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An approach to port classification: A case study of Great Lakes ports.

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AN APPROACH TO PORT CLASSIFICATION: A CASE STUDY OF GREAT LAKES PORTS

by

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ABSTRACT

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In the field of port geography there has been little agreement on the appropriate procedures and criteria to be used in the classification of ports. The purpose of this study was to evaluate measurement criteria and procedures used in previous port classifications. Great Lakes ports served as a test case, and Roemer's (1971) classification of these was the starting point. The study objectives were accomplished by 1) identifying the relevant criteria, 2) two independent trials of a procedure new to port classification, discriminant analysis, 3) an evaluation of the adequacy of criteria currently used in port classification, and the status of Roemer's classification of Great Lakes ports.

Once group membership and relevant variables were established, ports in each study year, 1966 and 1984, were randomly divided into development and crossvalidation samples. Discriminant analysis was first conducted on the

development samples where group membership was based on Roemer's grouping procedures. The results showed a significant proportion of cases were misclassified on the variables identified as good between-group discriminators.

Using the discriminant function coefficients on the significant variables, group membership for the crossvalidation groups was determined. Discriminant analysis was then conducted on the crossvalidation groups using only the significant variables so as to identify those values of the coefficients which would achieve the greatest success in assigning ports to correct classes. The results of the analyses showed a considerable improvement in the proportion of ports correctly grouped by the new coefficients. The five variables which emerged as good discriminators for both years were essentially the same. All, with the exception of one, had been identified in earlier studies as good measures of port status, suggesting that good variables have been in existence all along but that their success had been limited by the use of inadequate grouping procedures. This study showed that discriminant analysis with crossvalidation could be a sound procedure for developing classifications of ports.

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Chapter I

STUDY BACKGROUND

Classification may be viewed as a procedure used to impose order and coherence upon the flow of information received from the world around us. In the field of port geography, there have been many studies of individual ports (Mayer 1957, Mihelic 1969, Forward 1984), and numerous studies of port systems in various countries, (Bird 1963, Rimmer 1967, Stanley 1984). Attempts to classify the ports of a country or region appear to be few. Attempts to classify the ports of the Great Lakes appear to be fewer still.

Governments, port authorities, and others with interests in the shipping industry are concerned with port development and improvement. Ports must adopt strategies, if planning is to be a means of bringing rationality to decision making for development and improvement. Through the pursuit of goals in planning, port lands can be utilized in an orderly and advantageous way, with benefits spreading to surrounding areas.

By imposing order and coherence on how we understand ports, we lay the foundation for planning. We gain an understanding of their basic structures and operating characteristics. Where a system of ports exists with a high degreee of interaction as on the Great Lakes, (Provincial Great Lakes/Seaway Task Force 1981), ports are dependent upon each other's traffic. By understanding these inter-relationships, those managing or operating a port can identify its position in the system and direct the development of a integrated plan which might yield the best results.

Planning should proceed with knowledge, and classification is a procedure most useful in the early stages of the systematization of knowledge, for it draws attention to similarities among the members of a class and to differences between classes.

The few attempts at port classification undertaken have proceeded by examining port characteristics, usually through the use of maps and charts. Ports were simply grouped according to the characteristics they shared. If ports share many characteristics, then it may be that they differ in the intensity of those attributes. Hence a procedure which takes into account the varying intensities may pick up differences more easily and may be more suitable for developing a classification of ports.

Chapter II

SCOPE AND STUDY DESIGN

In the case of port classification, questions remain as to the best procedures to be followed, and as to the most appropriate variables to be used. The purpose of this study is to evaluate variables and procedures used by Roemer and others in the classification of ports. This will be achieved by:

1) An identification of the relevant variables (Chapter III).

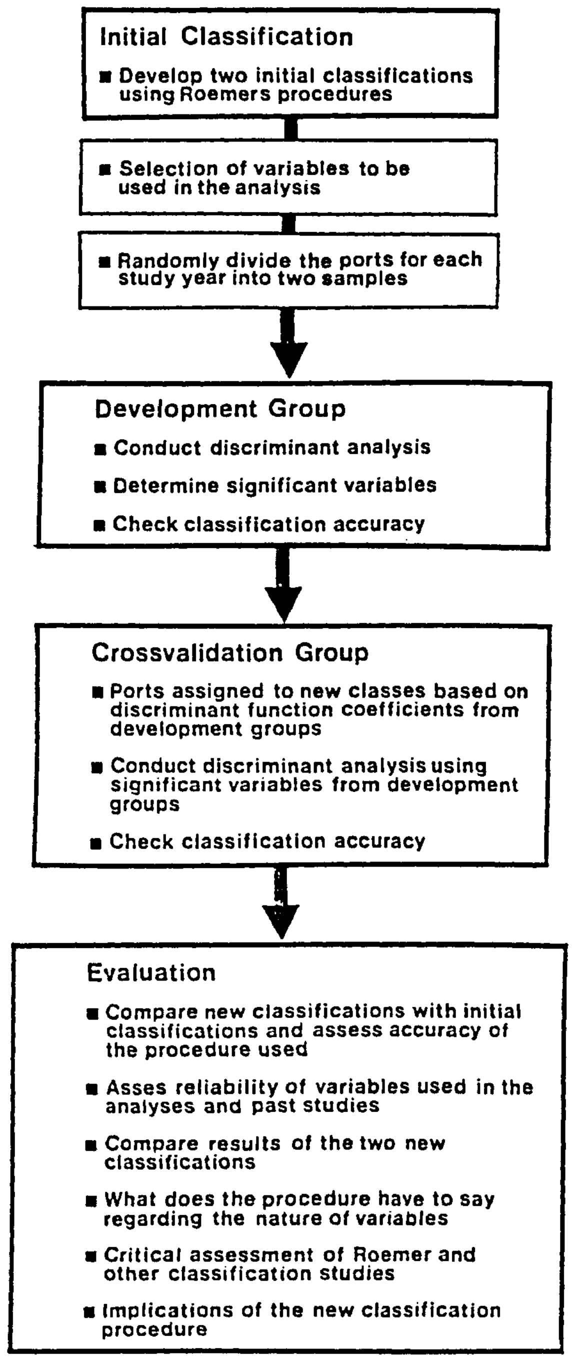
2) Two independent trials of a procedure new to port classification, discriminant analysis (Chapters IV, V, VI, VII).

3) Evaluation of the adequacy of variables currently used in port classification, and the status of Roemer's classification of Great Lakes ports (Chapter VIII).

Discriminant analysis was considered the most suitable procedure for the purposes of this study for it makes possible a distinction among a number of mutually exclusive groups by the identification of linear combinations of variables which are good at separating the groups. Discriminant analysis also leaves the classification open, allowing the prediction of group membership for previously unclassified cases. It is hoped to show that this procedure is a sound one for developing classifications of ports. The design of this study is outlined in Figure 1.

Figure 1

Study Design



To test the new classification procedure and the suitability of the variables more fully, two analyses will be conducted for all the commercial ports on the Great Lakes; one for 1966, which will approximate the time of Roemer's study, and a second for 1984, which will present a more up to date view of the organization and characteristics of the ports.

The initial grouping of ports will be determined by applying Roemer's procedures for classifying ports for each of the time periods (Chapter IV).

The results of any investigation using discriminant analysis are only useful if the variables used are soundly chosen. The variables to be used in this investigation will be drawn from the literature, and the author's perception of what might be important criteria for distinguishing between groups of ports (Chapter V).

Great Lakes Ports: 1966 Set

In 1966, there were 135 commercial ports in operation on the Great Lakes, forty eight in Canada, and eighty seven in the United States (Figure 2). The ports will be divided into 2 samples. One, referred to as the crossvalidation group, consisting of 1/4 of the ports, will be drawn from a list of the ports using a random numbers table. The remaining 3/4 of the ports will be referred to as the development group.

A discriminant analysis will then be conducted on the development group. The observed discriminant function

Figure 2: Great Lakes Ports 1966

coefficients based upon the variables which best reflect group differences will be used to develop a grouping of ports. Variables which were found not to be significant discriminators between groups will be dropped from the analysis beyond that stage.

Using the variables shown to be significant and the discriminant function coefficients generated above, the members of the crossvalidation group are assigned to classes. A second discriminant analysis will then be conducted on this group of ports using only those variables identified as significant for the development group so as to identify those values of the coefficients which would achieve the greatest success in assigning ports to correct classes. This analysis will thus generate a refined grouping of the ports (Chapter VI). This extended crossvalidation procedure is intended to not only confirm the utility of the variables identified but also to show how the best values of the coefficients might be discovered.

Great Lakes Ports: 1984 Set

In 1984, there were 126 commercial ports in operation on the Great Lakes, forty five in Canada, and eighty one in the United States (Figure 3). As in the 1966 analysis, ports will be grouped according to Roemer's procedures and divided into two samples (Chapter VII). At this stage, the development group, 3/4 of the ports, will be drawn using a random numbers table, and the remaining 1/4 of the ports will form the crossvalidation group. The analysis will then proceed in the same manner as the 1966 analysis (Figure 1).

The results of the sets will be reported in a manner that will clearly meet objectives of this study. First, in order to determine what variables are of significance in the classifications, the significant functions must be examined. In discriminant analysis, two functions are generated to separate a population into three groups, and the first function always accounts for the greatest porportion of the variance. In this study, if the remaining function accounts for less than 50 percent of the variance accounted for by the first function, it will be considered insignificant and not warrant further examination.

The statistical significance of relationships between the generated functions and group differences will be then reviewed using Wilks's Lambda so as to allow a test of the significance of the differences between the group means. The closer lambda values are to one, the less significant the difference there is between group means; values closer to zero indicate greater significances in the differences in group means.

A review of the generated standardized function coefficients and the pooled within-groups correlations will then follow. These will identify the relative importance of the variables identified as significant. An examination of the generated scatterplots will be undertaken so as to provide further insights into the degree of clustering of group members, and the extent of overlapping between groups.

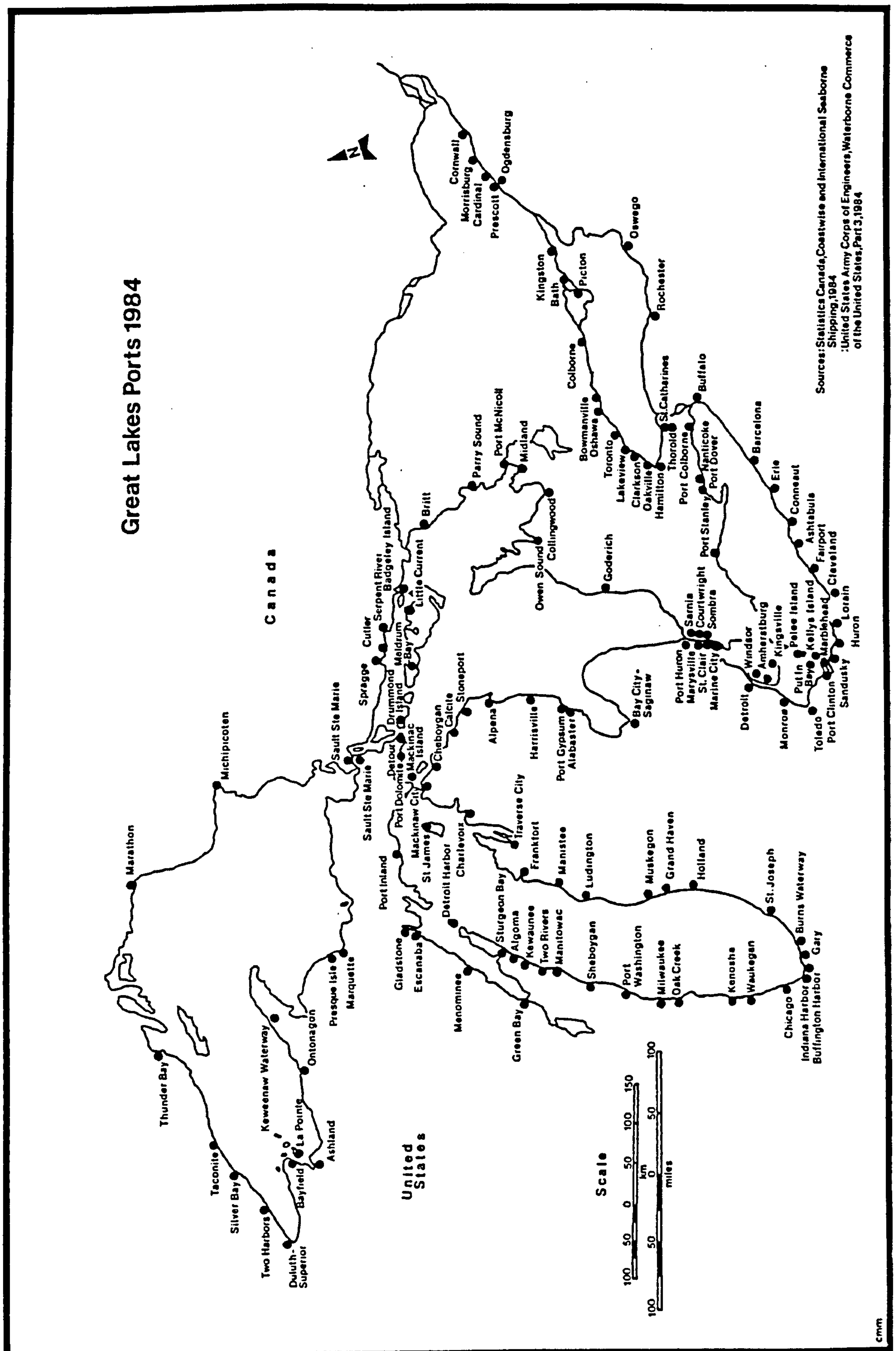
Finally, the results of the grouping by discriminant analysis will be compared with the original grouping so that the accuracy of the results can be assessed.

The analyses completed, Chapter VIII will bring together a number of conclusions regarding the suitability of the variables for port classifications, the use of discriminant analysis in port classification, and Roemer's port classification.

The final chapter of this study will consider the implications of the results for those in port and shipping industries (Chapter IX).

Figure 3

Great Lakes Ports 1984



Chapter III

REVIEW OF CRITICAL LITERATURE

It is through some form of identification of the characteristics of an object that we are able to distinguish it from other objects and thus classify it. In port geography, there has been little agreement among researchers on adequate criteria for the measurement of port status. Several criteria have been identified, some having advantages, others proving unreliable.

3.1 Early Port Classification

Morgan (1952) suggested that net registered tonnage was the best available measurement criterion for the classification of ports. It included all types of traffic entering and leaving ports. Using net registered tonnage as the discriminating variable, Morgan developed what he called a functional classification with eleven types of ports: naval ports, fishing ports, ferry ports, harbours of refuge, ports of call and bunkering ports, transhipment ports, entreports, free ports, out ports, coastwise and short sea ports, and tramp, tanker and liner ports.

Carter (1962) did not limit himself to a single criterion but proposed a multi-criteria approach. Using type of traffic, weight of cargo, nature of commodity, traffic flows, variety of commerce, he constructed a series of maps, one for each criterion, each showing the intensity of the particular criterion for 60 United States ports. Through a visual examination of the maps, Carter was able to identify 7 types of ports: ports associated with the manufacturing of steel, ports associated with petroleum refining, ports which serve as petroleum terminals, ports associated with mining activities, bulk material ports, general cargo ports, and ports which incorporate two or more of the above functions.

Rimmer (1967) believed that if the idea of a multi-criteria approach was to be accepted, differences between such criteria should be examined and steps taken to determine statistically if there was any one criterion superior to the others.

In his analysis, Rimmer identified the ports of New Zealand for 4 different years as conducting gross, overseas and coastal trade. If a superior port measurement criterion could be established, Rimmer wanted to determine if it applied to more than one time period and for more than one level of trade. He sought to answer these questions by determining coefficients of correlation between various measurements for the three levels of trade: net registered tonnage, cargo handling capacities, depth of approaches, weight of cargoes landed and shipped, and berthing accomodations. For overseas trade, an additional measure, values of cargoes landed and shipped, was included. Rimmer discovered that there were variations in the ability of measurements to clearly separate ports. He found that weight of cargo, having the highest correlation coefficients, was the best for identifying the status of New Zealand ports in all of the years selected, and for the three levels of trade.

Bird (1971) suggested a number of variables which could be used for differentiating ports: berthing accommodations for ships, cargo handling capacities, depth of approaches, depth of ship accommodations, weight of cargoes, value of cargoes, and net registered tonnage of shipping. The latter two variables were used by Bird (1963) in his Major Seaports of the United Kingdom. For these variables and those suggested by others, Bird discussed the disadvantages which should be seriously examined in terms of their impact on distinguishing the status of ports.

3.2 Great Lakes Ports

Roemer (1971) examined a number of aspects of the St. Lawrence Seaway, its ports, its hinterland, and presented a classification of Great Lakes-St. Lawrence River ports. Roemer mapped three variables for 90 ports; types of commodities, tonnage of cargoes shipped, and the ratio of inbound and outbound cargoes. She identified 5 types of commodities handled: iron ore, coal, grain, building aggregates, and a group identified as others. Ports were placed into one of three classes based upon the the quantity and number of commodities handled. Based on the tonnage of cargo shipped, the same ports were divided into 7 groups ranging from 100,000 tons to 50 million tons. Finally, traffic was divided into inbound and outbound movements for ports handling at least 500,000 tons.

3.3 Summary of Critical Literature

Major port classification schemes embraced three tasks. The first involves the researcher presenting measurement criteria considered significant for ports. Here, the question of the adequate choice of port measurement criteria seems to arise. The second task entailed the use of some procedure for assigning ports to classes, leading to the final task - the construction of a classification scheme (Table 1). In this study, Great Lakes ports will serve as the test case and Roemer's classification will be the starting point.

Table 1: Summary of Port Classifications

	MORGAN-1952 PORTS IN GENERAL	CARTER-1962 UNITED STATES PORTS	RIMMER-1966 NEW ZEALAND PORTS	BIRD-1971 PORTS IN GENERAL	ROEMER-1971 GREAT LAKES PORTS
VARIABLES, MEASUREMENT CRITERIA	Net registered tonnage	Type of traffic Weight of cargo Type of commodity Traffic flows Variety of commerce Value of foreign commerce	Net registered tonnage Cargo handling capacity Depth of approaches Weight of cargos landed and shipped Berthing accomodations	Berthing accomodations Cargo handling capacity Depth of port approaches Depth of ship accomodation Weight of cargos landed and shipped Value of cargos landed and shipped Net registered tonnage	Tonnage of cargo shipped Number and types of commodities Ratio of inbound and outbound traffic
PROCEDURE USED	Functional Classification	•Mapping each variable and drawing conclusions from the observed patterns	•Determining correlation coefficients between the measurement criteria and three levels of trade		•Mapping each variable
CLASSES OF PORTS	1 Naval Ports 2 Fishing Ports 3 Ferry Ports 4 Harbours of refuge 5 Ports of call and Bunkering Ports 6 Transhipment Ports 7 Entre Ports 8 Free Ports 9 Out Ports 10 Coastwise and Short Sea Ports 11 Tramp, Tanker and Liner Ports	1 Ports associated with the manufacturing of steel 2 Ports associated with mining activities 3 Ports associated with petroleum refining 4 Ports which serve as petroleum terminals 5 Bulk material ports 6 General cargo ports 7 Ports which incorporate two or more of the above functions	•Indentification of weight of cargo as the best measurement criterion		•Ports classified by commodity 1 Ports handling predominately one commodity 2 Ports handling predominately two commodities 3 Ports with mixed functions (commodities) •Ports classified by tonnage of cargo •Ports classified according to shipments and receipts

Chapter IV

THE INITIAL GROUPINGS

4.1 Introduction

The preliminary stage of the analysis is the assigning of the study subjects to various groups based on Roemer's (1971) two measurement criteria: total tonnage of commodities shipped and the number of commodities. Roemer's classification considered ports handling at least 100,000 ton of cargoes and thus was limited to 73 Great Lakes ports.

