MIT
SEA
GRANT
PROGRAM

USING CO-OPERATIVES TO AID THE NEW ENGLAND FISHING INDUSTRY

by
Henry S. Marcus
James R. Townley, Jr.
Alan J. Brown
Eddie Lee

Massachusetts Institute of Technology

Cambridge, Massachusetts 02139

Report No. MITSG 75-7
December 31, 1974

MITSG 75-7

USING CO-OPERATIVES TO AID

THE NEW ENGLAND FISHING INDUSTRY

by

Henry S. Marcus
James R. Townley, Jr.
Alan J. Brown
Eddie Lee

Report No. MITSG 75-7

Index No. 75-307-Nel

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS. 02139

SEA GRANT PROGRAM

ADMINISTRATIVE STATEMENT

Fishing co-operatives can provide the individual fisherman, who is essentially a small businessman, with economies of scale in purchasing supplies and transporting fish, a marketing organization, and tax advantages. Increasing the effectiveness of New England co-operatives depends in part on improved management practices.

A new fishing co-operative should carefully consider the framework of its accounting system. This report describes how accounting systems should reflect the way in which co-operatives function and how co-operatives differ from normal corporations. An established co-operative must consider all aspects of its business environment. This study looks at many key factors present in New England, such as the dependence of co-operatives marketing fin fish on one fish market in New York, the declining level of popular types of fin fish, the extremely competitive fresh fish processing industry, the imports of fresh fish from Canada, and the high level of imports of foreign fish in frozen form.

A federation of co-operatives could provide more bargaining power in the marketplace and greatly aid in providing a reliable supply of fish to meet a given demand; however, social, political, and geographic factors made formation of such a "super" co-op presently infeasible for the three New England co-operatives considered in this study. Innovative fisheries co-operatives could also explore the sale of seafood to distant domestic and foreign markets; underutilized species are particularly suited for such a venture. This research describes a system management approach for analyzing such complex innovative marketing schemes; this methodology is applied to analyze the feasibility of shipping fresh sea urchin roe from Maine to Japan.

Funds for this research effort and report came in part from the NOAA Office of Sea Grant, U.S. Department of Commerce Grant No. 04-5-158-1, and from the Massachusetts Institute of Technology.

Ira Dyer
Director

December 1974

ACKNOWLEDGEMENTS

This research was made possible with the help of a large number of persons comprising a wide variety of occupations, including: fishermen, fishing co-operative managers, processors, employees of federal agencies such as the National Marine Fisheries Service and the Department of Agriculture, personnel of state agencies, business analysts of Banks for Co-operatives, supermarket managers, and Certified Public Accountants. The authors are grateful for all assistance received.

The authors wish to thank the industry advisors, James Ackert, Gayle Charles, Thomas Fulham, and Hugh O'Rourke, and the initial Associate Investigator, Professor Gordon Bloom. These gentlemen were particularly valuable at the outset in steering the authors away from "dead end" paths of research. In addition, graduate students, Jack Price and Gary Miyashiro, provided aid to the authors.

The authors would also like to single out for thanks Roland Hodgdon and Porter Little of the Springfield Bank for Co-operatives, Thomas McGuire of the Chatham Seafood Co-operative, Leonard Stasiukiewicz of the Point Judith Fishermen's Co-operative Association, Joseph Taves of O. C. Moyer & Co., John O'Brien of the National Marine Fisheries Service, John

Linehan of Maritime Terminal, Inc., Reggie Bouchard of the Maine Department of Marine Resources, Ralph Stevens of the Stinson Carring Co., and John Stokes of the Tri Coastal Seafood Co-op, Inc.

The authors are indebted to Associate Dean Chuck Y. Gee, School of Travel Industry Management, University of Hawaii and his students, Sherman Anderson, Amy O. M. Chan, Elaine Hurip, and Susan Runyan, for performing a survey analyzing the feasibility of selling fresh New England seafood in Hawaii.

The NOAA Office of Sea Grant,Department of Commerce provided funding to make the project possible. The authors are duly grateful for this support.

Finally, the authors wish to add an additional word of thanks to Gayle Charles, former manager of the Provincetown Co-operative Fishing Industries. Not only did he provide valuable guidance and information to the authors, but he was also a constant source of encouragement and inspiration to the authors throughout this research.

CONTENTS

LIST OF FIGURES

PART 2: AN ANALYSIS OF ACCOUNTING SYSTEMS FOR FISHERIES CO-OPERATIVES

PART 3: FUTURE PROSPECTS FOR NEW ENGLAND DOMESTIC AND IMPORTED FISH PROCESSING AND HANDLING FACILITIES

LIST OF TABLES

PART 1

RESEARCH IN PERSPECTIVE

SUMMARY AND CONCLUSIONS

Background

Much has been written about the fishing industry and fishing co-operatives in general. Research related to analyzing statistical fisheries data, setting up a co-operative, applying different fishing techniques, etc. can be found, and the authors refer to these publications when appropriate in this four-part study.

However, the authors, in this research, are trying to provide insight into the New England fishing industry to help determine how fishing co-operatives can be more effective. The thrust of this research was to put into perspective the role of fishing co-operatives, their problems, and their future.

The Concept of Co-operatives

A myth held by many persons relates that co-operatives are designed to be non-profit organizations. While the myth continues to be believed by some, it is patently false. From a business point of view, co-operatives have certain tax advantages over corporations. Basically, the co-operative is a profit-making business just like a normal corporation except that the co-operative pays taxes on its profits at the tax rate of the individual members rather than at the higher corporate tax rate. Therefore, the individual member, theoretically, can gain a better return on his investment than through a corporate venture where he would receive dividends, after the corporation had paid taxes on its profits. Consequently, even businesses selling such non-agriculture products as soap powder have chosen to operate as co-operatives rather than normal corporations.

Thus, it can be seen that the co-operative is simply a form of business organization in many respects and must strive to serve an economic need or discontinue its existence.

New England Co-operatives

Table 1 shows a list of fishing co-operatives in New England. Several of these co-operatives were formed in the past few years. One of these new co-operatives asked for aid from the M.I.T. research team in setting up an accounting system. Surprisingly, nothing had been written specifically on this topic.

This request created an interesting challenge for the research team. An accounting system is basically a formalized information control mechanism which allows someone to manage a business. Consequently, a key prerequisite to designing an accounting system for a fishing co-operative is to understand how that fishing co-operative actually functions.

