage basin. The basin is heavily populated, containing some 10 million people in the U.S. portion and 1.2 million on the Canadian side.

Lake Erie is divided morphometrically and limnologically into three distinct basins: a shallow western basin with several large and small islands, a large flat central basin of intermediate depth, and a deeper eastern basin (Map II). That part of the lake east of a submerged ridge lying between Presque Isle, off Erie, Pennsylvania, and Long Point, in Ontario, Canada, has a relatively deep basin with a considerable area in excess of 120 feet in depth. The large central section of the lake has a broad, flat basin with a maximum depth of 84 feet. West of a line between Point Pelee, in Ontario, and the Marblehead Peninsula, in Ohio, the lake is much shallower. The entire western basin resembles a shelf raised well above the level of the eastern basin. The maximum depth of this basin is

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54 feet, but only a small part of the area exceeds 36 feet in depth. The eastern portion of the western basin is dominated by five islands, each of which has an area exceeding one square mile. Pelee Island, the largest, and Kelleys Island, the second largest, form the eastern boundary of the basin. A few miles west lie the Bass Islands. Surrounding the major islands are numerous small islands, reefs, and shoals (Map III). The islands and shoal areas form a partial barrier to the movement of water between the western basin and the rest of the lake. This has the effect of maintaining a separate and distinct environment in the western basin, which serves as an important spawning and nursery area for Lake Erie fish.

Lake Erie may be thought of as a large pool in the St. Lawrence River system, with water entering the lake at the western end and leaving it at the eastern end. About 90% of the lake's water, an average flow of 180,000 cubic feet per second, comes from the upper Great Lakes via the Detroit River. In addition, water from smaller tributaries and overwater precipitation contribute to Lake Erie's average outflow of 200,000 cubic feet per second. Although they are minor contributors on the average, Langlois has noted that tributaries along the Lake's southern shoreline can have a combined flow equal to that of the Detroit River, during periods of heavy precipitation. The flow from the upper lakes tends to be relatively constant in volume and free from silt and other suspended...
materials, while that from south shore tributaries is typically muddy.

The shallowness of Lake Erie, and the orientation of its long, narrow shape in the direction of the south westerly prevailing winds, make it subject to sudden environmental changes. Such changes occur during a storm when violent wave action churns up fine bottom sediments and makes the lake water very turbid. Most of the lake tends to be affected and, unlike the other Great Lakes, there is only a limited volume of deep water which remains unchanged by storms to serve as a haven for fish.

A number of factors, both natural and man-made, contribute to making Lake Erie a considerably different aquatic environment than the other Great Lakes. Its southerly location and relative shallowness combine to produce water temperatures which are the highest of the five lakes. In addition, Lake Erie contains a higher level of dissolved plant nutrients than the other Great Lakes, due primarily to the large amounts of municipal and industrial waste materials dumped into it by the population centers in its drainage basin. The growth of aquatic plants is directly related to water temperature and the availability of nutrients. These plants form the base of the food chain supporting stocks of fish. Ample amounts of plant nutrients, kept thoroughly mixed by wave action, and high water temperatures combine to give Lake Erie a potential for biological productivity which is unmatched in the other Great Lakes. The productivity of the lake is reflected in the fact that it has traditionally yielded a fish catch as large as the other Great Lakes combined.

Lake Erie is a component of the Great Lakes drainage system, receiving water from the upper lakes as well as its own heavily populated drainage basin. By Great Lakes standards, it is small, shallow, warm, and
subject to rapid environmental change. Its biological productivity has traditionally been high and as a fishery resource base it has been unsurpassed among the Great Lakes. As the following discussion will indicate, the intensive human use of the lake is changing its aquatic environment and its populations of fish.

The multiple uses of Lake Erie

Lake Erie is a large body of fresh water located in a densely populated region. Its waters are intensively used for a variety of purposes, some of which affect the Ohio fishing industry. A few of the multiple uses of Lake Erie affect the operations of the industry directly, but most effects are indirect, involving changes in the quality of the aquatic environment. Changes in the aquatic environment are related to the overall problem of changing fish populations in the lake. The uses of Lake Erie affecting the fishery resource base include: municipal and industrial waste disposal, agricultural run-off, commercial and recreational navigation, and test firing of military weapons.

Municipal and industrial waste disposal

The human population of the Lake Erie drainage basin contributes large amounts of waste materials to the lake. Water supplies are withdrawn, both for residential and industrial purposes, from the lake and its tributary streams. Waste materials are added during use, after which the water is returned to the lake or streams. More than 80% of the municipal and industrial wastes enter the western end of the lake and are distributed throughout it by a general west to east circulation.\footnote{U.S. Department of Health, Education and Welfare, Public Health Service, Division of Water Supply and Pollution Control, op. cit., pp. 9, 35-39.}
Two general types of municipal and industrial effluents affect the Lake Erie fishery, organic wastes and exotic chemicals. While relatively little is known of the effects of the latter on fish and other aquatic life, the effects of organic wastes upon the aquatic environment have been well documented. When organic wastes enter the water, they exert an immediate chemical demand for dissolved oxygen. In addition, they contain nutritive materials which become available to the metabolic processes of bacteria and other organisms. The residual products of the decomposition of waste materials are plant nutrients, such as nitrogen and phosphorus compounds. These are used in the growth of algae and other phytoplankton which bloom at or near the surface and ultimately settle to the bottom of the lake to decay. The decay of organic matter, such as algae, consumes vast amounts of oxygen which is subtracted from the lake's dissolved oxygen supply. In 1964, a deficit of 270 million pounds of gaseous oxygen was produced by the decay of algae grown in the lake. The large scale consumption of dissolved oxygen by decaying algae has caused some areas of the lake to become so devoid of oxygen that the widespread destruction of aquatic fauna, including fish, has resulted.

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In addition to biologically degradeable pollutants, there is evidence that other, more stable chemicals contained in municipal and industrial sewage may have an adverse effect upon the aquatic environment. The effects of these substances are not well understood but it has been shown that as little as one part per million of synthetic detergent can reduce the aeration potential of water by 20% to 30%, thus aggravating an already serious dissolved oxygen problem.\(^\text{49}\) Hopefully, this may be temporary, as many detergent manufacturers are now producing "soft", biologically degradeable detergents.\(^\text{50}\) Unfortunately, however, the chemical breakdown of soft detergents releases additional amounts of phosphorous compounds to spur algae growth.

**Agricultural run-off**

The natural run-off of precipitation from the rich agricultural lands of its drainage basin carries vast quantities of suspended silt and mud into Lake Erie. Most of the suspended materials are discharged into the lake by tributary streams along the south shore, after being eroded from the glacial and glaciolacustrine soils of their drainage basins. During one twelve month period in 1951-52, the Maumee, Portage, and Sandusky Rivers carried nearly three million tons of suspended sediment into western Lake Erie, with more than 80% of it coming from the Maumee River.\(^\text{51}\) In contrast to liquid pollutants from municipal and industrial sources, which are introduced into the lake in relatively constant amounts throughout the year, and from year to year, the discharge of silt and mud

\(^\text{49}\) Kneese, op. cit., p. 55.

\(^\text{50}\) Business Week, April 25, 1964, p. 140.

\(^\text{51}\) Langlois, op. cit., p. 57.
is highly variable. Generally, the maximum amount enters the lake during
the early spring when heavy rains bring the streams to flood stage. In
1951–52, 98% of the year’s suspended sediment was discharged into the
lake between December and June. The timing of the stream discharges is
important biologically since it coincides with the spring spawning and
hatching season of Lake Erie fish. While suspended, silt acts as a curtain
to screen out sunlight and limit photosynthesis by plankton, curtailing
plankton production at the very time it is most needed as food by young
fish.\textsuperscript{52} When suspended materials settle out, they tend to smother bottom
fauna and rooted vegetation, which serves to protect newly hatched fish
from predators. In addition, sand and gravel spawning beds have become
blanketed with thick layers of mud, rendering them unusable by some
desirable species of fish.\textsuperscript{53}

The agricultural run-off into Lake Erie includes, in addition to
silt and mud, increasing amounts of chemical pesticides, which have been
used increasingly in recent years to control weeds and destructive insects
in agricultural crops. While pesticides have been held responsible for
massive fish kills in various parts of the United States, they are not
known to exist in lethal concentrations in Lake Erie. These compounds are
chemically very stable, however, and they may have long term, cumulative
effects which are damaging to fish. At present, evidence of such effects
upon fish in Lake Erie is lacking.

\textsuperscript{52} Ibid., pp. 51–62.
\textsuperscript{53} Ibid., p. 25.
Commercial and recreational navigation

The operation of commercial and recreational vessels on Lake Erie causes an undetermined amount of damage to commercial fishing gear each year. Vessels which run over and through the nets range in size from small pleasure boats to large commercial lake freighters. Areas in which nets are damaged most frequently include the passages between the islands, and those between the islands and the mainland. Net damage by watercraft, mentioned in the literature as early as 1879, has traditionally been accepted as one of the hazards of commercial fishing. In recent years, the Ohio Commercial Fishermen's Association has cooperated with various boating organizations in an attempt to minimize the inconvenience and damage caused by collisions of pleasure boats with commercial nets. These efforts have included talks by fishermen to boating groups and the distribution of printed instructions regarding the proper ways to navigate in waters where nets are being used.

The increased navigational use of Lake Erie in recent years has contributed to water pollution. Vessels of all sizes dump garbage and sewage into the lake, usually in an untreated condition. Bottom materials from the Detroit River, Maumee Bay, Sandusky Bay, and various harbors are dumped into the lake as a result of dredging operations to maintain navigational channels. Dredging, which has been intensified in recent years due to low water levels in Lake Erie, transfers tons of settled industrial waste, mud and dead organic matter from the shallow areas where it was deposited to the deeper waters of the lake. There it is re-suspended by wave action and exerts a demand upon the lake's dissolved oxygen supply.

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54 Goode, op. cit., Section III, p. 129.
Test firing of military weapons

The United States Army Test and Evaluation Command operates the Erie Proving Ground which is located at the Erie Army Depot near Port Clinton, Ohio. As part of its testing of military weapons, the proving ground maintains a firing range impact area in western Lake Erie (Map III). This area is closed to all activities, including commercial fishing, during a large part of the year. The impact area has great potential as a fishing ground since it includes the Niagara Reef, which serves as one of the major spawning areas in the western basin. Despite the recently announced closing of the Erie Army Depot by the end of 1966, the Erie Proving Ground will remain in operation and a highly productive fishing ground will continue to be lost to the Ohio fishing industry.  

Trends in the use of Lake Erie water

At present, the waters of Lake Erie are intensively used for a variety of purposes. In the future, it is likely that they will be even more intensively used; the consequences of that use are likely to be even more unfavorable to the Ohio fishing industry than they are today. Water use for domestic purposes has increased fourfold in the United States since 1900, while industrial usage has increased eightfold. By 1980, according to present estimates, the demand for public and private domestic water supplies will double again; the industrial water demand will triple. As the demand for water becomes more acute, increasing attention will be

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55 Letter from Mr. Bert C. Alexander, Executive Assistant, Erie Proving Ground, Port Clinton, Ohio, June 23, 1964.

directed toward the world's greatest source of fresh water, the Great Lakes. The Lake Erie area is experiencing rapid population and industrial growth, and there is the increased possibility that water will be diverted to areas of need which are many miles from the lake. Such a diversion in northwestern Ohio is already in the planning stages.

The increased use of Great Lakes water implies heavier and more complex waste loads entering the lakes. It is estimated that more than 10,000 new chemical products are put into use in the United States each year, many of which ultimately show up in waste water. The appearance of new waste materials adds an additional dimension to the problem of treating increased amounts of waste water. The problem is especially acute in view of the fact that water treatment methods in use today are essentially the same as those used fifty years ago. The problem of water pollution is not insoluble from a scientific point of view. The great barrier is one of cost. It is technically conceivable that Lake Erie could be restored to the degree of water quality which existed prior to the settlement of white men along its shores. In terms of present levels of technology in water treatment, however, such an undertaking would be prohibitively expensive. For the foreseeable future, barring a sudden break-through in water treatment methods, the trend toward increased use of Lake Erie for the deposition of municipal, industrial and agricultural wastes must be viewed as irreversible.

57 Ibid., p. 295.
58 Sherman L. Frost, Executive Secretary, The Ohio Water Commission, quoted in The Commentator (Worthington, Ohio, November 19, 1964, p. 2.
59 Ibid.
The past three years have seen unprecedented attention and research effort directed toward the problem of pollution in Lake Erie. Both state and federal agencies have conducted studies to determine the extent and sources of water pollution. Recommendations have been made concerning improvements in waste treatment methods and water quality standards are being established for Lake Erie and its tributary streams. At present, it is difficult to foresee what effects these efforts will have on the aquatic environment in the lake. Likewise indefinite is the timing of the effects. It is unlikely, however, that improved waste treatment and enforced water quality standards would produce significant improvements in the aquatic environment for at least several years.

Lake Erie represents an extremely valuable natural resource, which is used for a variety of purposes. Those which affect the Ohio fishing industry include the deposition of municipal and industrial waste materials and the products of agricultural run-off, commercial and recreational navigation and the testing of military weapons. While some uses interfere with fishing operations directly, most are of concern because they contribute to a degradation of Lake Erie's aquatic environment. The environmental changes which have occurred in the lake and the alteration of its fish populations will be described in the next section. While significant steps have been taken toward the eventual abatement of water pollution in Lake Erie, population and industrial growth in the lake basin appear to preclude any dramatic change in the aquatic environment in the immediate future.

The changing aquatic environment of Lake Erie

The collection of information concerning the aquatic environment of Lake Erie has, in the past, been sporadic, scattered, and incomplete. Major surveys to collect data on the physical, chemical, and biological characteristics of the lake have tended to follow catastrophic events such as the disappearance of a particular valuable fish species or the closing of bathing beaches due to high bacteria counts in the water. In 1961, the first systematic and continuing analysis of water quality and aquatic life in the entire Lake Erie basin was begun by the U. S. Public Health Service, as part of its Great Lakes-Illinois River Basins Project which is aimed at the assessment and control of water pollution.61 The initial reports of this survey and the published results of earlier research form the basis for the following discussion of Lake Erie's altered aquatic environment.

Eutrophication of Lake Erie

The natural aging process of a lake, known as eutrophication, is normally a function of geologic time. During the early phases of its life cycle, a typical lake normally occupies the oligotrophic stage. The water is cold, clear, and rich in dissolved oxygen. Dissolved nutritive materials, and thus plankton and other forms of aquatic life are sparse. Coldwater fish, such as trout, predominate. In the more mature, or eutrophic stage, water temperatures are frequently higher and dissolved oxygen levels, especially in deep water, are lower. Turbidity and the level of dissolved plant nutrients are greatly increased. The typical eutrophic lake is characterized by a much higher level of biological productivity and larger

populations of plant and animal life. Fish populations are increased due to the greater availability of food organisms, but the species composition is changed to bass, catfish and other warm water fish which are better adapted to the low oxygen levels. 62

There is increasing evidence that the intensive use of Lake Erie water, described previously, has produced profound, and perhaps permanent, changes in the aquatic environment of the lake. Recently, investigations into the changing environment have centered around the possibility that the introduction of agricultural, municipal, and industrial effluents into the lake may have accelerated its aging process. There are numerous examples of accelerated eutrophication in the biological literature, all of which involve lakes much smaller than Lake Erie. Zürichsee in Switzerland and Lake Washington in the United States are examples of relatively large lakes where eutrophication has been documented. 63 It has generally been assumed that the vast amount of dilution which is characteristic of very large lakes would prevent the acceleration of eutrophication. The marked changes which have been observed in Lake Erie make it a unique situation, involving accelerated environmental change on a scale heretofore unknown.

The environmental changes associated with the eutrophication of Lake Erie may be observed in physical, chemical, and biological terms.


Chemical and physical changes include sharp increases in dissolved minerals, a slight increase in average water temperature, and drastic, seasonal declines in dissolved oxygen. Biologically, there has been a transition in bottom-dwelling fauna from clean-water organisms to species which are tolerant to high levels of pollution and low levels of oxygen. Plankton, especially algae, have increased dramatically in quantity, and species changes are apparent which indicate increasing eutrophication. The fish populations of the lake are likewise changing, apparently in response to the altered aquatic environment. Dominant species are rough, low value fish which are characteristic of eutrophic lakes. Unfortunately, the eutrophication of Lake Erie has produced a supply of commercial fish which the Ohio fishing industry is ill-equipped to harvest and market.

Physical and chemical changes

The physical and chemical changes which Lake Erie has undergone as a result of accelerated eutrophication are many and varied. In this discussion, only those having a direct bearing upon the degradation of the lake as a resource base for commercial fishing will be mentioned.\(^6^4\) The deposition of silt and mud, which enters the lake from its tributary streams, has increased, to the detriment of many forms of aquatic life.\(^6^5\) Once extensive aquatic meadows, consisting of rooted vegetation, which served as spawning and nursery areas for lake fish have been eliminated by silting.\(^6^6\)

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\(^6^5\) Ibid., p. 410.

\(^6^6\) Ibid., p. 25.
In addition, many areas of the lake bottom which were once covered by sand and gravel have been blanketed with mud, making them unusable for spawning.

The use of Lake Erie for the disposal of municipal and industrial wastes has increased the level of dissolved chemical compounds in its waters. Of particular concern is the enrichment of the lake by the addition of nitrogen and phosphorous compounds, which serve as plant nutrients in the growth of algae. Since, 1942, the concentrations of nitrogen and phosphorous compounds in the lake water have increased by more than 200% and 150% respectively. They are now beyond the critical levels at which large algae blooms occur, provided other growth conditions such as light, temperature and turbulence are favorable. The average water temperature of Lake Erie has increased modestly in recent years. Aside from normal year to year fluctuations, the long term average annual temperature has increased about 2°F. This 4°F increase has been attributed to a similar increase in average air temperature in the vicinity of the lake, but increasing use of lake water for industrial cooling purposes may be a contributing factor. Increased water temperatures provide a more favorable environment for the growth of algae and in addition, reduce the lake water's capacity to hold dissolved oxygen.

Increased concentrations of plant nutrients and organic waste materials have had both direct and indirect effects upon dissolved oxygen in Lake Erie, which is necessary for the respiration of commercial fish.

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67 Beet, op. cit., p. 158.


69 Beet, op. cit., p. 155.
and other desirable aquatic organisms. The oxidation of organic wastes contained in municipal and industrial effluents exerts an immediate demand upon the dissolved oxygen contained in the lake water. The by-products of oxidation contain plant nutrients which support large growths of algae and other phytoplankton. These die and eventually fall to the bottom of the lake to decay. Oxygen is consumed in this process, as well as in the respiration of aquatic animals. Significantly, the oxygen which is consumed in these chemical and biological processes is subtracted from the bottom waters of the lake. Oxygen is added to the lake water as a by-product of photosynthesis, and by diffusion from the atmosphere. Recharge takes place at the surface and in the first few feet of depth which are illuminated by sunlight. Vertical mixing, associated with turbulence and wave action, performs the important function of transporting oxygen to the bottom of the lake and carbon dioxide to the upper waters to be utilized in photosynthesis.  

The bio-chemical demand for dissolved oxygen in the bottom waters of the lake is now at an all-time high. With increasing frequency in recent years, dissolved oxygen supplies have been reduced to critically low levels. This usually occurs during the summer when high water temperatures hasten algae growth and decay and periods of calm weather reduce the vertical mixing of lake water by waves.

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70 Pincus, op. cit., p. 108.

The depletion of dissolved oxygen supplies has generally unfavorable effects upon the supply of commercial fish in Lake Erie. Occasionally severe low oxygen conditions lead to fish mortalities. In addition, areas of the lake which are nearly, or wholly, devoid of oxygen are unsuitable for such activities as spawning, hatching, and feeding. As increasing fractions of the lake are depleted of oxygen in summer, the normal habitat area for lake fish is correspondingly reduced. Commercial lake fish have also been indirectly affected through their food supplies. Low dissolved oxygen conditions are unfavorable, if not lethal, to many of the aquatic organisms which make up the food chain of valuable fish species. Among the biological changes associated with the accelerated eutrophication of Lake Erie is a drastic alteration in the amount and type of food available to fish.

The recent scientific research suggesting that Lake Erie is undergoing accelerated eutrophication, largely due to the acts of man, has in many instances been misinterpreted to the public. News media, in reporting that the lake is "aging" have fostered the misconception that Lake Erie is "dying", implying that aquatic life in the lake is being eliminated. Actually, just the reverse is true. The progressive enrichment of the lake has made it biologically more productive than at any other time in

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72 Ibid.

73 In August, 1964, an area of 2600 square miles, more than one-fourth the total area of Lake Erie, was practically devoid of dissolved oxygen in bottom waters, Nerthington, op. cit., p. 11.

74 Ibid., p. 11.
its history. Thomas estimates, for example, that biological productivity in the central basin increased 5.7 times between 1928 and 1960.75

Up to a point, increased biological productivity is desirable, since it results in larger numbers of the life forms which make up the food chain of commercial fish. The productivity of Lake Erie, however, has exceeded desirable levels. The great masses of plankton which are produced fall to the bottom of the lake where dissolved oxygen is consumed in the decaying processes. This has resulted in serious oxygen deficiencies in large areas of the bottom waters of the lake, which in turn, has produced undesirable changes in bottom dwelling organisms and the fish species which feed on them.

The aquatic food chain in Lake Erie which culminates in commercial fish, begins with the synthesis of plant material from sunlight, dissolved plant nutrients and carbon dioxide. The basic phytoplankton is fed upon by a wide variety of lesser animal forms which become food for fish. Some species of fish feed principally upon other fish, and these predators form the end link in the food chain of the lake. The increasing concentrations of plant nutrients in the lake have supported progressively larger crops of plankton.76 In a recent study, Davis has shown that the average


76 The size of the Lake Erie plankton crop has reached staggering proportions. On September 7, 1961, for example, a single algae bloom was observed which covered over 800 square miles of the lake surface between the western and central basins. The algae formed a continuous mat, approximately two feet in thickness, immediately below the surface. After four days, it sank to the bottom of the lake to decay (Victor L. Casper, "A Phytoplankton Bloom in Western Lake Erie, September, 1961," Paper presented at the Eighth Conference on Great Lakes Research, Ann Arbor, Michigan, March 29-30, 1965, pp. 5-6.)
concentration of phytoplankton in the waters of the central basin, off Cleveland, in 1962 was six times that of 1932.\textsuperscript{77}

The organisms which inhabit the bottom of Lake Erie are consumed by almost all of the lake's fish during some stage of their lives. It is believed that the scarcity of certain organisms may affect the growth and survival of the various fish species which feed upon them. The low oxygen conditions which have existed in the western and central basins have wrought profound changes in the quantity and quality of bottom-dwelling fauna. The changes which have occurred in the western basin are especially significant to fish like, since it is the spawning, hatching, and nursery area for most commercial species and has been described as the key area affecting the fish productivity of the entire lake.\textsuperscript{78}

The larval form of the mayfly was once the most abundant fishfood organism inhabiting the bottom of western Lake Erie. The population of this aquatic insect once averaged about 400 per square meter of lake bottom but in the mid-1950's, oxygen depletion in the bottom waters of the lake severely reduced their numbers\textsuperscript{79} (Table 8). Today the mayfly faces extinction in its former habitat.\textsuperscript{80} The decline in mayflies has been coincident


\textsuperscript{78}Langlois, op. cit., p. 346.


with increases in the populations of midge larvae, which are more tolerant to low oxygen conditions. Their numbers increased by five times between 1929 and 1957. Pollution tolerant aquatic worms increased over 40 times during this period.