The statistics used by Roemer to classify the United States ports were for 1964. Since there was no mention of the year for the data on which the Canadian ports were classified, Roemer's statistics were compared with those published by the Canadian government. This confirmed that the year was indeed 1964.

4.2 Great Lakes Ports: 1966/1984

Due to the nature of the shipping industry, the number of commercial ports on the lakes can vary from year to year. Small ports are particularly susceptible to upward and downward fluctuations in business. Two initial groupings were developed, one for 1966, the second for 1984. Fluctuations in the number of ports between these two years are evident, for in 1966, 135 commercial ports were identified on the lakes, compared to 126 in 1984.

The purpose of these initial groupings was not to duplicate Roemer's classes of ports; rather it was to replicate the procedures used in the development of her classification.

4.3 Classes of Ports

Roemer identified 3 types of ports.

I. Ports handling predominantly one commodity accounting for at least 40 percent of the total tonnage of that port.

II. Ports handling predominantly two commodities accounting for at least 70 percent of the total tonnage of that port.

III. Ports with mixed functions.

Roemer is not clear on the application of these rules. A concise breakdown of the ports into their appropriate classes is not given. Rather, a classification chart is provided from which one must interpret the rules in relation to what has been discussed in a general examination of selected ports. There is no discussion of how these rules were applied or how a port came to be put in a particular class. There is no detailed breakdown of commodities per port in terms of tonnage, or in terms of the percentage of the port tonnage accounted for by that cargo.

It is difficult to determine from the general examination which ports fall into particular classes. It is more difficult to understand her classification procedure. No examples are given to suggest how the rules are applied. The classification chart does suggest the amounts and types of cargoes shipped by ports, but does not appear to be an accurate means of determining which ports belong to a given class. In attempting to replicate Roemer's classification procedures, a number of flaws were identified in the chart which give an incorrect status to some ports. These will be discussed later in the study.

4.4 One Commodity Ports

Roemer defined ports of Group I as having one commodity accounting for at least 40 percent of the total tonnage of the port. This rule seems straight forward until it is applied. Ports handling a commodity which accounts for 41 percent of the total tonnage can find themselves in the same group as other ports having that same commodity accounting for 90 percent of their total tonnage. Assigning ports to this class is less complicated if the ports handled one commodity which accounted for a significant percentage of the total cargoes shipped.

4.5 Two Commodity Ports

Ports which may ship several commodities accounting for varying proportions of the total cargoes shipped seem to be more difficult to classify.

There were cases where a port handled 60 percent of its total tonnage in coal and 20 percent in limestone. Two commodities thus accounted for more that 70 percent of the total tonnage resulting in the port being assigned into Group II. But it may have also been classified into Group I since it has a commodity which accounted for more than 40 percent of the total tonnage.

It was therefore necessary to decide at what percentage a second commodity was to be considered significant enough to merit classifying a port into Group II, rather than Group I. This was done within the spirit of Roemer's rules. Since single commodity ports were required to have 40 percent of their total tonnage represented by a single commodity and two commodity ports were to have 70 percent of their total tonnage represented by two commodities, the difference, 30 percent, was chosen as the minimum percentage of the total tonnage the second commodity had to account before the port could be classified as a two commodity port.

4.6 Ports with Mixed Functions

Duplication of Roemer's procedures for assigning ports into Group III was likewise difficult. Two types of ports were identified in this group; small ports which supplied limited hinterlands, and larger ports which transhipped at least 5 million tons, 150,000 of which was shipped overseas.

The larger ports were classified easily, difficulties arose with the smaller ports. This may have been because Roemer concentrated on major ports and omitted smaller ports. Consequently it was again necessary to develop rules within Roemer's classification that would allow the assignment of these ports to a group. Small, mixed function ports were therefore identified as those not having any dominating commodities and their total tonnage was distributed among at least 3 commodities.

4.7 Summary of Classes

In order to develop a classification of Great Lakes ports using Roemer's procedures, some adjustments were required. The two groupings developed, for 1966 and for 1984, were based on the following rules:

I. Ports handling predominantly one commodity accounting for at least 40 percent of the total tonnage of that port.

II. Ports handling predominantly two commodities accounting for at least 70 percent of the total tonnage of that port. The lesser of the two commodities must account for at least 30 percent of the total tonnage handled.

III. Ports with mixed functions. i) Large ports with mixed functions tranship at least 5 million tons of which 150,000 tons are overseas cargo. ii) Small ports with mixed functions lack a commodity which accounts for at least 40 percent of the total tonnage. These ports must also trade in at least 3 commodities.

Chapter V

STUDY VARIABLES

5.1 Introduction

Multi-criteria procedures such as discriminant analysis allow the information contained in many variables to be summarized in a single index. Variables which were previously identified as desirable were included along with variables which had been omitted in past studies. Variables held to be unsatisfactory for port classification in earlier studies may yet be found to make a significant contribution. For this reason, some such variables were included in the analyses, in an attempt to see if their unsatisfactory performance was a function of the variables or of the procedures used in earlier classifications.

5.2 Collection of Data

Discoveries were made concerning the availability of data for the variables. Most important were the different measures used by Canada and the United States to identify the status of their ports, and the availabilty of data for those variables.

Statistics for United States ports are compiled by the Department of Commerce and the Army Corps of Engineers. Data collection and actual collection of statistics is the responsibility of the individual port. The agencies then simply collect statistics from the ports. Consequently, the number of variables for which all ports collect statistics is small. Larger ports will collect more varied types of measures. Smaller ports, often lacking the administrative organization, will collect fewer measures. Good data can be readily obtained for the larger ports but the same variables are often not available for smaller ports.

In Canada, collection of statistics is the responsibility of the individual ports. Ports, however, fall under the jurisdiction of the Federal government, unlike in the United States, where ports are administered by the Federal, and or state, and or local governments, as well as private interests. The collection of statistics is therefore more controlled in Canada , with an established set of measures collected by all ports.

There were four variables which proved unavailable for all ports for the two time periods of this study, but available for Canadian ports only: 1) net registered tonnage of shipping, 2) gross registered tonnage of shipping, 3) tonnage of containers shipped and 4) value of cargoes shipped. All of these were indentified in earlier port classifications as good indicators of port status.

5.3 Variables in the Analyses

Variables included in the aralyses and identified in the literature as indicatcrs of port status consisted of the total weight of cargoes shipped (TONNAGE), the variety cf cargoes shipped (VARCCM), total tonnages of cargos shipped into the port (INGC), total tonnage of cargoes shipped out of the port (OUTGO), the tonnage of cargoes shipped overseas-outside the Great Iakes (FCBEGO), and the tonnage of cargoes shipped within Canada and the United States (COASTGO).

Variables held unsatisfactory in the literature, but included in the analyses, consisted of the number of vessel transits in and out of a port (TRANSITS), depth cf approaches to the port (DEPAPP), and the depth at dockside (DEPDCCK).

A variable which appears not to have been considered in past studies was type of organization or public body responsible for the administration of the port. The variable (ADMIN) was therefore incorporated into the analyses (Table 2).

Table 2: Variables in the Analyses

Variable	Variable Description	Sources
TONNAGE	Weight of cargoes shipped (metric tonnes)	U.S. Army Corps of Engineers 1966,1984 Dominion Bureau of Statistics 1966 Statistics Canada 1984
VARCOM	Variety of commerce (number of commodities)	U.S. Army Corps of Engineers 1966,1984 Dominion Bureau of Statistics 1966 Statistics Canada 1984
INGO	Cargoes inbound (metric tonnes)	U.S. Army Corps of Engineers 1966,1984 Dominion Bureau of Statistics 1966 Statistics Canada 1984
OUTGO	Cargoes outbound (metric tonnes)	U.S. Army Corps of Engineers 1966,1984. Dominion Bureau of Statistics 1966 Statistics Canada 1984
FOREGO	Overseas bound cargoes (metric tonnes)	U.S. Army Corps of Engineers 1966,1984 Dominion Bureau of Statistics 1966 Statistics Canada 1984
COASTGO	Coastwise bound cargoes-includes cargoes shipped between Canada and U.S.A. (metric tonnes)	U.S. Army Corps of Engineers 1966,1984 Dominion Bureau of Statistics 1966 Statistics Canada 1984
TRANSITS	Number of vessel transits through the port.	U.S. Army Corps of Engineers 1966,1984 Dominion Bureau of Statistics 1966 Statistics Canada 1984
DEPAPP	Depth of approaches to the port (meters)	United States Great Pilot 1977,1986 Sailing Directions Great Lakes 1976,1982
DEPDOCK	Depth along dockside (meters)	United States Great Lakes Pilot 1977,1986 Sailing Directions Great Lakes 1976,1982 Greenwoods Guide to Great Lakes Shipping 1984
ADMIN	Port Administration	Greenwoods Guide to Great Lakes Shipping 1984 Seaway Maritime Directory 1984 United States Great Lakes Pilot 1977,1986 Ontario Ports Study 1984

5.4 Data Conversions to Metric

A number of variables used in the analyses were converted to metric. For United States ports, they consisted of the weight of cargoes shipped and all water depths for both 1966 and 1984; for Canadian ports, they consisted of the same measures but only for 1966.

5.5 Coded Variables

Two variables, (VARCOM) and (ADMIN) were not in a suitable format and were coded for the analyses.

5.5.1 Variety of Commerce

The variable (VARCOM) was developed using Carter's (1962) procedures for calculation of the variety of cargoes shipped. The number of commodities listed by the United States Army Corps of Engineers divided ports into 4 categories. Category one was identified as having a very low variety of commerce, handling between 1 and 25 commodities or 12.5 percent of the total number of commodities listed. Category two ports were identified as below average, handling between 25 and 100 types of commodities or 50 percent of the total number of commodities. Category three ports were identified as above average handling between 101 and 175 types of commodities, or 87.5 percent of the total number of commodities. Category four ports were identified as very high, handling between 176 and 200 commodities, or 100 percent of the total number of commodity types.

Using the number of commodities listed in Statistics Canada Standard Commodity Classification, and the number of commodities listed in the United States Army Corps of Engineers Waterborne Commerce reports, Great Lakes ports were placed into one of four categories. These categories were not identified as very low, below average, above average, or very high, as in Carter (1962) but coded on a scale of 1 to 4.

For 1966, 217 types of commodities were identified as shipped through Canadian ports. Code 1 ports handled between 1 and 17 commodities, code 2 ports handled from 28 to 108, code 3 ports from 109 to 189, and code 4 ports from 190 to 217 (Appendix B).

In 1966, 173 types of commodities were handled by United States ports. Code 1 ports handled from 1 to 22 commodities, code 2 ports from 23 to 87, code 3 ports from 88 to 153, and code 4 ports from 156 to 173 (Appendix B).

By 1984, the number of commodities listed by Statistics Canada and the U.S. Army Corps of Engineers had declined. Ports were placed into one of four categories again using the same proportions of commodities per category. Canadian ports handled 84 types of commodities. Code 1 ports handled from 1 to 10 commodities, code 2 port from 11 to 42, code 3 ports from 43 to 74, and code 4 ports from 75 to 84 (Appendix B).

In 1984, 159 commodities were shipped through United States ports. Code 1 ports handled from 1 to 20 commodities, code 2 ports from 21 to 80, code 3 port from 81 to 140, and code 4 ports from 141 to 159 (Appendix B).

5.5.2 Port Administration

Review of the types of port administrations on the lakes during the time periods reveals a definite hierarchy of three levels, the smaller ports dominant in the lowest level, the largest in the highest. The first level, code 1 ports, were identified as public ports administered by Federal, state, or local governments. Code 2 ports were identified as private ports operated and administered by private corporations. Code 3 ports were identified as those administered by port authorities and or harbour commissions.

Chapter VI

ANALYSIS OF GREAT LAKES PORTS 1966

6.1 Development Group 1966: An Initial Assessment

The 1966 analysis covers 102 ports, using 10 study variables. The first discriminant function accounted for 85.89 percent of the variance compared to Function II which accounted for 14.11 percent. This low value for Function II (less than 50% of that of Function I) suggests that it contributes little to the separation of ports, and does not warrant detailed examination as does Function I.

Examination of Wilks's Lambda test results shows that Function I has values which are in the middle range of Wilks's Lambda values, 0.5573242, while Function II has values which are very close to one, 0.9066301 (Table 3). This would suggest that we would be more likely to misclassify group members using Function II than with Function I due to the greater difficulty in distinguishing between group members.

Table 3: Canonical Discriminant Functions: Development Group 1966

Function	Percent of Variance	Cumulative Percent	Wilks's Lambda
1	85.89	85.89	0.5573242
2	14.11	100.00	0.9066301

6.2 Functions and Variables

Four variables were effective discriminators in the separation of Great Lakes ports. An examination of the standardized canonical discriminant function coefficients on Function I reveals that the variable variety of commerce (VARCCM) made the most significant contribution to the discriminant scores of the ports with the others making weaker contributions (Table 4).

Table 4: Standardized Function Coefficients: Development Group 1966

	Function I	Function II
TONNAGE	0.38491	-0.81411
VARCCM	0.81091	-0.02182
FOREGC	-0.21966	1.48228
ADMIN	0.23109	-0.44089

Pooled within - groups correlations between discriminating variables and canonical discriminant functions yield similar results. Variety of commerce (VARCCM) is again the most significant on the first function followed by total weight of cargoes shipped (TONNAGE). Type of port administration (ADMIN) ranked third, followed by total tonnage of cargoes shipped overseas (FOREGO).

6.3 Group Centroids

Due to overprinting of cases which fall close to one another, not all cases are displayed on the scatterplots, but the location of cases is identified sufficiently closely for the patterns to be identified. Evaluation of the scatterplots still offers some insights into the accuracy of this new grouping of ports. On the all-groups scatterplot, (Figure 4), group centroids for Group 1, and Group 2 ports are located close to each other. The close proximity may suggest that they share characteristics that differ little. Group 3 ports appear to be better separated, having a more isolated centroid. The possibilities of misclassifying a member of this group would thus appear to be smaller than for members of the other groups.

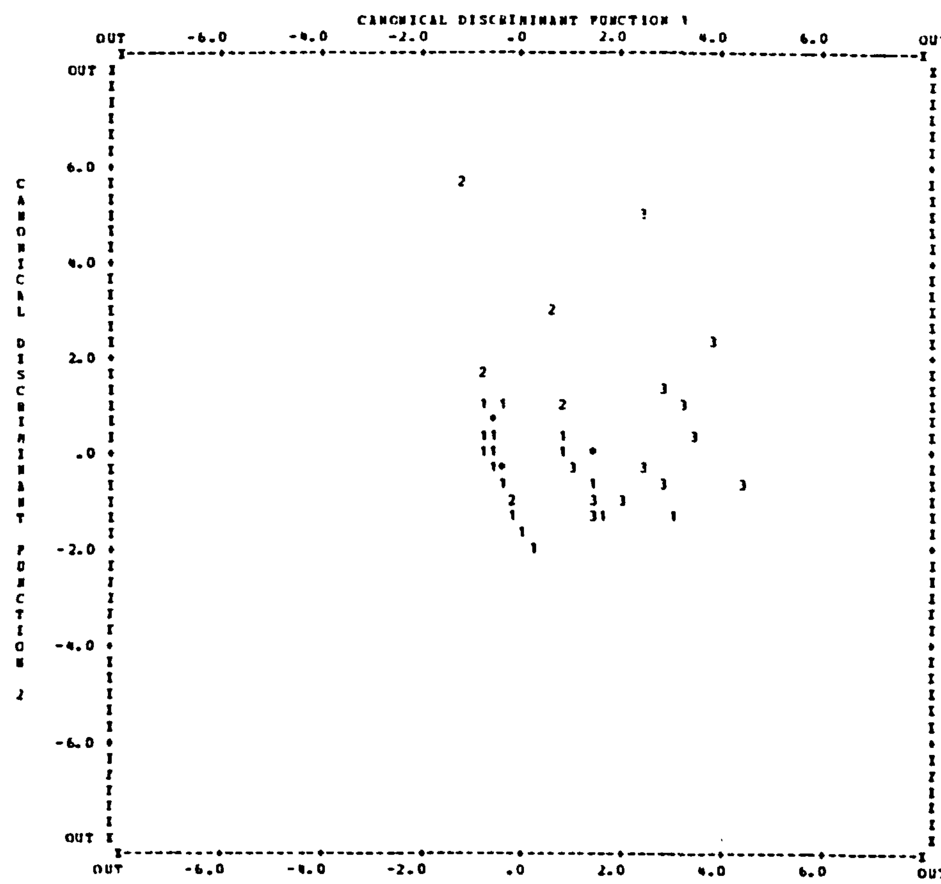


Figure 4: All Groups Scatterplot: Development Group 1966

An evaluation of the individual group scatterplots reveals that Group 1 ports seem to display a high concentration around their centroid (Figure 5), suggesting that members of this group have characteristics of similar intensities. The scatterplot for Group 2 reveals a weaker concentration about the centroid and no clustering of cases as in Group 1. This may suggest characteristics of more varied intensities (Figure 6). Group 3 ports seem to form two separate patterns about their centroid. One group seems to be clustered just below the centroid and the other dispersed to the right of it. These patterns in turn may suggest two types of ports within this group (Figure 7), ports with characteristics of similar intensities, and ports with very different intensities of those same characteristics.