By studying the accounting systems of various existing fishing co-operatives, the authors were able to understand how they operated, how they differed from normal corporations, and how they differed from each other. The results of this research are included in Part 2 of this study, An Analysis of Accounting

FISHERY CO-OPERATIVES IN NEW ENGLAND*

CONNECTICUT

Southern New England Fishermen's Association, Inc. (Stonington)

MAINE

Beals-Jones Co-op (Jonesport)
Boothbay Region Lobstermen, Inc.
Casco Bay Fisheries Co-op, Inc.
Corea Lobster Co-operative, Inc.
Fishermen's Co-operative Association (Biddeford Pool)
Maine Lobstermen's Association (Stonington)
New Harbor Fishermen's Co-op
Pemaquid Fishermen's Co-operative Association
Port Clyde Fishermen's Co-op
South Bristol Fishermen's Co-op
South Maine Lobstermen's Association (Biddeford Pool)
Spruce Head Fishermen's Co-op
Stonington Lobster Co-op, Inc.
Swan's Island Fishermen's Co-op, Inc.
Vinalhaven Fishermen's Co-op

MASSACHUSETTS

Chatham Seafood Co-operative
Gloucester Whiting Association, Inc.
New Bedford Seafood Co-operative Association, Inc.
Provincetown Co-operative Fishing Industries
The Atlantic Lobstermen's Co-operative, Inc. (Saugus)
Tri Coastal Seafood Co-op, Inc. (Newbury)

RHODE ISLAND

Point Judith Fishermen's Co-operative Association, Inc.

*For more information refer to Ref. 1 and Ref. 8

Table 1

Systems For Fishing Co-operatives. It is hoped that Part 2 of this study will be useful in aiding newly formed co-operatives to set up their accounting systems. While any such co-operative will need the assistance of a Certified Public Accountant, Part 2 will hopefully help them to understand the many functions of the co-operative and how they are reflected in an accounting system. Part 2 also explains alternative types of accounting systems available to be used by a new co-operative.

Financial Management

A financing device unique to co-operatives is the revolving fund plan. Many persons regard it as "the most effective plan for raising capital, maintaining co-operative practices, and keeping control of an association in the hands of its current members and patrons".[1] Through the revolving capital plan individual patron's contributions of capital are allocated on the books of co-operatives for return to them at a later date. A revolving fund period of ten years is not uncommon for agricultural co-operatives. Such a system, when operated properly, provides the co-operative with a constant source of working capital at a low cost while the members are assured of receiving their funds back at the end of the revolving fund period.

The use of revolving funds in fisheries co-operatives is explained in Part 2 of this study. However, it is interesting to note that the fin-fish co-operatives analyzed in this research

---

[1]Ref. 5, p. 39

were not able to set a definite revolving fund period because of the poor cash flows of the co-operatives. It must be explained that a fishing co-operative can determine what its profit or surplus will be simply by setting the rate at which the co-operative will charge its members for each pound of fish handled. If the co-operative charges a "high" rate to its members, the co-operative can retain more surplus funds via the revolving fund plan and return the funds at the end of the revolving fund period. With a "low" rate charged, the co-operative members see their money quicker but the co-operative now has to borrow money from the bank at high interest rates. Assuming that the fishing co-operative members cannot invest their funds at a return equal to the bank's borrowing rate--typically the case--it is in the best interests of the fishermen to have the co-operative charge a rate high enough to take care of its working capital needs and to maintain a revolving fund with a definite time period for reimbursing the members.

Managing Fishermen

The authors mentioned to fishing co-operative managers that it would be in the best interests of their members to increase the rate charged to its members so that they could decrease their short-term bank loans and maintain a formalized revolving fund plan with a definite time period. The managers agreed with the logic of the action but stated that their members simply wouldn't stand for the short-term loss of funds even though it was in their best interest in the long run.

The authors questioned persons who were familiar with both agricultural and fishing co-operatives to discover why agricultural co-operatives seemed to be able to handle revolving fund plans in a more efficient manner than the fisheries co-operatives. The answers related to the independent nature of the fisherman combined with the lack of government effort directed to fisheries co-operatives versus agricultural co-operatives. There are more than 7600 farm-related co-operatives in the U. S. compared to less than 100 fisheries co-operatives.[2] Traditionally, the Federal government through such means as the Farmer Co-operative Service, U. S. Department of Agriculture, has concentrated more resources on educating the farmers to using co-operatives effectively than the fishermen.

The behavioral characteristics of fishermen relative to land-lubbers may have a significant effect on the role of management in fishing co-operatives. The impact of the independent individualistic nature of fishermen should not be underestimated. A sociological study comparing fishermen to mill workers shows the importance of independence to the fishermen. When asked, "What are the most important things to you about your job? That is, what do you think you get from your job in comparison to other types of work you could do?", the most frequent response from fishermen was "independence"--an answer not mentioned at all by their land-lubber counterparts![3]

---

[2]Ref. 2, p. 1 and Ref. 1, p. 1

[3]Ref. 10, pp.55-56

In addition, the research shows that "fishermen tend to worry more about losing their boats than losing their wives, while, on the countrary, the mill workers worry about losing their wives than about losing their jobs."[4] Another difference between fishermen and land-based workers is the large number of taboos associated with the fishing industry.[5] While fishermen might disclaim believing in these "superstitions," they would often admit that they dared not "break the rule" of the superstitions aboard their own boats.[6]

Although fishermen belonging to co-operatives apparently realize the value of doing so, it may be that some fishermen view co-operatives as a "necessary evil." As one manager humorously described his relationship with the fishermen:[7]

> "Each fisherman is technically my boss. I wouldn't say they take advantage of this point, but at times my relationship with the fishermen is the same as a hydrant is to a dog."

Successful Fishing Co-operatives

Most co-operatives are involved in supplies and/or marketing. While many fishery co-operatives do only a small amount of marketing, the main three co-operatives marketing fin fish in New England are those in Pt. Judith, Chatham and Provincetown.

---

[4] Ref. 10, p. 106

[5] See table of taboos in Ref. 10, pp. 94-95

[6] Ref. 10, p. 96

[7] Ref. 4, p. 9

The authors originally planned to compare more successful co-operatives with less successful co-operatives. However, as one industry observer so bluntly put it, "If a co-operative is still running, it is successful. All the unsuccessful ones no longer exist."

The authors eventually agreed that this oversimplified statement was essentially correct. While the co-operatives studied varied in many ways, it was difficult to pinpoint differences that would greatly impact on the co-operative's success. Types of equipment were reasonable for the fishing done at each locality (most fishing trips of boats of co-operatives did not last more than a day or two). While geographic location of co-operatives put some at an advantage to others in respect to delivering the product to major markets, an efficient highway system in New England minimized any such disadvantages.

There are a number of finance programs available to fishermen and/or fisheries co-operatives including: fisheries loan fund, fishing vessel mortgage loan and insurance program, vessel construction differential subsidy program (presently inactive), capital construction fund, fishermen's protective fund, small business administration program, farm credit system, co-operative bank system and production credit system.[8] However, the use of these programs by various co-operatives and their members did little to explain the success or failure of a co-operative.