TABLE 8

CHANGES IN THE ABUNDANCE OF SELECTED BOTTOM-DWELLING ORGANISMS IN WESTERN LAKE ERIE, 1929-1957
(Population Per Square Meter)

<table>
<thead>
<tr>
<th>Organism</th>
<th>1929</th>
<th>1957</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mayfly Larvae</td>
<td>312</td>
<td>39</td>
<td>-700%</td>
</tr>
<tr>
<td>Midge Larvae</td>
<td>56</td>
<td>299</td>
<td>+134</td>
</tr>
<tr>
<td>Aquatic Worms</td>
<td>12</td>
<td>551</td>
<td>+491</td>
</tr>
</tbody>
</table>


The shift in bottom organisms toward pollution tolerant varieties is even more pronounced in the central basin than the western basin. As a consequence of more severe and prolonged oxygen deficiencies, even pollution tolerant species are declining in abundance. The eastern basin of Lake Erie, whose bottom waters are oxygen rich, has a wide variety of

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82 Beeton, op. cit., p. 154.
83 Worthington, op. cit., p. 13.
pollution sensitive bottom-dwelling animals which are not found in the rest of the lake. The fauna there have thus far been relatively little affected by pollution.

The changes which have occurred in the bottom fauna of Lake Erie are believed to be casually associated with the changing fish populations of the lake. Evidence collected after the initial die-off of mayfly larvae in the western basin in late 1953 indicated a food shortage among small forage fish which had previously fed heavily upon them. These small fish are an important food source for commercial fish, comprising, for example, 99% of the food supply of the highly prized yellow pike. Later evidence indicated that certain fish species had shifted their food supply from mayflies to midge larvae. The impact of changes in the aquatic food chain upon fish is not well understood. There is some indication, however, that less desirable species such as the sheepshead, which feed upon a wide variety of aquatic organisms, are able to adjust to the changes more successfully than those with more rigid feeding patterns.

Pollution of shoreline areas and tributary streams

The preceding discussion has been concerned with the physical, chemical and biological changes which have occurred in the open, or deeper, waters of the lake. Even more drastic environmental changes have occurred in shoreline areas and tributary streams. The lower reaches of tributary streams, and the bays at their mouths have traditionally served as spawning,


86 Ibid., pp. 10-11.
hatching and nursery areas for lake fish. Their usefulness for such purposes has now been greatly reduced by pollution. A systematic survey of water quality along the American shoreline, conducted in 1964, revealed that all major tributary streams were grossly polluted at their mouths and many were seriously polluted throughout large portions of their lengths. Water pollution acts as a barrier, cutting off lake fish from a portion of their normal habitat area.

The accelerated eutrophication of Lake Erie, largely the result of municipal and industrial waste disposal, may be measured in physical, chemical, and biological terms. Physical and chemical changes have altered the lake's biological life producing qualitative and quantitative changes in the food chain of fish. Although the cause and effect relationships appear to be complex and are little understood as yet, there is little doubt that the changing fish populations, described below, have been directly affected by changes in the types and amounts of food organisms.

The changing supply of commercial fish

Commercial species

Approximately 100 species of fish are known to inhabit Lake Erie and about 20 of them have been commercially harvested by the Ohio fishing industry. In any given year, the great bulk of commercial landings are composed of only five or six species. While relatively heavy fishing pressure has been directed toward a few species, the remaining fish stocks of the lake remain relatively untapped. Many of the underutilized species compete with commercially desirable fish for living space within the aquatic environment of the lake and, in addition, appear to invade the ecological

87 Langlois, op. cit., p. 259.
88 Northington, op. cit., p. 4.
niches of the latter as they are removed by fishing or suffer the unfavorable effects of water pollution. The biological capacity of Lake Erie to produce fish appears to be at an all-time high, but its productivity is increasingly being diverted into species which at present have little or no market value. Only a small fraction of the fish produced in the lake are presently being utilized by sport and commercial fishermen. Although they are not now being exploited, the remainder has considerable potential value (see Chapter 4).

The commercial fish harvested by the fishing industry vary widely in value. In an effort to describe this variation, the average landed value of each species was calculated for the 1950-59 decade, a period that is representative of the recent history of the industry. After arranging the values in descending order, they were divided into three groups with an equal number of species in each. For convenience, those species in the top group were designated "high value" fish, those in the middle group were labelled "medium value" and those in the bottom group were called "low value".

Among the commercial species here designated as high value, only yellow pike and catfish are presently caught in significant numbers and the yellow pike catch is now only a fraction of its former size. Sturgeon, whitefish, cisco and blue pike were once of major importance to the Ohio

80 Ibid.
81 The yellow pike (Stizostedion vitreum vitreum) is known by various names, including: pickerel, walleye, pike, walleyed pike, and yellow pike. In this study, the name yellow pike, used in midwestern fish markets, has been adopted. See Milton B. Trautmen, The Fishes of Ohio (Columbus: The Ohio State University Press, 1957) for scientific descriptions of Lake Erie fish.
### TABLE 9

**AVERAGE LANDED VALUE OF COMMERCIAL FISH, OHIO FISHING INDUSTRY, BY SPECIES, 1950-1959**

<table>
<thead>
<tr>
<th>Species</th>
<th>Average Value per Pound (cents)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Value</strong></td>
<td></td>
</tr>
<tr>
<td>Sturgeon (<em>Acipenser fulvescens</em>)</td>
<td>113.5</td>
</tr>
<tr>
<td>White fish (<em>Coregonis clupeaformis</em>)</td>
<td>52.4</td>
</tr>
<tr>
<td>Cisco (<em>Coregonis artedi</em>)</td>
<td>35.2</td>
</tr>
<tr>
<td>Yellow Pike (<em>Stizostedion vitreum vitreum</em>)</td>
<td>25.6</td>
</tr>
<tr>
<td>Blue Pike (<em>Stizostedion vitreum glaucum</em>)</td>
<td>23.6</td>
</tr>
<tr>
<td>Catfish (<em>Ictalurus punctatus</em>)</td>
<td>21.1</td>
</tr>
<tr>
<td><strong>Medium Value</strong></td>
<td></td>
</tr>
<tr>
<td>Sauger (<em>Stizostedion canadense</em>)</td>
<td>17.3</td>
</tr>
<tr>
<td>Buffalofish (<em>Ictiobus cuprinellus</em>)</td>
<td>14.4</td>
</tr>
<tr>
<td>Bullheads (<em>Ictalurus nebuleus; Ictalurus melas</em>)</td>
<td>13.9</td>
</tr>
<tr>
<td>Smelt (<em>Osmerus mordax</em>)</td>
<td>13.9c</td>
</tr>
<tr>
<td>White Bass (<em>Roccus chryseps</em>)</td>
<td>13.8</td>
</tr>
<tr>
<td>Yellow Perch (<em>Perca flavescens</em>)</td>
<td>13.6</td>
</tr>
<tr>
<td><strong>Low Value</strong></td>
<td></td>
</tr>
<tr>
<td>Burbot (<em>Lota lota lacustris</em>)</td>
<td>6.9</td>
</tr>
<tr>
<td>Suckers (<em>Catostomus commersonii</em>)</td>
<td>4.3</td>
</tr>
<tr>
<td>Carp (<em>Cyprinus carpio</em>)</td>
<td>4.3</td>
</tr>
<tr>
<td>Goldfish (<em>Carassius autatus</em>)</td>
<td>3.7</td>
</tr>
<tr>
<td>Sheepshead (<em>Apledinetus grunniens</em>)</td>
<td>3.2</td>
</tr>
<tr>
<td>Gizzard Shad (<em>Dorosoma cepedianum</em>)</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>All Species</strong></td>
<td>14.7</td>
</tr>
</tbody>
</table>


*Data available for 1959 only.
industry but are now caught only, occasionally, owing to their low levels of abundance in the lake. The reasons for their decline are discussed in a later section of this chapter.

Yellow perch and white bass are the most important medium value fish in the Ohio catch. Perch have replaced yellow and blue pike as the mainstay of the fishing industry in recent years. During the last five years, this species contributed one-fourth of the volume and nearly one-third of the value of the entire commercial catch. Smelt, which were introduced into the Great Lakes in 1913, are now one of the most abundant fish in Lake Erie. Inhabiting the central and eastern basins of the lake, smelt appear to be filling the environmental niches once occupied by the cisco and blue pike. Although they have been largely ignored by Ohio fishermen, Lake Erie fishermen in Ontario, Canada have developed special harvesting and marketing techniques for the small fish which mature at a length of about six inches.

Low value carp and sheepshead are abundant in Lake Erie and are important in the commercial catch. The two species now comprise over one-half of the total Ohio catch. The gizzard shad is also abundant in the lake but, unlike carp and sheepshead, few are harvested since markets for them have not yet been developed. Only a small fraction of the available populations of the three species is presently being utilized.

Long term trends in the populations of commercial fish

Any attempt to assess the long term abundance of the commercial fish which are available for capture by the Ohio fishing industry must be based on catch statistics. They represent the only data which are available for all commercial species, over long periods of time. Certain limitations in the use of these data, however, should be recognized. The intensity
of fishing effort is not uniform for all species. In general, fishing pressure is greater on high value species and less intense on those which are less valuable. In addition, changes in economic conditions, fishery regulations, and the efficiency of fishing gear have caused the fishing effort against most species to vary through time. Commercial catch data are not strictly representative of the fish actually lifted from the nets, since that part of the catch which is discarded, and not sold commercially, is not included in the statistics. The entire population of a given species is composed of individuals of all sizes and ages. Commercial catch data reflect only the abundance of large, mature fish. Despite these limitations, it is generally agreed that the abundance and catch of commercial fish is closely correlated. It should be noted, however, that the relative abundance of low value fish is likely to be understated in the catch statistics, while that of more valuable fish is overstated.

Table 10 and Figure 4 describe the composition of the Ohio fish catch for the period 1930-1964. This period was chosen because it is representative of the modern history of the fishery. In an effort to eliminate yearly fluctuations, averages of the catch of each species were calculated for the decades 1930-39, 1940-49, and 1950-59. In addition, the catches for the five-year period 1960-64 were averaged. During the decade of the 1930's, leading species in the commercial catch included: blue pike, yellow perch, sheepshead, yellow pike, and sauger. The high value blue and yellow pike made up more than 40% of the catch, and an additional 29% was composed of medium value yellow perch and sauger. Lower value sheepshead and carp comprised 17% of the catch.

A decade later, during the 1940's, blue and yellow pike made up 46% of the total catch, while the yellow perch catch dropped to 10%.
TABLE 10

SPECIES COMPOSITION OF THE OHIO COMMERCIAL FISH CATCH,
SELECTED PERIODS, 1930-1964\(^a\)

<table>
<thead>
<tr>
<th>Species</th>
<th>1930-39</th>
<th>1940-49</th>
<th>1950-59</th>
<th>1960-64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>Catch (000's of Total lbs)</td>
<td>% of Total Catch</td>
<td>Catch (000's of Total lbs)</td>
<td>% of Total Catch</td>
</tr>
<tr>
<td>Sturgeon</td>
<td>5.2</td>
<td>7.5</td>
<td>3.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Whitefish</td>
<td>436.9</td>
<td>704.4</td>
<td>190.8</td>
<td>4697.9</td>
</tr>
<tr>
<td>Cisco</td>
<td>34.3</td>
<td>291.1</td>
<td>43.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Yellow Pike</td>
<td>2284.5</td>
<td>3806.4</td>
<td>4697.9</td>
<td>562.8</td>
</tr>
<tr>
<td>Blue Pike</td>
<td>8717.6</td>
<td>6038.5</td>
<td>3541.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Catfish and Bullheads(^b)</td>
<td>494.8</td>
<td>839.9</td>
<td>1455.8</td>
<td>1246.6</td>
</tr>
<tr>
<td>Catfish</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Bullheads</td>
<td>--</td>
<td>--</td>
<td>70.3</td>
<td>94.5</td>
</tr>
<tr>
<td>Sauger</td>
<td>1630.4</td>
<td>702.6</td>
<td>136.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Buffalo</td>
<td>--</td>
<td>--</td>
<td>23.5</td>
<td>41.4</td>
</tr>
<tr>
<td>Smelt</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>6.1</td>
</tr>
<tr>
<td>White Bass</td>
<td>505.5</td>
<td>549.7</td>
<td>1420.1</td>
<td>1383.0</td>
</tr>
<tr>
<td>Yellow Perch</td>
<td>5634.8</td>
<td>2185.0</td>
<td>4416.5</td>
<td>3602.8</td>
</tr>
<tr>
<td>Burbot</td>
<td>307.3</td>
<td>364.3</td>
<td>133.8</td>
<td>6.7</td>
</tr>
<tr>
<td>Suckers</td>
<td>1057.0</td>
<td>513.6</td>
<td>354.2</td>
<td>202.6</td>
</tr>
<tr>
<td>Carp</td>
<td>1496.7</td>
<td>1559.5</td>
<td>2459.6</td>
<td>2978.0</td>
</tr>
<tr>
<td>Coldfish</td>
<td>141.3</td>
<td>98.5</td>
<td>114.6</td>
<td>234.4</td>
</tr>
<tr>
<td>Sheepshead</td>
<td>2758.7</td>
<td>3543.4</td>
<td>2721.8</td>
<td>4500.8</td>
</tr>
<tr>
<td>Gizzard Shad</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>6.2</td>
</tr>
<tr>
<td>Misc. Species</td>
<td>--</td>
<td>--</td>
<td>28.0</td>
<td>22.3</td>
</tr>
<tr>
<td>Totals</td>
<td>24,905.1</td>
<td>100%</td>
<td>21,233.7</td>
<td>100%</td>
</tr>
</tbody>
</table>

\(^a\)Calculated from: Norman S. Baldwin and Robert W. Saalfeld, Commercial Fish Production in the Great Lakes, 1867-1960
Great Lakes Fishery Commission, Technical Bulletin No. 3 (Ann Arbor: Great Lakes Fishery Commission, 1962) and Ohio Department of Natural Resources, Division of Wildlife, Commercial Fisheries Catch Summary for Lake Erie, Ohio, Publication W-200, 1961-64.

\(^b\)These species combined in the catch records from 1933 to 1946.

\(^c\)Less than 0.1%.
COMPOSITION OF THE OHIO COMMERCIAL FISH CATCH, BY VALUE OF SPECIES, FOR SELECTED PERIODS, 1930-1964

Figure 4
Sheepshead and carp rose to 21% of the total. As has been noted, this
decade marked an historic high in terms of the real value of the commercial
catch. Blue pike landings declined from the levels of the previous decade
but the harvest of yellow pike increased. The decade 1950-59 saw the catch
of yellow pike reach record levels, comprising 21% of the commercial catch.
The catch of blue pike continued to decline, representing 16% of the total,
or less than one-half its share twenty years earlier. Catfish increased
to 7% of the total, and yellow perch and white bass also yielded record
catches during this decade. The combined catch of sheepshead and carp
remained about the same, although a greater proportion was made up of
carp.

A drastic change in the species composition of the catch occurred
during the five year period 1960-64. Yellow pike declined precipitously,
and blue pike nearly disappeared. These two high value fish, which once
made up nearly one-half of the volume of the catch, contributed less than
4%. Yellow perch and white bass, while declining slightly in actual
volume, increased their share of the total catch to 21% and 9%, respectively.
The catch of sheepshead and carp increased markedly, both in terms of
volume and percentage of the total commercial catch. Together, these low
value species made up 50% of the total catch.

Despite the near disappearance of several important species, the
total volume of the commercial catch did not decline appreciably until the
1960's. From an average of nearly 25,000,000 pounds yearly during the
period 1930-39, the catch declined to slightly more than 21,000,000 pounds
in the 1940's and 1950's. By 1964, however, the catch had fallen to about
11,000,000 pounds. The reduced commercial catch in recent years does not
reflect a reduction in the total fish populations of Lake Erie. As noted
previously, the biological production of fish is believed to be at an all-time high. The reduced catch does, however, indicate a reduction in total fishing effort by the commercial industry. This is largely a consequence of the reduced abundance of preferred, high value species.

The shifts in species composition just described have had a significant effect upon the value of the commercial catch. Table 11 shows the average weight, landed value, and value per pound of the Ohio catch during the 1930's, 1940's, 1950's and the years 1960-64. The total landed value of the catch and its value per pound are expressed in constant dollars. The real value of the catch declined from more than $4,000,000 in the 1940's to less than $1,000,000 in 1964. The value of the catch, per pound, dropped from more than twenty cents to less than eight cents during the same period.

The causes of long term fish population changes

The drastic changes which have occurred in the fish populations of Lake Erie have been well documented by fishery scientists. The causes of the observed changes, however, have not been completely explained. Recent research indicates that the pronounced changes which have occurred in the aquatic environment are mainly responsible. In addition, the effects of a high level of fishing intensity upon preferred species and the introduction of exotic fish species into the lake appear to be contributing factors.

In explaining the decline of preferred, high value species in Lake Erie, most fishery scientists point to the changing aquatic environment as the principal cause. In particular, it has been noted that low levels

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TABLE 11

AVERAGE WEIGHT OF CATCH, AVERAGE LANDED VALUE OF CATCH, AND AVERAGE LANDED VALUE PER POUND OF CATCH, IN CONSTANT DOLLARS, OHIO COMMERCIAL FISHING INDUSTRY, SELECTED PERIODS, 1930-1964

(1957-1959 = 100)

<table>
<thead>
<tr>
<th>Years</th>
<th>Average Amount of Catch (pounds)a</th>
<th>Average Value of Catch (dollars)b</th>
<th>Average Value of Catch per pound (cents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930-1939</td>
<td>21,905,000</td>
<td>3,076,039</td>
<td>12.4</td>
</tr>
<tr>
<td>1940-1949</td>
<td>21,233,700</td>
<td>4,444,523</td>
<td>20.9</td>
</tr>
<tr>
<td>1950-1959</td>
<td>21,793,300</td>
<td>3,357,947</td>
<td>15.4</td>
</tr>
<tr>
<td>1960-1964</td>
<td>14,897,600</td>
<td>1,219,018</td>
<td>7.9</td>
</tr>
</tbody>
</table>

a Calculated from Table 2.
b Calculated from Table 4.

do of dissolved oxygen and generally higher water temperatures are unfavorable for most commercial species.93 It should be noted, however, that very little is known of the actual mechanics involved in the changing environment's effects on fish. The following quotation by Mr. C. W. Northington, Director of the U. S. Public Health Service's Lake Erie research, points

up the gaps in our knowledge.

Dr. N. W. Britt reported severe oxygen depletions in the bottom waters of the western basin in 1953. This condition practically eliminated the mayfly nymph population and subsequent occurrences of low dissolved oxygen have literally wiped out this species. Only those species of bottom organisms which are adapted to tolerate periods of low dissolved oxygen remain in most of the western basin. A few years after the mayfly nymph and other pollution-intolerant organisms were almost completely wiped out, the walleye (yellow pike) also virtually disappeared. This is still somewhat of a mystery story. Did the same physical conditions that brought on the low dissolved oxygen wipe out the walleye? Did the low dissolved oxygen do it or was it the break in his food chain that wiped him out? Was it silt covering spawning beds? Could it have been a combination of these three or even could it have been toxic materials and not related? We don't know yet, but we are still asking questions.94

Langlois has summarized the effects of a changing aquatic environment on fish.95 He notes that Lake Erie represents a marginal environment for both northern, cold water fish and southern, warm water species.96 In the early years of the fishery, most fish production was confined to cold water species, such as the whitefish, cisco, and blue pike. In recent years, as the eutrophication of the lake has increased, production has shifted to warm water species, such as yellow perch, sheepshead, and carp. Throughout this gradual process of change, those species which were capable of reproduction, survival, and growth under the greatest variety of conditions persisted longest. Those which required the most specific conditions were the earliest to be eliminated.97 It is logical to assume that as the Lake Erie environment continues to more closely approximate that of lakes characteristic of more southerly latitudes, the fish production within it

94Northington, op. cit., p. 13.
95Langlois, op. cit., p. 340.
96Langlois, op. cit., p. 340.
97Ibid., p. 183.
will be diverted more completely to warm water species. Thus, in the future, the availability of the highly prized food fish which have always been the specialty of the Ohio fishing industry is likely to be reduced. On the other hand, increases in the populations of already abundant low value species are likely. For the economic survival of the fishing industry and the efficient utilization of the fishery resources of the lake, increased attention must be paid to these species. In the next chapter, a number of alternatives in the harvesting and marketing of low value fish are discussed.

Many early investigations of the decline of high value Lake Erie fish led to the conclusion that it was due to overfishing on the part of commercial operators. The history of the Lake Erie fishery included an initial period of high output, dominated by preferred species, followed by a progressive deterioration in which the production of less desirable species became more prominent in the catch. This sequence was interpreted as overfishing in the simplest sense, that is, the fish stock was removed faster than it could reproduce itself. This interpretation held that first one group of species was depleted, then the fishermen turned to another group of pre-existing, less desirable fish and the process was repeated. As a result of successive, largely independent declines, the fish population was reduced to a few neglected species of lowest quality.

Recent research has tended to discount the earlier conclusions. Fishing activities are still viewed as a contributor to the changing fish populations, but one which has operated in conjunction with environ-

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99 Hile, op. cit., p. 2.
mental change. It is now believed that the major effect of fishing activity lies in the disturbance of ecological relations among the fish species, rather than in the simple depletion of a fish stock. Each fish species in Lake Erie occupies a distinct ecological niche in the aquatic environment. Fishing pressure, both by sport and commercial fishermen, is not directed at the various fish equally. High value, preferred species are fished more intensively than those of lower value. Furthermore, fishing pressure against these species has increased throughout the history of the fishery. This has been due both to the development of more effective fishing gear and the use of more units of gear by American and Canadian fishermen. A high level of fishing pressure on preferred species, as well as progressive changes in the aquatic environment, appear to have operated to the advantage of less desirable species, enabling them to gradually make up an increased percentage of the total biological fish production of the lake. Thus, fishermen did not turn from declining first choice fish to exploitation of a pre-existing stock of cheaper fish, but rather, through ecological changes, the poorer quality fish became more plentiful as the better ones grew scarce. It is unlikely that the biological production of fish has ever declined significantly in Lake Erie. The fishery productivity of the lake probably has increased with its fertility.

The invasion of the Great Lakes by the sea lamprey is well known. The eel-like parasite originated in the Atlantic Ocean, but migrated up the St. Lawrence River into Lake Ontario. With the construction of the

100 Frick, op. cit., pp. 70 and 136-137.
101 Hile, op. cit., pp. 3-4.
Welland Canal, the lamprey was able to by-pass Niagara Falls and enter Lake Erie as well as the upper Great Lakes. The sea lamprey decimated the valuable stocks of lake trout in Lakes Huron, Michigan, and Superior, but has had little effect in Lake Erie. The lamprey population of Lake Erie has never been large, due to the lack of suitable spawning grounds and the absence of preferred host fishes, such as the lake trout. Lake Erie's tributary streams are warm and turbid, while the lamprey requires cold, clear streams in which to spawn.