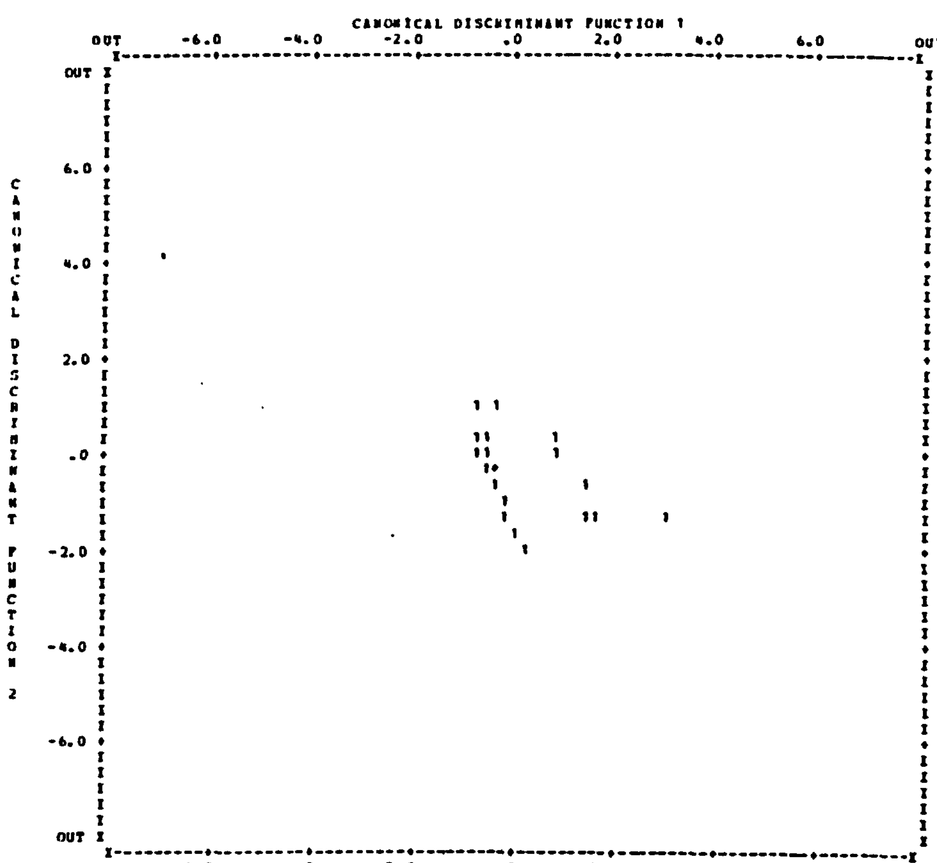


Figure 5: Group 1 Scatterplot: Development Group 1966

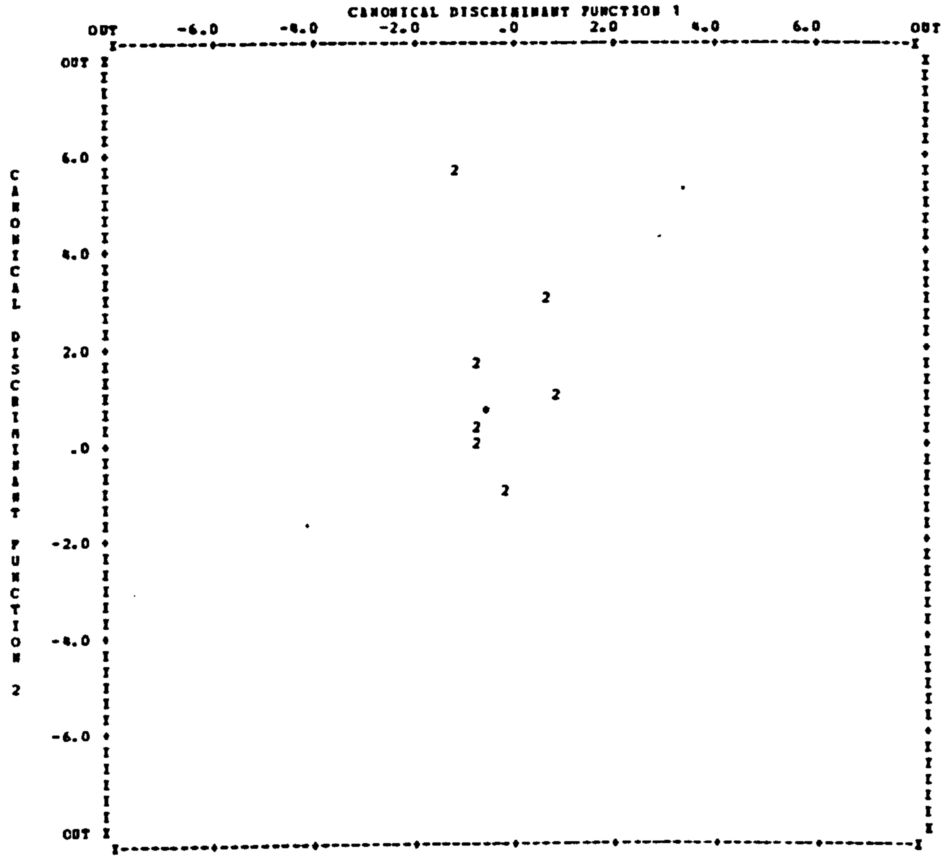


Figure 6: Group 2 Scatterplot: Development Group 1966

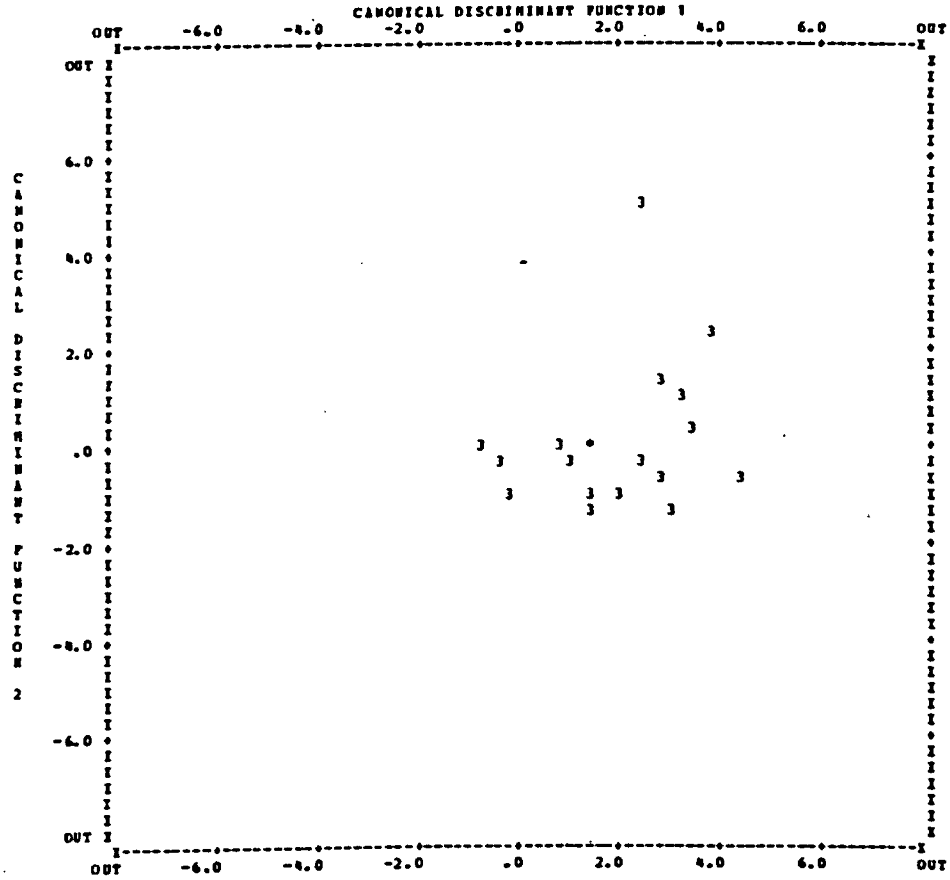


Figure 7: Group 3 Scatterplot: Development Group 1966

6.4 Classification Results: Development Group 1966

The four variables which emerged as significant from the 1966 analysis assigned seventy percent of the ports correctly. Seventy-one cases were assigned correctly and thirty-one incorrectly (Table 5).

Table 5: Classification Results: Development Group 1966

Actual Group	Number of Cases	Predicted Group Membership 1	2	3
Group 1	63	52 82.5%	4 6.3%	7 11.1%
Group 2	15	11 73.3%	3 20.0%	1 6.7%
Group 3	24	8 33.3%	0 0.0%	16 66.7%

Percent of "grouped" cases correctly classified: 69.61%

The diagonals in Table 5 represent the correct cases for each group. Group 1 ports were correctly assigned 82.5 percent of the time; Group 2 ports only 20 percent of the time. In most cases Group 2 ports were assigned to Group 1. Group 3 ports were correctly assigned 66.7 percent of the time.

6.5 Crossvalidation Group 1966: An Initial Assessment

The 33 ports in this group were re-assigned to a class based on the discriminant function coefficients from the development group, (Table 6), and then subjected to discriminant analysis.

Table 6: Discriminant Function Coefficents: Development Group 1966

CLASS =	1	2	3
(TONNAGE)	-0.02306664D-07	-0.1335708D-06	0.4737639D-07
(VARCCM)	4.139602	3.872512	6.900081
(FOREGO)	-0.8160652D-06	0.1830840D-06	-0.861194D-06
(ADMIN)	2.030516	1.43387	2.463943
(CONSTANT)	-4.752471	-4.057697	-10.19048

Once again two functions were generated. Function I accounted for 92.93 percent of the variance compared to Function II which accounted for 7.07 percent.

Wilks's Lambda for the groups of ports on Function I was 0.1295656, indicating significant differences in group means (Table 7). On Function II, lambda was 0.7370720, indicating less significant differences between group means. These results are similar to those from the development group.

Table 7: Canonical Discriminant Functions: Crossvalidation Group 1966

Function	Percent of Variance	Cumulative Percent	Wilks's Lambda
1	92.93	92.93	0.1295656
2	7.07	100.00	0.7370720

6.6 Functions and Variables

Examination of the standardized canonical discriminant function coefficients reveals that on Function I the variable (VARCOM) once more was most important, making the greatest contribution to the discriminant scores for each port, the three remaining variables making significantly weaker contributions (Table 8).

Table 8: Standardized Function Coefficients: Crossvalidation Group 1966

	Function I	Function II
(TONNAGE)	-0.04937	0.68436
(VARCOM)	0.99266	0.06072
(FOREGO)	-0.01745	-1.17531
(ADMIN)	0.14984	0.52227

Pooled within-groups correlations between discriminating variables and canonical discriminant functions revealed similar results. On Function I, (VARCOM) was once more most significant followed by (FOREGO), (TONNAGE), and (ADMIN).

6.7 Group Centroids

Review of the generated all groups scatterplots reveals patterns similar to those from the analysis for the development group. Ports in Group 1 tend to be more clustered about their centroid, and each other. Group 2 ports show a weak concentration about their centroid but are closer to members of Group 1 than Group 3. Group 3 ports seem to be more dispersed with no concentrations around their centroid. These observations may suggest that Group 1 and 2 ports once again may share characteristics of similar intensities while Group 3 ports would appear to have more variations in the intensities of their characteristics (Figure 8).

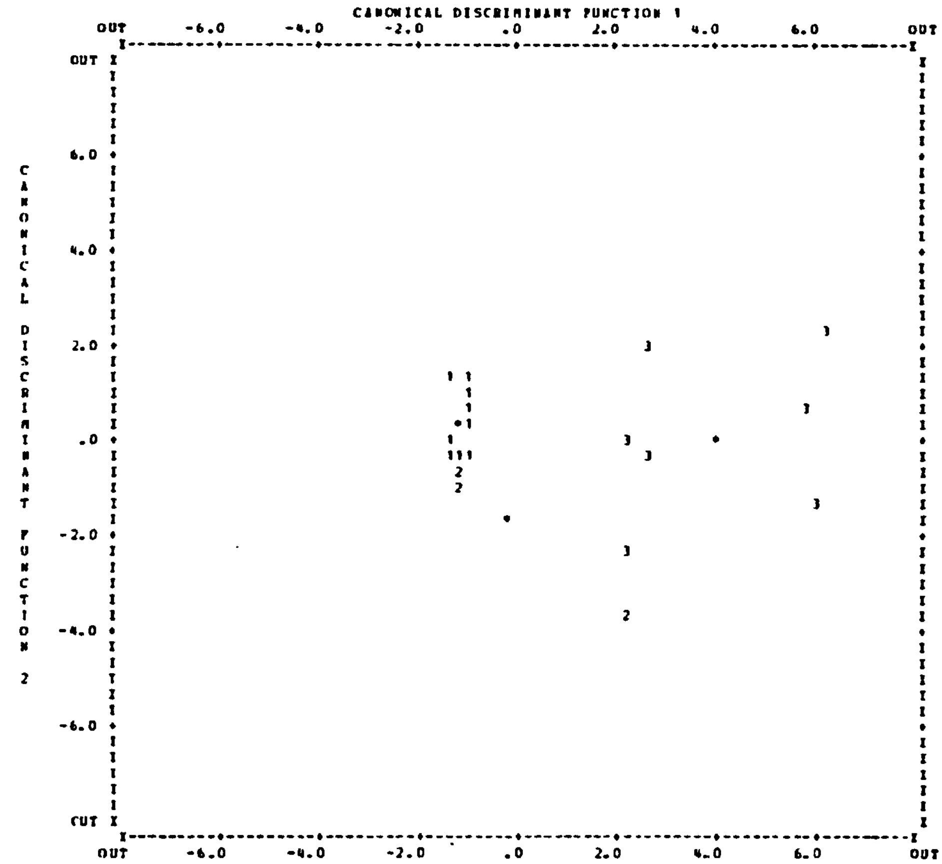


Figure 8: All Groups Scatterplot: Crossvalidation Group 1966

6.8 Classification Results: Crossvalidation Group 1966

The results of this classification are an improvement over those of the development group. Group 1 ports were correctly assigned 100 percent of the time. Group 2 ports were still incorrectly assigned to Group 1 a significant proportion of the time, and correctly assigned only 33.3 percent of the time. Note however there were only 3 cases in Group 2. Group 3 ports were correctly assigned 85.7 percent of the time. Overall, 90.91 percent of the ports were correctly assigned (Table 9).

Table 9: Classification Results: Crossvalidation Group 1966

Actual Group	Number of Cases	Predicted Group Membership 1	2	3
Group 1	23	23 100.00%	0 0.0%	0 0.0%
Group 2	3	2 67.7	1 33.3%	0 0.0%
Group 3	7	0 0.0%	1 14.3%	6 85.7%

Percent of "grouped" cases correctly classified: 90.91%

Chapter VII

ANALYSIS OF GREAT LAKES PORTS 1984

7.1 An Initial Assessment: The Development Group 1984

Of the two functions generated in the analysis of 1984 data, Function I accounted for 98.48 percent of the variance compared to Function II which accounted for only 1.52 percent. The dominance of Function I suggests that it be further examined; Function II appears to be insignificant, and does not meet the 50% of the Function I requirement for consideration.

Examination of Wilks's Lambda for the two functions supports this decision. Function I has values which are in the middle range of Wilks's Lambda values, 0.5903778. Function II has values which are almost equal to one, 0.9896578. This suggests that groups are better separated on Function I and we are less likely to incorrectly assign cases using this function than on Function II (Table 10).

Table 10: Canonical Discriminant Functions: Development Group 1984

Function	Percent of Variance	Cumulative Percent	Wilks's Lambda
1	98.48	98.48	0.5903778
2	1.52	100.00	0.9896578

7.2 Functions and Variables

In the 1984 data, four variables were effective in separating Great Lakes ports. An examination of the standardized canonical discriminant function coefficients reveals that on Function I, variety of commerce (VARCOM) made the most significant contribution to the discriminant score for each port. Following in significance were the variables type of port administration (ADMIN), and overseas bound cargoes (FOREGO). The weakest was the variable (DEPDOCK), water depth at dockside (Table 11).

Table 11: Standardized Function Coefficients: Development Group 1984

	Function I	Function II
(FOREGO)	0.31040	0.33933
(VARCOM)	0.76386	-0.85376
(DEPDOCK)	-0.55519	0.12909
(ADMIN)	0.43966	0.95073

On the pooled within - groups correlations between discriminating variables and canonical discriminant functions, (VARCOM) is again the most significant on the first function. Type of port administration (ADMIN) is second most significant. The variable inbound cargoes (INGC) is third, followed closely by the total weight of cargoes shipped (TONNAGE).

7.3 Group Centroids

Evaluation of the all-groups scatterplot (Figure 9), shows that centroids for Group 1 ports and Group 2 ports are located close to each other. The close proximity of cases from both groups may suggest some difficulty in assigning a particular case to its correct group. Group 3 ports appear to be better separated from the members of the other groups. The possibilities of incorrectly classifying a member of this group would thus appear to be smaller.

Evaluation of the individual scatterplots reveals that Group 1 ports display the greatest concentration around their centroid (Figure 10). This suggests that the members of this group have characteristics that differ little. The scatterplot for Group 2 reveals a similar concentration of group members around their centroid, though it is not as great, suggesting that these ports vary more on the noted characteristics (Figure 11). Group 3 ports appear to be scattered with a weaker concentration around their centroid. This pattern may suggest that these ports vary most in their characteristics (Figure 12).