---

[8] See References 6 and 7 for more information

Even when a fin-fish co-operative or the surrounding locality received a grant from the Economic Development Administration or the Office of Economic Opportunity, the impact on the success of the co-operative was not particularly noticeable. Factors that did seem of major importance were the choice of manager and the marketing system.

Importance of Leadership

Unlike a typical business corporation, each member of a fishing co-operative generally has one vote. Consequently, the role of manager in a co-operative made up of individualistic fishermen is both difficult and important. The authors' views are borne out by both domestic and international research. A United Nations report states, "The selection of a manager is of capital importance, particularly at the beginning, since on him depends the life or death of the co-operative. . . ."[9] Closer to home, a University of Rhode Island publication noted that, "Those with experience in co-operatives could not overemphasize the importance of the manager."[10]

Marketing of Fin Fish

While New England fishing co-operatives market their fresh fish to a number of locations, the majority of fish ends up at

---

[9] Ref. 3, p. 8

[10] Ref. 6, p. 5

at the Fulton Fish Market in New York. Here an unusual business transaction takes place. The businessman at the Fulton Fish Market, who is basically a wholesaler, receives delivery of the fish in the early morning hours. By the start of the normal business day he has already sold the fish. Then he calls the fishing co-operative to tell it the price he will pay for the fish.

Since a typical fishing co-operative supplies a small amount of fish relative to the volume of the Fulton Fish Market, the buyer in New York enjoys a position of power; essentially, he cannot lose no matter at what price he ends up selling the fish. Needless to say, the typical fishing co-operative is in a less than ideal position in this transaction.

Alternatives to the Fulton Fish Market include auctions at certain major fishing ports. However, possible collusion in some instances among the relatively small number of buyers works to the disadvantage of the fishing co-operative. This overall situation faced by the New England fishing co-operatives has led many persons to recommend that fishing co-operatives take a more active role in processing as well as marketing their fish directly to the retailer. A recent study concluded the integration of the functions of fishing, processing, marketing and distribution particularly by the fishermen themselves, may be the "way of the future."[11]

---

[11] Ref. 9, p. 42; take note of all the appendices.

Fish Processing

Consequently, the authors devoted Part 3 of this study to an analysis of New England handling and processing facilities for both domestic and imported fin fish. Frozen fish as well as fresh were included because these products compete to some extent in the marketplace.

Conclusions from Part 3 include the verification of the intuitive observation that processing of fresh fish in New England (unlike frozen fish) is a declining industry which is extremely competitive. In addition, interviews with supermarket officials in New England left little hope that a single fishing co-operative could do much in the way of selling fresh fish directly through a large supermarket chain. Obstacles to such a venture included the unpredictable nature of daily supply and the perishability of the product.

Competition From Canada

A further obstacle to the idea of having a co-operative market fresh fish to supermarkets in New England was the possible competition from fresh fish trucked into New England from Canada. This Canadian fish is typically sold at a lower price than local fish. The data developed in Part 3 shows that the volume of imported fish of popular varieties such as cod and haddock is sufficient to flood New England markets for such products. Research at Harvard Business School concerning the possible promotion of fresh ocean perch in New England reached similar conclusions:[12]

> "If fresh ocean perch were promoted in New England, the market would respond in a very predictable manner. First, the suppliers, knowing the price sensitivity of the market would be more price sensitive themselves and purchase (at) the lowest price available. Since more ocean perch would be sold fresh, it would now be economically feasible for the Canadians to ship the product down as they are presently doing for one of the country's largest grocery chains. This price, being significantly lower than the United States price, would immediately flood the market. The United States processors could no longer compete in the market and would have a very rough time even holding on to their present volume. An example of this could be the pollock promotion where even though the fish was not as price sensitive as ocean perch, the immediate effect of the promotion was to increase imports by 15%. Thus if ocean perch were promoted, it would most likely deteriorate the already depressed New England fisheries."

Formation of a "Super" Co-op

As in any industry, size plays a factor in fishing co-operatives. While a small co-operative having a disagreement with the buyers in Fulton Fish Market can find that Fulton Fish Market can simply refuse to accept delivery of his truckload of perishable fish (as has happened), a large co-operative has enough power in the marketplace to avoid this problem. The Pt. Judith Co-operative with approximately 16 million pounds of edible fish per year has such a volume and a variety of fish that its trucks have never been refused at the Fulton Fish Market.

---

[12]Ref. 11, p.26

The formation of a "super" co-op or federation of co-ops, consisting of Pt. Judith with the two smaller co-ops at Chatham and Provincetown, would provide a business entity with more bargaining power in the market place than any of the individual co-ops. In addition, such a tri-co-op venture would be better able to be a reliable supplier of various fish, since the pooling of the resources of the three co-ops would improve the probability of meeting a given demand for fish.

The reasons above led persons to speculate on the formation of such a "super" co-op. Mr. Robert Tabor, a Commercial Fisheries Extension Specialist with the Marine Advisory Service at the University of Rhode Island, was among the key persons promoting such a venture. Tables 2 and 3, developed from data assembled by Dr. J. Perry Lane of the National Marine Fisheries Service, show the potential resources of such a "super" co-op. One proposal recommended that the "super" co-op market fresh fish only, of highest quality, prepackaged and aimed through the food chains toward the consumer. A brand name emphasizing that the high quality fresh fish were caught on domestic vessels would hopefully reduce competition from Canadian fish. A processing and handling facility would be located separately from the existing facilities, perhaps in a depressed area available for aid from the Economic Development Administration or the Office of Economic Opportunity.

PT JUDITH
PROVINCETOWN
CHATHAM

MARKET AVAILABILITY

Total Weights Available by Month for All 3 Co-operatives - 1971 Data
(thousands of lbs)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cod	192	204	219	191	230	478	505	582	311	143	41	64
Haddock	19	35	22	16	12	65	154	177	119	62	9	23
Blackback	151	93	239	398	465	734	624	405	337	298	356	264
Yellowtail	591	733	887	936	686	349	173	129	212	141	241	290
Pollock	4	7	3	10	21	31	19	13	13	8	6	138
Whiting	14	9	82	42	191	707	690	479	294	162	170	179
Scallops	6	140	4	5	9	7	4	3	4	4	5	5
Tuna	---	---	---	---	---	1	46	31	20	6	6	---
Squid	8	25	30	13	89	41	27	11	49	100	204	26