The effects of other exotic fish species in the lake are not as well known as those of the sea lamprey. Several non-native species of fish have been introduced into Lake Erie, both deliberately and accidentally. These include carp, goldfish, buffalofish, smelt, brown trout, rainbow trout, landlocked salmon, and American eel. Most of the exotic species failed to thrive, but a few, notably the carp and smelt, found the environment favorable and quickly grew to abundance. Large populations of smelt now occupy the central and eastern basins, where they are believed to be occupying the environmental niche once held by the cisco and blue pike. Although relatively little is known of the effects of exotic species on desirable indigenous fish, the imported fish appear to offer formidable competition for space within the ecological system of the lake.

Short term fluctuations in the supply of fish

Apart from the long term, permanent declines in the populations of commercial species, there are great variations in abundance from year to year. The variations in abundance typical of most commercial species

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102 Langlois, op. cit., p. 213.
### Annual Catch of Yellow Perch, and Deviation from Average Annual Catch of Yellow Perch, Ohio Commercial Fishing Industry, 1954 - 1963

<table>
<thead>
<tr>
<th>Years</th>
<th>Catch (pounds)</th>
<th>Deviation from Average (pounds)</th>
<th>Deviation from Average (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1954</td>
<td>3,991,100</td>
<td>1,159,060</td>
<td>22.5</td>
</tr>
<tr>
<td>1955</td>
<td>1,948,100</td>
<td>3,202,060</td>
<td>62.2</td>
</tr>
<tr>
<td>1956</td>
<td>6,117,100</td>
<td>1,256,940</td>
<td>24.4</td>
</tr>
<tr>
<td>1957</td>
<td>7,892,600</td>
<td>2,742,140</td>
<td>53.2</td>
</tr>
<tr>
<td>1958</td>
<td>6,060,900</td>
<td>910,740</td>
<td>17.6</td>
</tr>
<tr>
<td>1959</td>
<td>8,261,700</td>
<td>3,114,540</td>
<td>60.5</td>
</tr>
<tr>
<td>1960</td>
<td>5,296,900</td>
<td>1,46,740</td>
<td>2.8</td>
</tr>
<tr>
<td>1961</td>
<td>2,059,900</td>
<td>3,100,260</td>
<td>60.2</td>
</tr>
<tr>
<td>1962</td>
<td>5,016,800</td>
<td>103,340</td>
<td>2.0</td>
</tr>
<tr>
<td>1963</td>
<td>4,523,500</td>
<td>626,660</td>
<td>12.2</td>
</tr>
<tr>
<td>1954-63 (average)</td>
<td>5,150,160</td>
<td>1,636,272</td>
<td>31.8</td>
</tr>
</tbody>
</table>

are exemplified by the catch of yellow perch during the decade 1954-63 (Table 12). During those years, the Ohio catch at one point exceeded 8,000,000 pounds, and at another fell to less than 2,000,000 pounds. The average yearly catch for the decade exceeded 5,000,000 pounds, but significantly, the mean deviation from the ten year average exceeded 30%. In four of the ten years, the deviation exceeded 50%, and in only two years was it less than 10%. It is noteworthy that these rather extreme fluctuations occurred during a decade in which the perch populations were at an all-time high in Lake Erie. The year to year fluctuations of most other commercial species are of a similar magnitude and are considered normal by the fishing industry.

The fluctuations in annual yield just described have decidedly unfavorable effects upon the income of fishermen and the stability of fish prices and markets. Periods of abundance tend to result in lower production costs, but also tend to develop keen competition for available market outlets, which are unable to absorb the larger supplies in an orderly fashion. The result is the sale of large portions of the catch at greatly reduced prices. In the autumn of 1962, during an unusually heavy run, the price of yellow perch from Lake Erie fell to six cents per pound on the Chicago market. It is reported that prices fell to as low as four cents per pound in some Ohio ports. This compares to an average price of twelve cents per pound in the previous year, when the perch catch was less than one-half that of 1962. Periods of scarcity, on the other hand, tend to sharpen the competition among fishermen for existing stocks of fish. Since marketing commitments must be met in order to retain customers, the amount of gear fished must be increased in order to produce a given catch of fish. This increases production costs sharply. The high prices which
prevail during periods of scarcity, and extended periods of unavailability of fish to the consumer, weaken its competitive position among products with which it is competing in the marketplace.

Year to year fluctuations in the catch of commercial species further affect the fishing industry by hampering its adjustment to long term changes in fish populations. Short term fluctuations tend to obscure long term trends. From the fishermen's point of view, it is difficult to tell whether a decline in catch of a given species is a temporary fluctuation or part of a long term decline. There appears to be a tendency for fishermen to feel that the decline of high value fish, such as the yellow pike, is temporary and that high levels of abundance will ultimately be restored. This sort of optimism has helped to keep the industry from shifting its attention and dependence to the populations of low priced, less desirable fish which are known to exist in great abundance in Lake Erie.

Causes of short term fluctuations

Short term, year to year fluctuations in the abundance of the various commercial species do not occur in any recognizable pattern and few have been investigated thoroughly enough to adequately explain their causation. In the cases where fluctuations have been adequately studied, they have been shown to be the result of variations in year class strength. A year class is the group of young fish which hatch and survive in a given calendar year. The amount of eggs which are spawned are normally greatly in excess of the number of fish which survive and grow to maturity. Although the fatality rate among young fish is normally very high and only a small fraction lives to maturity, occasionally environmental conditions permit an unusually large number to survive. A large recruitment in one year tends to enlarge the stock of a particular species until that year
class has passed through the fishery. The survival of a large year class one year normally means a large commercial catch two or three years later. The recruitment of an abnormally small year class has the opposite effect.103

It should be noted that, in addition to the year to year fluctuations in the supply of commercial fish described above, there is considerable variation in the size of the commercial catch within the year. These seasonal variations in the catch, however, are more related to the migration habits of lake fish than to changes in population levels. The seasonality of the Ohio commercial catch and its consequences for the industry are described more fully in Chapter IV.

Efforts to regulate the supply of commercial fish

Attempts to regulate the supply of commercial fish in Lake Erie began more than 100 years ago. In 1857, the first regulations on commercial fishing in Lake Erie were established by the Ohio Legislature.104 These laws, and the ones which followed, were enacted in the belief that the decreasing numbers of valuable fish in the lake were due to over-fishing. Laws were designed to limit fishing intensity by designating the types of fishing gear which could be employed, as well as when and where they could be used. Commercial fishing regulations have not accomplished their intended goals of restoring valuable fish species to high levels of abundance. They have failed largely due to the fact that the assumptions upon which they were based are now known to be largely invalid.

103Langlois, op. cit., pp. 184-185.
104Ibid., p. 372.
Another attempt to influence the supply of lake fish began in 1876. In that year, a state fish hatchery was established at Toledo to artificially hatch the eggs of desirable species, whose numbers were declining in the lake. The offspring were planted in western Lake Erie. Since 1890, fish have been artificially propagated on South Bass Island in the town of Put-In-Bay. Both whitefish and yellow pike were hatched in earlier years, but recently only yellow pike eggs have been available to the hatchery. Since the establishment of hatcheries, billions of young fish have been stocked in the lake. Studies have shown, however, that there is little or no relationship between the numbers of young fish planted and subsequent commercial catches. Langlois has noted that when environmental conditions in Lake Erie favor the survival of young fish, the natural spawning of even a few mature fish is sufficient to populate the lake. On the other hand, when environmental conditions are unfavorable, the hatchery-reared fish do not appear to fare any better than fish hatched in the lake.\(^ {105}\)

Attempts to regulate the abundance of preferred species by artificial propagation and the regulation of commercial fishing have been notably unsuccessful. Both methods continue to be employed, however, due largely to an institutional inertia which enables such public projects to survive long after the justification for them has disappeared.

During the last forty years, fishery scientists on both the state and federal level have conducted research into the changing fish populations of Lake Erie. Early studies, reacting to crisis, were confined to one species at a time in an attempt to explain their disappearance and suggest methods for restoring abundance. Often species were studies in only part

\(^{105}\) Langlois, op. cit., pp. 386-395.
of their habitat and without regard to the complex interrelationships which exist among species. More recently, long range continuing research has been undertaken in an effort to describe and explain the entire ecological system operating in the lake, and the changes which are occurring within it. Much has been learned but far more questions remain unsolved than have been answered.

As noted previously, the alteration of Lake Erie's aquatic environment through the introduction of municipal, industrial and agricultural pollutants is believed to be the primary cause of changes in its fish populations. A program of water pollution abatement, initiated at least partially in an effort to restore desirable fish populations, is just beginning. Any assessment of the success or failure of this program, in terms of regulating the supply of commercial fish, must of necessity lie in the future. At this time, however, it is uncertain whether the eutrophication of Lake Erie can be reversed and an earlier fishery ecology restored.

Summary

The fish populations of Lake Erie are the sole resource base of the commercial fishing industry in Ohio and changes in the quality of the resource base are among the most important reasons for the industry's decline. Lake Erie is an integral part of the Great Lakes drainage system, but its morphology and limnological environment are quite different from the other lakes. Due to its shallowness, warmth, and high natural fertility, Lake Erie has traditionally had the highest biological and fishery productivity of the five lakes.

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106 Hile, op. cit., p. 2.
The Lake Erie basin is heavily populated, and the waters of the lake are intensively used. Many of these uses have distinctly unfavorable effects upon the aquatic environment and, directly or indirectly, upon the fishing industry. Municipal and industrial waste disposal, as well as agricultural run-off, are pouring harmful substances into the lake in ever-increasing amounts. These materials have damaging effects upon some forms of aquatic life, while greatly stimulating the growths of others. The navigation of water craft on Lake Erie contributes to water pollution and frequently damages commercial fishing gear. A large, potentially rich fishing ground in western Lake Erie cannot be fully utilized by fishermen since it is reserved as an impact area for the test firing of military weapons. The demand for municipal and industrial water supplies from Lake Erie seems destined to increase in the future, and unless methods of waste treatment are greatly improved, the pollution level of the lake is likely to increase above present levels. The effects of recent pollution abatement efforts are, at present, difficult to assess, but from the point of view of the fishing industry, little improvement can be expected for at least several years. There is increasing evidence that the waste materials being dumped into Lake Erie are altering the aquatic environment of the lake and may be accelerating its natural aging process. The temperature, turbidity, and dissolved nutrient concentrations of the lake have increased, while dissolved oxygen concentrations have declined, in some cases to levels which are lethal to desirable fauna. The altered physical and chemical structure of the lake has been reflected in its biological life. Plankton, especially algae, growth has been greatly accelerated, with generally unfavorable effects upon dissolved oxygen supplies. Bottom-dwelling fauna, an important link in the food chain of commercial fish, have undergone
drastic quantitative and qualitative changes. The pollution of shoreline areas of Lake Erie and its tributary streams has been more severe than in the open lake. These areas once served as spawning and nursery areas for lake fish, but have now become unsuitable for that purpose.

Although approximately 100 species of fish inhabit Lake Erie, only about 20 have been harvested commercially. About one-third each of the commercial species may be described as high value, medium value, and low value fish. There is considerable variation in the market values of commercial species, and in recent years the fish populations, and commercial catch, of the lake have shifted from predominance of high value species to one of low value, less desired fish. The changing fish populations of the lake have caused declines in the volume, and especially the value, of the catch. The long term decline of high value fish is probably due primarily to the altered aquatic environment but the effects of fishing pressure and exotic fish species may be contributing factors. Short term, year-to-year fluctuations in the supply of most commercial species are characteristic of the Lake Erie fishery, contributing to the instability of fish prices, markets, and fishermen's incomes. In addition, they tend to mask long term fish population trends, thus hindering the adjustment of the fishing industry to them. Short term fluctuations appear to be due primarily to variations in the year class strength of particular species.

Attempts to influence the supply of commercial fish in Lake Erie date back more than a century. Programs to regulate commercial fishing and artificially propagate desired species have been well established in the state of Ohio for many years. Both methods, however, have been unsuccessful in restoring preferred species to abundance. In recent years, emphasis
has shifted toward comprehensive fishery research, to provide a better understanding of the fishery ecology of the lake, and water pollution control, aimed at improving the quality of the aquatic environment. While these efforts may eventually yield larger populations of high value fish, the present domination of low value species in Lake Erie is likely to continue in the foreseeable future.
CHAPTER IV

THE COMMERCIAL HARVEST OF FISHERY RESOURCES IN OHIO

In the last chapter, problems of a physical nature which are influencing Lake Erie as a resource base for the Ohio fishing industry are described. This chapter will focus upon the capture of commercial fish and problems of an economic, social, and political nature that are associated with the harvesting operations of the fishing industry.

The nature of fishery resources

Fish as common property resources

Fish stocks, like other natural resources, are utilized by man to satisfy human wants and needs. Most natural resources, including agricultural land, forests, and mineral deposits are owned outright by individuals or firms which engage in, or oversee, their exploitation. By acquiring title to the resource, the owners are assured exclusive utilization rights as long as ownership is maintained.

A basic characteristic of commercial fishing is the utilization of common property natural resources. Fish, like certain other resources,

such as air in the atmosphere, flowing streams and large bodies of water, and some outdoor recreational resources, can be used simultaneously by more than one individual or economic unit. No single user has exclusive rights to the resource, nor can he prevent others from sharing in its exploitation. An increase in the number of users affects each user's enjoyment of the resource.

Fishery resources are classified as common property in large part due to the difficulty of appropriating and defending exclusive use rights to them. Fish stocks are highly mobile and range over large areas, making the costs of acquiring and maintaining exclusive rights exceed the added benefits that such rights might produce. In addition, prevailing laws and customs commonly prevent the acquisition of exclusive rights to fishery resources. It has been a firmly based American tradition that all citizens should have an equal right to go fishing, whether for commercial gain or recreational enjoyment.

Effects of common property resources on fishing operations and the regulation of commercial fishing

The concept of the common property resource is fundamental to an understanding of the economic behavior of commercial fishermen and the problems inherent in the regulation of commercial fishing. In the utilization of a solely owned resource, the producer is able to adjust his rate of exploitation to costs of production and the price of the commodity produced. When the cost-price differential is large, production can be increased and when it is small production can be deferred until some future time when it is expected that the relationship between costs and prices will be more favorable. These resources can be managed profitably by the owner to produce long-term, sustained yields.
One of the unique features of a common property resource, such as a fish stock, is that the amount of productive effort applied is not subject to the restraints that govern the exploitation of a solely owned resource. The individual user of a common property resource is in competition with all the other users in an attempt to harvest a large share of the product for himself. The individual producer is unwilling to unilaterally restrain his efforts, since anything he leaves will be taken by other producers. A fisherman may realize, for example, that fish stocks would be improved if fish were allowed to propagate and reach more marketable size, but any attempt by him to increase yields by reducing his fishing effort simply results in a larger catch by other individuals. Furthermore, there is no limit on the number of operators that can participate in the fishery. Anyone is free to enter the fishery, subject only to licensing and fishing regulations imposed by the state. If any margin exists between prices and costs, there is a tendency for additional boats, fishing gear, and labor to enter the fishery until costs and prices approach equality. The exploitation of common property fishery resources by commercial fishermen poses the danger of depletion of fish stocks, as well as the economically inefficient use of capital and labor.

The Ohio fishing industry is totally dependent upon the fishery resources of Lake Erie. In addition, fishing industries in the states of New York, Pennsylvania, and Michigan in the United States, and the province of Ontario in Canada, conduct operations in the lake. Unlike solely owned resources, no individual or economic unit is responsible for, or can profit from, long-term sustained management of the fish stocks.

As this chapter will illustrate, the common property nature of the Lake Erie fish stocks has encouraged over-capacity in fishing gear, boats,
and labor by allowing unlimited entry into the industry. This condition, which has been aggravated by the decline in abundance of preferred species in recent years, has contributed to the low wages, profits, and return on invested capital which characterize the industry. During periods when certain species of fish are plentiful and easily caught, such as spawning runs, overproduction commonly occurs. In the absence of incentives for individual fishermen to defer production, each operator catches as many fish as he thinks he can sell. As the supply of fish on the market increases due to heavy production and the general lack of freezing and storage facilities in the industry, prices fall, often to unprofitable levels.

The regulation of commercial fishing in Lake Erie is fragmented among five governmental units despite the apparent migration of fish stocks from the waters of one state or province to another. Stringent regulations in one or two states have little effect on the well-being of fish stocks in the lake as a whole, since fishermen outside those states may correspondingly increase their capture of fish. The conservation measures enacted in Ohio, for example, are likely to benefit fishermen outside the state. Furthermore, non-uniform regulations produce variable costs of production and place some fishermen at a competitive disadvantage in the capture of common property fish and the marketing of fishery products.

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108 As was noted in Chapter II, the most profitable period in the recent history of the fishing industry occurred during World War II when entry into the fishery was restricted by the scarcity of boats, fuel, and nets.

109 In the late summer and fall of 1962, large runs of yellow perch forced landed prices of this species to four cents per pound in many Lake Erie ports. Many operators stopped fishing for perch, as the prices offered were below their costs of production.
Harvesting commercial fish

Competition for Lake Erie fish

The Ohio fishing industry competes for the fishery resources of Lake Erie with commercial fishermen from three other states and the Canadian province of Ontario. In addition, sport fishermen remove considerable quantities of fish from the lake.

During the three year period 1962-64, an average of 51,443,331 pounds of fish were landed annually by commercial fishermen (Table 13). Ontario fishermen captured about two-thirds of the total, with the Ohio industry landing slightly over one-fourth. The fishing industries of Michigan, Pennsylvania, and New York accounted for a combined total of less than 7% of the Lake Erie catch. U. S. fishermen once took as much as 70% of the Lake Erie catch.

TABLE 13

STATE AND PROVINCIAL DISTRIBUTION OF COMMERCIAL FISH LANDINGS IN LAKE ERIE

ANNUAL AVERAGE, 1962-64.8

<table>
<thead>
<tr>
<th>State or Province</th>
<th>Weight of Catch (Pounds)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontario</td>
<td>34,692,666</td>
<td>67.4%</td>
</tr>
<tr>
<td>Ohio</td>
<td>13,559,537</td>
<td>26.1%</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>1,459,466</td>
<td>2.8%</td>
</tr>
<tr>
<td>Michigan</td>
<td>1,432,966</td>
<td>2.8%</td>
</tr>
<tr>
<td>New York</td>
<td>298,700</td>
<td>0.6%</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>51,443,331</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

8Sources:
The fish catch by sportsmen in Lake Erie is of undetermined size. Incomplete and fragmentary evidence indicates, however, that the withdrawal of fish by sportsmen rivals that of commercial fishermen. A survey of sportfishing from boats in the Ohio waters of the lake during the summer months of 1960 showed a total catch of 1,302,097 pounds, a figure which was larger than the Ohio commercial catch during the same period. In the winter of 1963, 102,138 pounds of fish were caught by ice fishermen off the western shoreline of South Bass Island. Canadian fishery biologist J. D. Rosenborough has estimated that 5,000,000 pounds of smelt were taken by sportsmen in the Canadian waters of Lake Erie in 1959. Although precise data are lacking, it has been estimated that, at least for the U. S. waters of the lake, the sport fishing catch exceeds the commercial catch. Sport fishing and commercial fishing are not completely competitive. Commercial fishermen are prohibited by law from taking certain species of game fish and some commercial fish are not considered desirable by sportsmen. A large part of the sport catch, however, is made up of the species which are also the mainstays of the commercial industry. It is in these species, including yellow pike and yellow perch, where the real competition exists.


113 Personal interview with Mr. Jerry Manz, Fisheries Supervisor, Ohio Division of Wildlife, Sandusky, Ohio, August, 1965.
Future competition for Lake Erie fish is likely to be even more intense than at present. Ontario, Ohio's principal commercial competitor, has greatly expanded its industry since World War II and is investing up to $500,000 annually in new and improved facilities. Population growth, increased leisure time, and rising incomes make sport fishing an increasingly popular form of recreation. It has been estimated that the number of sport fishermen in Ohio may increase by as much as 150% by the year 2000.

The competition which the Ohio fishing industry faces in Lake Erie is of little concern for low value species, such as sheepshead, gizzard shad, and smelt. The populations of these fish are believed to be very large and they are relatively little utilized. The competition for higher value fish, including the yellow pike, yellow perch, and white bass is significant, since their numbers are limited and they are actively sought after by both sport and commercial fishermen. At present, the competition for these species by the Ohio industry is necessary for its very survival, since they account for a major share of its income. By shifting its attention to low value species, the fishing industry can broaden its income base to include resources for which there is presently only nominal competition.

---


Commercial fishing establishments and employment

Information concerning numbers of establishments and persons employed in the Ohio fishing industry are available from three separate sources. The latest year for which data are available from all is 1963. The Ohio Division of Wildlife maintains lists of commercial fishing licenses which it issues for the spring and fall fishing seasons. A tabulation of licenses issued in 1963 was made for this study. The United States Fish and Wildlife Service annually publishes the number of commercial fishermen employed in each state. Finally, the United States Bureau of the Census has recently issued the results of the first census of commercial fisheries to be conducted in modern times.

In 1963 commercial fishing licenses were issued to 352 persons and firms in Ohio. 116 Of these 211 were to operate trotlines in the tributary streams of Lake Erie. This activity is legally termed commercial fishing, but it makes an insignificant contribution to the commercial catch and is normally not considered a part of the Ohio fishing industry. The remaining 141 license holders can be considered as the establishments which constitute the industry.

The 1963 Census of Commercial Fisheries is based on a mail survey of operators of fishing boats of five registered gross tons or more, and a tabulation of Federal income tax returns from persons who listed their principal business activity as fishing. It lists 104 commercial fishing operators in Ohio, 52 of which had paid employees. Although representing only half of the listed fishing establishments, the operators with paid

116 Special tabulation of commercial license holders from the records of the Ohio Division of Wildlife, Sandusky, Ohio.
employees account for over 90% of the gross receipts of the industry. The establishments of the Ohio industry are small, averaging less than three employees each, for the year. Only one operator averaged more than twenty employees.

The U. S. Fish and Wildlife Service reports total employment, including seasonal and part-time workers. On this basis, the Ohio fishing industry employed 54,4 persons in 1963. Part-time employees made up 98% of the total, following a growing trend in recent years. The lack of continuous employment throughout the year, as well as relatively low wages, has made it difficult to retain and attract experienced and efficient workers in the fishing industry. When faced with the uncertainties of fishing as a livelihood, many fishermen have taken more dependable employment in nearby industrial plants.

High levels of skill and long periods of on-the-job-training and experience are required to perform some of the jobs in the industry. Many of these tasks, such as the operation of gill nets and the repair and rebuilding of fishing gear, are handled by men who are approaching, or have already reached, retirement age. While no data are available concerning the age structure of fishery employees, field observation has indicated that relatively few young men have entered the fishing industry in recent years. The industry may face a serious shortage of skilled labor in the future, even at present levels of activity. It would almost certainly

118 Ibid., p. 4.
face such a shortage if the fishery were suddenly restored to the levels of output which prevailed in the early 1950's.