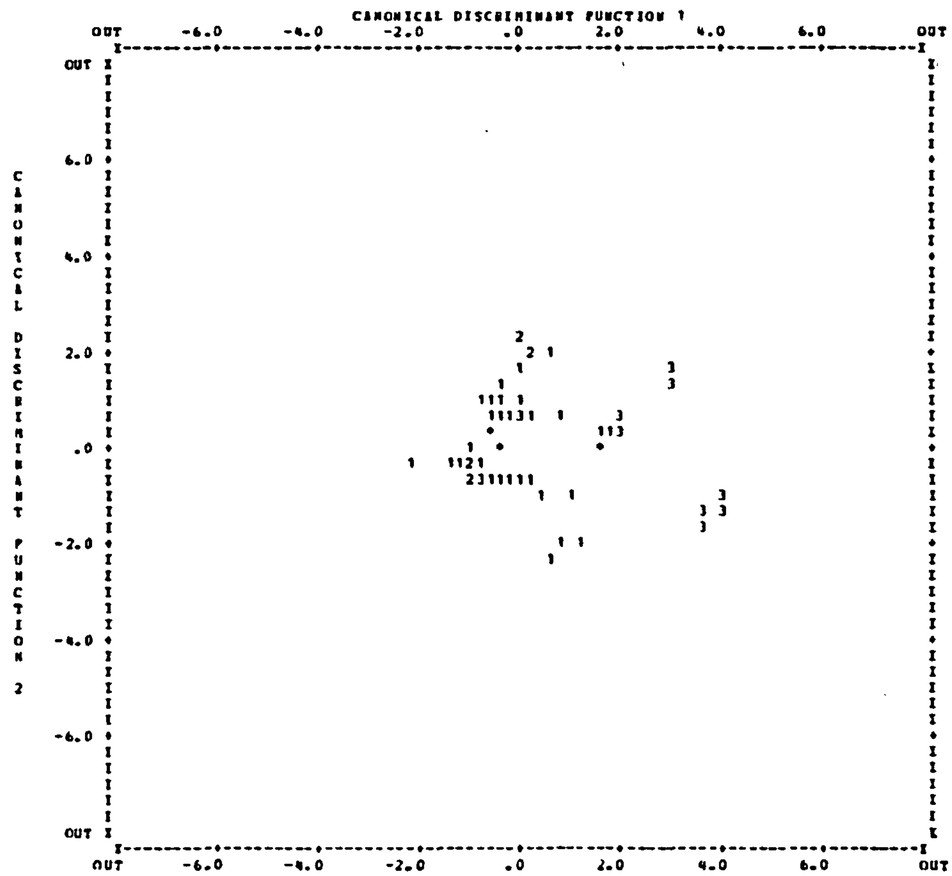


Figure 9: All Groups Scatterplot: Development Group 1984

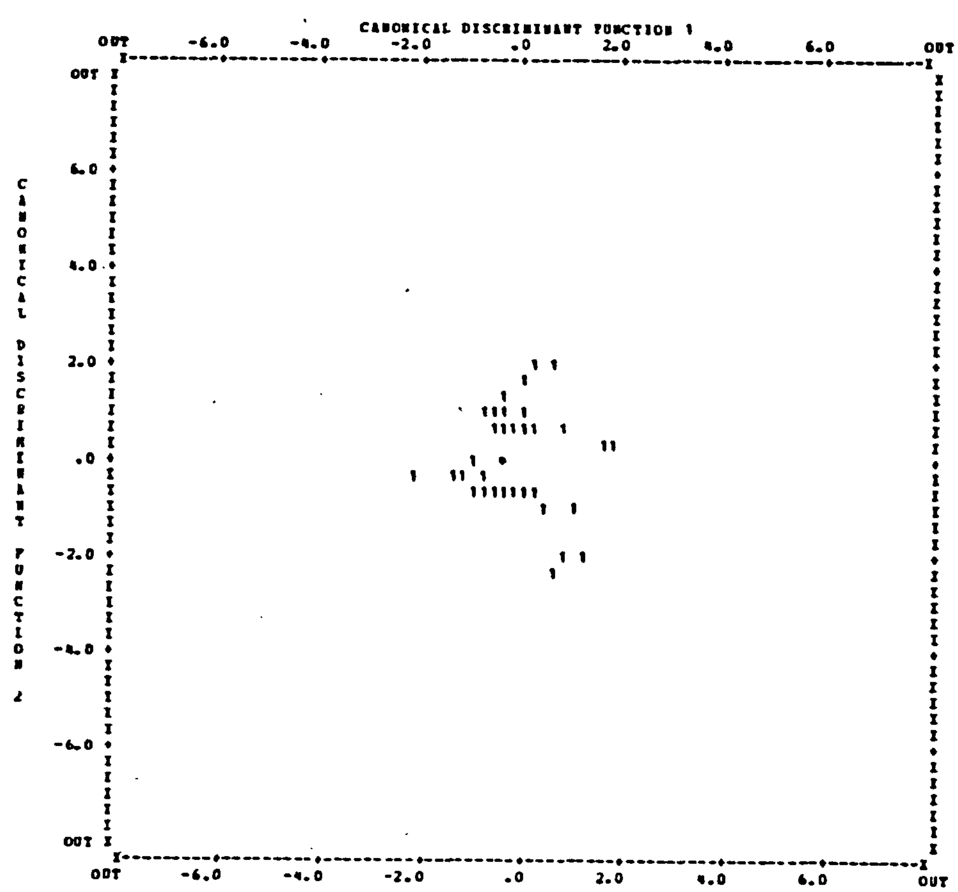


Figure 10: Group 1 Scatterplot: Development Group 1984

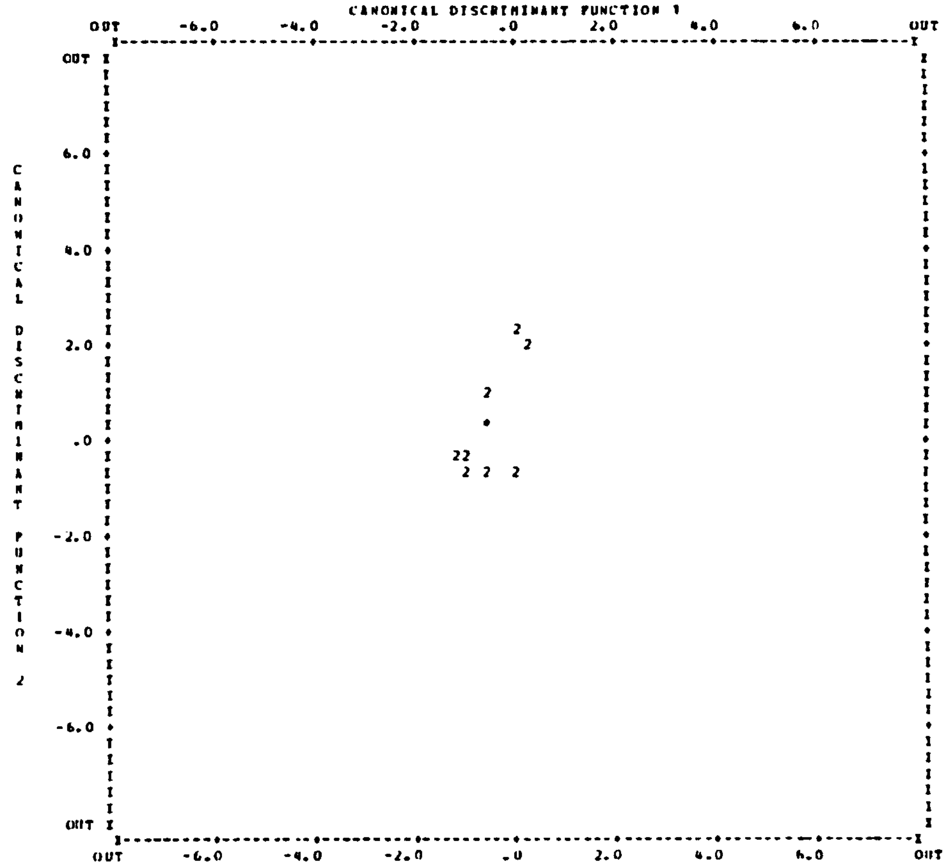


Figure 11: Group 2 Scatterplot: Development Group 1984

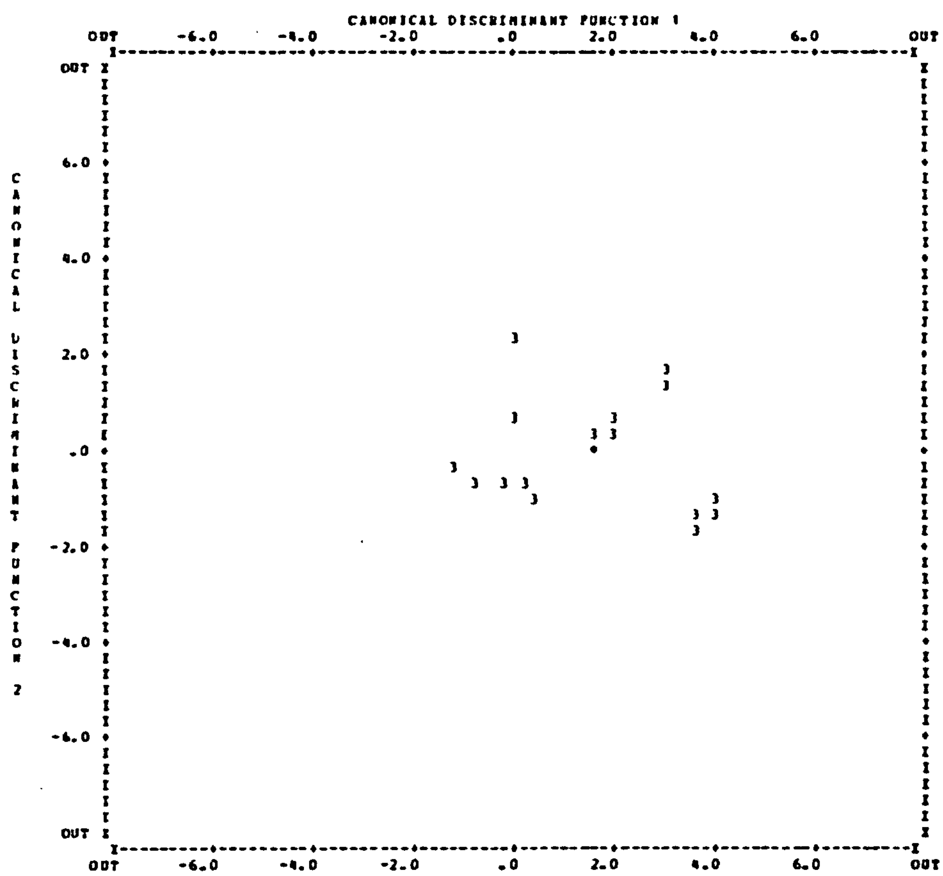


Figure 12: Group 3 Scatterplot: Development Group 1984

7.4 Development Group: Classification Results 1984

The 95 ports in this group were then grouped using the standardized canonical discriminant function coefficients and compared to the original grouping. Approximately fifty-two percent, fifty ports, were assigned correctly and approximately forty-seven percent, or forty-five, incorrectly (Table 12).

Table 12: Classification Results: Development Group 1984

Actual Group	Number of Cases	Predicted Group Membership 1	2	3
Group 1	67	35 52.2%	26 38.8%	6 9.0%
Group 2	9	5 55.6	4 44.4%	0 0.0%
Group 3	19	6 31.6%	2 10.5%	11 57.9%

Percent of "grouped" cases correctly classified: 52.63%

The diagonals in Table 12 represent the correct cases for each group. Group 1 ports were correctly assigned 52.2 percent of the time, Group 2 ports 44.4 percent, and Group 3 ports 57.9 percent.

7.5 Crossvalidation Group 1984

The 31 cases in this group were re-assigned to a class based upon the discriminant function coefficients generated from the development group, (Table 13), and then subjected to discriminant analysis.

Table 13: Discriminant Function Coefficients: Crossvalidation Group 1984

CLASS =	1	2	3
(FOREGO)	-0.6873225D-06	-0.6453143D-06	-0.3274599D-06
(VARCOM)	3.700045	2.751421	7.194152
(DEPDOCK)	0.1656674D-01	0.1719281D-01	0.1090107D-01
(ADMIN)	0.1398880	0.5171051	1.445619
(CONSTANT)	-8.741857	-8.775745	-12.73084

Of the two functions generated, Function I accounted for approximately 68.08 percent of the variance, compared to Function II which accounted for the remaining 31.92 percent.

Wilks's Lambda for the groups of ports on Function I was 0.0982313, indicating significant differences in group means. On Function II lambda was 0.4054605 (Table 14), suggesting again that we are less likely to mistake groups on Function I.

Table 14: Canonical Discriminant Function Coefficients: Crossvalidation Group 1984

Function	Percent of Variance	Cumulative Percent	Wilks's Lambda
1	68.08	68.08	0.0982313
2	31.92	100.00	0.4054605

7.6 Functions and Variables

Review of the standardized canonical discriminant function coefficients reveals that two variables made significant contributions to the discriminant scores of the port in this group: (VARCOM) and FOREGO). The other two variables made significantly weaker contributions (Table 15).

Table 15: Standardized Function Coefficients: Crossvalidation Group 1984

	Function I	Function II
(FOREGO)	0.50509	0.13804
(VABCCM)	1.04041	- 0.36587
(DEPDCCK)	-0.85859	0.53457
(ADMIN)	0.17855	0.96462

Pooled within group correlations show a similar pattern. On Function I, the variable (VABCOM) was most significant with (FOREGO) second in importance, followed by (ADMIN), and (DEPDCCK).

7.7 Group Centroids: Crossvalidation Group

Review of the generated scatterplots for the 3 groups of ports reveals patterns similar to those of the development group with a greater separation of group centroids. Ports in Groups 1 and 2 tend to be closer to one another while the members of Group 3 seem to be more separated from the other groups. Groups 1 and 2 also display more clustering around their centroids than Group 3 (Figure 13).

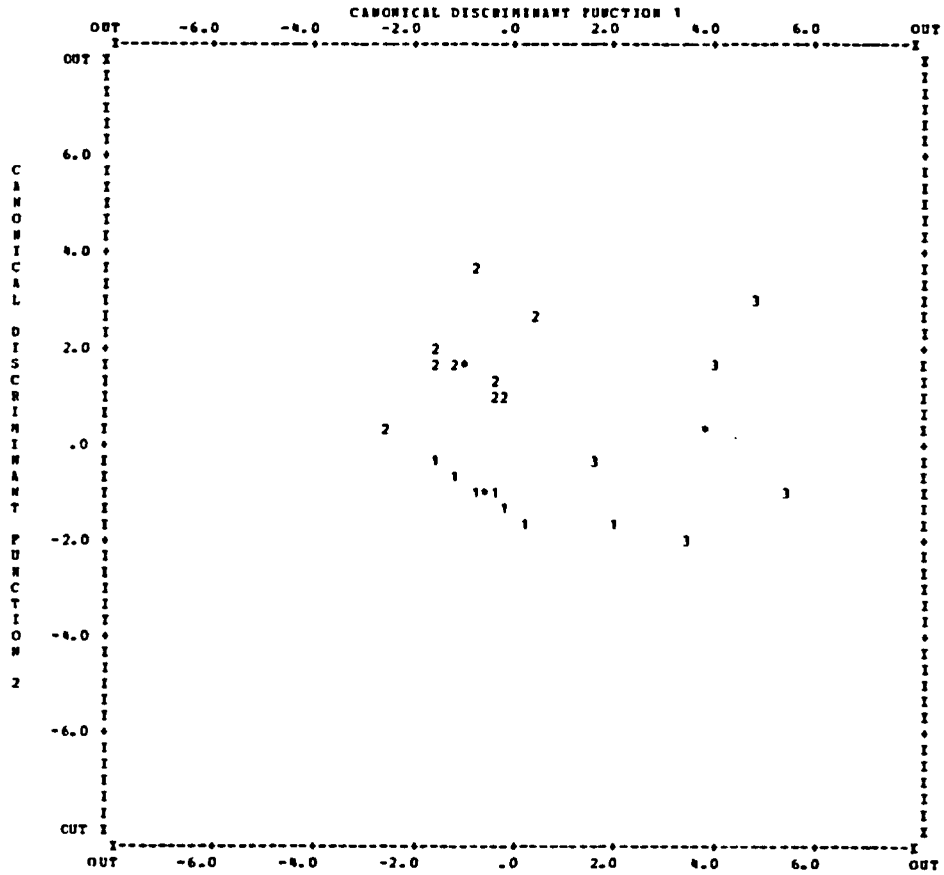


Figure 13: All Groups Scatterplot: Crossvalidation Group 1984

7.8 Classification Results: Crossvalidation Group 1984

The results of the classification seem to confirm the observations made above. Group 1 ports were never incorrectly assigned to Group 2, though appearing closer to them as a group on the scatterplot. Rarely were they assigned to Group 3. Group 2 ports appearing closer to Group 1 were always correctly assigned, as were Group 3 ports. The percent of cases correctly assigned overall by the discriminant function coeffients was an impressive 96.77 percent. Only 1 case out of 31 was incorrectly assigned (Table 16).

Table 16: Classification Results: Crossvalidation Group 1984

Actual Group	Number of Cases	Predicted Group Membership 1	2	3
Group 1	17	16 94.1%	0 0.0%	1 5.9%%
Group 2	9	0 0.0%	9 100.00%	0 0.0%
Group 3	5	0 0.0%	0 0.0%	5 100.00%

Percent of "grouped" cases correctly classified: 96.77%

Chapter VIII

DISCRIMINANT ANALYSIS IN PORT CLASSIFICATION: CONCLUSIONS

The analyses conducted showed differences from previous port classifications, including Roemer's. In the 1966 analysis of the development group sample, 30 percent of the ports were incorrectly assigned; in the 1984 analysis, 47 percent. Such large differences suggest that the variables used in the original groupings (Roemer's) were inappropriate or that the grouping procedures were imprecise. These two issues will now be addressed.

8.1 The Nature of Discriminating Variables

For the two years of this study, five variables were found to discriminate well between groups of ports (Table 17). Through the examination of these variables and those not identified in the analyses as significant, a number observations concerning the nature of Great Lakes ports can be made.

Three of these five variables were related to commodities handled and 3 were common to both study years. (TONNAGE), though identified in the literature as misleading with respect to the status of ports (Bird 1971), proved to be a

Table 17: Variatles Significant In Port Classification

Year	Variables
1966	(VABCCM), (TCNNAGE), (ADMIN), (FCREGO)
1984	(VARCCM), (FCREGO), (ADMIN), (DEPDOCK)

good discriminator when combined with cther variatles in 1966. In 1984, this variable was replaced by water depth at dockside, (DEPDCCK). An observation can however be made concerning these two variatles. Ports with the greatest water depths at dockside will be called on by larger vessels carrying greater tonnages than ports with more limited ship accommodations. Ports handling the largest vessels will generally handle greater tcnnages. One may therefore say that the variable (TCNNAGE) has not disappeared from the analysis in 1984 but is perhaps represented in the variable, (DEPDCCK), yet the correlations between these two variatles are quite low (1966 {0.31531}, 1984 {0.38747} in Appendix D).

The variable (ADMIN) generally reflects the importance of ports. Ports with the greater variety of commerce and greater tonnages of cargoes shipped tend to have local administrative bodies. Group 1 ports would predominantly be administered by private companies, state gcvernment in the U.S. and the Federal government in Canada. Group 2 ports while still administered by state and Federal governments had some cases of local administration.

The variable (FOREGO) was the weakest discriminator identified in 1966, and the second greatest contributor to the discriminant scores for ports in 1984. It seems to reaffirm the importance of international (overseas) trade as a measure of port status, as made in the literature.

Variables not found significant in the analysis allow other observations to be made concerning Great Lakes ports, and perhaps ports in general. The number of vessel transits through a port (TRANSITS) was found to be insignificant in discriminating among ports, as suggested in the literature. Ferry ports would for example have a disproportionate number of transits compared to their total tonnage of cargoes shipped. When compared with other ports of similar characteristics the variables inbound cargoes (INGO), outbound cargoes (OUTGO), and coastwise bound cargoes (COASTGO) were all excluded from the functions. The differences or similarities between ports on these variables did not assist in assignment to classes. This may have been due to the large number of ports, many one commodity, which seem to have predominantly one-directional cargo movements. Depth of approaches (DEPAPP) was likewise insignificant, as suggested in the literature.

8.2 Discriminant Analysis in Port Classification: An Assessment

The results of the two analyses turned out to be quite similar, with the exception of the 1984 development group (Table 18). The development groups tested Hoemer's classification procedure and variables against variables held to be good separators between groups. In the crossvalidation groups, the discriminant function coefficients of those variables were used to re-classify new ports. Discriminant analysis was then conducted using the identified variables. By doing this, more careful values on the functions were determined and the ability of those variables to separate groups was confirmed to be very good. The crossvalidation procedure, then, suggests that the discriminant analysis approach is effective.

Table 18: Accuracy of Port Classifications

	1966	1984
Development Groups	69.61%	52.63%
Crossvalidation Groups	90.91%	96.77%

Multi-criteria approaches were identified in the literature as being good procedures for assessing the status of ports. By using discriminant analysis, it was possible to consider many variables and select those which best separate groups of ports. Past port classification procedures did not permit this. Investigators found it difficult to distinguish the more important variables from the less significant.

Consequently, this analysis makes clear how variables which were identified in the literature as potential discriminators can be confirmed so by means of discriminant analysis.

8.3 Wilks's Lambda: Interpretation of Success in Port Separation

A comparison of Wilks's Lambda values generated in the analyses allows further insights. They show that for both years lambda decreased from the development to the crossvalidation groups on both functions, resulting in more ports being correctly assigned.

In the 1984 crossvalidation group, the lowest lambda values were observed on Function I, with values on Function II in the middle range of lambda values. They resulted in the best separation of group centroids on the scatterplot, and in an improved assignment of ports compared to the 1966 crossvalidation group (Table 19).

Table 19: Wilks's Lambda: 1966/1984

		1966	1984
Development Group	Function I	0.5573242	0.5903778
	Function II	0.9066301	0.9896578
Crossvalidation	Function I	0.1295656	0.0982313
	Function II	0.7370720	0.4054605

8.4 Improvements in Classifying: Development to Crossvalidation

Clearly in evidence has been an improvement in classification accuracy from the development to crossvalidation groups. A comparison of patterns observed from the scatterplots with the classification results from development and crossvalidation groups for both years presents some light on how difficult or easily ports could be assigned to their correct group over time.

In 1966, the scatterplots suggested that for both development and crossvalidation groups, Group 1 and 3 ports appeared to share characteristics which separated them from each other and from Group 2 ports.

Results from the analysis on the development group showed that Group 1 ports were correctly identified 82.5 percent of the time; in the crossvalidation group, they were all correctly assigned. Group 2 ports seemed to be a difficult lot to assign correctly. Although they were only once misclassified as Group 3, they were assigned to Group 1 73.3 percent of the time. After crossvalidation, they were sometimes assigned to Group 1, but now 66.7 percent of the time. Group 3 ports were assigned to Group 1 more often than to Group 2. After crossvalidation, they were no longer incorrectly assigned to Group 1, but still to Group 2.

In 1984, the scatterplots suggested similar patterns to those observed in 1966. Group 3 ports were most likely to be assigned to their correct group. Due to the clustering of Groups 1 and 2 ports, it was anticipated that these two would be difficult to separate into their correct group.

In the analysis on the development group, this was indeed the case. Group 1 ports were more likely to be assigned to Group 2 than to Group 3; Group 2 ports were never assigned to Group 3. Rather they were assigned to Group 1 55.6 percent of the time. After crossvalidation, they were no longer misclassified as Group 1, though still assigned to Group 3. Group 3 ports were assigned to both Group 1 and Group 2 in the development group; after crossvalidation, they were all correctly assigned.

Group 2 ports were the most difficult to assign to their correct group for 1966. In 1984, they were all correctly assigned after crossvalidation, while some Group 1 ports were still assigned to Group 3. Based on these results, two observations can be made. First, Group 2 ports appear to hold an ever changing ground between Groups 1 and 3 , and may warrant further study (see Figure 15). Secondly, the difficulty with Group 1 ports still being assigned to Group 3 after crossvalidation shows that there exists a difficulty in separating ports in Group 1 which fall close to ports sharing very similar intensities but belong to Group 3. This may be because there are two two types of Group 3 ports as suggested earlier, with one type similar to Group 1.

8.5 A Critical Assessment of Roemer's Classification

Although this study revealed some of the weaknesses of Roemer's procedures, similar observations can be made about other classifications, since the procedures used were similar. Looking back at Roemer's procedure, and variables, a number of flaws were evident which resulted in a classification of Great Lakes ports which was not complete, and could not be replicated.

The first flaw in Roemer's work may have been the use of too few variables, some of which were weak measures of port status. Three of Roemer's variables were incorporated into this study. Only one, total weight of cargoes shipped emerged as significant. The other variables, cargoes shipped in, and out bound proved to be weak discriminators. The procedure used also contributed to the poor results achieved, since it did not take into account the intensity of the selected variables. The fact that Roemer was not clear on grouping procedures is in evidence by a simple examination of the statistics and the classification itself. Group membership was shown to be difficult to determine in many cases.