Table 2

*   Less than 1/2%
--- None reported

PERCENTAGE OF TOTAL CATCH FOR GIVEN SPECIES BY ALL 3 CO-OPERATIVES - 1971 DATA

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cod	P-Town	5	4	4	3	3	4	4	3	---	---	---	---
	Chatham	*	1	1	2	3	11	12	16	10	4	1	1
	Pt. Judith	1	2	3	1	*	*	*	*	*	*	1	1
Haddock	P-Town	1	*	*	*	1	2	13	2	2	5	1	1
	Chatham	2	2	3	2	1	7	8	22	14	3	*	1
	Pt. Judith	*	*	*	*	*	*	*	1	1	*	*	1
Blackback	P-Town	1	*	2	4	5	3	5	5	4	3	2	1
	Chatham	---	---	---	---	---	---	---	---	---	---	---	---
	Pt. Judith	2	2	3	5	6	13	10	4	3	3	7	5
Yellow-tail	P-Town	2	2	2	2	2	2	1	1	1	1	1	2
	Chatham	---	---	---	---	---	---	---	---	---	---	---	---
	Pt. Judith	9	12	15	15	10	5	2	2	3	2	4	4
Pollock	P-Town	1	2	1	2	1	1	1	1	2	1	2	49
	Chatham	*	*	*	1	6	10	6	7	3	2	*	---
	Pt. Judith	--	---	---	---	---	---	---	---	---	---	---	---
Whiting	P-Town	---	---	---	---	---	*	3	3	3	3	3	*
	Chatham	---	---	---	---	---	---	---	---	---	---	---	---
	Pt. Judith	*	*	3	1	6	23	20	13	7	3	2	6
Scallops	P-Town	3	70	2	2	5	3	2	1	2	2	3	3
	Chatham	---	---	---	---	---	---	---	---	---	---	---	---
	Pt. Judith	---	---	---	---	---	---	---	---	---	---	---	---
Squid	P-Town	---	---	---	---	28	*	*	---	*	2	2	---
	Chatham	---	---	---	---	3	1	*	*	*	*	---	---
	Pt. Judith	1	3	4	2	5	3	3	1	6	11	23	3
Tuna	P-Town	---	---	---	---	---	1	43	29	19	5	5	---
	Chatham	---	---	---	---	---	---	---	---	---	---	---	---
	Pt. Judith	---	---	---	---	---	---	---	---	---	---	---	---

Table 3

The authors had been looking forward to working with supporters of this "super" co-op concept to help evaluate its feasibility and possibly aid its implementation. However, while the general idea of "super" co-ops was seen to have definite potential benefits, a combination of social, political, and geographic factors made such a venture infeasible for the three specific co-ops considered.

New Markets for New England Seafood

The problems encountered by New England fishing co-operatives in marketing their products in northeast part of the U. S. caused the authors to consider more distant markets for New England seafood. Part 4 describes a survey conducted in Hawaii to determine the feasibility of airfreighting fresh New England fish to Hawaii. (All the work on this survey was directed by Associate Dean Chuck Y. Gee of the School of Travel Industry Management at the University of Hawaii.) New England lobster is presently airfreighted to Hawaii and preliminary results of the survey show potential for flounder and other New England fish. However, more research is needed in this area before reaching definite conclusions.

Foreign countries also provide potential markets for New England seafood as shown by the success of a new fishing co-op shipping tuna to Japan. While such a venture faces dangers from competition and domestic quotas, it shows that opportunity does exist for innovative fish co-ops.

Underutilized Species

Much attention has recently been focused on underutilized species in New England. With an initial earmarking of $400,000 in Federal funds, the National Oceanic and Atmospheric Administration, through its National Marine Fisheries Service, has instituted the New England Fisheries Development Program. Several advisors were named to represent industry in the program. The New England Fisheries Development Program is planned for three years, but this is flexible according to NMFS. During the three-year time period, government expenditures are expected to be about $2 million. Initial plans call for efforts to be concentrated on a three-pronged effort to catch, process, and market three abundant resources that are not fully utlized--offshore crabs, squid and mixed species that are now usually discarded at sea because they are considered to have little or no value. Some of this seafood, not particularly popular in New England, is in great demand in certain foreign countries.

Systems Management Approach

It is clear that potential exists for shipping New England seafood to distant markets. In Part 4 of this study, the authors present a systems management approach to analyzing the economic feasibility of complex business ventures shipping New England seafood to distant markets. While this methodology can be applied to any seafood product, the authors chose an example of shipping fresh sea urchin roe from Maine to Japan, an enterprise not yet commercially tried.

Fresh sea urchin roe is an interesting item for study. Since large quantities are located within the state coastal waters of Maine, the state could manage the resource if it chose to do so. In addition, foreign competition will not enter this area. While the roe could theoretically be exported to countries other than Japan, since the roe is now shipped to Japan from California, Japanese experts brought to Maine by Japan Airlines feel that the roe in Maine is of superior quality to the West Coast product and will demand a higher price in Japan. Because the amount of processed roe from each sea urchin weighs so little, it would be feasible for many business ventures to join together and pool their resources to decrease the transportation costs of shipping the roe. Consequently, the economic characteristics of the business system would encourage cooperative actions between fishermen, or possibly processors, to make this enterprise more profitable. While it would appear that this venture is only marginally profitable, based on the research in Part 4, the authors would recommend that a test shipment be made to Japan to verify the assumptions used in the economic calculations.

Concluding Comments

While government actions, such as the 200-mile limit, will have significant effects on the overall profitability of the New England fishing industry, the fishing co-operative will continue to serve an important role in the industry. Recently, a federation of Maine co-operatives was formed with the help of Mr. John Mathieson of State of Maine, Department of Marine Resources. More than ten co-operatives, many new and extremely eager for help, created the Maine Association of Co-ops. While it is too soon to predict the success or failure of this venture, there is no doubt that cooperative action has a great potential in New England. The authors hope that this four-part study will be able to play a small role in aiding fishing co-operatives in New England.

REFERENCES

1. Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service. United States Department of the Interior. "List of Fishery Co-operatives in the United States. 1969-1970" Fishery Leaflet 627, June 1970.

2. Farmer Co-operative Service, U. S. Department of Agriculture, "Statistics of Farmer Co-operatives, 1969-1970," FCS Research Report 22, July 1972.

3. Food and Agriculture Organization of the United Nations, Manual on Fishermen's Studies, FAO Fisheries Studies, No. 13, Rowe, 1971.

4. Gersuny, Carl and Poggie, John J., Jr., "A Fishermen's Co-operative: Open System Theory Applied," Maritime Studies and Management, April 1974.

5. Hulbert, Helim H.; Griffin, Nelda; and Gardner, Kelsy B., "Methods of Financing Farmer Co-operatives," Farmer Co-operative Service, U. S. Department of Agriculture, General Report 32, June 1957.

6. Marine Advisory Service, University of Rhode Island, "Fisheries Co-operatives: Their Formation and Operation," Marine Memorandum 20, 1972.

7. Mathieson, John H., Marine Engineering Advisor, Extension Service, State of Maine, "A Report on Financial Assistance Presently Available to Fishermen," October 1972.

8. Mathieson, John H., Marine Engineering Advisor, Extension Service, State of Maine, "Maine Fisherman's Organization List," February 8, 1974.