Fishing industry employees are paid only about two-thirds as much as the average for all Ohio industries (Table 5). They are highly paid, however, compared to fishermen in Ontario, Ohio's major fishing competitor. It is difficult to make valid comparisons between the two industries, as Ontario fishermen commonly receive a share of their catch in payment for their services, whereas fishermen in Ohio are paid in wages. In 1963, the average Ohio fisherman was paid an annual wage of $3,230.00.\textsuperscript{120} In contrast, the average annual share to crewman on an Ontario gill net boat in 1960 was $1,350.00.\textsuperscript{121} A substantial part of the difference in wage rates between the two areas is due to the character of the labor market in each. In northern Ohio, especially along the shore of Lake Erie, the industrial economy is well developed, the labor market is competitive, and "opportunity costs" of labor are high. By comparison, the northern shoreline of the lake in Ontario is relatively underdeveloped. Here workers have fewer employment opportunities and the general level of wages is lower.

Despite its relatively low labor costs, the Ontario industry is rapidly replacing manpower with capital equipment. Since World War II, the number of Canadian fishermen on Lake Erie declined by almost half, while the value of their equipment doubled.\textsuperscript{122} In Ohio, employment in fishing has declined less sharply, although the percentage of part-time

\textsuperscript{120}U. S. Bureau of the Census, loc. cit.
\textsuperscript{122}Ibid., p. 1148.
workers has increased (Table 1). The value of equipment in the Ohio industry has dropped sharply in recent years (Table 6).

The productivity of Ohio fishermen is now about half that of their Ontario rivals, although a decade ago they were substantially the same (Table 1). Measured by volume, the average catch per fisherman in Ontario has increased sharply in recent years while in Ohio, it has declined. The value of catch per man has increased in Ontario, but in Ohio it has fallen by more than half.

**Table 1**

**PRODUCTIVITY OF FISHERMEN IN THE ONTARIO AND OHIO FISHING INDUSTRIES ON LAKE ERIE, BY VOLUME AND VALUE, 1954 AND 1963**

<table>
<thead>
<tr>
<th>Industry</th>
<th>Year</th>
<th>Number of Fisherman</th>
<th>Weight of Catch (Pounds)</th>
<th>Weight of Catch Per Man (lbs.)</th>
<th>Volume of Catch (Dollars)</th>
<th>Value of Catch Per Man (Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontario</td>
<td>1954</td>
<td>981</td>
<td>28,900,000</td>
<td>29,590</td>
<td>3,406,000</td>
<td>3476</td>
</tr>
<tr>
<td></td>
<td>1963</td>
<td>667</td>
<td>35,300,000</td>
<td>52,690</td>
<td>2,530,000</td>
<td>3749</td>
</tr>
<tr>
<td>Ohio</td>
<td>1954</td>
<td>791</td>
<td>23,400,000</td>
<td>29,110</td>
<td>3,214,000</td>
<td>4101</td>
</tr>
<tr>
<td></td>
<td>1963</td>
<td>544</td>
<td>14,200,000</td>
<td>25,740</td>
<td>1,080,000</td>
<td>1985</td>
</tr>
</tbody>
</table>


The labor cost advantages which the Ontario fishing industry enjoys vis-a-vis the Ohio industry are only partially the result of lower wage rates. Of equal, if not greater, importance has been the progressive attitude of Canadian fishing establishments as reflected in their willingness to invest in new methods and equipment, which has made labor more
productive and efficient. Significantly, this has occurred with the assistance and cooperation of a progressive governmental program of fishery research and regulation.

Ohio fishing districts and fishing ports

Data in two forms are available concerning the locational structure of the Ohio fishing industry. Both sets of data are reported by the Ohio Division of Wildlife. Five fishing districts, covering the Ohio waters of Lake Erie and inland tributary streams, have been established and commercial catch statistics are reported for each. In addition, data are available on the receipt of fish by each of 12 major fishing ports in the state.

The Ohio Division of Wildlife's five fishing districts cover all of Lake Erie and its tributary streams within the state which yield commercial fish (Map IV). District One includes the area of the lake west of Huron, District Two lies between Huron and Fairport, and District Three extends from Fairport eastward to the Pennsylvania line. District Four and District Five are composed of Sandusky Bay and inland tributary streams, respectively. As Table 15 indicates, District One accounts for almost half of the Ohio catch. Lying within the district are the rich fishing grounds of the western basin of the lake and the island region. District Four, comprising the warm, shallow waters of Sandusky Bay, is second most important, producing over 30% of the total catch. About 13% of the catch comes from District Two, while Districts Three and Five produce about 5% each.

The fish caught in Districts One, Two, and Three are received at 12 fishing ports. Ten of them are along the lakeshore at the mouths of tributary streams, while the other two are on islands in the lake. The catch from Districts Four and Five is landed at various points where seines and trotlines are operated, and is not included in the port statistics.
LAKE ERIE FISHING DISTRICTS
AND FISHING PORTS
IN OHIO

Map. IV
TABLE 15

OHIO COMMERCIAL FISH CATCH, BY FISHING DISTRICT, ANNUAL AVERAGE, 1962 - 64

<table>
<thead>
<tr>
<th>District Number</th>
<th>Description of District</th>
<th>Weight of Catch (lbs.)</th>
<th>Percent Of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>West of Huron</td>
<td>6,350,647</td>
<td>46.8%</td>
</tr>
<tr>
<td>No. 2</td>
<td>Huron to Fairport</td>
<td>1,745,671</td>
<td>12.9</td>
</tr>
<tr>
<td>No. 3</td>
<td>East of Fairport</td>
<td>699,339</td>
<td>5.1</td>
</tr>
<tr>
<td>No. 4</td>
<td>Sandusky Bay</td>
<td>4,119,260</td>
<td>30.4</td>
</tr>
<tr>
<td>No. 5</td>
<td>Tributary Streams</td>
<td>644,952</td>
<td>4.6</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>13,559,537</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

*Source: Ohio Division of Wildlife, Commercial Fisheries Catch Summaries for Lake Erie, 1962-64.*

Port Clinton is the major port of the Ohio fishing industry, in terms of the amount of fish handled (Table 16). This port receives 27.9% of the catch from the open lake. Of secondary importance are Toledo, Vermilion, Sandusky, and Huron with percentages of total catch ranging from 15.7% to 12.4%. The remaining ports, located in eastern Ohio and the island region, are of relatively minor importance.
### TABLE 16

RECEIPTS OF COMMERCIAL FISH BY OHIO FISHING PORTS, ANNUAL AVERAGE, 1962-64

<table>
<thead>
<tr>
<th>Ports</th>
<th>Weight of Receipts (Pounds)</th>
<th>Percent Of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toledo</td>
<td>1,384,452</td>
<td>15.7%</td>
</tr>
<tr>
<td>Port Clinton</td>
<td>2,443,295</td>
<td>27.9%</td>
</tr>
<tr>
<td>Bass Islands</td>
<td>449,480</td>
<td>5.1%</td>
</tr>
<tr>
<td>Kelleys Island</td>
<td>433,367</td>
<td>1.6%</td>
</tr>
<tr>
<td>Sandusky</td>
<td>1,163,916</td>
<td>13.3%</td>
</tr>
<tr>
<td>Huron</td>
<td>1,092,707</td>
<td>12.4%</td>
</tr>
<tr>
<td>Vermilion</td>
<td>1,187,935</td>
<td>13.6%</td>
</tr>
<tr>
<td>Lorain</td>
<td>133,616</td>
<td>1.3%</td>
</tr>
<tr>
<td>Cleveland</td>
<td>67,196</td>
<td>0.8%</td>
</tr>
<tr>
<td>Fairport</td>
<td>215,230</td>
<td>2.8%</td>
</tr>
<tr>
<td>Ashtabula</td>
<td>155,097</td>
<td>1.8%</td>
</tr>
<tr>
<td>Conneaut</td>
<td>329,032</td>
<td>3.7%</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>8,795,353</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

*Source: Ohio Division of Wildlife, Commercial Fisheries Catch Summaries for Lake Erie, 1962-64.*

It is notable that Ohio's commercial catch is spread over many small ports. This is typical of Great Lakes fisheries and it has hindered the efficiency of unloading, processing, storage, and transportation of fish and fish products. These are operations in which scale economies would produce cost savings, if the industry's catch were concentrated in one, or perhaps two, ports.
Composition of the catch

The catch of the Ohio fishing industry is distributed among 11 species of fish. By weight, sheepshead, yellow perch, and carp are most important. In combination, these three species comprise over three-fourths of the total catch, while white bass and catfish are of secondary importance (Table 17). When measured by value, yellow perch and catfish are the most significant species, making up over half of the total. White bass and yellow pike are also important contributors to the value of the Ohio catch. Due to their high value per pound, catfish and yellow pike are more important to the industry than their modest volume would indicate.

TABLE 17

SPECIES DISTRIBUTION OF THE OHIO CATCH, BY WEIGHT
AND VALUE, ANNUAL AVERAGE, 1962-64a

<table>
<thead>
<tr>
<th>Species</th>
<th>Weight of Catch (Pounds)</th>
<th>Percent of Total</th>
<th>Value of Catch (Dollars)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffalo fish</td>
<td>63,000</td>
<td>0.5%</td>
<td>7,177</td>
<td>0.7%</td>
</tr>
<tr>
<td>Bullheads</td>
<td>118,500</td>
<td>0.9</td>
<td>12,256</td>
<td>1.1</td>
</tr>
<tr>
<td>Carp</td>
<td>2,754,900</td>
<td>20.3</td>
<td>86,217</td>
<td>7.8</td>
</tr>
<tr>
<td>Catfish</td>
<td>1,078,700</td>
<td>8.0</td>
<td>263,623</td>
<td>24.0</td>
</tr>
<tr>
<td>Gizzard Shad</td>
<td>7,700</td>
<td>0.1</td>
<td>227</td>
<td>b</td>
</tr>
<tr>
<td>Goldfish</td>
<td>227,100</td>
<td>1.7</td>
<td>6,655</td>
<td>0.6</td>
</tr>
<tr>
<td>Sheepshead</td>
<td>3,966,100</td>
<td>29.1</td>
<td>74,899</td>
<td>6.8</td>
</tr>
<tr>
<td>Suckers</td>
<td>182,100</td>
<td>1.3</td>
<td>5,890</td>
<td>0.5</td>
</tr>
<tr>
<td>White Bass</td>
<td>1,197,300</td>
<td>8.8</td>
<td>176,979</td>
<td>16.1</td>
</tr>
<tr>
<td>Yellow Perch</td>
<td>3,552,100</td>
<td>26.2</td>
<td>308,064</td>
<td>28.0</td>
</tr>
<tr>
<td>Yellow Pike</td>
<td>406,300</td>
<td>3.0</td>
<td>156,118</td>
<td>14.2</td>
</tr>
<tr>
<td>Others</td>
<td>13,200</td>
<td>0.1</td>
<td>1,176</td>
<td>0.2</td>
</tr>
<tr>
<td>Totals</td>
<td>13,559,500</td>
<td>100.0%</td>
<td>1,099,281</td>
<td>100.0%</td>
</tr>
</tbody>
</table>


bLess than 0.1%. 
Seasonality of fish production

The production of commercial fish in Ohio is highly seasonal, with heavy catches during some months and very light catches during others. Uneven production is aggravated by a shortage of freezing and storage facilities in the fishing industry. The result is an unsatisfactory marketing pattern in which the greater part of the industry's catch is sold on the fresh fish markets at prices which are depressed due to over-supplies.

TABLE 18

COMMERCIAL FISH PRODUCTION BY MONTH

ANNUAL AVERAGE, 1962-64

<table>
<thead>
<tr>
<th>Month</th>
<th>Weight of Catch (pounds)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>584,394</td>
<td>4.2%</td>
</tr>
<tr>
<td>April</td>
<td>3,521,222</td>
<td>26.0</td>
</tr>
<tr>
<td>May</td>
<td>3,890,551</td>
<td>28.7</td>
</tr>
<tr>
<td>June</td>
<td>1,841,428</td>
<td>13.6</td>
</tr>
<tr>
<td>July</td>
<td>714,832</td>
<td>5.3</td>
</tr>
<tr>
<td>August</td>
<td>633,205</td>
<td>4.7</td>
</tr>
<tr>
<td>September</td>
<td>699,999</td>
<td>5.2</td>
</tr>
<tr>
<td>October</td>
<td>1,004,925</td>
<td>7.1</td>
</tr>
<tr>
<td>November</td>
<td>611,476</td>
<td>4.5</td>
</tr>
<tr>
<td>December</td>
<td>51,404</td>
<td>0.4</td>
</tr>
<tr>
<td>Totals</td>
<td>13,559,537</td>
<td>100.0%</td>
</tr>
</tbody>
</table>


Commercial fishing is illegal under Ohio law during the months of January and February; hence, the commercial season extends from March
through December.\textsuperscript{122} During the season, production is concentrated in the spring, with exceptionally heavy catches occurring during April and May (Table 18). More than half of the yearly catch is made during these two months, with two-thirds of the annual total produced in the three month period, April through June. A much smaller production peak occurs during the fall, especially during October.

The uneven distribution of fish production throughout the year has unfavorable effects upon the operations of the fishing industry. Capacity in fishing equipment and processing facilities must be adequate to handle the large spring catches. During the rest of the season, much of it is idle, but the overhead costs are present whether the equipment is used or not. A similar problem exists with respect to labor. During periods of peak production large numbers of fishermen and shoreworkers are needed. In slack times they must be kept on the payroll to insure their availability when needed or laid off to seek other employment. In the latter case, workers frequently collect unemployment insurance to which the fishing establishments must contribute.\textsuperscript{123}

The marketing of fishery products is also affected by the seasonality of the catch. Due to the shortage of frozen storage capacity in the industry, fish must be sold within a short time after they are caught. The demand for freshwater fish is relatively constant when compared to fluctuations in supply. As a result, supply and demand are seldom in balance and prices are subject to considerable fluctuation. The

\textsuperscript{122}An exception is the taking of smelt, only, in experimentally licensed gear as approved by the Chief of the Ohio Division of Wildlife.

\textsuperscript{123}Ohio Bureau of Unemployment Compensation data indicate that employer contributions to unemployment compensation, as a percentage of total wages, is 50\% higher in the fishing industry than the average for all industries in the state.
actual prices received by Ohio fishermen for their catch are not a matter of public record but published prices at Chicago, the nation’s largest freshwater fish market, are a good index of the relative changes in fish prices in the Midwest. Prices of Lake Erie produced fish tend to be highest in the winter and late summer when supplies are light, and lowest in the spring and fall when production is heavy. Yearly price fluctuations of 100%, or more, are not uncommon among important species such as yellow perch, sheepshead, and yellow pike.

To a considerable extent, costs of production in commercial fishing vary inversely with the size of the catch. When fish are plentiful and the catches are large, fixed production costs can be spread over a large volume of fish resulting in low per-unit costs. Conversely, when fish are scarce and catches are small, per-unit production costs are high. The response of both prices and production costs to levels of output results in a situation wherein the margin between costs and prices is always small. This is due, to a considerable extent, to the small size of fishing establishments and the common property nature of the fish stocks. The combination of these factors effectively precludes deferring production in an effort to bring supply and demand into balance and level out price fluctuations. It is obvious that part of the problem of price fluctuations could be solved by the increased use of frozen storage for fish. This possibility will be discussed in a later section.

Fish production by type of fishing gear

Five types of fishing gear are used by the Ohio industry to harvest commercial fish. The gear and its operation are described below. Trap

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nets and haul seines are the most important types of gear now in use, producing over 90% of the total commercial catch (Table 19). Gill nets harvest about 7% of the catch, while trotlines and fyke nets are only minor contributors.

TABLE 19

OHIO FISH PRODUCTION, BY TYPE OF FISHING
GEAR, ANNUAL AVERAGE, 1962-64^a

<table>
<thead>
<tr>
<th>Fishing Gear</th>
<th>Weight of Catch (Pounds)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trap Nets</td>
<td>6,217,918</td>
<td>15.9%</td>
</tr>
<tr>
<td>Haul Seines</td>
<td>6,175,464</td>
<td>15.5%</td>
</tr>
<tr>
<td>Gill Nets</td>
<td>957,584</td>
<td>7.0%</td>
</tr>
<tr>
<td>Trot Lines</td>
<td>163,207</td>
<td>1.2%</td>
</tr>
<tr>
<td>Fyke Nets</td>
<td>45,266</td>
<td>0.4%</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>13,559,537</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>


Trap nets are employed throughout the Ohio waters of Lake Erie and are the predominate type of gear used west of Cleveland. Trap nets are used mainly for the capture of yellow perch, although sheepshead, white bass, and yellow pike are also important species in the trap net catch (Table 20). The seine fishery is heavily oriented toward sheepshead, catfish, and carp, with goldfish and white bass as minor species. These fish frequent the shallow water near the lake shore between Sandusky and Toledo, and in Sandusky Bay, where seines are operated. Gill nets are the most widely used type of gear in the Ohio waters east of Cleveland, but they are also widely employed in other parts of the lake, especially in the island region. Gill nets produce mainly yellow perch and yellow pike,
although some sheepshead and carp are also taken. Fyke nets and trotlines are fished in the shallow waters of embayments and inland streams. Trotlines are fished mainly for catfish, while fyke nets are set for white bass.

TABLE 20

PERCENTAGE DISTRIBUTION OF THE OHIO COMMERCIAL CATCH,

BY TYPE OF FISHING GEAR AND SPECIES OF FISH

ANNUAL AVERAGE, 1962-64a

<table>
<thead>
<tr>
<th>Species</th>
<th>Trap Nets</th>
<th>Haul Seines</th>
<th>Gill Nets</th>
<th>Trot Lines</th>
<th>Fyke Nets</th>
<th>All Gear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffalo</td>
<td>0.3%</td>
<td>0.7%</td>
<td>0.1%</td>
<td>--</td>
<td>0.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Bullheads</td>
<td>0.6%</td>
<td>1.3%</td>
<td>0.1%</td>
<td>2.1%</td>
<td>0.5%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Carp</td>
<td>3.4%</td>
<td>39.4%</td>
<td>5.1%</td>
<td>5.1%</td>
<td>2.3%</td>
<td>20.3%</td>
</tr>
<tr>
<td>Catfish</td>
<td>3.3%</td>
<td>11.5%</td>
<td>1.6%</td>
<td>90.1%</td>
<td>3.8%</td>
<td>8.0%</td>
</tr>
<tr>
<td>Goldfish</td>
<td>0.2%</td>
<td>3.5%</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1.7%</td>
</tr>
<tr>
<td>Gizzard Shad</td>
<td>0.1%</td>
<td>b</td>
<td>b</td>
<td>--</td>
<td>0.1%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Sheepshead</td>
<td>26.6%</td>
<td>37.3%</td>
<td>4.9%</td>
<td>2.4%</td>
<td>7.7%</td>
<td>29.1%</td>
</tr>
<tr>
<td>Suckers</td>
<td>2.4%</td>
<td>0.4%</td>
<td>0.7%</td>
<td>--</td>
<td>2.5%</td>
<td>1.3%</td>
</tr>
<tr>
<td>White Bass</td>
<td>13.3%</td>
<td>4.5%</td>
<td>6.2%</td>
<td>0.2%</td>
<td>68.5%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Yellow Perch</td>
<td>46.4%</td>
<td>0.8%</td>
<td>63.5%</td>
<td>0.1%</td>
<td>12.4%</td>
<td>26.2%</td>
</tr>
<tr>
<td>Yellow Pike</td>
<td>3.4%</td>
<td>0.4%</td>
<td>17.7%</td>
<td>--</td>
<td>1.7%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Others</td>
<td>b</td>
<td>0.2%</td>
<td>0.2%</td>
<td>b</td>
<td>--</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

Totals      | 100.0%    | 100.0%      | 100.0%    | 100.0%     | 100.0%    | 100.0%   |

aSource: Ohio Division of Wildlife, Commercial Fisheries Catch Summaries for Lake Erie, 1962-63-64.

bLess than 0.1%.

Fishing methods and equipment

The methods used by the Ohio fishing industry to capture commercial fish are considerably different than those employed by the more familiar and better documented marine fisheries of the United States. In an effort to acquaint the reader with the equipment and methods used in
Ohio, the following brief descriptions are provided.

**Trap Nets.**—The trap net, a modification of the earlier pound net, consists of a long "lead" of coarse mesh webbing which guides the fish into the net, a V shaped "heart" through which they are led deeper into the net and a final trap, or "bailing car," where the fish are held until their removal (Figure 5). The mesh size of the webbing decreases from front to back (lead to bailing car), but is large enough to permit undersized fish to escape. The trap net has tarred webbing on all four sides and is held upright on the lake bottom by a system of floats, weights and anchors. It is a large piece of equipment. A typical net would have a lead of 40 feet in depth and 400 feet in length, a heart 60 feet long and 30 feet deep, and three traps leading to the bailing car with a combined length of 60 feet and depth ranging from 30 feet at the front to 11 feet at the back.

A series of 10 to 20 trap nets are commonly set in a line at right angles to the shoreline to intercept known migrations of fish. They are tended by open boats, ranging in length from 30 to 60 feet, with inboard gasoline or diesel engines (Figure 6). Trap nets are commonly left in the water for two or three weeks at a time. During this period the trap net boat visits the nets every day or two to remove the fish. The bailing car end of the net is lifted by a power winch and the fish are removed using hand dip nets. The fish are dumped into sorting trays where they are separated by hand into saleable species of legal size, undesirable species, and undersized fish. The latter two categories are thrown overboard and the rest are put into shallow wooden boxes and covered with crushed ice.

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126 For a more detailed description of Ohio fishing gear, see Langlois, op. cit., pp. 303-331.
Figure 5. Underwater view of a trap net (after Ohio Division of Wildlife).
Figure 6. A trap net boat tending the nets (after Ohio Division of Wildlife as sketched by L. T. Lane).
In many cases, the lengths of valuable fish are actually hand measured to determine if they can legally be kept. A large majority of the fish handled are discarded. After two or three weeks, the nets are taken out of the water and brought to shore for cleaning, drying, and retarring. This is necessary to prevent bacterial decomposition of the fibers in the webbing. Cleaning is done by a high pressure jet of water which is played over the nets as they are unloaded at the docks. The nets are then taken to specially maintained, grass covered drying grounds where they are left in the sun for several days. Subsequently, the nets are mended, retarred, and put back into the lake.

Due to their relatively high cost and the expensive facilities needed to maintain them, trap nets are operated only by the larger establishments in the industry. A single net costs about $1,500.00 and the larger operators license up to 100 nets at a time. The large power trap net boats and the necessary cleaning, drying, repairing, and storage facilities on shore add to the overhead costs of trap net operations.

Gill Nets.- Gill nets are used by both large and small fishing establishments in the Ohio industry. A gill net consists of webbing to which floats are attached to the top, and weights are attached to the bottom. The net is kept extended and upright in the water by the floats and weights, with anchors and marker buoys at the ends (Figure 7). A fine thread mesh is used to snare the fish when it attempts to swim through the net. Mesh sizes are carefully controlled by law and small fish can pass through the webbing unharmed. A mesh size of three inches is commonly used in the Ohio industry. The net has a depth of 30 meshes, or seven and one-half feet. A gill net is 250 feet long and 50 or more nets may be tied together to form a single string.
Figure 7. Underwater view of a gill net (after G. T. Sundstrom).

Figure 8. A gill net tug (after G. T. Sundstrom).
Gill nets may be fished by hand from small rowboats or from large inboard motor boats using power net lifters. The latter are steel-hulled fishing tugs ranging in size from 40 to 70 feet, which have their entire superstructure enclosed for the protection of the crew in bad weather (Figure 8). The larger gill net operators lift and set their nets each day. They are highly mobile and range over wide areas, subject only to the availability of fish and the jurisdiction of their license within the boundaries of the state. Since they completely remove their gear from the water each day they can reset it in any new location that, in their judgement, will enable them to catch more fish.