Roemer's classification was also based on a misrepresentation to some degree of the commodities handled by the ports on the lakes. A good example is Goderich, Ontario, which was identified as a one commodity port, handling predominantly grain. If we were to examine the commodities handled ourselves, we would discover salt to be a major commodity.

The absence of petroleum as a significant commodity in her classification also casts a shadow on the nature of the ports. For many, petroleum and petroleum related products account for large proportions of the total cargoes shipped.

Problems such as these can be perhaps related to the procedure used in the development of the classification. The literature shows that a number of attempts at classifying ports have been undertaken without any clearly defined procedure. Rather, there has been a preoccupation with the selection of the best possible variables and measures of port status. This concern, though justified, is perhaps reason for the difference of opinions on appropriate variables. In this study, the preoccupation has been with the procedure, and the result has been the identification of good port separation criteria, for the procedure chosen had as one of its tasks the identification of appropriate variables.

Chapter IX

STUDY IMPLICATIONS

9.1 A View of Great Lakes Ports

The number of ports in operation on the Great Lakes can vary from year to year depending on a wide range of market and economic conditions. By using discriminant analysis this study analysed some of the knowledge we have about these ports in a systematic fashion.

Group 3 ports appear to have been the most important in terms of overall trade on the lakes. They were usually the larger urban metropolitan areas, serving the larger hinterlands, handling the highest proportions of general cargoes, having the greatest overseas trade, handling most cargoes, the greatest variety of cargoes and being locally administered by a port authority or harbour commission. These were in a sense predominantly international lake ports.

Group 2 ports were characterized by smaller urban areas serving more limited hinterlands, little or no overseas trade, few commodities, and a variety of port administrations. Tonnages handled by these ports also varied, with some handling more than those ports in Group 3. Bulk cargoes were more important to these ports. Trade was limited generally to within the lakes. These could be seen as national lake ports.

Group 1 ports were characterized by the smallest urban areas serving the most limited hinterlands and the smallest amount of overseas trade. A number of ports in this group could be characterized as being primarily bulk cargo oriented with an imbalance of cargo movement, cargoes inbound or outbound dominating. Many of these ports handled large volumes of material, and were administered by private corporations, local, and or state and or Federal governments. These can be seen as local lake ports.

9.2 Patterns and Trends of Great Lakes Shipping

The most striking aspect of trade on the lakes concerns the tonnages and varieties of cargoes handled. While the total tonnage of cargoes handled increased from 105 261 360 tonnes in 1966 to 147 730 692 tonnes in 1984, and international trade increased from 85 787 834 tonnes in 1966 to 90 595 771 tonnes in 1984, a number of ports experienced declines, with the notable cases from Group 3. Buffalo N.Y. is perhaps the best example. In 1966, 16 884 626 tonnes were transhipped compared to only 1 682 190 in 1984. Other ports in Group 3 which experienced declines, though not of the same magnitude, included Duluth-Superior and Toronto. Declines in tonnages and varieties of cargoes appear to have been a contributing factor to some 1966 Group 3 ports such as Menominee, Port Huron, Manitowac and Muskegon, shifting to Group 1 in 1984.

Increases in the tonnage of cargoes generally resulted in ports shifting up to Groups 2 or 3. Group 2 ports seldom moved up to Group 3, rather they were more likely to decline to Group 1. Group 1 ports seldom moved up to Group 3, rather they moved up Group 2, for example, Calcite, and Morrisburg (Appendix E).

9.3 Uses of Port Classification

Recently, there has been a re-awakening of Great Lakes ports, shipping companies, governments and others with economic interests in the status of the Great Lakes as a transport system. All have been in search of new knowledge. The economic status of Great Lakes ports suffered during the early 1980's, due in part to the changing economic conditions of the time but also due to inability of ports and shipping companies to secure new cargoes to replace ones which declined in earlier years. In a sense, ports had to become more competitive with other modes of transport and tidewater ports on the continent. Today, the Great Lakes/St. Lawrence Seaway are trying to do just this. Trade missions to Europe and new concepts in port management reflect a new spirit. There has been a genuine attempt to recapture lost cargoes and secure new ones from rail and trucking.

Markets cannot grow forever and cargoes cannot always be secured from other modes of transportation. The only alternative is increased inter-port competition for cargoes. It seems that this approach has not been investigated as clearly as the previous option.

Through the use of a classification procedure such as the one employed here, operating ports obtain a view of the competition in the geographic market place. Ports wishing to improve economic status or just maintain current position in the market may find information presented by this type of classification procedure useful. It may prove useful too in the early stages of developing a policy which is designed to secure new cargoes for the port. The classification allows the port to identify its position in the geographic area, say the Great Lakes. It allows the port to see more clearly those ports with which it has most things in common, ports belonging to the same group. These are probably the immediate competition, ports which deal in similar varieties and quantities of cargoes. It allows the identification of ports in other classes which may be themselves targets for the securement of cargoes. It allows the port to identify those ports in other groups which pose the greatest competition.

If the division of the market place into various levels is known, valuable time and money can be saved in the implementation of trade and planning strategies. First by conducting an internal examination of the port itself, port managers can look towards other ports within the group in greater detail for guidance and ideas which could be effectively implemented with successful results. Poor examples of management or policy can also be more easily identified.

Classifications of ports, say those on the Great Lakes, conducted on a yearly basis, can prove to be useful in long term planning and development of transportation policies by higher levels of government; by highlighting port movements between classes and the disappearance and appearance of ports, effective plans can be initiated for systematic change. Understanding the complete system of ports, their characteristics, a plan for the development of the entire Great Lakes region can be undertaken with a clear understanding of past and present port arrangements.

Through knowledge, successful port development and operations can be maintained and improved. Through classification, a sure start can be made on the road to that knowledge about ports. In this study, the variables which emerged as significant discriminators between groups; variety of commerce (VARCOM), overseas bound cargoes (FOREGO), and weight of cargoes shipped (TONNAGE), had all been identified in earlier studies as good measures of port status. Port administration (ADMIN) was the only variable which was not previously identified as a good discriminator but emerged as one. This suggests that good variables have been in existence all along, but that their success had been limited by inadequate grouping procedures. Through the procedure outlined using discriminant analysis, a start on the road to that knowledge has been made. A sound replicable classification of ports has been more easily achieved and appropriate measures of port status identified more precisely.

Appendix A

INITIAL CLASSIFICATIONS

Table 20: Initial Classification 1966: Group 1 Ports

Britt, Ont.	Cobourg, Ont.
Cutler, Ont.	Morrisburg, Ont.
Oakville, Ont.	Parry Sound, Ont.
Whitby, Ont.	Cornwall, Ont.
Colborne, Ont.	Courtwright, Ont.
Erieau, Ont.	Trenton, Ont.
Port Burwell, Ont.	Port Credit, Ont.
Port Hope, Ont.	Depot Harbour, Ont.
Cardinal, Ont.	Michipicoten, Ont.
Collingwood, Ont.	Port McNicoll, Ont.
Prescott, Ont.	Midland, Ont.
Red Rock, Ont.	Marathon, Ont.
Port Maitland, Ont.	Alpena, Mi.
White Lake, Mi.	Marquette, Mi.
Escanaba, Mi.	Presque Isle, Mi.
Manistique, Mi.	Keweenaw Waterway, Mi.
Marysville, Mi.	Harbor Beach, Mi.
Monroe, Mi.	St. Clair, Mi.
Charlevoix, Mi.	Sault Ste. Marie, Mi.
Grand Haven, Mi.	Drummond Isl., Mi.
Port Huron, Mi.	Leland, Mi.
South Haven, Mi.	Calcite, Mi.
St. Joseph, Mi.	Port Dolomite, Mi.
Port Inland, Mi.	Stoneport, Mi.
Marine City, Mi.	Cheboygan, Mi.
Harrisville, Mi.	Gladstone, Mi.
Bayfield, Wis.	Detroit Harbor, Wis.
Two Harbors, Wis.	Michigan City, Ind.
Gary, Ind.	Ashland, Wis.
Green Bay, Wis.	Port Washington, Wis.
Sheboygan, Wis.	Oak Creek, Wis.
Fairport, Ohio	Marblehead, Ohio
Huron, Ohio	Sandusky, Ohio
Waddington, N.Y.	Rochester, N.Y.
Dunkirk, N.Y.	Sackets Harbor, N.Y.
Ogdensburg, N.Y.	Waukegan, Ill.
Silver Bay, Minn.	Buffington Harbor, Ind.
Grand Marais, Minn.	

Table 21: Initial Classification 1966: Group 2 Ports

Belleville, Ont.	Kingsville, Ont.
Kingston, Ont.	Brockville, Ont.
Oshawa, Ont.	Port Stanley, Ont.
Sarnia, Ont.	Wallaceburg, Ont.
Clarkson, Ont.	St. Catharines, Ont.
Picton, Ont.	Amherstburg, Ont.
Goderich, Ont.	Port Colborne, Ont.
Owen Sound, Ont.	Manistee, Mi.
Ontonagon, Mi.	Traverse City, Mi.
Lime Isl., Mi.	Ashtabula, Ohio
Lorain, Ohio	Conneaut, Ohio
Racine, Wis.	Two Rivers, Wis
Indiana Harbor, Ind.	

Table 22: Initial Classification 1966: Group 3 Ports

Toronto, Ont.	Windsor, Ont.
Welland, Ont.	Thorold, Ont.
Hamilton, Ont.	Sault Ste. Marie, Ont.
Thunder Bay, Ont.	Menominee, Mi.
Franfort, Mi.	Ludington, Mi.
Muskegon, Mi.	Detroit, Mi.
Holland, Mi.	Mackinac, Mi.
St. James, Mi.	Sturgeon Bay, Wis.
Kewaunee, Wis.	Manitowac, Wis.
Kenosha, Wis.	Chicago, Ill.
Toledo, Ohio	Duluth-Superior, Minn.-Wis.
Cleveland, Ohio	Put-In-Bay, Ohio
Erie, Pa.	Buffalo, N.Y.
Oswego, N.Y.	

Table 23: Initial Classification 1984: Group 1 Ports

Amherstburg, Ont.	Badgeley Isl., Ont.
Bath, Ont.	Britt, Ont.
Cardinal, Ont.	Clarkson, Ont.
Colborne, Ont.	Collingwood, Ont.
Courtwright, Ont.	Cutler, Ont.
Goderich, Ont.	Kingston, Ont.
Kingsville, Ont.	Lakeview, Ont.
Meldrum Bay, Ont.	Little Current, Ont.
Nanticoke, Ont.	Michipicoten, Ont.
Oakville,Ont.	Owen Sound, Ont.
Picton, Ont.	Port Dover, Ont.
Port McNicoll, Ont.	Prescott, Ont.
Sombra, Ont.	Serpent River, Ont.
Sarnia, Ont.	St. Catharines, Ont.
Waukegan, Ill.	Mackinac, Mi.
Two Harbors, Minn.	Ashland, Wis.
Bayfield, Wis.	Silver Bay, Minn.
Taconite, Minn.	Indiana Harbor, Ind.
Gary, Ind.	Buffington, Ind.
Presque Isle, Mi.	Drummond Island, Mi.
Muskegon, Mi.	Grand Haven, Mi.
Holland, Mi.	Port Washington, Wis.
Sheboygan, Wis.	Green Bay, Wis.
Alpena, Mi.	Port Huron, Mi.
Marysville, Mi.	St. Clair, Mi.
Marine City, Mi.	Monroe, Mi.
Ogdensburg, N.Y.	Port Inland, Mi.
Algoma, Wis.	Cheboygan, Mi.
Gladstone, Mi.	Mackinac City, Mi.
Marquette, Mi.	Menominee, Mi.
Alabaster, Mi.	Sault Ste. Marie, Mi.
Calcite, Mi.	Escanaba, Mi.
Marblehead, Ohio	Oak Creek, Wis.
Port Dolomite, Mi.	Port Gypsum, Mi.
Stoneport, Mi.	Sandusky, Ohio
Huron, Ohio	Lorain, Ohio
Conneaut, Ohio	Rochester, N.Y.
Barcelona, N.Y.	Harrisville, Mi.
Keweenaw Waterway, Mi.	

Table 24: Initial Classification 1984: Group 2 Ports

Midland, Ont.	Morrisburg, Ont.
Parry Sound, Ont.	Spragge, Ont.
Oshawa, Ont.	Bowmanville, Ont.
Port Colborne, Ont.	Manistee, Mi.
Detour, Mi.	Ontonagon, Mi.
Charlevoix, Mi.	Manitowac, Wis.
Sturgeon Bay, Wis.	Two Rivers, Wis.
Fairport, Ohio	Port Clinton, Ohio
Ashtabula, Ohio	Traverse City, Mi.

Table 25: Initial Classification 1984: Group 3 Ports

Cornwall, Ont.	Sault Ste. Marie, Ont
Windsor, Ont.	Toronto, Ont.
Thunder Bay, Ont.	Thorold, Ont.
Port Stanley, Ont.	Pelee Isl., Ont.
Hamilton, Ont.	Detroit Harbor, Wis.
LaPointe, Wis.	Duluth-Superior, Minn.-Wis.
Chicago,Ill.	Burns Waterway, Ind.
Ludington, Mi.	Milwaukee, Wis.
Kewaunee, Wis.	Saginaw-Bay City, Mi.
Detroit, Mi.	Kelly's Isl., Ohio
Frankfort, Mi.	Kenosha, Wis.
Mackinac, Mi.	Put-In-Bay, Ohio
St. James, Mi.	Toledo, Ohio
Cleveland, Ohio	Erie, Pa.
Buffalo, N.Y.	Oswego, N.Y.

Appendix B

VARIETY OF COMMERCE

Table 26: Variety of Commerce: Canadian Great Lake Ports 1966

Code	Commodities Handled	Percent of Total Commodities	Number of Cases
1	1 - 27	12.5	40
2	28 - 108	37.5	5
3	109 - 189	37.5	3
4	190 - 217	12.5	0

Table 27: Variety of Commerce: United States Great Lakes Ports 1966

Code	Commodities Handled	Percent of Total Commodities	Number of Cases
1	1 - 22	12.5	63
2	23 - 87	37.5	14
3	88 - 153	37.5	10
4	154 - 173	12.5	0

Table 28: Variety of Commerce: Canadian Great Lakes Ports 1984

Code	Commodities Handled	Percent of Total Commodities	Number of Cases
1	1 - 10	12.5	40
2	11 - 42	37.5	5
3	43 - 74	37.5	2
4	75 - 84	12.5	0

Table 29: Variety of Commerce: United States Great Lakes Ports 1984

Code	Commodities Handled	Percent of Total Commodities	Number of Cases
1	1 - 20	12.5	66
2	21 - 80	37.5	11
3	81 - 140	37.5	2
4	141 - 159	12.5	0

Appendix C

PORTS IN OPERATION FOR ONE STUDY YEAR

Table 30: Ports Operational Only in 1966

Racine, Wis.	Grand Marais, Minn.
Michigan City, Ind.	Manistique, Mi.
Algonac, Mi.	Harbor Beach, Mi.
Leland, Mi.	Waddington, N.Y.
Lime Isl., Mi.	South Haven, Mi.
White Lake, Mi.	Great Sodus Bay, N.Y.
Dunkirk, N.Y.	Sackets Harbor, N.Y.
Belleville, Ont.	Brockville, Ont.
Cobourg, Ont.	Erieau, Ont.
Depot Harbour, Ont.	Port Burwell, Ont.
Port Credit, Ont.	Port Maitland, Ont.
Port Hope, Ont.	Trenton, Ont.
Whitby, Ont.	Red Rock, Ont.
Wallaceburg, Ont.	Welland, Ont.

Table 31: Ports Operational Only in 1984

LaPointe, Wis	Algoma, Wis.
Alabaster, Mi.	Burns Waterway, Ind.
Port Gypsum, Mi.	Mackinac City, Mi.
Barcelona, N.Y.	Kelly's Isl., Ohio.
Bath, Ont.	Bowmanville, Ont.
Meldrum Bay, Ont.	Nanticoke, Ont.
Pelee Isl., Ont.	Port Dover, Ont.
Sombra, Ont.	Lakeview, Ont.
Serpent River, Ont.	Spragge, Ont.
Badgeley Isl., Ont.	

Appendix D

POOLED WITHIN-GROUPS CORRELATION MATRICES

Table 32: Correlation Matrix: Development Group 1966

	TONNAGE	VARCCM	INGO	OUTGO	COASTGC	FOREGO	TRANSITS	DEPAPP	DEPDOCK	ADMIN
TONNAGE	1.00000									
VARCOM	0.37474	1.C0000								
INGO	0.60674	0.30685	1.00000							
CUTGO	0.81696	0.21445	0.25805	1.00000						
COASTGO	0.95716	0.29629	0.58799	0.76339	1.00000					
FOREGO	0.77794	0.43157	0.57507	0.59479	0.64849	1.00000				
TRANSITS	0.46810	0.23655	0.11402	0.04189	0.49094	0.27746	1.00000			
DEPAPP	0.32142	0.19851	0.25394	0.25003	0.29950	0.30898	0.10607	1.00000		
DEPDOCK	0.31531	0.26826	0.26319	0.22679	0.28449	0.33322	0.10968	0.90495	1.00000	
ADMIN	0.26591	0.33253	0.26990	0.27412	0.21129	0.27538	-0.11174	0.20215	0.20038	1.C0000

CORRELATIONS WHICH CANNOT BE COMPUTED ARE PRINTED AS 99.0.

Table 33: Correlation Matrix: Crossvalidation Group 1966

	TONNAGE	VARCCM	FORFGO	ADMIN
TONNAGE	1.00000			
VARCCM	0.25926	1.C0000		
FCREGO	0.62663	0.30676	1.C0000	
ADMIN	0.36709	0.10544	0.29730	1.00000

CORRELATIONS WHICH CANNOT BE COMPUTEC ARF PRINTFD AS 99.0.

Table 34: Correlation Matrix: Development Group 1984

	TONNAGE	VARCOM	INGO	OUTGO	COASTGO	FOREGO	TRANSITS	DEPAPP	DEPDOCK	ADMIN
TONNAGE	1.00000									
VARCOM	0.41380	1.00000								
INGO	0.64706	0.48563	1.00000							
OUTGO	0.76783	0.12870	0.02454	1.00000						
COASTGO	0.95072	0.40107	0.60355	0.72949	1.00000					
FOREGO	0.75384	0.29304	0.51217	0.58080	0.52162	1.00000				
TRANSITS	0.21889	0.20618	0.24182	-0.00933	0.24497	0.07942	1.00000			
DEPAPP	0.41166	0.35275	0.32156	0.28365	0.39136	0.32401	-0.01468	1.00000		
DEPDOCK	0.38747	0.40334	0.33209	0.24392	0.36465	0.31702	-0.02070	0.91038	1.00000	
ADMIN	0.29389	0.45048	0.31464	0.13292	0.32313	0.14235	-0.08671	0.39998	0.43099	1.00000

CORRELATIONS WHICH CANNOT BE COMPUTED ARE PRINTED AS 99.0.

Table 35: Correlation Matrix: Crossvalidation Group 1984

	FOREGO	VARCOM	DEPDOCK	ADMIN
FOREGO	1.00000			
VARCOM	0.29029	1.00000		
DEPDOCK	0.40695	0.60096	1.00000	
ADMIN	-0.13144	0.00000	-0.12589	1.00000

CORRELATIONS WHICH CANNOT BE COMPUTED ARE PRINTED AS 99.0.