9. Mulvihill, Donald F., and Konopa, Leonard J., Final Report--NOAA 2-34364, Application of Computer Technology and Advanced Physical Distirbution Techniques to Seafood Marketing, Center for Business and Economic Research, College of Business Administration, Kent State University, Kent, Ohio, August 1974.

10. Poggie, John J., Jr., and Gersuny, Carl, Fishermen of Galilee, University of Rhode Island, Marine Bulletin Series November 17, Kingston 1974.

11. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service Market Research and Services Division, "The Promotion of Ocean Perch in New England," May 1973.

PART 2

AN ANALYSIS OF ACCOUNTING SYSTEMS FOR FISHERIES CO-OPERATIVES

CHAPTER I

FISHERIES CO-OPERATIVES — AN INTRODUCTION

Fisheries co-operatives, based on the concept of other forms of co-operatives such as farmers' co-operatives, have become increasingly more popular in recent years as a result of rising costs and the inability of fishermen as individuals to cope with the uncertain fluctuations in supply and demand for fishery products, as well as with wholesale fish dealers who have consistently taken advantages of the fishermen due to their inherently weaker bargaining positions.

Frederick J. Smith, a marine economist from Oregon State University, defined the co-operative principle: "A fishery co-operative is a group of individual fishermen acting together for mutual benefit; it is an organization designed to accomplish group objectives. Through the co-operative, members jointly perform or obtain services which individuals could not perform or obtain alone. Fishermen members own the co-operative by owning capital stock or by paying membership fees. Each member usually has only one vote, in contrast to non-co-operative corporations where votes are based upon the number of shares held by an individual. Therefore, ownership and controls are equally vested in each of the co-operative members guaranteeing all members equal voice in the affairs of the organization. Management is usually placed in the hands of persons selected by the board of directors who, in turn, are elected by the members." [1]

---

1. Ref. 16, pp. 1-2.

There are about one hundred co-operative associations in the commercial fisheries of the United States. Of the 139,000 fishermen, about 11 thousand are members of fishery co-operatives.[2] Many fishery co-operatives located in the United States perform both a marketing and a purchasing function. In marketing, the co-operative may take a fisherman's catch and handle or process it for later sale, or it may act as a bargaining agent and arrange to sell and deliver the catch to another firm. Supplies and equipment required for fishing operations are stocked and sold to fishermen.

By joining a co-operative and pooling their resources, members can obtain a combination of one or more of the following services:

1. Acquire their own trucks to carry their catch to markets or processing plants;

2. Obtain repair facilities and get their vessels and gear serviced as employer rather than client;

3. Pool their catch and employ marketing specialists to sell more advantageously than they could do individually;

4. Purchase supplies and equipment on a wholesale basis;

5. Secure competent representation in dealing with banks and other financial institutions, e.g., assist members in obtaining loans;

6. Operate retail stores, freezing plants and cold storage warehouses on behalf of the co-operating fishermen;

7. Provide dock facilities;

---

2. Ref. 12 pp. 1-3

8. Operate processing plants (filleting rooms, etc.) and ice plants;

9. Provide business record services and market research inaccessible to the unaffiliated individual;

10. Facilitate contacts with state and federal agencies on behalf of members (e.g. legislative lobbying, contact with the National Marine Fisheries Service).

These services of fishing co-operatives are primarily ways for coming to grips with the social environment by means more advantageous than those available to unaffiliated fishermen.[3]

A fishery co-operative is formed on a non-profit basis from the legal and accounting standpoint. But it is important to realize that a co-operative has to operate economically and efficiently in order to survive.

In organizing a fishery co-operative, the fishermen should proceed by examining the common problems and needs, defining the purpose and functions of the proposed co-operative, checking its economic feasibility, and finally investigating the procedures of establishing a co-operative. Such assistance can be obtained from the Co-operative Extension Service, Oregon State University Sea Grant Marine Advisory Program, National Marine Fisheries Service, Small Business Administration, some local attorneys, accountants, and financial institutions.

When it has been determined that a co-operative should be organized and its services are identified, consideration should

---

3. Ref. 1, pp. 4-6.

then be given to its legal, capital and operational structure. Such information can be obtained from the literature that deals with the organization and operation of fisheries co-operatives:

1. Organizing and Operating A Fishery Co-operative, parts one and two, by Frederick J. Smith.

2. Fisheries Co-operatives: Their Formation and Operation, Marine Advisory Service, University of Rhode Island Marine Memorandum 30.

3. Organizing and Operating Fishery Co-operatives in the United States, United States Department of the Interior.

4. Special Presentation at Sea Grant Conference of March 28-29 1972, by Leonard J. Stasiukiewicz, general manager of Point Judith Fishermen's Co-operative Association.

5. A Fishermen's Co-operative: Open System Theory Applied, by Carl Gersuny and John J. Poggie, Jr.

Accounting Needs of A Fishery Co-operative

To determine the efficiency of the operation of a fishing co-operative, some means of measurement have to be devised for control and decision-making. This is where the data gathering of an accounting system would come in. An accounting system is the organization of forms, records, and reports, closely co-ordinated to facilitate business management through the determination of certain basic and required information, and the analysis thereof.

For a fishery co-operative, such information can be the amount of profit earned in a given period; the assets, liabilities, and net worth of the co-operative at any time; the volume of products transacted in a given period; inventory on hand; amounts customers still owe, or the amounts still owing to fishermen; and also such information required to prepare federal and state income tax reports, etc.

The procedures via which the various information is recorded are as important as the design of the forms involved. In this study attempts are made to provide some general guidelines in setting up an accounting system for a fishery co-operative. The approach is to first examine some of the philosophies behind the formation of a fishery co-operative in Chapter I. Chapter II is a discussion of accounting systems in general, pointing out their importance in modern business, and describing some of their contents. In Chapter III, basic elements of accounting are introduced. That includes the definition of accounting terms, examples of procedures in bookkeeping, a sample of chart of accounts, and the trend in automation in accounting practices. Taxation aspects of fishery co-operatives is the topic for Chapter IV. The similarities and dissimilarities between a co-operative and non-co-operative are analyzed with regard to the tax laws applicable. Then, in Chapter V, the framework for a design of an accounting system is set up by describing how such a framework can be applied towards a model fishery co-operative. In the process, a model co-operative is created. For this study, the author had conducted surveys on three New England fishery co-operatives. These findings are recorded in Chapter VI. Finally, some concluding remarks will be presented in the last chapter.

CHAPTER II

THE NATURE OF ACCOUNTING SYSTEMS

Introduction

Management is faced with decision-making responsibilities every day. In making many of these decisions, management has to rely on the information provided them. A great deal of this information comes from accounting, which may be defined broadly as a systematic means of providing information on the economic affairs of an organization.