On the larger boats, power net lifters are used. The nets with fish in them are brought into the boat and stacked in boxes, from which crew members remove the fish by hand. Undesirable and undersized fish are discarded and the catch is put into wooden boxes and covered with crushed ice. After the fish are removed the nets are taken to shore to be hung on reels for drying, while a second string is used for resetting. The nets are not tarred, but are treated with copper oleate in kerosene to retard deterioration before being returned to the water.

Nylon gill netting was introduced in the decade following World War II and is now in widespread use. Nylon made possible greater productivity in the gill net fishery, being stronger and less visible in the water than cotton or linen. It is more efficient in taking fish and less expensive to maintain; its service life is longer and it does not require the expense involved in frequent repairs and treatment with preservatives.

Gill nets have traditionally been fished on the bottom of the lake, but in the early 1950's an improved fishing technique known as "canning" was developed in the Ontario fishing industry. By using various sizes of
floats, the gill nets can be suspended at any depth between the surface and the bottom to take advantage of fish swimming off the bottom. Despite its apparent success in Canada, for unknown reasons the practice has not been adopted in Ohio.

A major disadvantage of gill net fishing is the frequent quality deterioration of the catch, particularly in the summer months when water temperatures are high. Unlike the trap net which keeps the fish alive until removal, fish become entangled in the gill net and soon die. The longer the dead fish remains in the water, the greater the quality deterioration of the flesh. When the nets cannot be lifted daily, due to weather conditions or other reasons, the proportion of unsaleable fish in the catch rises abruptly. Due to their generally lower quality, fish caught in gill nets are less preferred in the market place than those captured in trap nets and seines.

Haul Seines.—Haul seines were the first type of commercial fish-gear to be used in Lake Erie. Today, large seines, hauled by power winches, are still important contributors to the Ohio catch. A haul seine consists of heavy webbing, ranging in length from less than 100 rods (1650 feet) to the legal maximum of 300 rods (4950 feet). A typical seine might be 13 feet deep in the center and 10 feet deep on either end. Long pull ropes are attached to both ends of the seine and extend to shore where they are connected to a power winch (Figure 9). To operate the seine, it is loaded on a scow which is towed out to the full length of the pull lines. This may be a distance of a mile or more from the shore. The seine is then strung out parallel to the shoreline and the pull lines are taken in to shore. The lines are attached to a power winch which pulls the seine toward the shore trapping the fish between the seine and the shore. When
Figure 9. A haul seine in operation (after Ontario Department of Lands and Forests).
the seine is almost entirely upon the shore, the fish in it are removed with hand dip nets. They are then put into wooden boxes for immediate sale or transferred to live holding ponds for later marketing. The time required for two men to set and haul the seine is approximately three and one-half hours. A single haul may yield from two to six tons of fish and the seine is normally hauled twice in a day.

Seining is conducted in shallow water along the lake shore and in Sandusky Bay by numerous operators. Each one maintains his own exclusive seining grounds, which must initially be cleared of rocks and other debris which would interfere with the operation of the seine. The grounds are carefully inspected each spring, and after heavy rains, to remove any debris which may have drifted into them.

**Fyke Nets and Trotlines.**—Fyke nets and trotlines are among the minor types of gear used by commercial fishermen. Both are used in bays and shallow waters near shore. The fyke net consists of a series of circular funnels made of netting in which fish are trapped, after having been led into the net by v-shaped wings (Figure 10). The net ranges from two to five feet in diameter and from 9 to 18 feet in length. It is usually set in the mouths of tributary streams to intercept the spawning runs of some species of commercial fish.

Unlike the other types of gear, trotlines are used by persons who would not normally be thought of as commercial fishermen. Trotline operators make their living in other jobs, but supplement their incomes by selling fish which they catch in their spare time. The trotline is composed of a series of baited hooks suspended from a line which is supported by floats. Both ends of the line are secured by weights or anchors. The trotlines, which are commonly used in lower courses of the
Figure 10. Underwater view of fyke net (after G. T. Sundstrom).
tributary streams flowing into the lake, are visited every day or two by the operator who removes the fish caught and rebaits the hooks.

Production costs

The Ohio fishing industry traditionally has used high cost methods to capture high value fish. Of the three major types of gear in use, trap nets and gill nets have the highest production costs per pound of fish captured and seines have the lowest. While no actual production cost data exist, conversations with fishermen indicate that the minimum cost of landing fish from trap nets and gill nets averages five to seven cents per pound. Haul seines, which require less overhead, maintenance, and hand labor, can produce for as low as one to three cents per pound. No cost estimates are available for fyke nets and trotlines but in view of the hand labor involved in their operation, unit costs are presumed to be at least as high as for trap nets and gill nets.

The types of fishing gear which have been used in the Ohio industry were well suited to the capture of the high priced fish which once dominated the catch. In recent years, however, the percentage of low priced species has increased until they now constitute a large majority of production and the average value of the catch has declined steadily. It appears likely that the production of low value fish will increase, in the foreseeable future, due to their abundance in the lake. With the exception of haul seines, the fishing gear now in use do not allow a sufficient margin between production costs and landed values. Because of this, and to have any hope of profitable exploiting presently under-utilized species, the fishing industry must consider alternative methods of catching fish.
Alternative production methods

The efforts of commercial fishermen and government fishery agencies have been combined in the search for new, low cost fishing methods. The United States Bureau of Commercial Fisheries at Ann Arbor, Michigan, with the cooperation of the Ohio Division of Wildlife, has conducted feasibility studies on a number of types of fishing gear during the past few years. All of the experiments have included gear which is in use in the United States, but is new to the Great Lakes. Of the types of gear tested, the otter trawl appears to be the most promising for use in Lake Erie.126

The otter trawl consists of a cone-shaped bag of netting which is dragged through the water behind a boat (Figure 11). The trawl is about 50 feet in length and is made of cotton or nylon fibers. It can be fished on the bottom or at mid-water depths. Electronic sounding devices, or "fish finders," are used to locate schools of fish and to determine the depth at which to trawl for them. It also determines the roughness of the bottom topography, an important consideration in trawling to avoid damaging the net.

Field studies have indicated that commercial quantities of fish can be taken by trawl in the Ohio waters of Lake Erie. Although trawling can harvest several species of fish, including yellow perch, catfish, carp, sheepshead, and smelt, only smelt can legally be captured in Ohio by this

Figure II. Underwater view of an otter trawl (after G. T. Sundstrom).
method. This has been a factor in the reluctance of Ohio fishermen to convert to trawling despite its growing popularity in other Great Lakes fishing industries. In 1963, over 11,000 hours of trawling were carried on in the United States waters of the Great Lakes. Most of this was in Lake Michigan, but a number of Pennsylvania fishermen were trawling in Lake Erie. In the Ontario waters of Lake Erie, 105 trawls were in operation in 1963.

Trawling offers a number of advantages for commercial fishing. Low unit costs based upon high volume production is the principal consideration. The operation of the trawler is mechanized and comparatively little hand labor is involved. Two men can operate an average size trawler. After a period of trawling, the net is lifted by power winch and the catch is dumped directly into a fish hold below decks. When the trawler docks, its catch can be unloaded by a shore-based vacuum fish pump with a capacity of several tons of fish per minute. Existing gill net and trap net boats can be converted to trawlers at reasonable cost (Figure 12). These vessels can produce fish at far lower costs than traditional methods of fishing. Production costs, which are estimated at one to two cents per pound, would be competitive in animal food and

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Figure 12. A gill net tug converted to a trawler (after Gordon and Brouillard).
industrial products markets, as well as providing a greater margin of profit in fish for human consumption.  

In addition to its low cost, trawling is less seasonal than traditional methods of fishing. Trawlers can produce throughout the year, except during parts of the winter when the entire lake is ice covered. Year-round production is an important consideration in supplying low value fish to potential animal food and industrial fish product markets, and would be an added benefit in the production of food fish (Chapter V).

Recent fish population trends in Lake Erie indicate a dramatic increase in the number of low value fish and a corresponding decrease in high priced species. Although biological information on these species is limited, it appears that Lake Erie could support annual catches of smelt, gizzard shad, sheepshead, and carp totaling as much as 100,000,000 pounds. Only a small fraction of the total biological production is now being utilized; the rest is wasted.

If the fishing industry is to exploit the large stocks of fish just described, it must do so with high volume, low cost methods. Although human food markets would absorb part of the catch, most would be sold as raw material for various animal food industries. Trawls, supplemented by haul seines, are the only types of gear now used which


could economically produce fish for the two to three cents per pound which these markets would pay.\textsuperscript{133} This type of fishery will not permit the traditional landing of catches at many small ports. The establishment of processing plants will be dependent upon the availability of large quantities of fish at a single port. The transportation of raw industrial fish by commercial carriers is not practical due to the high costs involved. If several trawlers unload at one point, it will be possible for industrial users to establish docking and unloading facilities to serve them.\textsuperscript{134}

Lake Erie commercial fishing regulations

The authority to regulate commercial fishing in Lake Erie is vested in the states and province which have portions of the lake within their boundaries. On the United States side of the lake, Michigan, Ohio, Pennsylvania, and New York license and regulate commercial fishing by residents. In addition, non-resident licenses may be issued to residents of neighboring states but in practice very little of this is done. By federal law in both countries, Canadian and United States fishermen are prohibited from fishing outside their territorial limits. Each of the political units involved has established a separate body of fishery regulations, despite the fact that they share a common body of water and, to a considerable extent, common fish stocks.

Fishery regulations have been built up slowly over a period of more than a century. Generally this has occurred through a process of

\textsuperscript{133}Jones, "Present and Future Aspects of the Great Lakes Commercial Fisheries," \textit{op. cit.}, p. 11.

\textsuperscript{134}Gordon and Brouillard, \textit{op. cit.}, p. 14.
adding items of legislation one by one, with little thought of their relationship to other regulations or to the fishery as a whole.\textsuperscript{135} Thus, the regulation of Lake Erie fisheries has been carried out through a patchwork accumulation of laws and directives, rather than by well organized, uniform legislation.

The desirability of interstate and international agreement on regulatory policy and uniformity of fishing laws has been recognized for many years. Attempts to establish uniform regulations for Lake Erie have been numerous, but none has been successful.\textsuperscript{136} In 1954, a joint United States-Canadian convention of Great Lakes fisheries established the Great Lakes Fisheries Commission. The commission's specific purpose is to control the sea lamprey in the upper Great Lakes and conduct research concerning common stocks of fish between the cooperating governments. Although the commission is the principal instrument of cooperation between the United States and Canada in matters pertaining to fisheries of the Great Lakes, it has no regulatory powers.

Although five sets of fishing regulations are in force in Lake Erie, attention in this study will be focused on those of Ohio and Ontario. The fishing industries of these two areas account for about 91% of the Lake Erie commercial catch, and Ontario is Ohio's principal competitor, both for the capture of lake fish and the sale of them in midwestern markets.

\textsuperscript{135} Ralph Hile, "Fishing Regulations," The Fisherman, Vol. 20, No. 3 (March, 1952), p. 3.

\textsuperscript{136} Uniformity was nearly achieved in 1946 when a treaty was signed by the United States and Canada. The U. S. Senate failed to ratify it, however, when vigorous opposition developed to a provision granting authority to a proposed commission to regulate the fisheries of all the Great Lakes.
A comparison of Ohio and Ontario fishing regulations

Three types of regulations are significant in a comparison of the Ohio and Ontario fishing industries. These are size limits on commercial fish, the types of fishing gear which may be used, and the mesh sizes of nets. Minimum size limits for most commercial fish have been established by Ohio law, but in Ontario there is a size limit only on yellow pike (Table 21). Ohio fishermen may keep 10\% of the undersized fish of each species which they remove from their nets, but all the rest must be thrown back into the lake, whether they are alive or not. In Ontario, fish which are large enough to be marketable may be kept once they are caught.

TABLE 21

MINIMUM LEGAL SIZE LIMITS OF
SELECTED COMMERCIAL FISH SPECIES IN
THE OHIO AND ONTARIO WATERS OF LAKE ERIE\(^a\)

<table>
<thead>
<tr>
<th>Species</th>
<th>Total Length in Inches</th>
<th>Ohio</th>
<th>Ontario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Pike</td>
<td>11</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Buffalo Fish</td>
<td>15</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Bullheads</td>
<td>9</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Carp</td>
<td>None</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Catfish</td>
<td>11/4</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Gizzard Shad</td>
<td>None</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Goldfish</td>
<td>None</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Sheepshead</td>
<td>None</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Smelt</td>
<td>None</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Suckers</td>
<td>12</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>White Bass</td>
<td>9</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Yellow Perch</td>
<td>8</td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Yellow Pike</td>
<td>15-1/2</td>
<td></td>
<td>11/4</td>
</tr>
</tbody>
</table>

\(^a\)Source: Great Lakes Fishery Commission, Summary of Laws Relating to Commercial Fishing on the Great Lakes, 1964 (Mimeographed).
The types of fishing gear which may be licensed for use in Ontario and Ohio are similar. They include: gill nets, trap nets, pound nets, fyke nets or hoop nets, haul seines and trawls. In Ohio, the mesh size of nets is carefully controlled, and only certain sizes may be used. The Ontario fishermen may vary mesh sizes selectively to catch fish of marketable size. Trawls are licensed on an experimental basis in Ohio, for the taking of smelt only. Other commercial species may not be captured by trawls. In Ontario, trawls may be used to produce any commercial fish, subject to the designation of the Department of Lands and Forests.

Competitive effects of fishing regulations

The non-uniform fishing regulations which operate in Lake Erie have frequently worked to the disadvantage of the Ohio industry. In their competition with Canadian fishermen for the capture of the common property fish stocks of the lake, Ohio fishermen work under relatively stringent regulations. This has a tendency to reduce Ohio's share of the catch, leaving more fish to be caught by Ontario. This point is illustrated by the catch of yellow perch during the five year period 1960-64 (Table 22). The perch population of Lake Erie was dominated during this period by individuals hatched during 1959. The 1959 year class of perch reached marketable size in 1961 when they were harvested in large numbers by the Ontario industry. Ohio size limits on perch, however, did not permit them to be kept by the Ohio industry until the fall of 1962, more than a year after the Ontario harvest had begun. Fish of the 1959 year class were caught by both industries throughout the remaining 1962 season and most of 1963. By 1964 almost all the fish of this age had passed through the fishery and a less abundant year class took its place.
### TABLE 22

**COMMERCIAL LANDINGS OF YELLOW PERCH BY THE ONTARIO AND OHIO FISHING INDUSTRIES IN LAKE ERIE, 1960-1964**

<table>
<thead>
<tr>
<th>Year</th>
<th>Weight of Catch (pounds)</th>
<th>Ohio</th>
<th>Ontario</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>5,296,000</td>
<td></td>
<td>11,663,000</td>
</tr>
<tr>
<td>1961</td>
<td>2,060,000</td>
<td></td>
<td>17,281,000</td>
</tr>
<tr>
<td>1962</td>
<td>5,046,000</td>
<td></td>
<td>20,859,000</td>
</tr>
<tr>
<td>1963</td>
<td>4,523,000</td>
<td></td>
<td>17,963,000</td>
</tr>
<tr>
<td>1964</td>
<td>1,086,000</td>
<td></td>
<td>8,351,000</td>
</tr>
</tbody>
</table>


During the three year period 1961-63, Ontario fishermen landed over 56,000,000 pounds of yellow perch in Lake Erie. Ohio fishermen landed only about 11,000,000 pounds during the same period. While other factors, such as fishing effort and gear efficiency should not be overlooked, non-uniform fishing regulations played a major role in producing the observed five-fold differential in the catch. A similar situation may occur in the future with respect to yellow pike. The Ohio size limit has recently been increased from thirteen inches to fifteen and one-half inches, while the Ontario limit remains at fourteen inches. Thus fish which must now be thrown back by Ohio fishermen can be landed and sold in Ontario.

By specifying the types of fishing gear which may be used, the introduction of new, more efficient gear has been discouraged. This has had an unfavorable competitive effect, not only with respect to other Great Lakes fishing industries, but also to modern ocean fisheries which market...
their products widely in the midwest. There is evidence, for example, that the development of a trawl fishery is being hampered by restrictive regulations. Regular commercial fishing licenses are not issued for trawlers. Trawls may be operated on a permit basis but the permit may be withdrawn at any time. As a result, fishermen are reluctant to convert to new gear and processors are slow to invest in the modern shore facilities which would consume much of the trawler catch. A second restriction which limits the potential of trawling is the regulation governing the species which may be taken by this type of gear. At present, smelt may be captured by trawls, but more valuable food fish, such as yellow perch, cannot. It has been estimated that earnings of trawl operators would be increased by 25% if they were allowed to harvest any commercial species they could catch and market.¹³⁷

Some objectives for the management of fishery resources

A century of fishing regulations on Lake Erie has not achieved the desired objective of sustaining the populations of highly valued fish. Instead, the numbers of very valuable fish have declined, while those of low priced, relatively undesirable species have increased. Existing regulations have increased the production costs of commercial fishermen and the prices of fishery products to the consumer. Technological stagnation in the industry has been encouraged and the utilization of large populations of low priced fish has been discouraged. The lack of uniformity in regulations has worked to the disadvantage of states, such

as Ohio, which have relatively stringent fishing laws. Ohio fishermen have had a difficult time competing for their share of the common property fish stocks of the lake.

In the future, the states and province which claim the Lake Erie fishery resources should manage them on an intelligent, rational long-term basis. Proper management must recognize that fish stocks are renewable, common property resources. Because fish are mobile and free to migrate from one jurisdiction to another, fishery regulations should be uniform throughout the lake. This might be accomplished by a treaty between the two national governments involved, or by informal agreements between the regulatory agencies of the states and the province of Ontario. Uniform regulations would put the Ohio industry on an even footing with other fishing industries operating in the lake.

Like other renewable resources, fish stocks can be managed so as to produce a maximum sustained yield over a long period of time. This is the amount of fish which can safely be removed from a fish stock without damaging the stock itself. Once established, the level of fishing activity can be adjusted to it, perhaps by the establishment of annual quotas for each species. The determination of quotas for Lake Erie fish, and the management of the fishery, for long-term sustained yields would require extensive biological research into productivity of fish stocks, the effect of fishing pressure on fish populations, and the

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The changes which appear to be occurring in the aquatic environment would provide a further complicating factor.

The management of Lake Erie fishery resources on a sustained yield basis would not guarantee an economically healthy commercial fishing industry. Once quotas were established, fishermen could rush men and equipment into the fishery in order to capture as much of the quota for themselves as they could. This would result in increased production costs, and unemployed labor and capital once yearly quotas were filled. Proper management of fishery resources would entail restricting the entry of men and equipment into the fishery. This might be done by limiting the number of fishing licenses issued to a level which would most efficiently harvest the quota. Alternatively, a fishing operator might contract with an appropriate government agency for the removal of a specified amount of fish, with the choice of fishing methods left to the operator.

The management of the common property, renewable fishery resources of Lake Erie must involve the conservation of labor, management, and capital as well as fish. There is little precedent for this in publicly owned fisheries, but procedures similar to those outlined above are commonly employed in the management of public forests, rangeland, and petroleum resources.

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139 For an example of this kind of research in marine fisheries see: R. J. H. Beverton and S. J. Holt, On the Dynamics of Exploited Fish Populations (London: Her Majesty's Stationery Office, 1957), pp. 1-533.

Summary

Unlike most natural resources which may be owned by the individuals or firms which exploit them, fish stocks are common property resources. The common property status of the Lake Erie fish stocks has encouraged the inefficient use of capital equipment and labor, and has contributed to the low returns to management and labor which now characterize the Ohio fishing industry. Although Lake Erie fish are the common property of five governmental units whose fishermen operate in the lake, fishing is regulated independently by each of the five governments. Non-uniform regulations place the fishermen in some states, including Ohio, at a competitive disadvantage in the capture and sale of Lake Erie fish.

The Ohio fishing industry competes for Lake Erie fish with commercial fishermen from Pennsylvania, New York, Michigan, and Ontario, Canada, as well as large numbers of sport fishermen. Ontario is the major commercial competitor in the harvest of Lake Erie fish, accounting for over two-thirds of the commercial catch. Sport fishermen are also important competitors, as their harvest rivals the commercial catch in size.

In 1963 the Ohio fishing industry was comprised of 1141 fishing establishments. Almost all are small, averaging about three employees each. Employment in fishing totaled 544, with 98% being part-time workers. Fishing wages are low compared to other industries in the state, and the lack of full-time employment has made it difficult to attract and retain dependable labor supplies. When compared to the competing Ontario fishing industry, Ohio wages are higher, but labor productivity is lower producing a labor cost advantage in Ontario's favor.
Fishing operations are conducted in five districts, with District One, including the open lake west of Huron, and District Four, comprising Sandusky Bay, producing three-fourths of the catch. Fish are landed at twelve ports along the lake shore. Port Clinton handles the largest volume, with Toledo, Sandusky, Vermilion and Huron being of secondary importance.

Although eleven species of fish are represented in the commercial catch, six are the mainstays of the industry. Sheepshead, yellow perch and carp comprise three-fourths of the catch by volume. By value, yellow perch, catfish, white bass, and yellow pike represent 80% of the catch. Fish production is seasonal, with two-thirds of the annual catch taken in three months during the spring. Fishing and processing capacity is geared to the heavy spring production, and is partially idle during the remainder of the year. Fish are sold almost immediately after capture. Heavy production during the spring frequently "gluts" the markets, driving prices far below slack season levels.

Five types of fishing gear are used within the industry. Trap nets and haul seines produce over 90% of the catch. Trap nets, set in the deep waters of the open lake, capture mainly yellow perch, sheepshead, and white bass. Carp, sheepshead, and catfish are caught in haul seines in the shallow waters close to shore and in Sandusky Bay. Gill nets, Fyke nets, and trotlines are relatively minor producers of fish. With the exception of haul seines, the fishing methods now used by the Ohio industry are high cost, and not well suited to the low value species which now dominate the catch. Experiments with alternative fishing methods indicate that otter trawls are the most feasible type of new gear for use in Lake Erie. They are now being used by fishermen in Pennsylvania and Ontario.
Commercial fishing in Lake Erie is regulated by the states and province which border the lake. Regulations vary considerably among them, with those in Ohio being among the more restrictive. In the competing Ontario fishing industry, regulations have been relaxed in recent years, and are now much more liberal than those in Ohio. The effect of non-uniform fishery regulations on the Ohio industry has been to reduce Ohio's share of the Lake Erie commercial catch. Existing fishery regulations have failed in their objective of preserving adequate populations of highly valued fish. Instead, they have increased the cost of fishing, encouraged technological stagnation in the fishing industry, and rendered more difficult the task of profitably utilizing the large populations of fish which now inhabit the lake. Future management of the Lake Erie fishery resources should be aimed at producing a long-term maximum sustained yield of fish, as well as the efficient use of management, capital, and labor. This might require the establishment of annual production quotas on certain species of fish and the restriction of entry of fishing equipment and labor into the fishery. Through inter-governmental cooperation, fishing regulations could be made uniform throughout the lake, and its fish stocks could be managed in their entirety, rather than piecemeal, as is presently the case.
CHAPTER V

PROCESSING AND MARKETING ACTIVITIES OF THE OHIO FISHING INDUSTRY

The processing and marketing of commercial fish, after capture, is the subject of the following chapter. This chapter will also be concerned with economic, social, and political problems facing the Ohio fishing industry in these phases of its operations.