Appendix E

GROUPS OF PORTS AND DISCRIMINANT SCORES

Table 36: Development Group 1966:Groups and Discriminant Scores

CASE SEQNUM		ACTUAL GROUP		HIGHEST PROBABILITY GROUP	P(D/G)	P(G/D)	2ND HIGHEST GROUP	P(G/D)	DISCRIMINANT SCORES...	
1	KEWEENAW WATERWAY, MI.	1		1	0.9154	0.5129	2	0.4328	-0.7568	0.0393
2	DULUTH-SUPERIOR, MINN.	3		3	0.2917	0.9796	1	0.0160	2.8433	-0.5867
3	TWO HARBORS, WIS.	1		1	0.7853	0.6492	2	0.2216	-0.2940	-0.8743
4	ASHLAND, WIS.	1		1	0.9296	0.5211	2	0.4222	-0.7371	-0.0023
5	MARQUETTE, MI.	1		1	0.9674	0.5506	2	0.3826	-0.6585	-0.1571
6	GRAND MARAIS, MINN.	1		1	0.9168	0.5135	2	0.4319	-0.7551	0.0356
7	ONTONAGON, MI.	2	**	1	0.9167	0.5135	2	0.4319	-0.7552	0.0358
8	TACONITE, MINN.	1		1	0.3556	0.6757	3	0.2069	0.0297	-1.5590
9	GLADSTONE, MI.	1		1	0.9254	0.5185	2	0.4255	-0.7433	0.0106
10	MENOMINEE, MI.	3		3	0.8268	0.5076	1	0.2953	0.7863	0.0353
11	GREEN BAY, WIS.	1	**	3	0.3695	0.8015	1	0.1703	1.5191	-1.3686
12	STURGEON BAY, WIS.	1	**	3	0.4602	0.7699	1	0.1925	1.4089	-1.2082
13	KEWAUNEE, WIS.	3		3	0.6115	0.9525	1	0.0331	2.3721	-0.1733
14	MANITOWAC, WIS.	3		3	0.0806	0.9850	1	0.0134	3.0543	-1.4821
15	SHEBOYGAN, WIS.	1		1	0.9305	0.5217	2	0.4214	-0.7356	-0.0052
16	PORT WASHINGTON, WIS.	1		1	0.9434	0.5303	2	0.4102	-0.7150	-0.0493
17	WAUKEGAN, ILL.	1		1	0.5678	0.6649	3	0.1727	-0.1049	-1.2090
18	CHICAGO, ILL.	3		3	0.0115	0.9986	1	0.0011	4.3206	-0.6127
19	KENOSHA, WIS.	3	**	1	0.5972	0.6632	2	0.1692	-0.1259	-1.1645
20	MICHIGAN CITY, IND.	1		1	0.9162	0.5132	2	0.4323	-0.7558	0.0371
21	RACINE, WIS.	3	**	1	0.9200	0.5154	2	0.4295	-0.7507	0.0264
22	TWO RIVERS, WIS.	2	**	1	0.9202	0.5155	2	0.4294	-0.7505	0.0260
23	BUFFINGTON, IND.	1		1	0.8617	0.6322	2	0.2480	-0.3394	-0.7295
24	ESCANABA, MI.	1		1	0.8463	0.6419	2	0.2452	-0.3767	-0.7647
25	GARY, IND.	1	**	2	0.9097	0.6172	1	0.2959	-0.3246	1.0982
26	SAULT STE MARIE, MI.	1		1	0.9174	0.5114	2	0.4333	-0.7471	0.0449
27	DRUMMOND ISL., MI.	1		1	0.9628	0.5319	2	0.4013	-0.6498	-0.0658
28	MANISTIQUE, MI.	1	**	3	0.8265	0.5111	1	0.3000	0.7892	-0.0281
29	FRANKFORT, MI.	3		3	0.5907	0.9545	1	0.0322	2.3955	-0.2229
30	MANISTEE, MI.	2	**	1	0.9356	0.5246	2	0.4175	-0.7273	-0.0202
31	MUSKEGON, MI.	3		3	0.8541	0.5841	1	0.2786	0.9345	-0.2722
32	ALPENA, MI.	1		1	0.9760	0.5723	2	0.3533	-0.6043	-0.2776
33	SAGINAW-BAY CITY, MI.	3		3	0.8966	0.6379	1	0.2443	1.0565	-0.2759
34	PORT HURON, MI.	1	**	3	0.8387	0.5229	1	0.2937	0.8143	-0.0338
35	MARYSVILLE, MI.	1		1	0.9349	0.5245	2	0.4178	-0.7291	-0.0193
36	DETROIT, MI.	3		3	0.1145	0.9888	2	0.0059	3.2574	0.9841
37	TOLEDO, OHIO	3		3	0.0032	0.9938	2	0.0048	3.8528	2.3822
38	ALGONAC, MI.	1		1	0.9158	0.5130	2	0.4326	-0.7563	0.0392
39	CHARLEVOIX, MI.	1		1	0.9187	0.5146	2	0.4305	-0.7525	0.0302
40	CHEBOYGAN, MI.	1		1	0.9196	0.5151	2	0.4298	-0.7513	0.0276
41	HARBOR BEACH, MI.	1		1	0.9169	0.5136	2	0.4318	-0.7549	0.0351
42	HARRISVILLE, MI.	1		1	0.9189	0.5148	2	0.4303	-0.7522	0.0295
43	HOLLAND, MI.	3	**	1	0.9240	0.5177	2	0.4266	-0.7452	0.0148
44	LELAND, MI.	1		1	0.9171	0.5137	2	0.4317	-0.7546	0.0347
45	LIME ISL., MI.	1		1	0.9247	0.6169	2	0.2809	-0.4321	-0.5822
46	MACKINAC, MI.	3	**	1	0.9156	0.5129	2	0.4327	-0.7566	0.0389
47	MARINE CITY, MI.	1		1	0.9196	0.5151	2	0.4299	-0.7513	0.0277
48	MONROE, MI.	1		1	0.5964	0.6633	2	0.1691	-0.1254	-1.1658
49	PORT CLINTON, OHIO	2	**	1	0.9169	0.5136	2	0.4318	-0.7549	0.0352
50	PUT-IN-BAY, OHIO	3	**	1	0.9158	0.5130	2	0.4326	-0.7563	0.0382
51	SOUTH HAVEN, MI.	1		1	0.9180	0.5143	2	0.4310	-0.7534	0.0320
52	ST. JAMES, MI.	3	**	1	0.9155	0.5128	2	0.4328	-0.7568	0.0392

** DENOTE MISCLASSIFIED CASES

NOTE: THE ABOVE RESULTS MAY NOT CORRESPOND TO THE GROUP SCATTERPLOTS
DUE TO OVERPRINTING OF CASES

Table 36 - continued

CASE SEQNUM		ACTUAL GROUP		HIGHEST GROUP	PROBABILITY P(D/G)	P(G/D)	2ND HIGHEST GROUP	P(G/D)	DISCRIMINANT SCORES...	
53	TRAVERSE CITY, MI.	2	**	1	0.9219	0.5165	2	0.4282	-0.7482	0.0210
54	CALCITE, MI.	1		1	0.1536	0.6587	3	0.2681	0.2439	-2.0120
55	MARBLEHEAD, OHIO	1		1	0.9538	0.5384	2	0.3996	-0.6951	-0.0913
56	SANDUSKY, OHIO	1	**	2	0.9548	0.6318	1	0.3264	-0.7654	0.9447
57	HURON, OHIO	1		1	0.9192	0.5048	2	0.4375	-0.7189	0.0743
58	FAIRPORT, OHIO	1		1	0.9012	0.4879	2	0.4539	-0.7054	0.1540
59	ASHTABULA, OHIO	2		2	0.0446	0.7258	3	0.1977	0.6525	2.9115
60	CONNEAUT, OHIO	2		2	0.0000	0.9928	1	0.0061	-1.1743	5.7119
61	ERIE, PA.	3		3	0.4540	0.7801	1	0.1845	1.4411	-1.2185
62	BUFFALO, N.Y.	3		3	0.4129	0.9103	1	0.0755	2.0123	-1.1447
63	ROCHESTER, N.Y.	1	**	3	0.8623	0.7473	1	0.1936	1.3305	-0.5019
64	GREAT SODUS BAY, N.Y.	1	**	2	0.9042	0.5036	1	0.4483	-0.7889	0.3462
65	OSWEGO, N.Y.	3		3	0.5117	0.7711	1	0.1889	1.4092	-1.1199
66	OGDENSBURG, N.Y.	1	**	3	0.1436	0.9825	1	0.0151	2.9492	-1.1835
67	DUNKIRK, N.Y.	1		1	0.9168	0.5135	2	0.4319	-0.7551	0.0356
68	SACKETS HARBOR, N.Y.	1		1	0.9177	0.5141	2	0.4312	-0.7538	0.0328
69	WADDINGTON, N.Y.	1		1	0.9177	0.5141	2	0.4312	-0.7538	0.0328
70	AMHERSTBURG, ONT.	2	**	1	0.8739	0.4834	2	0.4650	-0.7696	0.1800
71	BELLEVILLE, ONT.	3	**	1	0.6508	0.6519	2	0.1810	-0.1293	-1.0732
72	BRITT, ONT.	1		1	0.9233	0.5166	2	0.4276	-0.7443	0.0200
73	CLARKSON, ONT.	1		1	0.8946	0.6221	2	0.2614	-0.3546	-0.6572
74	COBOURG, ONT.	2	**	1	0.9188	0.5141	2	0.4308	-0.7509	0.0323
75	COLBORNE, ONT.	1		1	0.9509	0.5360	2	0.4027	-0.7010	-0.0788
76	COURTWRIGHT, ONT.	1		1	0.9561	0.6011	2	0.3004	-0.4505	-0.4833
77	CUTLER, ONT.	1		1	0.9307	0.6146	2	0.2847	-0.4404	-0.5647
78	ERIEAU, ONT.	1		1	0.8704	0.4818	2	0.4669	-0.7731	0.1874
79	HAMILTON, ONT.	3		3	0.0000	0.6601	2	0.3328	2.3795	4.9279
80	KINGSTON, ONT.	2	**	1	0.8747	0.4806	2	0.4664	-0.7543	0.1922
81	KINGSVILLE, ONT.	2	**	1	0.8993	0.4999	2	0.4469	-0.7621	0.1011
82	MIDLAND, ONT.	1		1	0.9300	0.5184	2	0.4242	-0.7287	0.0101
83	OAKVILLE, ONT.	1		1	0.9283	0.6156	2	0.2831	-0.4370	-0.5719
84	OSHAWA, ONT.	2	**	1	0.6759	0.6474	2	0.1969	-0.1352	-1.0313
85	OWEN SOUND, ONT.	1		1	0.9213	0.5140	2	0.4302	-0.7428	0.0323
86	PARRY SOUND, ONT.	1		1	0.9254	0.5173	2	0.4264	-0.7398	0.0162
87	PICTON, ONT.	1		1	0.9230	0.4738	2	0.4455	-0.5140	0.1969
88	THUNDER BAY, ONT.	3		3	0.1416	0.9910	1	0.0053	3.3265	0.4951
89	PORT BURWELL, ONT.	1	**	2	0.8972	0.4990	1	0.4526	-0.7884	0.3260
90	PORT COLBORNE, ONT.	2		2	0.6926	0.7488	1	0.2239	-0.8642	1.5261
91	PORT MAITLAND, ONT.	1		1	0.9156	0.5129	2	0.4327	-0.7566	0.0389
92	PORT MCNICOLL, ONT.	1		1	0.9258	0.5188	2	0.4251	-0.7426	0.0092
93	PORT HOPE, ONT.	1		1	0.9110	0.5092	2	0.4368	-0.7598	0.0568
94	PORT STANLEY, ONT.	2	**	1	0.8892	0.4915	2	0.4554	-0.7593	0.1403
95	PRESCOTT, ONT.	1	**	3	0.8084	0.4949	1	0.2829	0.7741	0.2105
96	SARNIA, ONT.	2	**	3	0.4874	0.4359	2	0.3553	0.7667	1.0537
97	THOROLD, ONT.	3	**	1	0.9975	0.5480	2	0.3599	-0.4735	-0.1885
98	TORONTO, ONT.	3		3	0.1525	0.9651	2	0.0226	2.7247	1.4568
99	CORNWALL, ONT.	1		1	0.9143	0.5110	2	0.4345	-0.7547	0.0478
100	TRENTON, ONT.	1		1	0.9170	0.5137	2	0.4317	-0.7547	0.0349
101	MORRISBURG, ONT.	1		1	0.9114	0.5094	2	0.4365	-0.7586	0.0554
102	WHITBY, ONT.	1		1	0.9153	0.5124	2	0.4332	-0.7561	0.0410

** DENOTE MISCLASSIFIED CASES

NOTE: THE ABOVE RESULTS MAY NOT CORRESPOND TO THE GROUP SCATTERPLOTS DUE TO OVERPRINTING OF CASES

Table 37: Crossvalidation Group 1966: Groups and Discriminant Scores

- CASE SEQNUM	ACTUAL GROUP		HIGHEST PROBABILITY GROUP	P (D/G)	P (G/D)	2ND HIGHEST GROUP	P (G/D)	DISCRIMINANT SCORES...	
1 PRESQUE ISLE, MI.	1		1	0.8771	0.8471	2	0.1529	-1.3265	-0.3050
2 BAYFIELD, WIS.	1		1	0.9053	0.8493	2	0.1507	-1.2487	-0.2549
3 SILVER BAY, MINN.	1		1	0.4830	0.9939	2	0.0061	-1.3665	1.3784
4 MILWAUKEE, WIS.	3		3	0.0060	1.0000	2	0.0000	6.1934	2.4199
5 INDIANA HARBOR, IND.	3		3	0.0822	0.9963	1	0.0033	2.5033	1.3756
6 DETROIT HARBOR, WIS.	1		1	0.9056	0.8495	2	0.1505	-1.2488	-0.2541
7 OAK CREEK, WIS.	1		1	0.7690	0.9780	2	0.0220	-1.0334	0.3967
8 DETOUR, MI.	1		1	0.9160	0.8568	2	0.1432	-1.2523	-0.2267
9 LUDINGTON, MI.	3		3	0.1647	1.0000	2	0.0000	5.7596	0.6924
10 GRAND HAVEN, MI.	1		1	0.9189	0.8654	2	0.1346	-1.2902	-0.2106
11 ST. JOSEPH, MI.	2	**	1	0.6689	0.6992	2	0.3008	-1.2607	-0.7072
12 ST. CLAIR, MI.	1		1	0.9931	0.9401	2	0.0599	-1.2863	0.2409
13 WHITE LAKE, MI.	1		1	0.9065	0.8501	2	0.1499	-1.2489	-0.2519
14 PORT DOLOMITE, MI.	1		1	0.7038	0.9826	2	0.0174	-1.0478	1.0136
15 PORT INLAND, MI.	1		1	0.6636	0.9849	2	0.0151	-1.0528	1.0826
16 STONEPORT, MI.	1		1	0.4757	0.9921	2	0.0079	-1.0757	1.4005
17 LORAIN, OHIO	1		1	0.9603	0.8997	2	0.1003	-1.3235	-0.0609
18 CLEVELAND, OHIO	3		3	0.0490	1.0000	2	0.0000	5.9382	-1.2640
19 BROCKVILLE, ONT.	1		1	0.9036	0.8483	2	0.1517	-1.2490	-0.2591
20 CARDINAL, ONT.	1		1	0.9271	0.9551	2	0.0449	-1.0156	0.5379
21 COLLINGWOOD, ONT.	1		1	0.9077	0.8511	2	0.1489	-1.2500	-0.2486
22 DEPOT HARBOUR, ONT.	2	**	1	0.5191	0.5882	2	0.4118	-1.2673	-0.9558
23 GODERICH, ONT.	1		1	0.8431	0.8133	2	0.1867	-1.2633	-0.3924
24 LITTLE CURRENT, ONT.	1		1	0.8547	0.7871	2	0.2129	-1.0397	-0.3557
25 MARATHON, ONT.	1		1	0.9726	0.9374	2	0.0626	-1.0212	0.3595
26 MICHIPICOTEN, ONT.	1		1	0.9821	0.9293	2	0.0707	-1.0238	0.2912
27 PORT CREDIT, ONT.	3	**	2	0.0589	0.8396	3	0.1583	2.2063	-2.2911
28 RED ROCK, ONT.	1		1	0.9061	0.8499	2	0.1501	-1.2499	-0.2523
29 ST. CATHARINES, ONT.	1		1	0.9577	0.9454	2	0.0546	-1.0207	0.4314
30 SAULT STE MARIE, ONT.	2		2	0.0113	0.9908	3	0.0091	2.1609	-3.7385
31 WALLACEBURG, ONT.	1		1	0.8965	0.8439	2	0.1561	-1.2496	-0.2764
32 WELLAND, ONT.	3		3	0.2433	0.9409	2	0.0495	2.2714	-0.0721
33 WINDSOR, ONT.	3		3	0.4182	0.9849	2	0.0138	2.6790	-0.2425

** DENOTE MISCLASSIFIED CASES

NOTE: THE ABOVE RESULTS MAY NOT CORRESPOND TO THE GROUP SCATTERPLOTS DUE TO OVERPRINTING OF CASES

Table 38: Development Group 1984: Groups and Discriminant Scores

CASE SEQNUM		ACTUAL GROUP		HIGHEST PROBABILITY GROUP	P(D/G)	P(G/D)	2ND HIGHEST GROUP	P(G/D)	DISCRIMINANT SCORES...	
1	DULUTH-SUPERIOR, MINN.	3		3	0.0839	0.9855	2	0.0075	3.0352	1.7265
2	TWO HARBORS, WIS.	1	**	2	0.8202	0.5602	1	0.4125	-0.7650	0.8869
3	ASHLAND, WIS.	1		1	0.6075	0.5169	2	0.4721	-1.2926	-0.4652
4	BAYFIELD, WIS.	1		1	0.6367	0.4853	2	0.3207	0.1780	-0.8071
5	LA POINTE, WIS.	3	**	1	0.6367	0.4853	2	0.3207	0.1780	-0.8071
6	SILVER BAY, MINN.	1	**	2	0.8202	0.5602	1	0.4125	-0.7650	0.8869
7	TACONITE, MINN.	1	**	2	0.8435	0.5527	1	0.4148	-0.6797	0.9671
8	WAUKEGAN, ILL.	1	**	2	0.1388	0.5323	1	0.2959	0.2861	2.1174
9	CHICAGO, ILL.	3		3	0.0294	0.9986	1	0.0010	4.0714	-1.0048
10	INDIANA HARBOR, IND.	1	**	3	0.9561	0.8589	1	0.0800	1.7913	0.2534
11	BURNS WATERWAY, IND.	3		3	0.7591	0.9166	1	0.0458	2.0930	0.5795
12	BUFFINGTON, IND.	1	**	2	0.8578	0.5446	1	0.4159	-0.5838	0.8550
13	GARY, IND.	1	**	2	0.8262	0.5536	1	0.4113	-0.6389	0.9117
14	PRESQUE ISLE, MI.	1	**	2	0.7982	0.4928	1	0.4903	-1.0643	-0.0987
15	DRUMMOND ISL., MI.	1		1	0.7828	0.5266	2	0.4493	-0.9111	-0.5082
16	TRAVERSE CITY, MI.	2	**	1	0.7136	0.5074	2	0.3485	0.0066	-0.7644
17	MANISTEE, MI.	1		1	0.7545	0.5294	2	0.4480	-0.9456	-0.5459
18	GRAND HAVEN, MI.	1		1	0.8208	0.5225	2	0.4511	-0.8626	-0.4552
19	HOLLAND, MI.	1		1	0.7571	0.5292	2	0.4481	-0.9424	-0.5424
20	ST. JOSEPH, MI.	1		1	0.8011	0.5334	2	0.4[illegible]47	-0.7749	-0.5[illegible]
21	MILWAUKEE, WIS.	3		3	0.8550	0.8824	1	0.0647	1.9042	0.4901
22	PORT WASHINGTON, WIS.	1		1	0.8011	0.5334	2	0.4347	-0.7749	-0.5856
23	SHEBOYGAN, WIS.	1		1	0.8032	0.5331	2	0.4348	-0.7722	-0.5826
24	KEWAUNEE, WIS.	1		1	0.8273	0.5347	2	0.4114	-0.5132	-0.6464
25	PORT HURON, MI.	1		1	0.0354	0.4843	3	0.3442	0.5097	-2.4692
26	ALPENA, MI.	1		1	0.7551	0.5294	2	0.4480	-0.9448	-0.5451
27	MARYSVILLE, MI.	1		1	0.6061	0.5168	2	0.4723	-1.2955	-0.4645
29	MARINE CITY, MI.	1		1	0.6061	0.5168	2	0.4723	-1.2955	-0.4645
29	DETROIT, MI.	3		3	0.0242	0.9984	1	0.0012	4.0149	-1.2890
30	KELLY'S ISL., OHIO	3	**	1	0.5494	0.4538	2	0.2885	0.3544	-0.8481
31	PORT INLAND, MI.	1	**	2	0.8721	0.5359	1	0.4178	-0.5061	0.9268
32	DETOUR, MI.	2	**	1	0.6484	0.5204	2	0.4664	-1.2073	-0.4850
33	ALGOMA, WIS.	1		1	0.5509	0.4544	2	0.2890	0.3515	-0.8475
34	CHARLEVOIX, MI.	2	**	1	0.8273	0.5347	2	0.4114	-0.5132	-0.6464
35	DETROIT HARBOR, WIS.	3	**	1	0.5056	0.4354	3	0.2930	0.4397	-0.8680
36	FRANKFORT, MI.	1		1	0.8160	0.5345	2	0.4275	-0.6896	-0.6054
37	KENOSHA, WIS.	3	**	2	0.1483	0.5863	1	0.3076	0.0244	2.1782
38	MACKINAC, MI.	1		1	0.7734	0.5226	2	0.3727	-0.1690	-0.7264
39	MARQUETTE, MI.	1		1	0.6061	0.5168	2	0.4723	-1.2955	-0.4645
40	ONTONAGON, MI.	1		1	0.8127	0.5312	2	0.3936	-0.3425	-0.6961
41	PUT-IN-BAY, OHIO	3	**	1	0.7734	0.5226	2	0.3727	-0.1690	-0.7264
42	SAULT STE MARIE, MI.	1		1	0.7545	0.5294	2	0.4480	-0.9456	-0.5459
43	ST. JAMES, MI.	1		1	0.7734	0.5226	2	0.3727	-0.1690	-0.7264
44	STURGEON BAY, WIS.	2		2	0.1388	0.5323	1	0.2959	0.2861	2.1174
45	ALABASTER, MI.	1	**	2	0.8733	0.5160	1	0.4182	-0.3298	0.7858
46	CALCITE, MI.	1	**	2	0.8613	0.5445	1	0.4166	-0.5915	0.8466
47	ESCANABA, MI.	1		1	0.5635	0.5130	2	0.4778	-1.3808	-0.4447
48	MARBLEHEAD, OHIO	1		1	0.7804	0.5316	2	0.4415	-0.8603	-0.5657