Information from accounting is used by different people in an organization to attain different objectives. For example, executives in a business organization must use accounting information to improve the efficiency of the enterprise, while investors need accounting information in deciding how much money to invest in the enterprise and on what terms.[1]

The value of accounting to management rises with the help management needs. If the job is complex, big, and demanding, there is too much risk in using intuition, hunch, hearsay, and a highly personalized approach to making decisions. The alternative is data, as the standard for decision making. And much if not nearly all of the data wanted by management for decision making is gathered, sifted, studied, and made available to management in meaningful contexts by the accounting system.[2]

Nature of Accounting System

The accounting system is an organization of forms, records, and reports, closely coordinated to facilitate business management through determining certain basic and required information. The

1. Ref. 3, p. 3.
2. Ref. 4, p. 3.

information that management needs to obtain includes the following: 1) the amount of profit earned in a given period; 2) the assets, liabilities, and net worth of the business at any time; 3) a large amount of supplementary detailed information such as the amount of sales, how much the customers have paid, the amount they still owe, the amount of purchases, the amounts still owing to the creditors, and inventories on hand; 4) information required for the preparation of federal and state income tax reports, withholding tax reports, employee earnings reports, distribution costs, and rate making data for public utilities.

The principle activity within the accounting system is the processing of data; indeed the system as a whole may be looked upon as a complex data processor. Various devices ranging upward from simple adding machines have long been used to handle segments of the data processing activities, and with the development of more advanced machines, increasingly large segments of accounting systems have become mechanized. Electronic computers represent a major advance in this direction, and in many instances they can be used to handle all phases of a complete section of an accounting system without human intervention.[3]

No matter what the nature of the business may be, every accounting system is made up of the following:

1. A series of printed forms such as invoices, vouchers, checks, and reports, which are used in establishing certain accounting and office systems and routines, and which are the basis for making accounting entries.

---

3. Ref. 11, pp. 3-5.

2. A series of books, or substitutes therefor, in which the original entries are made from these records. These books are the large number of journals that may be used.
3. A series of ledgers in which the information recorded in the journals is summarized or collected under account headings.
4. A series of reports or statements such as trial balances, abstracts of ledgers, income statements, and balance sheets.
5. A series of clerical operations which must be performed in recording the accounting information on forms, journals, and ledgers, and in providing reports and statements. The most common of these operations are writing, reproducing, calculating, listing, sorting, and transferring to and matching the information on forms or in the accounting books or records.
6. An increasing use of machines and equipment to expedite the work, lower the cost of performance, and reduce the possibility of error. These may be grouped as follows:[4]

WRITING DEVICES

- Typewriters
- Billing machines
- Autographic registers
- Check-writing and check-signing devices
- Addressing machines
- Pegboards

REPRODUCING DEVICES

- Duplicating machines
- Addressing machines
- Numbering devices
- Microfilming
- Photo-copiers

CALCULATING MACHINES

- Adding machines
- electronic devices
- Elapsed-time computers
- Postage scales
- Tickometers

SORTING DEVICES

- Punched-card sorters
- Keysorters
- Mechanical tabulators and counters
- Bursting or cutting machines
- Cash registers

---

4. Ref. 14, pp. 3-6.

ACCOUNTING AND TRANSFERRING MACHINES

- Posting machines
- Journalizing machines
- Cash registers
- Tabulating machines
- Integrated data processing devices
- Electronic computers
- Teletypewriting and telegraphic devices

CHAPTER III

INTRODUCTION TO BASIC ACCOUNTING

Accounting can be broadly defined as the systematic way of recording the events of an organization in order to provide the management or parties concerned with adequate information for decision making. From the accountant's point of view, a business enterprise may appear to be a collection of assets subject to a common control and employed for profit. This concept is closely related to the two basic reports the accountant produces: the balance sheet, which includes a list of the firm's assets; and the income statement, which shows the amount of profit obtained from their use.

An asset is a thing of value to its owner. Examples of assets are bank deposits, claims against customers for goods sold or services rendered, and inventories. The firm's assets are financed from two sources, its owners and its creditors. A creditor is someone from whom the firm has borrowed capital, the amounts of which are called its liabilities. Owners, unlike creditors, have no fixed dollar claims against the firm. Instead, they have residual interest, the rights to that portion of the firm's assets and profits that are left over after the creditor's claims are met. The amounts contributed to the enterprise by the owners are often referred to as the proprietors' or owners' equity.

A complete description of the status of an organization at a point in time requires a list of its liabilities and equities as well as its assets, and these are shown in the balance sheet or statement of financial position. If liabilities of a firm are included under the heading of equities, as a creditor's equity, then in a sense, the assets and equities of a firm are merely two ways of describing the same capital mass. The assets are the forms and the equities are the sources of the company's capital, and thus the assets and equities appearing on the firm's balance sheet must be equal. ASSETS = EQUITIES. See Fig. 5-1.

The significant events in the life of a business firm are the changes in its assets and equities--what the accountant calls transactions. Since the equality of assets and equities cannot be destroyed, each transaction must give rise to equal and opposing effects, that is, to two or more changes such that the symmetry of the balance sheet is maintained. Thus, assets and equities may be increased equally, as when money is borrowed, or decreased equally, as when the loan is repaid. Similarly, assets may be converted into other assets. This concept of the dual nature of a company's capital and the recognition of the effect of every transaction on both classifications underlies the recording system described as double-entry bookkeeping, which will be discussed later on.

Since profit is the main concern of a business enterprise, events that generate profit or income are of particular significance. Profit or loss of a firm may be defined as the increase or decrease in the firm's assets that result- from its operations and not from additional investments of capital by owners and creditors. These relationships are shown in the income statement or statement of operations as illustrated in Fig. 5-2.

Obviously, the capital forms and sources and the operations of a firm involve physical objects of widely varying physical characteristics. However, each has one common attribute of interest to a business—its money prices as the common denominator in arriving at the amounts of assets, equities, and net income.

Transaction Analysis

The accounting equation provides us with a framework within which to analyze transactions as they occur. The equation in each case is how the transaction affects the firm's asset and its equities. For purposes of illustration, four transactions are considered in the following:

1. Mr. Jones formed Jones Company with initial capital of $20,000.
2. Jones Company received $5,000 worth of supplies on credit from a supplier.
3. Jones Company purchased $7,000 worth of equipment in cash.
4. Jones Company negotiated a 2-year lease on the office space, and paid the rent for three months in advance for $2,400.

The analysis of these events can be summarized as follows:

TABLE 3-1

Asset Increase	Accompanied	Owner's Equity Increase
Cash $20,000	by	Jones, Proprietor $20,000

This recording indicates quite exactly the nature of the divorcement between Mr. Jones and Jones Company. The company has the $20,000; Mr. Jones has an equity in the business in the amount of $20,000.