Processing the catch
Processing methods and products

In addition to catching commercial fish, the Ohio fishing industry is involved in various types of processing. Processing includes everything that is done to the fish after it is caught, except distributive functions, which adds to its utility or value. In some cases the form of the fish is changed, and in others it is only iced and packed for shipment. The Ohio industry has never engaged in elaborate processing of its catch. Most of it is sent to market in the round (as caught). A minority, usually the higher value species, are dressed (gutted) or filleted.

Of the 31 establishments which constituted the fishing industry in 1963, 23 were engaged in processing. Generally, they were the larger firms, which conduct their own fishing operations and also purchase

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the catch of smaller fishermen. Ohio processors are small in scale. The largest employs only 37 persons and the second largest only six. 1142

In contrast, fish processing in the competing Ontario fishing industry of Lake Erie is concentrated in large establishments. One, a private company, employs 400 workers during the peak spring production runs. 1143

In addition, 125 smaller fishermen are organized into five cooperatives which perform processing and marketing functions for their members. 1144

Like its harvesting methods, the Ohio fishing industry's processing operations are labor intensive. Hand labor is used to move the catch into the processing plants and dressing and filleting are done mainly by hand. In some plants, hand-held scaling machines are used as part of the filleting operation. Filleting is confined almost exclusively to yellow perch and yellow pike and results in a highly saleable, convenience product. Hand filleting is costly. Rule of thumb estimates indicate a filleting cost of $8 - 12 per pound of fillets, including plant overhead. Larger fish are cheaper to fillet, per pound, than small ones.

An unusual form of processing and storage is the keeping of live fish in holding pens. These fish, primarily carp, catfish, and goldfish, are captured by haul seines and carefully transferred to fenced-in areas of flowing streams. Here the fish are kept until sold. Sometimes they are fattened on corn, or other cereal grains prior to sale.

1142 Ohio Department of Industrial Relations, Ohio Directory of Manufacturers, Columbus, Ohio, 1964.


Due to a lack of freezing and frozen storage facilities, most of the industry's products are shipped to market as fresh, iced fish. Whole fish and fillets are packed in 60 pound wooden boxes with crushed ice above and below them. The boxes are placed in insulated cooling rooms for several hours prior to shipment so that the fish may be cooled down to a temperature of $32^\circ-34^\circ F$. Just before loading, additional ice is added to the boxes and the lids are nailed shut.

The seasonal nature of fish production hampers the efficiency of processing and packing operations. Physical capacity must be large enough to handle the gluts which occur in the spring, but during the rest of the year facilities are underutilized. Laborers, especially skilled filleters, are difficult to recruit in the competitive northern Ohio labor market for work which may last only a few weeks.

In addition to fish for human consumption, low value species, such as sheepshead, are sold to mink ranches for feed. Without processing, the fish are loaded on trucks as they are taken from the nets. Filleting waste and trimmings are also used as mink feed. Processing plants commonly provide this material, free of charge, to anyone who will haul it away.

Live fish are sold for stocking in privately owned, "pay-fishing" ponds throughout the midwest. Pond operators, who charge their customers a fee for recreational fishing, buy various species of Lake Erie fish and transport them in tank trucks. Some fish, usually carp, are also shipped alive to specialty fish stores in eastern and midwestern cities for sale as human food.

A large commercial fishing and fish processing firm in Ontario provides a contrast in technological efficiency and scale of operation
with the establishments of the Ohio industry. The company, located in Wheatley, Ontario, is owned and operated by seven brothers. Each of them has blended his talents and interests into the successful operation of the firm.\textsuperscript{145} A 40,000 square foot processing plant is served by the company's own fleet of fishing boats and fish are also purchased from independent fishermen operating on Lake Erie. During slack seasons, fish are shipped from the Atlantic coast and inland lakes in western Canada for processing. Production lines are kept operating in the summer by processing and freezing locally grown fruits and vegetables.

During the heavy production runs of the spring fishing season, two shifts of 300 employees each are engaged in processing. An adequate labor supply is readily obtained, since the peak season in fishing and fish processing comes earlier in the year than the peak in demand for workers in harvesting and processing the extensive fruit and vegetable crops of southern Ontario.\textsuperscript{146} Almost all of the handling and processing operations in the plant are mechanized. An exception is filleting which is done both by machine and as many as 100 hand filleters. The plant is equipped with a modern machine shop where much of the handling and processing equipment is designed and built.

A variety of processed fish products are produced in the modern, sanitary plant. Headless dressed fresh and frozen smelt and fresh and frozen yellow perch fillets are among the more important items produced. Some fillets are breaded and cooked under infrared heat and then frozen as a convenience food product. Breaded and cooked fish sticks and fish

\textsuperscript{145} Green, \textit{op. cit.}, p. 13.

\textsuperscript{146} Frick, \textit{op. cit.}, p. 54.
portions are produced from imported saltwater fish. Unlike the Ohio industry, where fish are packed in large quantities for the wholesale trade, many products are frozen in twelve ounce and one pound packages for sale in grocery stores and supermarkets. These carry the brand name of the company and are sold as far away as southern California. Filleting wastes and other fish scrap materials are collected throughout the plant by an automatic conveyor system which is connected to a grinding machine. After grinding, the material is packed in 50 pound bags and frozen for later sale as animal feed.

Freezing and frozen storage capacity is large, again in contrast to the typical Ohio plant. A modern pressure-plate sharp freezer, with a capacity of 100,000 pounds per day, quickly freezes fishery products to a temperature of -40°F. A large cold storage facility with a capacity of 10,000,000 pounds is used to store fish waiting to be processed, as well as finished products. Custom storage of frozen foods enables the company to achieve full use of plant storage capacity.

The large Canadian fishing and fish processing operations, such as described above, offer a number of important cost advantages over the smaller Ohio establishments. The large scale plant gains economies in production costs by using modern production techniques, specialized management, and labor saving machinery. In addition, they have a broader financial base with which to finance improvements. The ability to service customers promptly, from cold-storage stocks or through continuous production, is an important competitive advantage. The large processor is able

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to spread his brand promotion and other sales and advertising costs over a wide range of products. Fast, flexible delivery service is provided by the processor owning and operating his own fleet of trucks. Canadian fishing companies depend on the United States as their major market. Since World War II, they have made progressively deeper penetrations into the fishery products markets of the country, particularly in the midwest. This has been accomplished by efficient production methods and a willingness to develop new products. Low cost production methods now permit Canadian yellow perch fillets to be sold in northern Ohio at prices which Ohio fishermen cannot meet, despite a long haul to market and an import tariff of one and one-half cents per pound. An example of successful product development is provided by frozen dressed smelt. Unknown a few years ago and ignored by Ohio fishermen, the abundant Lake Erie fish is now sold in attractive consumer packages throughout the United States.

Alternative processing methods and products

The Ohio fishing industry suffers from high cost production and processing methods for the products it now sells. In addition, it is plagued by limited market outlets for many of the fish which are now abundant in Lake Erie. Recent research has indicated a number of avenues of escape from these problems. Some involve improving the efficiency of processing present products while others require new items which the industry does not now produce. The products discussed below include food items for human consumption and industrial products which would be used in animal diets.

Food Products.—For a number of years, American food-buying preferences have been shifting toward convenience products which require
a minimum of preparation prior to cooking. In the field of fishery products this has meant an increase in demand for fish fillets and a corresponding decrease in per-capita demand for whole and dressed fish. Fillets of yellow pike, yellow perch, and white bass are highly saleable items now being produced. Gefilte fish, minced fish balls or cakes, have traditionally been prepared from the whole freshwater fish by Jewish housewives for ceremonial occasions and religious holidays. In recent years prepared, factory-packed gefilte fish has been successfully introduced and sold as a canned convenience product.\textsuperscript{148} Considerable quantities of frozen carp fillets are used in the manufacture of this product.\textsuperscript{149}

Due to the high cost of filleting fish by hand, Ohio fishermen have tended to sell many of their fish in the round to food processing plants in the larger midwestern cities. By so doing, they receive a relatively low price for their fish and forfeit the value which is added by processing. Great strides have been made recently in the machine filleting of fish. A Swedish firm now produces a machine which will dress and fillet 150 fish per minute. It is operated by two men and automatically adjusts to various sizes of fish.\textsuperscript{150} A machine especially designed to fillet yellow perch has been perfected by a Michigan engineering company. The machine, priced at $8500, is fed by one man and can fillet approximately 500 fish per hour. Fillet yields per

\textsuperscript{148}In 1961 the U. S. production of gefilte fish was estimated to be in excess of 13 million pounds, valued at $5 million (Frick, op. cit., p. 26).

\textsuperscript{149}Jones, "Present and Future Aspects of the Great Lakes Commercial Fisheries," op. cit., p. 3.

pound of round fish are within 3% of skilled hand filleting. The machine just described represents a considerable investment, by industry standards, but could be paid off quickly from savings in hand filleting costs. Using a conservative estimate of four cents as the average cost of filleting a pound of fish by hand, only 212,500 pounds of perch would be required to amortize the cost of the machine. The Ohio industry catches in excess of 3,500,000 pounds of perch per year. In addition to reducing processing costs, machine filleting would help to solve the labor problems which plague the industry.

The recent trend toward convenience fishery products has included "ready-to-cook" and "heat-and-eat" items, such as frozen breaded fillets, fish sticks, and fish portions. These can be made from a variety of species, but yellow perch and white bass appear to offer the best possibilities. Although they are produced by Canadian fishing firms and American food processing companies, the Ohio industry has made no attempt to market these popular consumer products. Highly processed specialty products offer a substantial potential market for under-utilized freshwater fish. Chief among these are sausage-type products such as weiners and bologna, made entirely from fish. In Japan the production of fish sausages, which began in 1954, now exceeds 400,000 metric tons per

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152 Frick, op. cit., p. 61

In the United States, considerable quantities of all-fish weiners are sold on Fridays at baseball and football games. Sausage-type products have been developed, on an experimental basis, using such Lake Erie species as yellow perch, sheepshead, carp and catfish. By varying the seasonings used, they can be made to resemble products made with meat, or have a distinctive fish flavor of their own. Other products which appear to have marked possibilities include fish cakes and canned delicatessen items made from smelt, yellow perch, and sheepshead.

If new food products such as those described above are to be successful in utilizing available fish species now in limited demand, research and development effort will be required in both processing and marketing. Quality and price are important considerations in consumer acceptance of new products. Strict quality control will be necessary in their production, as will low processing and raw material costs. Skillful promotion will be needed to develop markets, but efforts in this direction will not completely achieve their purpose unless brand names are used to differentiate the products, so that competitors do not reap the principal benefits of the markets which are established. It should be noted that Lake Erie products are, and will continue to be, in competition with other fishery products of freshwater and marine origin.

Fish flesh is extremely perishable and begins to deteriorate as soon as the fish dies. Deterioration can be arrested, however, by sub-
jecting the fish to low temperatures. Ohio fishermen have always relied mainly upon ice to preserve their fish before and after processing. Since icing is only temporarily effective, fish have to be sold within a few hours of capture. Some refrigeration freezing is done but capacity is limited and generally inadequate for long term storage. Highly seasonal production and the lack of significant storage capacity has produced gluts of fish on the market during certain seasons and shortages during others. Fish prices are very responsive to supplies, with the result that much of the industry's catch is sold at low prices.

The Ohio industry needs improved preservation methods to improve the quality of its products as well as evening out market flows to take advantage of higher prices which prevail during slack fishing seasons. One way to maintain the high quality of fish is to cool it rapidly after capture. Recent research has shown that this can be done effectively by immersing the fish in refrigerated lake water aboard the fishing vessel. By this method, fish can be cooled from 70°F to 32°F in 70 minutes. Conventional techniques of covering fish with crushed ice requires 160 minutes to achieve the same amount of cooling. For long term storage, of perhaps several months, fish must be frozen to temperatures below 0°F. Quick-freezing, which is conventionally done at -40°F to -60°F, produces the best product since smaller ice crystals are formed, and there is less water loss and drying out of the fish upon thawing. Liquid nitrogen, at a temperature of -320°F, is now being used for freezing by immersion or spraying. Freezing of fish is almost instantaneous. Smelt, for example

can be frozen to 0°C in 30 seconds. The process is now being used in Ohio to freeze fruit.

A solution to the shortage of frozen storage capacity in the industry might be found in portable cold storage warehouses now in use for fishery products by a Cleveland food processing firm. The structures are made of pre-fabricated aluminum panels with refrigerated cooling units similar to window-size air conditioners. The basic storage unit has a capacity of 500,000 pounds and can maintain temperatures below 0°F. One of these structures can be assembled on site for $40,000, and two or more can be joined to produce any size warehouse desired. Two new methods for preserving fishery products are freeze drying and irradiation. These processes, while presently expensive, allow fish to be stored indefinitely without refrigeration.

*Industrial Products.* Extremely large amounts of superior protein, in the form of underutilized fish, are now being wasted in Lake Erie. While the actual numbers of such fish are undetermined, there is little doubt that the sustainable yield is equal to many times the present commercial catch. Perhaps the greatest single problem facing the Ohio fishing industry is finding low cost methods of catching these fish and also finding products and markets in which they can be utilized. The following discussion des-

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cribes those industrial products which might feasibly be made from under-utilized Lake Erie fish. Fish used as raw material for industrial fishery products must be low in cost and large in volume. This would require a reversal of the Ohio industry's traditional orientation toward high cost, high profit, and low volume production for human consumption. For the most economical processing of industrial products, catches must be concentrated in a few ports and be spread over as long a fishing season as possible.

Pet foods, for both dogs and cats, offer a large potential market for Lake Erie fish. Pet food manufacturers once relied heavily upon horse-meat as a source of meat protein, but in recent years the growth of their market and the decreased availability of horsemeat have made fish a major source of supply. Pet foods are produced in canned and in dry forms, with the latter utilizing fish in the form of meal. Fish from Lake Michigan and Lake Superior are now being used in substantial quantities for pet foods. Lake Erie fish can also be used in the diets of zoo animals. Zoo animals food must be of high quality, but can be sold at premium prices. Most zoos pay human food prices for the fish they now purchase. Feeding research is needed to determine the extent to which freshwater fish can be substituted for marine fish in the diets of some animals, and for red meat in the diets of others.

One of the best potential products to utilize surplus Lake Erie fish is feed for commercially raised fur animals. Principal among these

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are ranch mink which have traditionally been fed on horsemeat and meat and poultry packing wastes. While these products are still widely used on mink ranches, their prices have risen steadily in recent years and fish is increasingly being used as a substitute. Although substantial amounts of fish from Lake Erie and the other Great Lakes are now being fed to mink in the interior of the United States, most of the fish used in this region is shipped from the Atlantic coast. The preparation of fish for mink feed begins with the grinding of whole fish and/or wastes from human food processing. The ground fish is then packaged in paper bags and sharp frozen. Frozen storage must be at temperatures of 0°F. or lower. Strict attention must be paid to quality control in the processing of mink feeds. Mink are delicate animals, refusing to eat feed which is even slightly deteriorated. Percentage compositions of protein, fats, vitamins, and minerals in the feed product must be known and indicated on the package.163

A number of problems are involved in the use of Lake Erie fish as mink feed. With the exception of sheepshead, the important lake species contain the enzyme thiaminase. Thiaminase destroys Vitamin B₁ (thiamin) in the mink's diet, causing paralysis and eventual death.164 Fish containing thiaminase must be cooked prior to feeding or be mixed, or alternated, with non-thiaminase fish in the diet. Unfortunately, the peak demand for mink feed occurs during late fall and early winter, while the peak fishing season on the lake is now in the spring. This necessitates that the fish be stored or that fish production be increased during the period of peak demand.

163 Stansby, op. cit., pp. 238-239.

Fish meal is an important source of protein for livestock feeds and an additional potential outlet for under-utilized Lake Erie fish. The nation's consumption has increased rapidly in recent years and domestic production has not been able to meet the demand, with the result that more than half of the U. S. supply is now imported from overseas. Fish meal can be used to supplement the rations of all livestock but in the United States, poultry and hogs are the major consumers. In addition to supplying needed proteins, vitamins and minerals, fish meal contains an unidentified ingredient which stimulates growth and development of young chicks and hogs. This provides a competitive edge over other sources of protein for animal diets.165

A number of processes are used to produce meal from whole fish wastes, but the basic stages of production are similar. Fish are initially ground and then heated in a rotating cylinder, using steam or burning gasses as a heat source. After a period of heating, the material is pressed to remove valuable oils and excess water, then drying is continued until all moisture has been removed. The finished meal may be handled in bulk or put into bags. Fish meal plants on Lake Erie would have to be small in capacity due to the nature of the fishery, but small, efficient plants have been developed.166 Fish must be available at low cost for reduction into fish meal. In an analysis of the costs of production of a small fish meal plant operating in the U. S. Gulf Coast area, Robas


indicates production costs of about $105 per ton, excluding the value of oils produced, if raw material fish are valued at one cent per pound. The plant, which has the capacity to process 17,300 pounds of fish into 2.16 tons of fish meal in 8 hours, would require an investment of about $30,000. Since labor costs are higher in northern Ohio than in the Gulf Coast area, costs of producing fish meal using Lake Erie fish would probably be slightly higher, perhaps $107 - $110 per ton. It has been suggested that, due to their small scale of operation, Lake Erie fish meal plants would probably sell their products to small mills in the midwest which do custom feed mixing for farmers. Since these mills purchase meal in less than carload lots, they pay a higher price per ton than larger mills. On such mill, within 30 miles of the lake was paying $182 per ton for fish meal in the summer of 1965.

The seasonality of fish production in the Ohio industry would be a problem in the production of fish meal, as in all industrial fishery products. The catch could be made less seasonal by the adoption of fishing gear such as the otter trawl, and whole fish can be stored for a period of several weeks to several months prior to reduction by the use of chemical preservatives. Fish meal plants must be carefully designed and operated to avoid polluting the air with undesirable odors and nearby water bodies with liquid wastes. In this way they can avoid the nuisance


169 Interview with Mr. George Kahle, Manager, Tiffin Farmers Cooperative Association, Tiffin, Ohio, August 12, 1965.

complaints which have plagued some older plants. Fish meal production in the Great Lakes area is new, and only one plant is in operation thus far. This is in Milwaukee, utilizing rough fish from Lake Michigan.

Among other potential products from Lake Erie fish is fish protein concentrate, or "fish flour," a highly refined type of fish meal. This product is now in use as an additive in pet foods and mink feeds, and is under study by the U. S. Food and Drug Administration as a possible protein supplement for human diets. Since small plants are required for its production, fish flour might lend itself to production in the Lake Erie area.

The commercial possibilities of two species of shellfish which inhabit Sandusky Bay are now being studied by the U. S. Bureau of Commercial Fisheries. One is a live-bearing Japanese snail which was introduced into the bay a number of years ago and is now so abundant that haul seines operating there become covered with them. The snails are highly prized by aquarists and might form the basis of a small fishery. At least a dozen freshwater mussels inhabit Sandusky Bay, some of which may be suitable for use in making core pellets, fragments of shells inserted into oysters to form the nuclei of cultured pearls. The Japanese cultured pearl industry receives its entire supply of core pellets from Tennessee River mussel shells. The harvest of shells, which sell for as much as $180

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per ton, has declined rapidly in recent years and no substitute has yet been found. Several thousand tons of shells are needed each year.\textsuperscript{175}

As the foregoing discussion indicates, there are a variety of alternatives in processing and in products which would improve the utilization of Lake Erie fish. The implementation of new processing methods and products can best by accomplished by larger economic units than now characterize the industry. These might be private firms or cooperatives, although a recent investigation of the Ontario fishing industry indicated that cooperatives there are generally less successful than private firms due to ineffective management.\textsuperscript{176} Larger organizations would be better able to attract capital for investment in new equipment and would be able to integrate several forms of processing under unified management. Integration of processing would make possible the efficient utilization of all the fish caught by a fishing vessel. High value fish could be processed into food items and sold for human consumption. Processing wastes and less desirable species in the catch might be processed into one or more types of industrial products.

Marketing fishery products
Markets and market outlets

Fishery products produced by the Ohio fishing industry are sold mainly within the state, with lesser amounts shipped to surrounding midwestern states. Very little information is available concerning the marketing patterns of fishery products, particularly those of the Great Lakes.

\textsuperscript{175}"Declining Harvest From the Tennessee River Investigated," Commercial Fisheries Review, Vol. 25, No. 10 (October, 1963), p. 27.

\textsuperscript{176}Frick, \textit{op. cit.}, p. 59.
Surveys of the location of markets for fish in the United States were conducted in 1936 and 1946 by Kahn and Stolting. In these surveys fresh and frozen fish caught in the Great Lakes were marketed almost exclusively in the states bordering the lakes. The large freshwater fish markets of Chicago and New York were once important outlets for Ohio fish. In recent years, however, they have become almost insignificant. New York was once the principal market for high quality Lake Erie fish, which were sold there at premium prices. By 1962, the flow of Ohio fish to New York had stopped completely. Chicago, which received nearly 2,200,000 pounds of Ohio-caught fish in 1941, handled less than 250,000 pounds in 1965.

The market area for the Ohio fishing industry has shrunk due to a variety of factors. The industry's catch is much smaller now than in the past and can more easily be absorbed by nearby markets, which have continued to grow in population. Moreover, the species composition of the catch has shifted toward lower quality fish which are less desired in distant markets. In addition, lower value fish will less readily stand the increased costs of long distance shipment. Finally, market competi-


tion, especially from Canadian fishery products, has helped to drive Ohio fish out of many of its traditional markets.

There are four major types of market outlets for Ohio fishery products. Unfortunately, no quantitative data are available concerning the relative importance of each type. Fish, both whole and processed, are retailed to consumers at fish markets which some fishing firms maintain adjacent to their processing plants and docks. This trade is especially important during the summer tourist season along the Lake Erie shoreline.

Considerable amounts of fishery products, especially fillets, are sold to restaurants. Those in northern Ohio often feature Lake Erie fish on their menus. Institutions, such as schools and hospitals, also purchase the products of the Ohio fishing industry. In this market, where buyers are especially price conscious, Ohio fishermen have had difficulty meeting the price competition of Canadian imports and domestic salt-water species.

Retail food stores, perhaps the most important distributors of fishery products, sell large quantities of Ohio fish. In recent years there has been a shift in emphasis from specialty fish and meat markets toward large supermarkets in the retailing of fish, following a general trend in consumer

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181 Although the importance of restaurants in the sales of Lake Erie fish has not been established, a survey by the U. S. Fish and Wildlife Service in 1955 indicated that 37% of the fresh and frozen fish in the U. S. was marketed through restaurants. Over half of the fresh and frozen shellfish were sold in this manner (Fish and Shellfish Consumption in Public Eating and Drinking Places, Special Scientific Report - Fisheries No. 218, June, 1957, p. 2).