** DENOTE MISCLASSIFIED CASES

NOTE: THE ABOVE RESULTS MAY NOT CORRESPOND TO THE GROUP SCATTERPLOTS DUE TO OVERPRINTING OF CASES

Table 38 - continued

- CASE SEQNUM		ACTUAL GROUP		HIGHEST PROBABILITY GROUP	P(D/G)	P(G/D)	2ND HIGHEST GROUP	P(G/D)	DISCRIMINANT SCORES...	
49	OAK CREEK, WIS.	1	**	2	0.7256	0.4331	1	0.3934	0.1879	0.6654
50	PORT GYPSUM, MI.	1	**	2	0.7968	0.4657	1	0.4071	0.0144	0.7057
51	STONEPORT, MI.	1	**	2	0.8613	0.5445	1	0.4166	-0.5915	0.8466
52	TOLEDO, OHIO	3		3	0.0947	0.9844	2	0.0080	2.9976	1.6853
53	SANDUSKY, OHIO	1	**	3	0.1389	0.7194	1	0.2034	1.2966	-1.3512
54	LORAIN, OHIO	1		1	0.6098	0.5091	2	0.4807	-1.3231	-0.3816
55	CLEVELAND, OHIO	3		3	0.7569	0.8931	1	0.0574	1.9653	0.6699
56	FAIRPORT, OHIO	2	**	1	0.7626	0.5229	2	0.4564	-0.9858	-0.4730
57	ASHTABULA, OHIO	2		2	0.9915	0.5078	1	0.4511	-0.5932	0.4163
58	CONNEAUT, OHIO	1	**	2	0.5756	0.4920	1	0.3711	0.0854	1.1582
59	ERIE, PA.	3		3	0.9696	0.8299	1	0.0959	1.6838	0.2491
60	BUFFALO, N.Y.	1	**	3	0.9616	0.8090	1	0.1066	1.6176	0.2898
61	PORT CLINTON, OHIO	1		1	0.5939	0.4707	2	0.3051	0.2662	-0.9276
62	ROCHESTER, N.Y.	1	**	2	0.1213	0.4637	1	0.2727	0.5421	2.0579
63	BARCELONA, N.Y.	1		1	0.5494	0.4538	2	0.2885	0.3544	-0.8481
64	HARRISVILLE, MI.	1	**	2	0.1957	0.5291	1	0.4694	-2.2484	-0.2430
65	KEWEENAW WATERWAY, MI.	1		1	0.6484	0.5204	2	0.4664	-1.2073	-0.4850
66	BADGELEY, ISL., ONT.	1		1	0.8297	0.5343	2	0.4198	-0.5946	-0.6185
67	BRITT, ONT.	1	**	2	0.8763	0.5267	1	0.4184	-0.4208	0.8069
68	CARDINAL, ONT.	1	**	2	0.7979	0.5648	1	0.4095	-0.7922	0.9213
69	COLLINGWOOD, ONT.	1		1	0.8168	0.5344	2	0.4275	-0.6885	-0.6042
70	CORNWALL, ONT.	3	**	1	0.6131	0.5162	2	0.4727	-1.2871	-0.4554
71	COURTRIGHT, ONT.	1	**	2	0.4418	0.5474	1	0.3575	-0.0867	1.5040
72	CUTLER, ONT.	1	**	2	0.8435	0.5527	1	0.4148	-0.6797	0.8671
73	GODERICH, ONT.	1	'	1	0.9049	0.5062	2	0.4634	-0.7821	-0.2541
74	HAMILTON, ONT.	3		3	0.1467	0.9821	1	0.0090	2.9185	1.4743
75	KINGSTON, ONT.	1		1	0.6607	0.5198	2	0.4666	-1.1901	-0.4739
76	KINGSVILLE, ONT.	1		1	0.8182	0.5298	2	0.3935	-0.3321	-0.6747
77	LAKEVIEW, ONT.	1	**	2	0.6753	0.5557	1	0.3892	-0.3935	1.1799
78	LITTLE CURRENT, ONT.	1	**	2	0.8440	0.4931	1	0.4144	-0.1541	0.7515
79	MARATHON, ONT.	3	**	2	0.8120	0.4794	1	0.4093	-0.0561	0.7455
80	MELDRUM BAY, ONT.	1		1	0.8023	0.5086	2	0.3702	-0.0847	-0.6343
81	MIDLAND, ONT.	2	**	1	0.7238	0.5268	2	0.4542	-1.0309	-0.5263
82	MORRISBURG, ONT.	2		2	0.8425	0.5528	1	0.4145	-0.6770	0.8699
83	NANTICOKE, ONT.	1	**	2	0.7158	0.4892	1	0.3929	-0.0116	0.9390
84	OAKVILLE, ONT.	1	**	3	0.6365	0.4487	1	0.2803	0.8341	0.5497
85	OSHAWA, ONT.	2		2	0.1388	0.5982	1	0.3063	-0.0273	2.2273
86	PELEE ISL., ONT.	1		1	0.7977	0.5279	2	0.3844	-0.2625	-0.7042
87	PICTON, ONT.	1	**	2	0.7982	0.5452	1	0.4060	-0.4691	0.9723
88	PORT DOVER, ONT.	1		1	0.5509	0.4543	2	0.2890	0.3521	-0.8469
89	PORT STANLEY, ONT.	3	**	1	0.8162	0.5316	2	0.4353	-0.7554	-0.5643
90	SARNIA, ONT.	1	**	3	0.0760	0.4970	1	0.3638	0.8264	-2.1183
91	SOMBRA, ONT.	1	**	2	0.8673	0.5159	1	0.4172	-0.3204	0.7960
92	THOROLD, ONT.	1	**	3	0.4584	0.5304	1	0.3026	0.9215	-1.0275
93	ST. CATHARINES, ONT.	1	**	2	0.8327	0.5533	1	0.4126	-0.6534	0.8955
94	TORONTO, ONT.	3		3	0.0297	0.9970	1	0.0023	3.6878	-1.6466
95	WINDSOR, ONT.	3		3	0.0504	0.9965	1	0.0026	3.6147	-1.3984

** DENOTE MISCLASSIFIED CASES

NOTE: THE ABOVE RESULTS MAY NOT CORRESPOND TO THE GROUP SCATTERPLOTS DUE TO OVERPRINTING OF CASES

Table 39: Crossvalidation Group 1984: Groups and Discriminant Scores

SEQNUM	GROUP		GROUP	P (D/G)	P (G/D)	GROUP	P (G/D)	SCORES...	
1 LUDINGTON, MI.	1	**	3	0.0373	0.5329	1	0.4658	1.9368	-1.5153
2 MUSKEGON, MI.	1		1	0.5067	0.9442	2	0.1558	-1.6387	-0.3892
3 MANITOWAC, WIS.	1		1	0.9890	0.9801	2	0.0199	-0.5624	-1.0923
4 GREEN BAY, WIS.	3		3	0.3239	1.0000	2	0.0000	3.9440	1.7232
5 SAGINAW-BAY CITY, MI.	3		3	0.0547	0.9964	1	0.0036	3.3367	-2.1355
6 ST. CLAIR, MI.	1		1	0.4855	0.8446	2	0.1554	-1.6931	-0.3959
7 MONROE, MI.	1		1	0.8628	0.9428	2	0.0572	-1.1205	-0.7462
8 OGDENSBURG, N.Y.	2		2	0.2618	0.9963	1	0.0032	0.3395	2.6825
9 CHEBOYGAN, MI.	1		1	0.8520	0.9903	2	0.0096	-0.1908	-1.3250
10 GLADSTONE, MI.	1		1	0.9890	0.9801	2	0.0198	-0.5639	-1.0927
11 MACKINAC CITY, MI.	1		1	0.6050	0.9949	2	0.0046	0.1823	-1.5573
12 MENOMINEE, MI.	1		1	0.8628	0.9428	2	0.0572	-1.1205	-0.[illegible]
13 TWO RIVERS, WIS.	1		1	0.6050	0.9949	2	0.0046	0.1823	-1.557[illegible]
14 PORT DOLOMITE, MI.	2		2	0.7580	0.9825	1	0.0175	-1.6901	1.7773
15 HURON, OHIO	1		1	0.4477	0.7772	2	0.2228	-1.6548	-0.2237
16 OSWEGO, N.Y.	2		2	0.1723	0.9998	1	0.0002	-0.7782	3.5442
17 AMHERSTBURG, ONT.	1		1	0.8520	0.9903	2	0.0096	-0.1908	-1.3250
18 BATH, ONT.	2		2	0.0864	0.5372	1	0.4628	-2.5909	0.1889
19 CLARKSON, ONT.	2		2	0.8180	0.9112	1	0.0888	-0.4517	1.2884
20 COLBORNE, ONT.	2		2	0.5377	0.7495	1	0.2501	-0.2039	0.9520
21 MICHIPICOTEN, ONT.	2		2	0.6817	0.8519	1	0.1480	-0.3055	1.0873
22 OWEN SOUND, ONT.	1		1	0.9908	0.9714	2	0.0286	-0.7535	-0.9747
23 PARRY SOUND, ONT.	1		1	0.9908	0.9714	2	0.0286	-0.7535	-0.9747
24 PORT COLBORNE, ONT.	1		1	0.9625	0.9668	2	0.0331	-0.3567	-0.8662
25 PORT MCNICOLL, ONT.	1		1	0.9890	0.9801	2	0.0198	-0.5639	-1.0927
26 PRESCOTT, ONT.	1		1	0.4816	0.8300	2	0.1700	-1.6075	-0.3532
27 SERPENT RIVER, ONT.	2		2	0.9679	0.9778	1	0.0222	-1.1978	1.7475
28 SPRAGGE, ONT.	3		3	0.0900	0.5968	1	0.3746	1.6883	-0.3020
29 THUNDER BAY, ONT.	3		3	0.0175	1.0000	2	0.0000	4.7348	2.9202
30 BOWMANVILLE, ONT.	2		2	0.7369	0.9881	1	0.0119	-1.6937	1.9243
31 SAULT STE MARIE, ONT.	3		3	0.1257	1.0000	1	0.0000	5.3880	-1.0703

** DENOTE MISCLASSIFIED CASES

NOTE: THE ABOVE RESULTS MAY NOT CORRESPOND TO THE GROUP SCATTERPLOTS
DUE TO OVERPRINTING OF CASES

Appendix F

PORT GROUPINGS USING DISCRIMINANT ANALYSIS

Figure 14

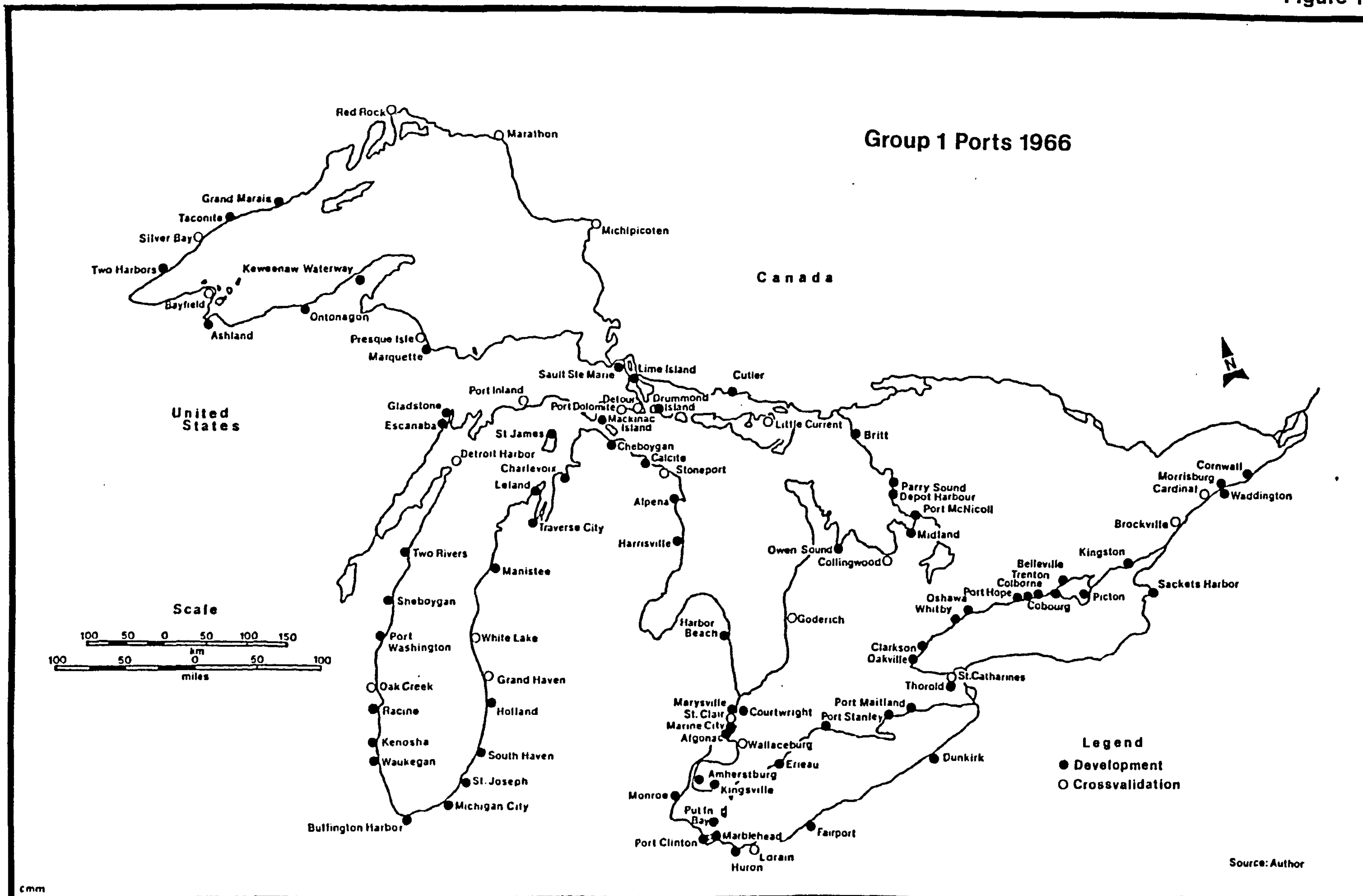
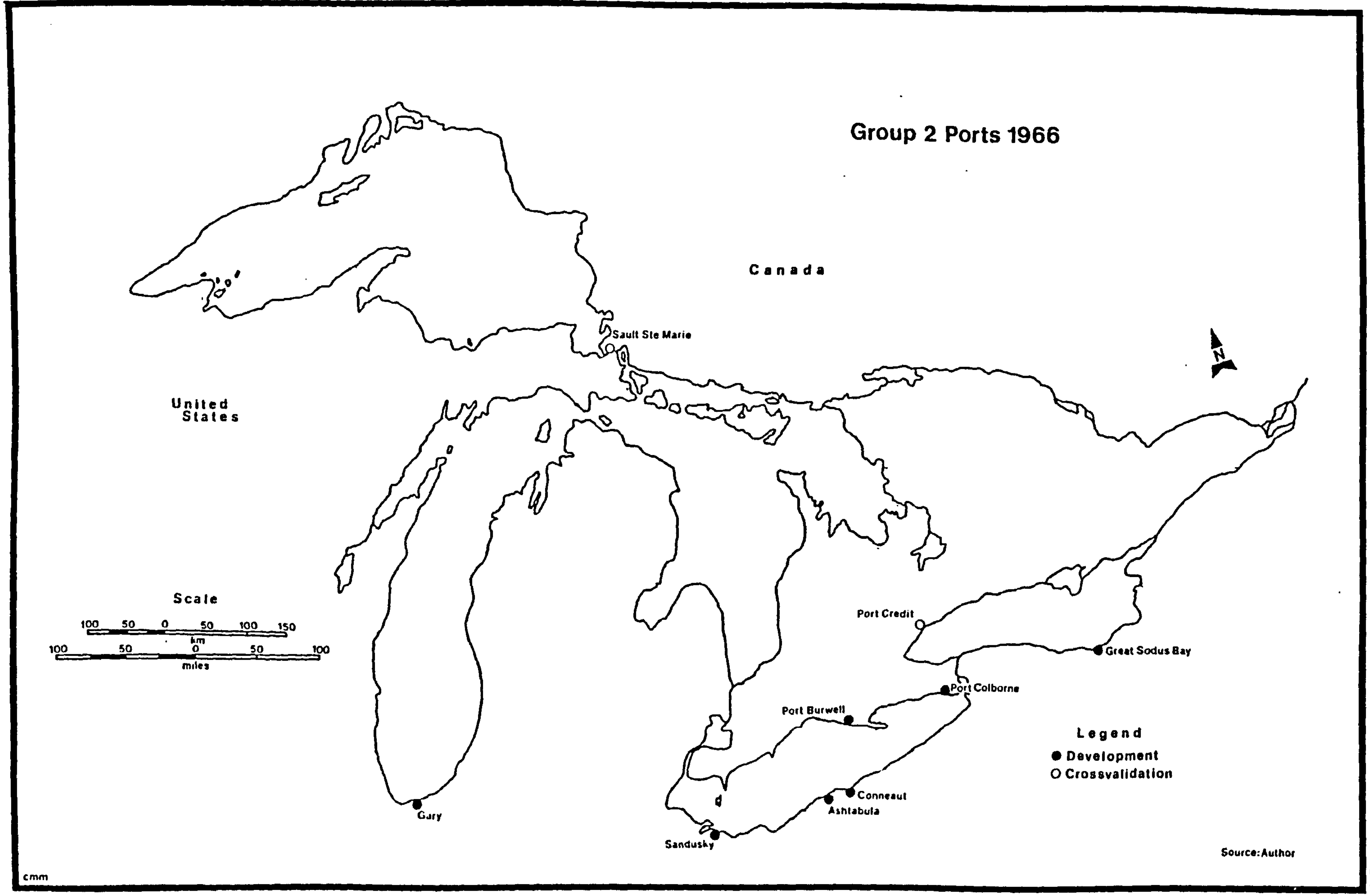
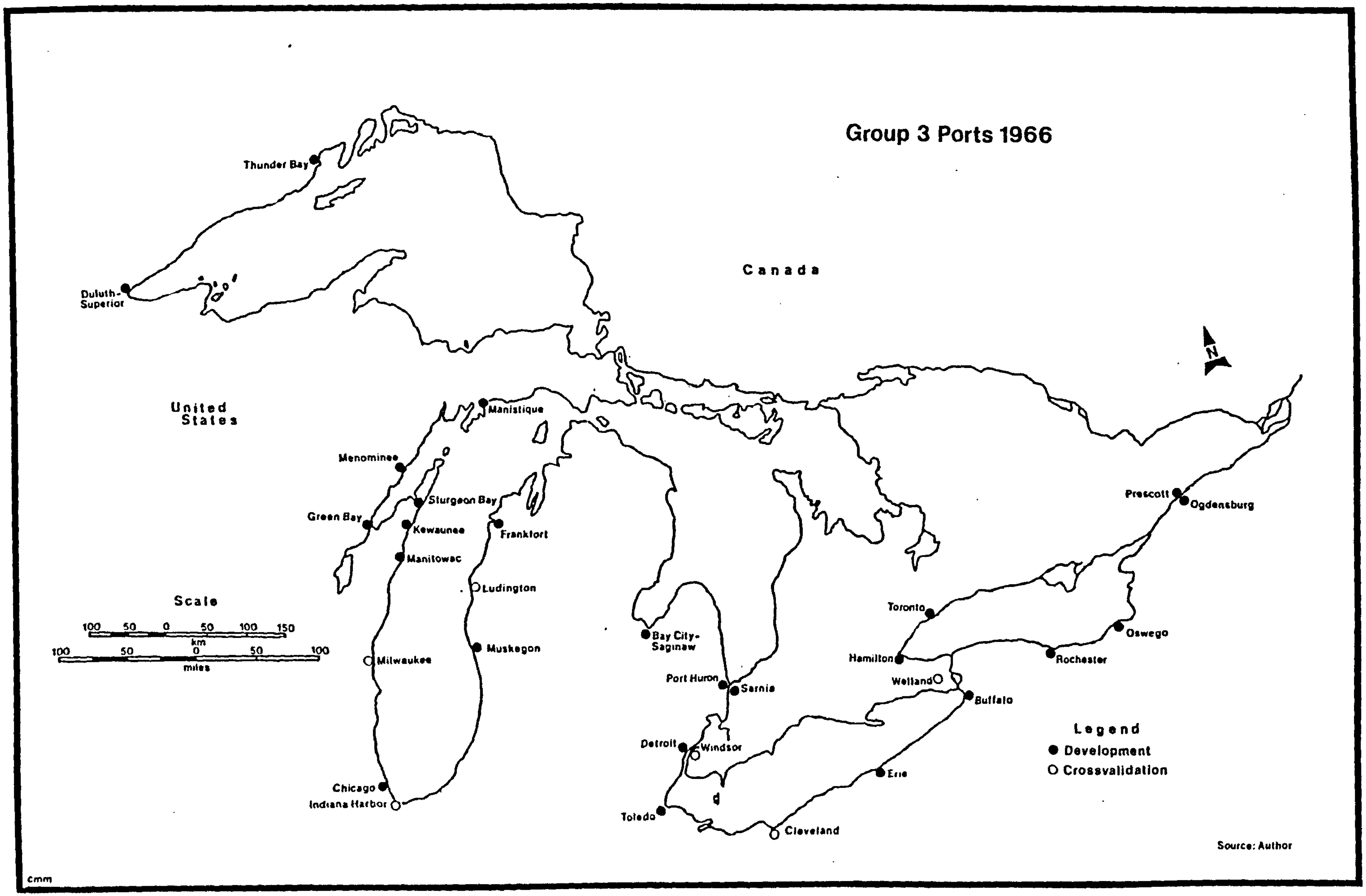