In the second transaction, the firm acquired an asset, $5,000 worth of supplies. Since the supplier extended credit for a period of time, a liability of equal amount was also created. Hence:

TABLE 3-2

Asset Increase	Accompanied	Liability Increase
Inventory $5,000	by	Accounts Payable $5,000

Note that this transaction involves both a purchase by the Jones Company and a short-term investment in that firm by the supplier. Purchases made on a credit basis are an important source of capital for most business concerns.

The equipment was purchased for cash, and therefore involved simply the exchange of one asset for another:

TABLE 3-3

Asset Increase	Accompanied	Asset Decrease
Equipment $7,000	by	Cash $7,000

In the last transaction, the firm acquired for $2,400 the use of building space for three months. Since this clearly represents certain value to the firm, it is considered to be an asset:

TABLE 3-4

Asset Increase	Accompanied	Asset Decrease
Prepaid Rent $2,400	by	Cash $2,400

Again, one asset has been exchanged for another with no change in the equities, and the total assets remain unchanged at $25,000.

These assets were supplied partly by Mr. Jones ($20,000) and partly by the supplier ($5,000). The accounting equation is still in balance.

Bookkeeping Method: Accounts

It would not be difficult to prepare a balance sheet for Jones Company at this point, since only four transactions have taken place, and one could easily go back to the basic documents relating to them—bank deposit slips, check stubs, and supplier bills or invoices—and draw off the information needed. Anyone who relies on this method for decision-making would soon run into great difficulties as transactions accumulate. Even a small firm will have many thousands of these transactions over the course of one year. Some means of dealing with these transactions systematically and efficiently is needed. This need had led to the development of the concept of the account.

An account is simply a place in which to record the effects of many different kinds of transactions on a particular kind of asset or equity. Thus cash is readily distinguishable from any other kind of asset such as merchandise inventories. Any transactions involving cash are recorded in the cash account. In the example, the cash account would show the following figures :

TABLE 3-5: CASH

Date	Description	Increase	Decrease	Balance
Month,day	Investment	20,000		20,000
" "	Equipment purchase		7,000	13,000
" "	Prepayment for rent		2,400	11,600

Double-Entry Bookkeeping

In the example, it has been shown that the four transactions involve the determination of the types of assets and equities affected and how the changes were to be recorded. Then an entry was made to record these classified effects in the appropriate accounts. In the system being used, each transaction was shown to have effects on two kinds of assets or equities—in other words, on two accounts. This followed automatically from the fact that the balance sheet merely shows two aspects of the same thing. Thus if one asset increases, it follows that another asset is reduced, that an equity is increased, or both. This is the basis for the bookkeeping method most commonly in in business firms of any size, double-entry bookkeeping.

T-Accounts

The account may take any one of a number of forms, depending on the kind of data processing equipment used and on the preferences of the accounting system designer. It is useful to keep a complete record of changes in account balances. The simplest form of an account is the "T-account" or "Skeleton account" as illustrated below:

TABLE 3-6: Account Title

Amounts of changes in one direction	Amounts of changes in the opposite direction

The cash account of Jones Company should appear as follows in T-account form:

TABLE 3-7 : CASH

Beginning balance....... 0	Transaction 3 7,000
Transaction 1 20,000	Transaction 4 2,400
Balance, date 11,600	

The conventional rules governing the use of T-accounts may be summarized as follows:

1. An increase in an asset, is entered on the left side of the T as is the balance in the asset account.
2. A decrease in an asset is entered on the right side of the T.
3. An increase in an equity, is entered on the right side of the T, as is the balance in the equity account.
4. A decrease in an equity is entered on the left side of the T.[1]

A more general notion used by an accountant is as follows:

Debit for an entry on the left side, meaning by this an increase in an asset or a decrease in an equity; and

Credit for an entry on the right side, meaning by this an increase in an equity or a decrease in an asset. (The abbreviations for these two terms are Dr. and Cr., respectively.)

The Chart of Accounts

The first step in establishing an accounting system is to prepare a complete list of the account titles to be used, based on a study of the nature of the enterprise, the needs of its management, and requirements of law. This list is known as the chart of accounts, and the file of accounts which it represents is known as the ledger.

1. Ref. 3, pp. 25-40.

In most firms, the accounts are coded by numbers. The numbering system offers several benefits:

1. The use of account numbers speeds the writing of account-distribution data on the face of incoming vendor invoices.
2. The training of clerical personnel who are required to perform accounting functions is made easier when a chart of accounts is provided and its purpose and use explained.
3. Account numbers promote accuracy when posting to General Ledger accounts.
4. Account numbers simplify an audit or review of the books.
5. Use of account numbers speeds the recording of month-end closing entries.

The Chart of Accounts appearing on the following pages shows typical headings which may serve as the foundation of accounting systems for most all firms ranging from the smallest to those whose sales figures reach into millions of dollars.

CHART OF ACCOUNTS[2]

ASSETS

1. Petty Cash
2. Cash on Hand
3. Cash in Bank

5. Accounts Receivable
6. Other Receivables
7. Notes Receivable
8. Advances to Employees

---

2. Ref. 19, pp. 120-124.

10. Inventory on Hand - Department 1
11. " " - " 2
12. " " - " 3
13. " " - " 4
14. " " - " 5

40. Securities
41. Life Insurance - Cash Value

50. Land
51. Buildings
52. Machinery and Equipment
53. Delivery Equipment
54. Office Equipment
55. Furniture and Fixtures
56. Leaseholds and Improvements

60. Prepaid Taxes
61. Prepaid Insurance
62. Prepaid Interest
63. Prepaid Advertising

70. Deposits
75. Cash Sales Clearing

LIABILITIES, RESERVES AND NET WORTH

101. Accounts Payable

102. Notes Payable

120. Accrued Interest Payable

121. Accrued Payroll - Wages Earned but not paid

122. Accrued Taxes Owed

123. Sales Taxes Collected

125. Income Taxes - Previous Year

126. " " - Current Year

150. Reserve for Bad Debts

151. Reserve for Depreciation - Buildings

152. Reserve for Depreciation - Machinery and Equipment

153. Reserve for Depreciation - Delivery Equipment

154. " " " - Office Equipment

155. " " " - Furniture and Fixtures

201. Capital Stock Outstanding

202. Surplus

203. Dividends (unpaid)

211. Profit and Loss Account

SALES INCOME ACCOUNTS

301. Sales - Department 1

302. " - " 2

303. " - " 3

304. Sales - Department 4

305. " - " 5

PURCHASES OR COST OF GOODS SOLD ACCOUNTS

401. Purchases - Department 1
402. " - " 2
403. " - " 3
404. Purchases - Department 4
405. " - " 5

EXPENSES

Salaries and Selling Expense

501. Salaries
502. Salaries - Officials
503. Commissions Paid
504. Advertising
505. Travel and Entertainment
506. Delivery Expense
507. Bad Debt Expense
508. Freight, Express, Cartage