182 In August of 1963, with its own fishing industry in a severe depression, the State of Ohio placed orders for 600,000 pounds of frozen fish for institutional use in fiscal 1964. Only 2500 pounds were Ohio-caught fish, with the remainder being Canadian and marine products due to their lower prices. After vigorous complaints by Ohio fishermen, the amount of Ohio-caught products was increased to 200,000 pounds (Interview with Mr. Ray Full, President, Ohio Commercial Fishermen's Association, August, 1963).
sales of food items. Between 1936 and 1964, the percentage of U. S. food sales in supermarkets increased from 49% to 75%. There has been a corresponding decline in specialty stores, such as fish markets. In the city of New York, for example, the number of fish markets decreased from 1200 to 500 in the 1946-56 decade. It is estimated that at least 85% of the nation's fresh fish and 65% of its frozen fish is now sold in supermarkets. Thus, supermarket sales are an increasingly important outlet for food fish.

In addition to fishery products for human consumption, whole sheepshead and other rough fish are sold at lakeside for mink feed. In existence since 1957, this is one of the most recently developed markets for Lake Erie fish. A large, and rapidly growing market for live fish is represented by pay-fishing lakes in Ohio and surrounding states. In Ohio alone, more than 1,000,000 pounds of fish were purchased for stocking purposes in 1958. Catfish make up over half of the fish stocked, with bullheads, carp, and yellow pike as lesser species. Although fish are purchased from a variety of sources, commercially caught fish from Lake Erie are most widely used for stocking.

Ethnic influences have had an important impact upon the marketing patterns of fish in the United States, particularly those from the Great Lakes. Jewish religious observances, especially in the summer and fall, by custom utilize freshwater fish prepared in Kosher style in the diet.

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Consumption of lake fish on such occasions appears to be declining on a per-capita basis, but it remains an important factor in determining demand which is thus associated with the Sabbath observance and with thirty or more special holidays and fast days each year. The increase in demand at these times accentuates the fluctuations in fish prices arising from other causes. Similarly, the religious observance of Lent and meatless Fridays by Roman Catholics and some Protestants has affected the temporal pattern of market demand for fishery products. Over 80% of consumer fish sales are made on Thursday, Friday and Saturday, with almost 50% on Friday. Negro and eastern European ethnic groups also are above average consumers of fishery products. It has been observed that New York City which is inhabited by large numbers of Jews, Catholics, Negroes, and eastern Europeans, has a per-capital consumption of fishery products of 25.8 lbs., more than two and one-half times the national average.

Market competition

Fishery products produced by the Ohio industry face vigorous competition in Midwestern markets from a variety of sources. Foodfish must compete with non-fish sources of animal protein, as well as ocean-caught fish and freshwater fish from outside the state. Fish for animal

166 Royal Commission on Canada's Economic Prospects, op. cit., p. 88.


188 Borgstrom and Heighway, op. cit.

feed are sold in competition with other Great Lakes fish and marine species, and live fish for stocking purposes compete with artificially propagated and stream-caught fish.

The most important competitors of fish in human diets are red meat, particularly beef and pork, and poultry (Table 23). On a per-capita basis, Americans consume about 170 pounds of red meat, 36 pounds of poultry, and 10 pounds of fish per year. The per-capita consumption of meat has been increasing slowly since 1940, as incomes have risen. Poultry has advanced rapidly in popularity in recent years, doubling in per-capita use between 1940 and 1960. The dramatic increase has been attributed to falling prices the development of a standardized product, and the improvement of marketing.

**TABLE 23**

**HISTORICAL AND PROJECTED ANNUAL PER-CAPITA CONSUMPTION OF RED MEAT, POULTRY, AND FISH, SELECTED YEARS, 1940-2000a**

(Pounds)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Meat</td>
<td>112</td>
<td>115</td>
<td>161</td>
<td>175</td>
<td>187</td>
<td>190</td>
<td>195</td>
</tr>
<tr>
<td>(Carcass Wt.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td>17</td>
<td>25</td>
<td>34</td>
<td>38</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>(Edible Wt.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td>10</td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>(Edible Wt.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

channels. Per-capita consumption of fish, including shellfish, has not changed significantly for many years, although there has been some noticeable shifting toward higher quality and more convenient items. Modest increases in the per-capita consumption of red meat and poultry are forecast for the future. Fish, already a relatively minor contributor of animal protein in American diets, is likely to remain so in the future. Dairy products and eggs are also important sources of dietary protein, but are less substitutable for fish than red meat and poultry.

Freshwater fish comprise a very small fraction of annual fish consumption in the United States. It is estimated that, of the approximately ten pounds of fish consumed per capita per year, one-half pound, or 5%, is from freshwater sources. In the midwestern states, the market area for Ohio fish, the importance of freshwater fish is considerably greater. Although consumption data are not available on a regional basis, an estimate can be made based upon fishery products received at Chicago, the midwest's largest fish market. Freshwater fish comprise 42% of the fresh and frozen fish handled at Chicago, but data are not available for receipts of canned and cured products. Since almost half of the fish consumed nationally are canned or cured, it may be estimated that over 20% of the fishery products received at Chicago, and consumed in the midwest, are of freshwater origin.

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191 Frick, op. cit., p. 29.

The midwestern states have had a tradition of acceptance of freshwater fish, due both to the proximity of major areas of production in the Great Lakes and Mississippi River system and the settlement of the region by central and eastern European immigrants, who brought with them a preference for freshwater species. Fish and shellfish of marine origin have gradually invaded interior markets by stressing convenience, reasonable prices, active promotion of nationally known brands, and sales through supermarkets. Frozen groundfish fillets from such species as cod, halibut, haddock, and ocean perch were first introduced in the early 1930's. They were marketed first in the New England area, but have since become popular throughout the country, where over 370,000,000 pounds are now sold.\footnote{U. S. Bureau of Commercial Fisheries, \textit{Packaged Fishery Products}, 1965.} There is a high rate of substitution in the market place between these products and fillets of yellow perch, a major product of Lake Erie fisheries. Despite more elaborate promotion and packaging and higher transportation costs, they often are priced lower in midwestern consumer markets than yellow perch.\footnote{Keith Brouillard and Walter C. Jones, "Competition for the Yellow Perch Fishery," (U. S. Bureau of Commercial Fisheries, Ann Arbor, Michigan, 1963), pp. 1-3 (Mimeographed).} Shrimp has become a serious competitor of traditional fishery products since World War II. Sold mainly in frozen dressed form and as a breaded convenience item, about 300,000,000 pounds are now consumed annually.\footnote{U. S. Bureau of Commercial Fisheries, \textit{Fisheries of the United States}, 1965, p. 39.} Breaded fish sticks and fish portions, prepared from ground fish fillets, are the latest successful invaders of freshwater fish markets. Yearly sales of these
frozen, ready-to-cook products now amount to 220,000,000 pounds, having tripled since 1957.\textsuperscript{196} Any survey of market competition must include canned tuna and salmon. Tuna consumption, the largest of any species of fish in the nation, has risen to an all time high of 4,09,000,000 pounds, while canned salmon is relatively stable at about 150,000,000 pounds.\textsuperscript{197} The four types of products mentioned above comprise about 30% of the edible fishery products sold in the United States. Market competition of another type is presented by fish caught by sportmen and consumed in the home. Per-capita consumption is estimated at three pounds, which is in excess of the ten pounds of commercial fish products consumed each year.\textsuperscript{198}

In addition to ocean-caught fish and shellfish, the Ohio fishing industry faces competition in midwestern markets from freshwater fish of foreign and domestic origin. Imports are almost exclusively from Canada and will be discussed separately below. Since consumption data by area and type of product are lacking, it is difficult to determine the extent to which domestic freshwater fish compete with Ohio products. Generally, the catch of the other Great Lakes states is composed of different species than those of Ohio, thus minimizing competition between them. Instances of significant competition include carp from the Michigan waters of Lake

\textsuperscript{196}U. S. Bureau of Commercial Fisheries, \textit{Fish Sticks, Fish Portions, and Breaded Shrimp}, 1965.

\textsuperscript{197}U. S. Bureau of Commercial Fisheries, \textit{Fisheries of the United States}, 1965, pp. 36-37.

\textsuperscript{198}Ibid., p. 46.
Erie and Lake Huron, yellow perch from Michigan, Pennsylvania and Wisconsin, and yellow pike from Michigan and Minnesota. Low value fish, for human food and animal feed, are caught in large quantities in the streams, lakes, and reservoirs of the Mississippi River system. Increasingly in recent years, these fish have been shipped to markets in the Great Lakes states where they compete with similar products from Lake Erie. Catfish from Florida have become important competitors of Ohio-caught catfish on midwestern markets in recent years. In 1965, Florida supplied more than half of the total supply of this valuable fish on the Chicago market.\footnote{U. S. Bureau of Commercial Fisheries, Market News Service, Receipts and Prices of Fresh and Frozen Fishery Products at Chicago, 1965.}

Imports of freshwater fish from Canada

Canada is the largest and only significant foreign supplier of freshwater fish for United States markets. In recent years, it has been responsible for more than 98% of such imports into the United States.\footnote{U. S. Bureau of the Census, U. S. Imports of Merchandise for Consumption, Report FT125, December 1964 and 1965.}

The Canadian freshwater fishing industry has always been based primarily on export trade to American markets, with approximately 75% of the Canadian freshwater catch being marketed in the United States.\footnote{Frick, op. cit., p. 33.}

Canadian fish have been imported into this country in large volume for many years. In 1924, a survey showed Canadian exports to the United States amounting to 41,600,000 pounds. In the same year, the domestic Great Lakes catch totaled 78,500,000 pounds, for a total supply of
120,100,000 pounds of lake fish on the United States market. By 1964, forty years later, imports from Canada had risen to 46,200,000 pounds, while the U.S. Great Lakes catch fell to 46,700,000 pounds. The domestic market supply totaled 112,900,000 pounds. During the period, imports increased by 35%, but perhaps more significantly, Canada's share of the U.S. market rose from one-third to one-half, an increase of 50%.

Canadian exports of fish to the United States are the product of commercial fishing operations conducted in a large number of freshwater lakes in the interior of the country. The more important producing areas include the Canadian waters of the Great Lakes, entirely within the Province of Ontario, Lakes Winnipeg, Winnipegosis, and Manitoba in the Province of Manitoba, and Lesser Slave Lake in Alberta. Great Slave Lake, in the District of Mackenzie, Northwest Territories, has become a major producer of high quality fish since its opening to commercial fishing in 1946. Fishing is conducted throughout the year on the northern lakes, with nets cast under the ice and the catch frozen naturally during the winter months.

The composition of Canadian imports is similar to that of the U.S. Great Lakes catch. Although many valuable products are included,

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202 U.S. Tariff Commission, Lake Fish: A Study of the Trade Between the United States and Canada in Freshwater Fish with Cost of Production Data, Tariff Information Series - No. 36, 1927.


204 The "prairie lakes" of western Canada now dominate the New York and Chicago markets for highly prized white fish and lake trout, following the sea lamprey's decimation of stocks of these fish in the Great Lakes (U.S. Bureau of Commercial Fisheries, Market News Service, Receipts and Prices of Fresh and Frozen Fishery Products at Chicago, 1961), p. XVII.
attention here will be directed toward those fish which are available for capture in Lake Erie, and are directly competitive with the Ohio fishing industry (Table 24). Import data differentiated by species is available

**TABLE 24**

**UNITED STATES IMPORTS OF SELECTED FRESHWATER FISHERY PRODUCTS, 1960-1961**

(Thousands of Pounds)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole and Dressed Fish</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow Pike</td>
<td>b</td>
<td>1,504</td>
<td>1,801</td>
<td>8,637</td>
<td>9,033</td>
</tr>
<tr>
<td>Yellow Perch</td>
<td>b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smelt</td>
<td>8,637</td>
<td>8,781</td>
<td>11,968</td>
<td>10,011</td>
<td>8,637</td>
</tr>
<tr>
<td>Unclassified</td>
<td>5,419</td>
<td>4,801</td>
<td>4,562</td>
<td>7,332</td>
<td>8,180</td>
</tr>
<tr>
<td>Fish Fillets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow Pike</td>
<td>6,616</td>
<td>4,519</td>
<td>3,462</td>
<td>2,548</td>
<td>2,282</td>
</tr>
<tr>
<td>Yellow Perch</td>
<td>3,664</td>
<td>8,084</td>
<td>4,238</td>
<td>9,840</td>
<td>11,805</td>
</tr>
<tr>
<td>Unclassified</td>
<td>1,110</td>
<td>2,515</td>
<td>6,435</td>
<td>10,340</td>
<td>37,696</td>
</tr>
<tr>
<td>Totals</td>
<td>32,117</td>
<td>36,205</td>
<td>40,340</td>
<td>37,696</td>
<td>36,487</td>
</tr>
</tbody>
</table>


*bData for whole and dressed yellow perch are unavailable for 1963 and 1964. During these years, yellow perch imports were included with unclassified whole and dressed fish.*

*cData for yellow perch fillets are unavailable for 1960 and 1961. Imports of perch fillets were included with unclassified fish fillets during these years.*

for only three Lake Erie fish. These are yellow pike, yellow perch, and smelt. Imports of other Lake Erie species are included in an "unclassified" category. Due to changes in data collection procedures, import totals for whole and dressed yellow perch and yellow perch fillets are unavailable for 1963-64, and 1960-61, respectively.
The total volume of imports did not change significantly during the five-year period, 1960-64. Yellow pike imports have increased, especially with respect to fillets. Yellow pike shipments now come primarily from the Canadian prairie lakes, since Great Lakes landings have declined in recent years. Yellow perch imports, were increasing until 1964, when the Canadian catch in Lake Erie dropped by 50%. Smelt in whole and dressed form comprise the largest volume of Lake Erie species in imports. These shipments reached a peak in 1962 and have declined since. Unclassified fish species, including such Lake Erie species as catfish, bullheads, sheepshead and white bass, have been imported in decreasing numbers throughout the period.

Imports of Canadian freshwater fish are received primarily in the states bordering the Great Lakes. New York, Chicago, Detroit, and Buffalo are the principal cities of first destination. Although information relating to the marketing of these fish is sketchy, it appears that about 75% are sold in population centers near the lakes, with the remainder going mainly to the New York City area. Some imported products are redistributed from these centers elsewhere in the United States. Frozen dressed smelt from Ontario, for example, have been observed in retail stores in southern California. Most imported fish are repackaged at the wholesale level and are not identifiable as imports. A complete picture of market distribution for imports, like domestic products, cannot be constructed due to lack of data.

The effects of Canadian fishery imports on the Ohio industry are generally unfavorable. Production and processing costs in Canada are

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205Frick, op. cit., pp. 32-33.
lower than in Ohio, as a result of lower labor costs and mechanized operations. Import duties of one-half cent per pound on whole fish and one and one-half cents per pound for fillets are totally ineffective as a barrier to trade.\textsuperscript{206} Due to these factors, Canadian fish can frequently be sold in the United States at prices which are lower than Ohio production costs. In addition to depressing prices generally, imports, especially those from Ontario, tend to aggravate seasonal market gluts. At the present time, this is most significant in the market for yellow perch. The following incident illustrates the effect of imports on fish prices. During the spring of 1961 imports of whole and dressed yellow perch from Ontario were at very low levels. Market supplies in the midwest were scarce, and prices were unusually high at 35 cents per pound. Throughout the next year, Ontario production of perch and exports to the U. S. increased, reaching a peak in late spring of 1962. Prices, meanwhile, dropped as supplies became heavy. By the summer of 1962, they had fallen to 8 cents per pound.\textsuperscript{207} This was the period, noted previously, when the yellow perch population of Lake Erie was composed, almost entirely, of young fish hatched in 1959. Though slightly below the legal size limit in Ohio, millions of pounds of these fish were caught on the Canadian side of the lake by Ontario fishermen. By the time Ohio fishermen were legally permitted to catch them, a large share of the perch crop had been harvested and U. S. markets were so saturated with Canadian-caught fish that prices had been reduced to unprofitable levels.

\textsuperscript{206} Francis Masson and J. B. Whitely, \textit{Barriers to Trade Between Canada and the United States} (Montreal: Canadian-American Committee, 1960).

\textsuperscript{207} Frick, \textit{op. cit.}, p. 41.
Brouillard has suggested that the importation of lake trout from Canada may be of limited benefit to American fishermen. Since the sea lamprey all but eliminated lake trout from the Great Lakes, U.S. landings have been very small. Imports of trout from Canada's prairie provinces have helped to maintain a greater market than would have been possible with only the domestic production. Thus, if lake trout populations are restored following the eradication of the lamprey, catches will be more saleable than they might have been without imports. The same sort of reasoning might be applied to certain Lake Erie species, such as yellow pike, which have become scarce as a result of environmental changes produced by water pollution. Market supplies now come primarily from the Canadian prairie lakes. If pollution in Lake Erie can be controlled, and such species restored to abundance, future catches may be easier to sell since their traditional markets will not have been invaded by other species of fish.

Regardless of the effects of Canadian fishery imports, they are a factor to be reckoned with in the future of the Ohio fishing industry. Canadian shipments to the U.S. can readily be maintained at present levels, and may be increased in the future. It has been estimated that Canadian landings of freshwater fish could be increased by as much as 40%. There is no evidence that the duties now in effect on fishery products will be increased to the extent that imports will be curtailed. The trend in recent years has been to reduce tariffs in order to promote trade between

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the two countries, a condition which can be expected to continue into the foreseeable future.

Transportation

Ohio fishery products are transported to market primarily by truck. On short hauls, trucks are exclusively used and on the relatively long distance hauls to Chicago, trucks handle more than 80% of present shipments. In earlier times, the industry relied heavily upon less-than-carload (L.C.L.) rail express to get their fish to market. Some shippers, especially the larger ones, are increasingly using their own trucks instead of common carrier vehicles.

Transportation costs represent a substantial portion of the market value of fishery products. Wooden boxes in which fish are packed with ice for shipment cost from $1.00 to $1.25 each, representing a cost of 2 cents per pound for the net weight of fish they contain. A large share of the gross weight of a fresh, iced fish shipment is composed of the weight of boxes and ice. Lighter and cheaper containers than those now used would reduce shipping costs, as would a greater emphasis on filleting which removes the roughly half a whole fish which is unmarketable waste.

Freight rates on fresh and frozen fishery products, the only ones now produced by the Ohio fishing industry, have risen markedly in recent years. Rail express rates increased by 10% between 1947 and 1960, and motor carrier rates increased by 11% during the same period.

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211 Frick, op. cit., p. 50.

increases have contributed both to a shift to privately owned trucks, which provide more flexible, if not lower cost, service, and a gradual withdrawal from distant markets.213 The advantages of larger economic units have been mentioned previously, in connection with production and processing operations. Transportation cost advantages would also accrue to such units by permitting larger size shipments which would receive the lower truck-load and car-load rates, offered by both motor and rail carriers. Most shipments now receive relatively expensive L.C.L. rail, and less-than-truckload (L.T.L.) rates.

Potential markets for Lake Erie fish

Food Products.—The per-capita consumption of fishery products is low in comparison to other protein products and has remained stable for many years (Table 23). The stagnation in per-capita fish consumption has occurred in spite of efforts to increase the appeal of fishery products by improved packaging and building in more convenience through filleting, breading, and pre-cooking.211 Efforts to increase consumption meet with a variety of cultural resistances. Fish carries a stigma that is associated with penitence being prescribed for some religious groups for certain periods or days. Fishery products have traditionally been lower in price than land animal protein products and have been consumed by low income people. Low priced fish are often considered socially inferior to higher


211 Some observers credit these innovations with preventing what might otherwise have been a substantial decline in per-capita fish consumption. (Borgstrom and Heighway, op. cit., p. 251).
priced protein products. Because of this there is a tendency for consumers to shift away from fish to other forms of protein, as their incomes rise.215 Due to the extreme perishability of fish flesh, the problem of maintaining consistently high quality from catching to consumption has never been completely solved. Nationally publicized reports have shown that a high percentage of various seafood products in retail stores is sub-standard in quality.216 As a result, fishery products do not enjoy as high a level of consumer confidence as other protein foods. These, and many other factors have restricted per-capita consumption of fish in the past and are likely to prevent any dramatic increases in the future.

Despite stable per-capita fish consumption, the market for fishery products is growing due to population increase. Table 25 shows the United States consumption of fish for food, by decade, from 1940 to 1960, and projections to the year 2000. The total domestic consumption of fishery products is expected to be nearly twice the 1950 level by 2000. It is unlikely, however, that the same types of products will be consumed in the future, as in the past. There is a strong trend toward frozen convenience items, with new products entering the market place continually. It was estimated in 1962, that 85% of the fishery products then on sale in retail stores were not on the market ten years earlier.217

215Ibid., p. 250.


### TABLE 25

**HISTORICAL AND PROJECTED POPULATION AND HUMAN CONSUMPTION OF FISHERY PRODUCTS,**

**SELECTED YEARS, 1940-2000**

<table>
<thead>
<tr>
<th>Year</th>
<th>Population (Millions)</th>
<th>Fishery Products (Billions of lbs.: Edible Weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>132</td>
<td>1.40</td>
</tr>
<tr>
<td>1950</td>
<td>152</td>
<td>1.76</td>
</tr>
<tr>
<td>1960</td>
<td>180</td>
<td>1.89</td>
</tr>
<tr>
<td>1970</td>
<td>208</td>
<td>2.08</td>
</tr>
<tr>
<td>1980</td>
<td>245</td>
<td>2.45</td>
</tr>
<tr>
<td>1990</td>
<td>287</td>
<td>2.87</td>
</tr>
<tr>
<td>2000</td>
<td>331</td>
<td>3.31</td>
</tr>
</tbody>
</table>


If Ohio fishermen are to maintain, and perhaps expand, their share of future food fish markets, they will have to change their orientation from sales of fresh, round fish to frozen fillets and other convenience items. Frozen, highly processed products are more acceptable to both retailers and consumers than traditional market forms. For the consumer, these products save valuable time and effort by reducing the necessary preparation prior to serving. Retail stores prefer frozen packaged fish because they are easier and cheaper to store and display, and have a longer shelf-life than whole fresh fish. Many large supermarket chains have tended to drop fresh fish and handle only frozen products.²

The potentials for expanding the markets for fishery products are large. Only a small minority of possible retail sales are now being realized. It is estimated that only 13% of supermarket shoppers purchase fish, a much smaller proportion than for other protein foods. There is also a considerable potential for expanding sales of fish to restaurants. Less than half of the restaurants in the north central region of the United States serve any kind of fish. The relative lack of market penetration by fishery products may be due to the very small amounts of money which are spent on advertising and market promotion. Table 26 indicates the relative backwardness of the fishery products industry in these essential market expanding activities.

**TABLE 26**

**EXPENDITURES FOR ADVERTISING AND MARKET PROMOTION OF SELECTED UNITED STATES FOOD PRODUCTS INDUSTRIES, 1957**

<table>
<thead>
<tr>
<th>Industry</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus Products</td>
<td>$5,000,000</td>
</tr>
<tr>
<td>Dairy Products</td>
<td>$3,000,000</td>
</tr>
<tr>
<td>Meat Products</td>
<td>$2,000,000</td>
</tr>
<tr>
<td>Broiler Chickens</td>
<td>$300,000</td>
</tr>
<tr>
<td>Fishery Products</td>
<td>$100,000</td>
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</tbody>
</table>


Industrial Products.—Markets for non-food, industrial, fishery products are growing at a considerably faster rate than those of fishery products for human consumption. During the decade between 1954 and 1964, the consumption of edible fishery products increased by 19%, while that of industrial products rose by 104%. The demand for industrial products has risen so fast that domestic production has not kept pace, and the U. S. is fast becoming a major world importer of these commodities. In 1964, 71% of the nation's supply of industrial fishery products was imported from other nations. Of the industrial products which might feasibly be made from under-utilized Lake Erie fish, the following discussion is centered on four which appear to have the largest potential markets, and about which most market information is available. These are pet foods, feed for ranch mink, fish meal, and live fish for stocking in recreational fishing lakes.