Group 1 Ports 1966
Canada
United States
Red Rock
Marathon
Grand Marais
Taconite
Silver Bay
Two Harbors
Keweenaw Waterway
Bayfield
Ashland
Ontonagon
Presque Isle
Marquette
Michipicoten
Sault Ste Marie
Lime Island
Cutler
Port Inland
Gladstone
Escanaba
Detour
Port Dolomite
Drummond Island
Mackinac Island
Little Current
Britt
St James
Detroit Harbor
Charlevoix
Leland
Traverse City
Cheboygan
Calcite
Stoneport
Alpena
Harrisville
Two Rivers
Manistee
Sheboygan
Port Washington
White Lake
Oak Creek
Grand Haven
Racine
Holland
Kenosha
Waukegan
South Haven
St. Joseph
Michigan City
Buffington Harbor
Parry Sound
Depot Harbour
Port McNicoll
Midland
Owen Sound
Collingwood
Goderich
Harbor Beach
Marysville
St. Clair
Marine City
Algonac
Courtwright
Wallaceburg
Erieau
Amherstburg
Kingsville
Monroe
Put In Bay
Marblehead
Port Clinton
Huron
Lorain
Fairport
Dunkirk
Port Maitland
Port Stanley
Thorold
St.Catharines
Clarkson
Oakville
Oshawa
Whitby
Port Hope
Colborne
Trenton
Belleville
Cobourg
Picton
Kingston
Sackets Harbor
Brockville
Cardinal
Morrisburg
Cornwall
Waddington
N
Scale
100 50 0 50 100 150
km
100 50 0 50 100
miles
Legend
● Development
○ Crossvalidation
Source: Author
cmm

Figure 15



Group 2 Ports 1966
Canada
United States
Sault Ste Marie
Port Credit
Great Sodus Bay
Port Colborne
Port Burwell
Conneaut
Ashtabula
Sandusky
Gary
N
Scale
100 50 0 50 100 150
km
100 50 0 50 100
miles
Legend
● Development
○ Crossvalidation
Source: Author
cmm

Figure 16



Group 3 Ports 1966
Canada
United States
N
Thunder Bay
Duluth-Superior
Manistique
Menominee
Sturgeon Bay
Green Bay
Kewaunee
Frankfort
Manitowoc
Ludington
Milwaukee
Muskegon
Chicago
Indiana Harbor
Bay City-Saginaw
Port Huron
Sarnia
Detroit
Windsor
Toledo
Cleveland
Erie
Buffalo
Welland
Hamilton
Toronto
Rochester
Oswego
Prescott
Ogdensburg
Scale
100 50 0 50 100 150
km
100 50 0 50 100
miles
Legend
● Development
○ Crossvalidation
Source: Author
cmm

Figure 17

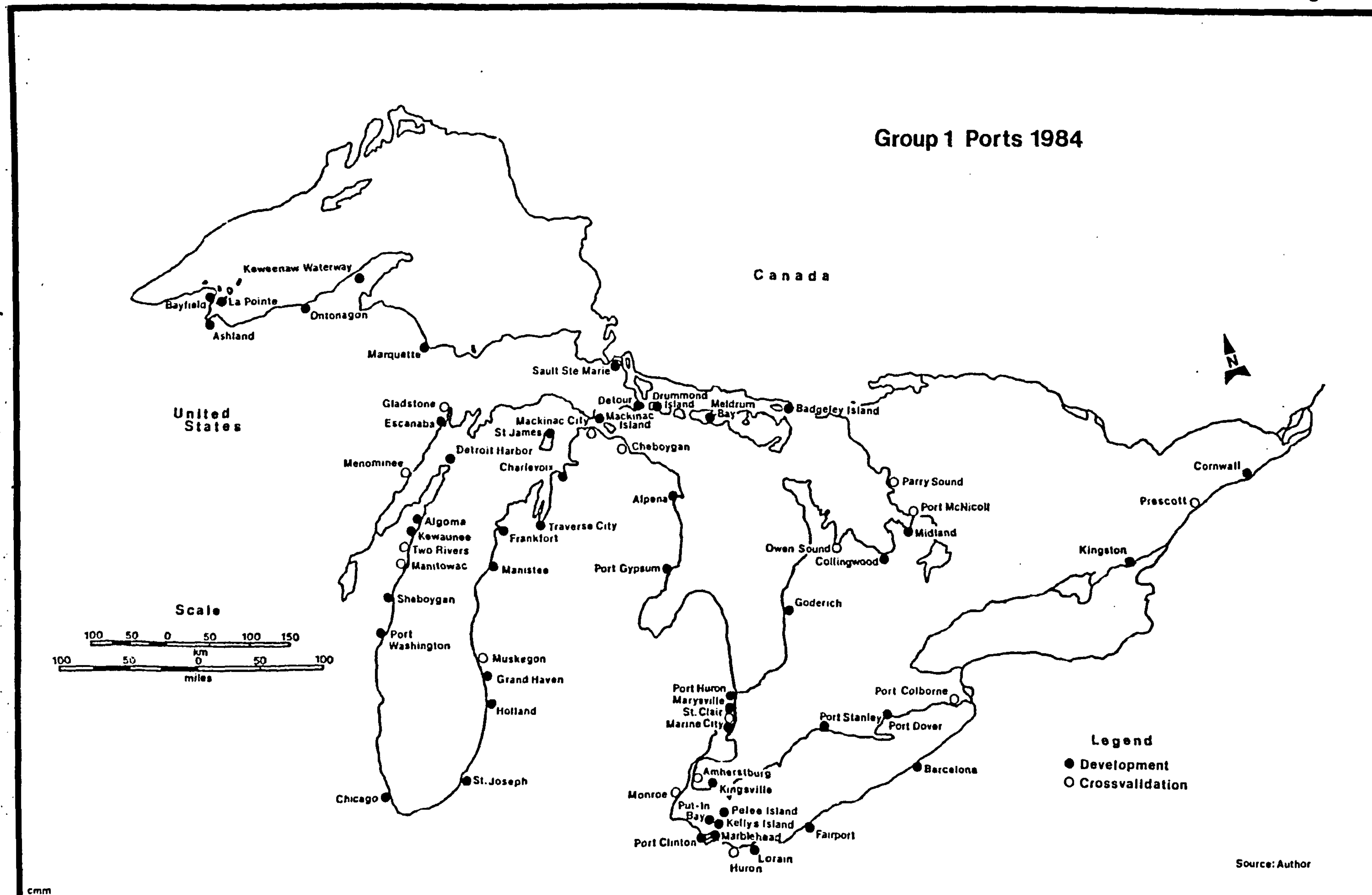
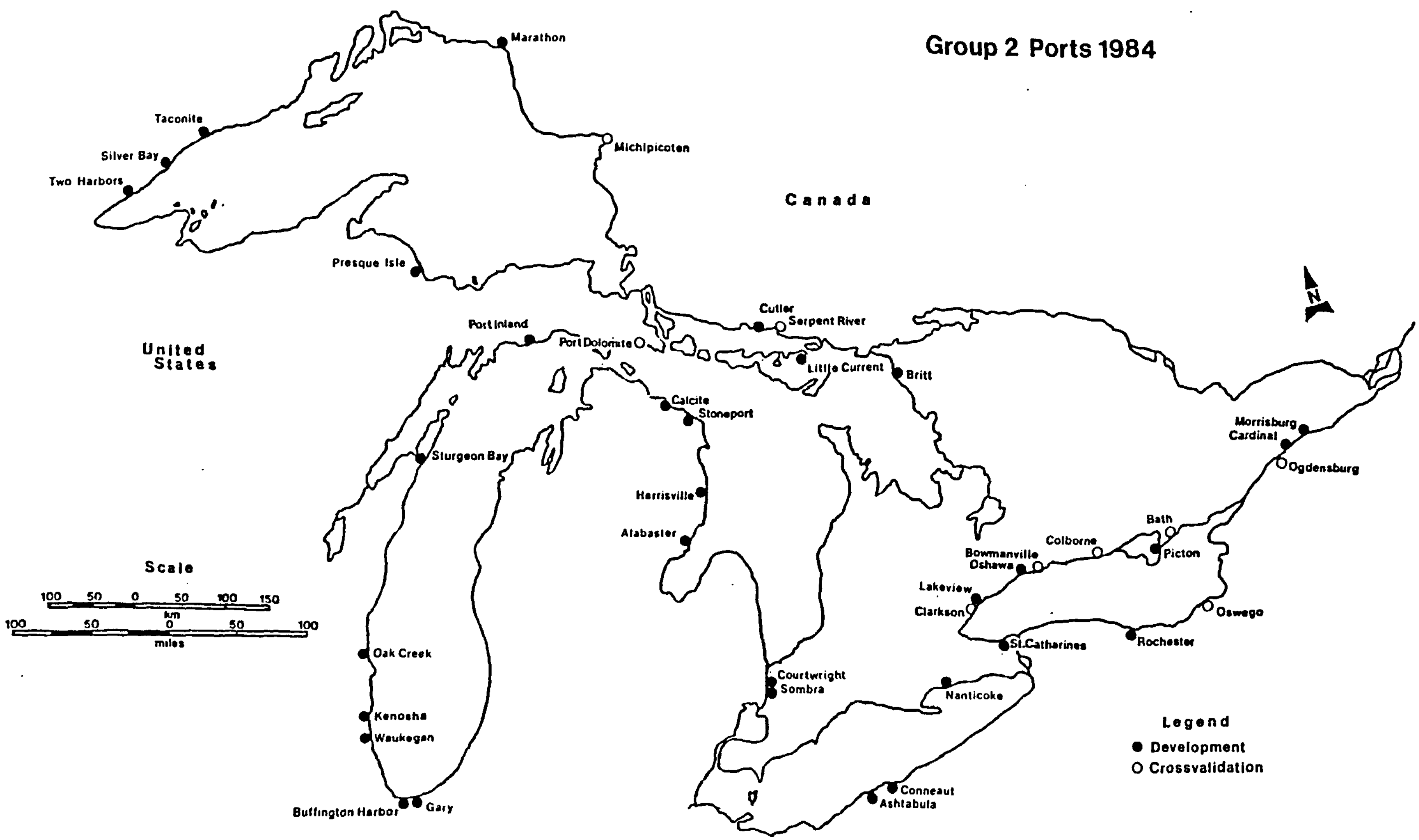

Group 1 Ports 1984
Canada
United States
Keweenaw Waterway
Bayfield
La Pointe
Ashland
Ontonagon
Marquette
Sault Ste Marie
Detour
Drummond Island
Meldrum Bay
Badgeley Island
Mackinac City
Mackinac Island
St James
Cheboygan
Gladstone
Escanaba
Detroit Harbor
Charlevoix
Menominee
Alpena
Traverse City
Frankfort
Algoma
Kewaunee
Two Rivers
Manitowac
Manistee
Port Gypsum
Sheboygan
Port Washington
Muskegon
Grand Haven
Holland
Chicago
St. Joseph
Parry Sound
Port McNicoll
Midland
Owen Sound
Collingwood
Goderich
Cornwall
Prescott
Kingston
Port Huron
Marysville
St. Clair
Marine City
Port Colborne
Port Stanley
Port Dover
Amherstburg
Kingsville
Monroe
Put-in Bay
Pelee Island
Kellys Island
Marblehead
Port Clinton
Lorain
Huron
Fairport
Barcelona
Scale
100 50 0 50 100 150
km
100 50 0 50 100
miles
Legend
● Development
O Crossvalidation
Source: Author
cmm

Figure 18

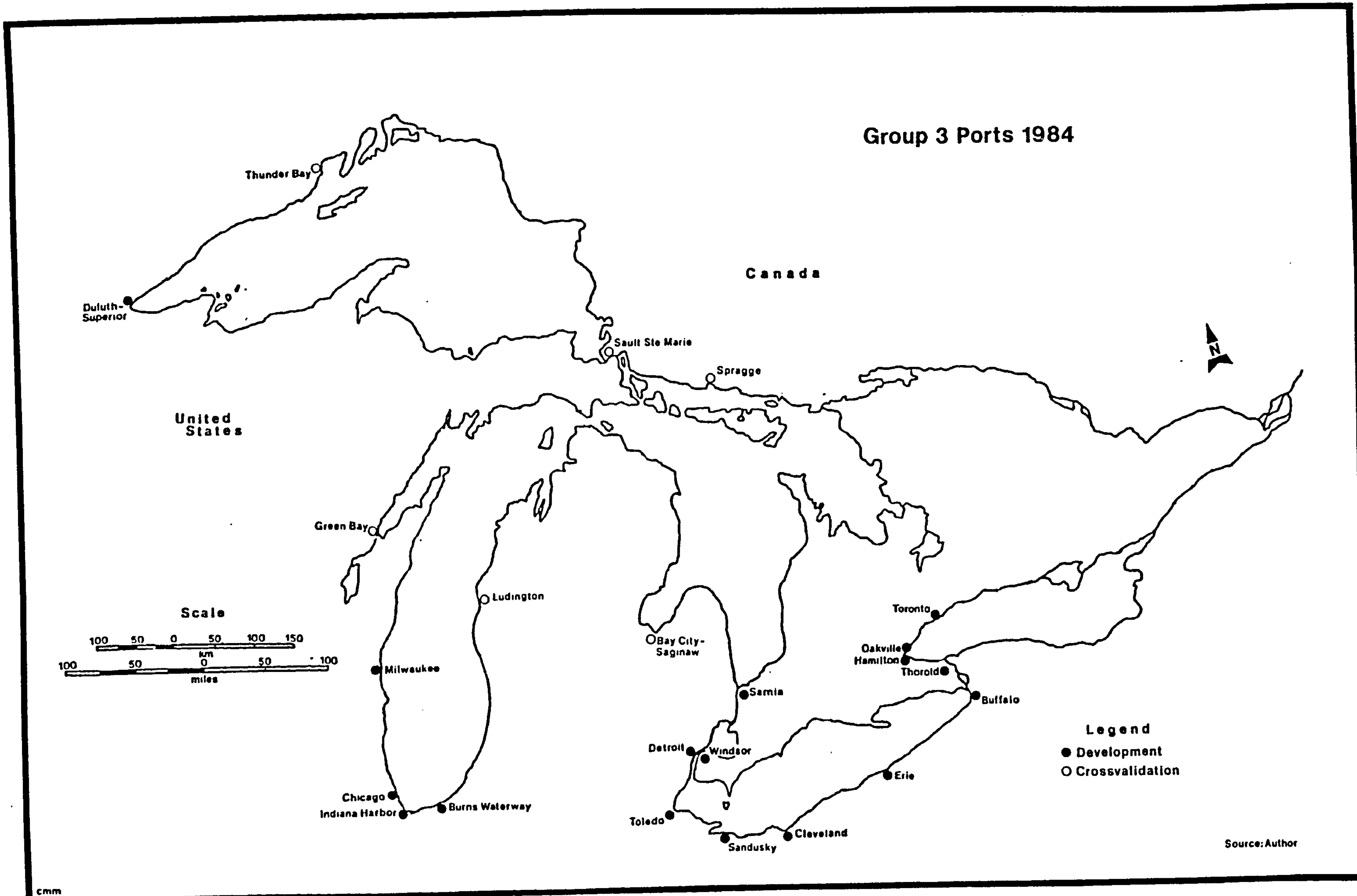
Group 2 Ports 1984



Source: Author

cmm

Figure 19



Group 3 Ports 1984

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