The pet food industry represents a particularly large and rapidly growing market for industrial fishery products. It now produces over three billion pounds of canned and dry dog and cat foods, with sales of over $530 million. Pet foods are one of the fastest growing segments of the domestic food products industry, increasing sales by one-third in the five years between 1958 and 1963. The growing suburbanization of the American population has increased the number of family owned pets, now estimated to number about 50 million, and increasing numbers are fed commercially prepared foods. The rapid growth which has characterized

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222 "Catering to the Cats and Dogs," Business Week, November 9, 1963, pp. 64-68.
the industry in the past is expected to continue, since only about one-third of the nation's cats and dogs are now fed on commercial foods. 223

Fish are an important source of animal protein for pet foods. About 400 million pounds of whole fish and fish processing scrap were used to make canned pet foods in 1961, and an additional 100 million pounds of fish meal was consumed in the preparation of dry cat and dog foods. It has been estimated that a billion pounds of industrial fishery products will be needed by 1970. 224 Only a few species of Great Lakes fish are presently used by pet food processors, with production now centered on Lake Michigan. Two species, smelt and carp, are also abundant in Lake Erie.

The mink ranching industry of the United States is a major present, and potential, user of whole fish and fish scrap. The number of mink kept on commercial ranches is unknown, but can be estimated from available data on pelt production. "Kits," young mink from which pelts are taken, numbered 6,951,000 in 1962. 225 An average of 33 adult breeding animals are needed to produce each 100 pelt-bearing kits. 226 Thus, an additional 2,294,000 must be added to bring the total domestic mink population to 9,245,000. The production of ranch mink has increased rapidly since the


224 Ibid.


wide-spread establishment of the industry following World War II. Pelt production more than tripled between 1951 and 1962.  

The Great Lakes states are the center of the U. S. mink industry, accounting for about 65% of the national pelt production. It is estimated that fish consumption in this area, on an annual per-animal basis, is 30 pounds for kits and 36 pounds for adult breeding animals. Thus, fish consumption by mink would total 186,550,000 pounds in the Great Lakes states, based on 1962 population estimates. In Ohio alone, fish consumption for mink feed is nearly 12,000,000 pounds, an amount equivalent to the total catch of the Ohio fishing industry in 1961. About 15% of the fish now used by Great Lakes mink ranchers is of freshwater origin. The remainder consists of whole fish and fish processing scrap shipped from the marine fisheries of the Atlantic coast.

Although the market for fishery products as mink feed is now large, it can be expected to grow considerably in the future. In the Great Lakes area, fish comprise only one-fourth of the feed consumed by mink, while in the western U. S., fish frequently make up one-half or more of the diet. It is expected that the proportion of fish in the rations of Great Lakes mink may increase due to rising prices of competing protein products, such as horsemeat and meat by-products. In addition, if present trends continue, the area's mink population will double by 1970.

227 National Board of Fur Farm Organizations, op. cit.


229 Jones, "Fish in the Mink Ration," op. cit.

By far the largest users of industrial fishery products are manufacturers of livestock and poultry feeds, who use fish meal and related products as protein supplements. Consumption of fish meal and fish solubles has increased rapidly in recent years, doubling in little more than a decade. In the Great Lakes area, 12,955,000 tons of livestock and poultry feeds were manufactured in 1962. In addition, an undetermined amount was prepared for their own use by farms and feedlots. Using the U. S. Census's East North Central states average of 2% as the proportion of fish meal in such feeds, an estimated 260,300 tons of meal were consumed in the states bordering on the Great Lakes. Since five tons of fish are required to produce one ton of meal, fish meal consumption in the Great Lakes area represents the equivalent of 2,603,000,000 pounds of raw fish. This figure is roughly 26 times the present commercial fish catch from the Great Lakes, by the United States and Canada.

In Ohio, an estimated 11,780 tons of fish meal are used in the production of feeds. About 62% is consumed by small manufacturing plants and grain elevators which turn out feed in relatively small quantities. These are believed to be the most likely market for fish meal produced from Lake Erie fish, since they tend to buy in less than carload lots and pay premium prices for meal. The raw fish equivalent of this market is about 260,000,000 pounds, 20 times the Ohio commercial catch. Fish

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meal is presently made from marine fish on the Atlantic and Gulf coasts of the United States, and over half of the domestic consumption is imported, mostly from Peru. If fish meal can be made at reasonable cost from Lake Erie fish, it could be sold within a relatively short distance of the lake. Thus, a substantial transportation cost advantage would exist with respect to present suppliers who must ship their products hundreds, and even thousands, of miles to reach midwestern markets.

Recreational fishing lakes in the midwestern area offer a modest market for live Lake Erie fish used for stocking. Unfortunately, little information is available concerning the size and growth potential of this market. A survey conducted in 1958 by the Ohio Division of Wildlife provides a view of pay lakes in Ohio. An admission charge for the privilege of fishing was levied in 211 lakes within the state. About 1,000,000 pounds of live fish were purchased in 1958 for stocking in the lakes, with Lake Erie species predominating. Catfish made up about half of the fish stocked, but yellow pike, carp, bullheads, and sheepshead were also used. The average age of pay fishing lakes in Ohio in 1958 was 9 years, indicating their relatively recent development. It was estimated that, at prevailing rates of growth, the number of pay lakes, and their patrons, would double in five years.

Market research and development

As indicated above, potential markets exist, nearby, for all the fish which the Ohio fishing industry can ever be expected to produce. Many of the markets are unfamiliar to Ohio fishermen, however, and research will be needed to successfully develop them. Careful and detailed market research

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233Doherty, op. cit., pp. 2, 6, and 12.
is needed to determine the character and size of markets, as well as the extent of competition in them. Feasibility studies, perhaps including pilot plant operations and test marketing, should be conducted to ascertain the profitability of producing the new products. Since new equipment and facilities would be needed to serve these markets, potential sources of low-cost investment capital should be investigated.

Market development efforts, if they are undertaken, are likely to be a joint effort of the fishing industry and various levels of government. The U. S. Bureau of Commercial Fisheries, at Ann Arbor, Michigan, has done some work of this type and is continuing its investigations. Its work, however, is spread over the entire Great Lakes fishery and funds for market development studies are limited. The State of Ohio is committed to a policy of encouraging new industries within the state, and assistance in market development activities may be expected from various state agencies. Colleges and universities within the state might be tapped for research personnel, equipment, and funds. Within the fishing industry, some form of cooperative effort would be required, since few of the firms which now exist can afford to conduct research and development efforts individually. The Ohio Commercial Fishermen's Association might coordinate such efforts within the industry.

**Summary**

The fishery products marketed by the Ohio fishing industry are not highly processed. Fishing establishments which engage in processing are small in size and their methods are labor intensive. In contrast, fish processing in the competing Ontario industry is carried on in large, modern establishments where mechanized handling, frozen storage, and the
development of new, convenience products is emphasized. Canadian caught and processed fish have made deep penetrations into U. S. fishery products markets in recent years. Mechanized processing, the development of new convenience-type consumer products, and quick-freezing and frozen storage are innovations which would increase the fishing industry's profits, and make its products more acceptable in the marketplace. The processing of presently under-utilized species into several industrial fishery products appears to be economically feasible. These include pet foods, food for zoo animals, feed for ranch mink, and fish meal for livestock feeds.

Ohio fishery products are marketed primarily within the Lake Erie area, although they were once shipped in large quantities to markets in New York and Chicago. Strong market competition is offered by a variety of products. Although the per-capita consumption of fish has remained stable for a number of years, that of other sources of superior protein such as poultry and red meat, has increased. Highly processed attractively packaged, and reasonably priced fishery products of marine origin are strong competitors of Ohio-caught fish in midwestern markets.

Canadian-caught lake fish have been imported into the United States for many years. In the last 40 years, the total volume of imports has increased modestly, but has become a much larger share of total supplies on domestic markets, due to reduced U. S. catches. Canadian fish now supply about half of the domestic market. The principal Lake Erie species imported are yellow pike, yellow perch, and smelt. The importation of Canadian fish has generally unfavorable effects upon the Ohio industry. Due to lower production, and processing costs, imports of fish can be sold in the American midwest cheaper than Ohio fish can be produced. In addi-
tion to depressing prices generally, imports tend to aggravate seasonal market gluts, driving prices even lower. Present import duties are ineffectual as a barrier to trade in fishery products.

The potential for expanding present food fish markets appears to be large. Per-capita consumption, now much lower than for most other protein foods, could be increased and population growth continues to enlarge the number of consumers. To share in market growth, Ohio fishermen must consider those products with the greatest growth potential, highly processed, frozen convenience items. Market promotion and advertising activities must be increased to compete with other protein products.

Industrial fishery products markets are expanding rapidly, and appear capable of absorbing products made from presently under-utilized Lake Erie species. Markets with considerable growth potential in the midwest include pet foods, feed for ranch mink, fish meal, and live fish for stocking in recreational fishing lakes. Present consumption of fish in these products represents an amount several times the total Great Lakes fish catch. Extensive market research and development efforts, will be needed to successfully tap these large potential markets for Lake Erie fish.
CHAPTER VI

CONCLUSIONS AND SUGGESTED RESEARCH

Conclusions

The Lake Erie commercial fishing industry in Ohio is now in the depths of the most severe depression in its history. The decline began about 1944 and has continued with only minor interruptions to the present time. A combination of factors, which are biological, economic, political, and social in nature, are responsible for the industry's present condition. Despite its depressed state, however, the fishing industry continues to make significant, though localized, contributions to the well-being of Ohio and the nation.

Lake Erie, the sole resource base for the Ohio fishing industry, is the warmest, shallowest, and most fertile of the Great Lakes. The physical conditions of the lake represent a mixed blessing to the fishing industry. On the one hand, the lake's high biological productivity has traditionally produced large populations of commercial fish but, on the other hand, it is very susceptible to the undesirable effects of over-fertilization resulting from the disposal of man-made waste materials.

The location of Lake Erie in an urban-industrial region and the increasingly intensive human use of its waters have produced a number of detrimental effects upon the Ohio fishing industry. Most significant has been the alteration of the lake's aquatic environment by the disposal of municipal and industrial wastes and the deposition of silt from agricultural
run-off. The introduction of these materials into the lake has accelerated its natural aging processes, causing profound qualitative and quantitative changes in water chemistry and aquatic flora and fauna. Where once the lake produced large populations of highly prized food fish, it now favors the growth of less desirable species. Notable, but less important problems associated with Lake Erie as a fishery resource base include the reservation of a potentially rich fishing ground for the test firing of military weapons and the damage to fishing gear resulting from the navigation of watercraft.

The commercial fishing industry has never utilized more than a small fraction of the total fishery resources of Lake Erie. The fishing activities of commercial operators, as well as large numbers of sportsmen, have been directed mainly toward those species which were most desired as food fish, a practice which has placed these preferred species at a further disadvantage in their competition with other fish for living space within the aquatic environment of the lake. The biological production of fish in Lake Erie appears to be at an all-time high but an increasing share is now devoted to low value species which are ill-suited to the present harvesting, processing, and marketing methods of the fishing industry.

Attempts by government to influence the composition of Lake Erie's fish populations in favor of the more valuable species date back more than a century. Fish hatcheries have artificially propagated billions of desirable fish and released them in the lake. In addition, commercial fishing regulations have attempted to limit the intensity of fishing pressure on certain valuable species. Despite the expenditure of large amounts of public funds to operate hatcheries and enforce fishing regulations, both programs have failed to preserve the abundance of high value fish.
The trend toward a dominance of low value species in both fish populations of Lake Erie and the Ohio commercial catch seems likely to continue in the foreseeable future. Although programs of fishery research and water pollution abatement are presently in evidence and will probably be expanded in the future, they are unlikely to produce immediate and dramatic reversals of present trends. The fishing industry should adjust to its changing resource base by considering methods which will enable it to profitably harvest, process, and market the growing numbers of low value fish. Herein lies the industry's greatest challenge and also its greatest opportunity.

A basic characteristic of commercial fishing lies in the nature of the natural resource which is exploited. Fish stocks are common property resources, to be utilized simultaneously by a number of fishermen. No user has exclusive rights to any part of the resource and each is free to pour capital, labor, and other factors of production into the fishery in unlimited amounts. Unlike the case of the more common solely owned resource, there is little incentive for individual users to defer production in an attempt to manage the resource on a long-term, sustained yield basis. Overproduction and overcapacity are encouraged, costs tend to approach earnings, and low wages, profits, and returns on invested capital are characteristic. The regulation of commercial fishing seldom recognizes the common property status of fishery resources. Although fish are free to swim from one jurisdiction to another, in Lake Erie regulation is fragmented among five governmental units. Since regulations are not uniform, fishermen in areas having liberal fishing laws tend to benefit at the expense of those covered by more stringent regulations.

The Ohio fishing industry has harvested a steadily decreasing share of Lake Erie's fishery resources in recent years. While it was once
the leading industry on the lake, it is now overshadowed by the fishing industry of Ontario, Canada, which accounts for over two-thirds of the Lake Erie commercial catch. In addition, the catch by sportsmen is increasing and appears to equal the commercial catch within the United States waters of the lake. Competition from both sources, especially for high value species, is likely to intensify in the future.

The firms which make up the fishing industry are small in size. Large, fully integrated companies which once dominated the industry have been replaced by much smaller establishments engaging primarily in fishing operations. Most existing firms lack professional management and sufficient financial strength to cope with the challenges in mechanization and product and market development which now face the industry. By contrast, the competing Ontario fishing industry is led by large, well managed, heavily capitalized firms. A consolidation of Ohio's small fishing establishments into more viable economic units is needed to improve the industry's chances for future success.

Employment in the Ohio industry has declined rapidly in recent years, both in numbers of employees and in hours worked. Employment is now almost exclusively part-time. Wages in the fishing industry have fallen far below the average for Ohio workers but are still substantially above those of the competing Ontario industry. The productivity of Ontario fishermen is now about twice that of Ohio, although a decade ago they were similar. Labor productivity is related to investment in capital equipment which has doubled in Ontario since World War II, while in Ohio the value of equipment is now only one-third of the 1954 level. Due to low wages and the lack of permanent, full-time employment opportunities, the fishing industry has difficulty attracting dependable workers in the highly competitive labor market of northern Ohio.
Ohio's commercial fish catch is landed at many small fishing ports. This has tended to reduce the efficiency of unloading, processing, storage, and transportation of fish, operations in which scale economies could produce cost savings if the catch were concentrated in fewer ports. Fish production is highly seasonal and there is a shortage of freezing and storage facilities in the industry. During periods of heavy production, fish markets become glutted and a large share of the industry's output must be sold at depressed prices. Throughout the remainder of the year, catches are small, unit production costs are high, and fish must be sold at relatively high prices if a profit is to be made. Harvesting and processing capacity must be geared to peak production runs and is relatively idle during much of the year.

Fishing gear now in use by the Ohio industry is not well suited to the capture of low value fish which now dominate the commercial catch. With the exception of the haul seine, the types of gear now in use have production costs which are in excess of the value of many of the species harvested. Fishing costs are further increased by hand-measuring the lengths of several species, a practice which is dictated by current fishing regulations. Otter trawls, currently in use in Ontario and Pennsylvania, offer a lower cost and less seasonal alternative to present fishing methods. The adoption of trawling, however, will require a change in Ohio fishing regulations which now limit its use to experimental capture of smelt.

Commercial fishing regulations in Ohio are among the most stringent on Lake Erie. In contrast, the competing Ontario industry operates under laws which have been liberalized in recent years. Existing Ohio regulations now produce a definite competitive advantage in favor of Ontario fishermen. This has helped them to capture an increasingly larger share of the available
fish stocks of Lake Erie. In Ohio, the fishing industry's share of the total lake fish catch is declining and production costs have increased. By specifying the types of gear which may be used Ohio laws have encouraged technological stagnation in the industry.

Ohio fishing regulations have failed as a device to conserve high value fish populations. They should be replaced by a comprehensive management program for fishery resources. The aim of such a program should be a maximization of economic and social well-being and a minimization of costs. The interests of both sport and commercial fishermen should be recognized and those fishery resources allocated to the commercial fishing industry should be harvested in the most efficient manner possible. Entry into the fishery should be controlled if capital, labor, and management, as well as fishery resources, are to be conserved.

Despite a growing consumer preference for highly processed fishery products, Ohio fishermen continue to sell their catch in relatively unprocessed condition. Some processing is done, but it is labor intensive and costs are high. Using modern Ontario fishery firms as a model, the Ohio industry might profit from the processing of higher value fish into a variety of convenience food items. Low value fish from Lake Erie, now mostly wasted, could be processed into industrial fishery products. In both cases, high volume, mechanized methods would be needed to keep the costs of products competitive in the marketplace.

The market for Ohio fish is now confined primarily to the Lake Erie area after once having extended to such cities as New York and Chicago. Competition from processed and attractively packaged marine fish, as well as imported Canadian lake fish, has played a major role in Ohio's shrinking markets. Both competitors have lower production costs than Ohio fishermen
and their products tend to depress market prices. Canadian fish are especially troublesome in that they tend to aggravate the normal seasonal market gluts. Existing import duties are too low to act as a barrier to trade in lake fish.

In order to strengthen its market position in the future, the Ohio fishing industry must be cognizant of, and react to, trends in the consumption of fishery products. Per-capita consumption of food fish is stable and thus market growth for these products is keyed to population increase. Within the food products group, however, there is a noticeable shift in consumer preference toward convenience items. During the past decade, the consumption of non-food, industrial fishery products expanded at a rate approximately five times that of food fish products. The nation, and especially the midwest, is deficient in such products and they are imported in large amounts. Pet foods, feed for ranch mink, fish meal for livestock feeds, and live fish for stocking in recreational fishing lakes represent rapidly growing markets where Lake Erie fish products might be sold.

The decline of the Ohio fishing industry can be attributed to a number of interrelated physical and cultural factors. Efforts to revitalize the industry must be aimed at changing those factors which can be changed and adjusting to those which cannot. In general, it is the cultural factors, including economic and political problems, which are most amenable to change. Physical factors, especially those associated with the Lake Erie resource base, are much more difficult to correct and if improvements are made the industry should have little difficulty in adapting to them. The first change which should be made, and the one upon which all the others may depend, is in the attitudes of individual members of the fishing industry and government agencies concerned with fishery management. Conservatism,
watchful waiting, and rivalry must give way to progressive thinking,
vigorous action, and a spirit of cooperation if any real progress is to be made.

The major conclusions of this study are summarized in the following brief statements:

1. The Lake Erie commercial fishing industry in Ohio has been in poor economic health for more than two decades. This is due not to any single factor, but to a complex of problems which are biological, economic, political, and social in nature. It is important to recognize the complex nature of the problems facing the industry. Efforts to revitalize the industry must be aimed at a wide range of problems. Programs which are restricted to only one type of problem, such as biological ones, are unlikely to achieve success.

2. The increasing use of Lake Erie for the disposal of man-made waste materials is altering the lake's aquatic environment, and with it, the resource base of the Ohio fishing industry.

3. Lake Erie's biological production of fish is probably at an all time high but, unfortunately, a large fraction of present production is devoted to fish species which are low in price and not highly desired as food fish.

4. The artificial propagation and stocking of fish in Lake Erie and the regulation of commercial fishing operations were established in an effort to maintain large populations of high value, desirable fish species. Both programs have failed in their stated objectives.

5. The trend toward an increasing dominance of low value species in both the Lake Erie fish populations and the Ohio commercial catch is likely to continue, despite a probable expansion of effort in the fields
of fishery research and water pollution abatement. If it is to survive, the fishing industry must adjust its operations to the changing fishery resource base of Lake Erie.

6. Fish stocks are the common property of all fishermen, rather than being solely owned like most other resources. The common property nature of fishery resources contributes to low wages and profits in the fishing industry, as well as complicating the conservation of fish stocks.

7. The Ohio fishing industry's share of the Lake Erie fish catch has declined steadily in recent years, while those of sport fishermen and Canadian commercial fishermen have increased. Significantly, Canadian fishing regulations are much more liberal than those of Ohio, which places Ohio fishermen at a disadvantage in the competition for Lake Erie fish.

8. The Ohio fishing industry is composed of small firms which generally lack the financial strength to cope with the problems now facing them. A consolidation of small establishments into larger, more viable economic units is needed.

9. Employment in the fishing industry has declined and is now mainly part-time. Wages are substantially below those of other Ohio industries. Low wages and the lack of full-time employment make it difficult to attract dependable workers in the highly competitive northern Ohio labor market.

10. Labor costs are higher in the Ohio fishing industry than in Ontario, the major competitor. This is due in part to lower wage rates in Ontario, but equally important is the fact that the productivity of labor is higher there. Labor productivity is closely related to investment in modern labor saving equipment.
11. Although the industry witnessed a variety of technological inventions and innovations in its early years, the methods and equipment now in use have changed little in the last 30 years. The technological stagnation of the fishing industry can be traced, in part, to commercial fishing regulations which spell out in great detail, the types of gear which may be used.

12. Most of the fishing gear now in use has production costs which are too high to efficiently harvest the low value fish species which have come to dominate the fishery resource base of Lake Erie. Among lower cost alternatives, the otter trawl appears to be the most feasible for use in Lake Erie. New fishing methods must involve high volume, low cost production and the mechanized handling of catches in only a few fishing ports.

13. Serious consideration should be given to the abandonment of present Ohio commercial fishing regulations, in favor of a program of comprehensive management of fishery resources. Such a program should include quotas on commercial species, the restriction of entry into the fishery, and freedom on the part of fishermen to use the most efficient means of harvesting fish.

14. Existing supplies of high value fish should be processed into more convenient products, in line with changing consumer preferences. The scarcely tapped reservoirs of low value fish in Lake Erie could be made into such industrial fishery products as pet foods, mink feed, and fish meal. Markets for these products are expanding at a rate several times that of food fish and nearby areas could absorb all that the industry would be likely to produce.
Suggested research

This study should not be considered the last word on the Ohio fishing industry. Rather, it is the writer's hope that it will be a first step toward a more complete and detailed analysis of the industry and its problems. This study has tended to provide more questions than answers and many of these questions require additional research, beyond the writer's present scope. The suggested research topics which follow are not intended to be an exhaustive list, but rather to serve as examples of the types of studies which might profitably be undertaken.

Limnologists and fishery biologists need to further investigate the relationship between water pollution and fish life in Lake Erie. Of particular value would be an explanation of the actual mechanics involved in the detrimental effects of pollutants upon desirable species of fish. Fishery scientists might also study the effects of the invasion and explosive growth of certain exotic fish, such as the smelt, upon indigenous species of Lake Erie fish. Students interested in the optimum utilization of natural and human resources should investigate and propose alternatives to the present management of Lake Erie fishery resources. Experts in the fields of food technology and food marketing could study the present processing and marketing methods in the industry, suggesting possible changes and improvements. Behavioral scientists, perhaps in the field of management, might be interested in an investigation of the apparent conservatism of commercial fishermen. Finally, the economic geographer should compare this fishing industry with others in an effort to build a body of knowledge in this relatively underdeveloped sector of his field.
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