General Administrative and Office Expense

520. Company Car Expense
521. Other Supplies
522. Memberships, Dues, Publications
523. Legal and Auditing
524. Telephone and Telegraph
525. Stationery and Office Supplies
526. Postage
527. Miscellaneous

Fixed Expense Group

540. Rent
541. Heat, Light, Power and Water
542. Insurance
543. Maintenance of Buildings
544. Maintenance of Equipment
545. Amortization of Leaseholds and Improvements
546. Payroll Taxes
547. Taxes on Property

Depreciation Expense

560. Depreciation on Buildings

561. " " Machinery and Equipment

562. " " Delivery Equipment

563. " " Office Equipment

564. " " Furniture and Fixtures

ADDITIONS TO INCOME

701. Cash Discounts Earned

702. Interest Earned

703. Bad Debts Recovered

704. Sales of Scrap

705. Other Income

706. Cash Over

DEDUCTIONS FROM INCOME

801. Cash Discounts Allowed

802. Interest Paid Out

803. Other Deductions

804. Cash Short

810. Provision for Income Taxes (Federal)

811. Provision for other Income Taxes

Books of Original Entry - Journals and Forms

Books of original entry are those in which the first accounting entries are made. The entries, usually more complete than in any other record, are arranged in chronological order, and have explanations in considerable detail. The journal represents one of the first permanent accounting records of a business transaction.

Before determining how to adapt the journals to a particular business, it is necessary to examine a list of the different journals that can be used. It is wise to build the journal catalog around a core of basic books. These basic books, so common that they are used by practically every business concern requiring the services of an accountant, are: 1) a Sales Journal or Register, 2) a Purchase Journal or Voucher Register, 3) a Cash Receipts Journal, 4) a Cash Payments Journal or Check Register, and 5) a General or Miscellaneous Journal. Refer to Figs. 3-1 to 3-8 for details.

Books of Final Entry - The Ledgers

The books in which all the firm's accounts are recorded are called ledgers. The ledgers are used to sort and summarize the information given in the journals. The process of sorting and transferring to the ledgers is known as posting. Details of transactions are not posted to the ledgers, as they can always be traced from the journals.

The accounts in a ledger fall into three groups: 1) accounts with customers, 2) accounts with creditors, and 3) accounts repre-

Books of Original Entry—Journals and Forms

TWO-COLUMN GENERAL JOURNAL

GENERAL JOURNAL

Date 19—		Description	Post Ref.	Debits	Credits
Feb.	2	Office Equipment	10	250.00	
		Frank Kane, Capital	12		250.00
		Invested adding machine			
	4	Office Equipment	10	250.00	
		Royal Typewriter Company	111		250.00
		Bought typewriter on account			

FIG. 3-1

FOUR-COLUMN JOURNAL

GENERAL JOURNAL

Date		Description	L. F.	General Dr.	Accounts Pay. Dr.	General Cr.	Accounts Rec. Cr.
Feb	2	Office Equipment	10	250.00			
		Frank Kane, Capital	12			250.00	
		Invested adding machine					
	4	Office Equipment	10	250.00			
		Royal Typewriter Company	111			250.00	
		Bought typewriter on account					
	5	Frank Roberts (Accounts Payable)	90		110.00		
		Notes Payable	15			110.00	
		Gave a 60-day note on account					
	12	Notes Receivable	3	900.00			
		Donald Cushing (Accounts Receivable)	50				900.00
		Received 30-day note for sale made on January 24					

FIG. 3-2 Ref. 13

DIVIDED EIGHT-COLUMN JOURNAL

GENERAL JOURNAL

DEBITS				L. F.	Description	L. F.	CREDITS			
Notes Receivable	Accounts Receivable	Accounts Payable	General				General	Accounts Receivable	Accounts Payable	Notes Payable
					Feb. 2, 19—					
			250.00	10	Office Equipment					
					Frank Kane, Capital	12	250.00			
					Invested adding machine					
					4					
			250.00	10	Office Equipment					
					Royal Typewriter Co.	111			250.00	
					Bought typewriter on a/c					

FIG. 3-3

Ref. 13

SALES JOURNAL

Date		Account	Invoice Reference	L. F.	Accounts Receivable Current (Control) (Dr.)	Accounts Receivable Lease 19__ (Control) (Dr.)	Sales Dept. 1 (Cr.)	Sales Dept. 2 (Cr.)	Lease Sales Dept. 1 (Cr.)	Cash Sales Dept. 1 *	Cash Sales Dept. 2 *	Total Cash Sales *	Total Daily Sales *
Feb.	1	N. K. Glowman	2001		56 89		56 89						56 89
	2	B. G. Walton	2002			250 00			250 00				250 00
	26	Cash		√						393 66	478 00	871 66	871 66
	27	O. J. Newby	2578		128 75			128 75					
	27	R. Y. Follen	2579			125 00			125 00				253 75
	28	Harry Fennell	2580		225 00		125 00	100 00					
	28	Cash		√						284 45	345 23	629 68	854 68
					410 64	375 00	181 89	228 75	375 00	678 11	823 23	1,501 34	2,286 98

FIG. 3-4 Ref. 13

MULTICOLUMN PURCHASE JOURNAL

				Merchandise Cost							General Ledger			
		Account Payable To	Accounts Payable (Control) Cr.	Purchases Dept. 1 Dr.	Purchases Dept. 2 Dr.	In Freight and Cartage Dept. 1 Dr.	In Freight and Cartage Dept. 2 Dr.	Purchasing Expense (Control) Dr.	Selling Expense (Control) Dr.	Administrative Expense (Control) Dr.	Debit	Credit	L. F.	Account
Apr.	2	Lemoyne-Fergus Co.	968.67		968.67									
	6	V. M. Pavian	69.70					69.70						
	10	Drummond & Co.	1,670.13	1,670.13										
	13	Harry Ansell	117.45						117.45					
	16	Paymaster	2,500.00					658.48	1,581.70	718.30		88.75		F.I.C.A. Tax Payable
												369.73		W.H. Tax Payable
	20	Baker Fixture Co.	857.89								857.89			Store Equipment
	22	P. M. RR. Co.	25.78								25.78			Store Equipment
	25	Macon-Mills, Inc.	117.65						117.65					
	28	Jiles & Nadden	3,002.39		3,002.39									
	30	P. M. RR. Co.	88.56				88.56							
			9,418.22	1,670.13	3,971.06		88.56	728.18	1,816.80	718.30	883.67	458.48		

FIG. 3-5

Ref. 13

CASH RECEIPTS JOURNAL

Date		Account	Explanation	L. F.	Cash Dr.	Sales Discount Dr.	Accounts Receivable Current (Control) Cr.	Accounts Receivable Lease 19__ (Control) Cr.	Cash Sales Dept. 1 Cr.	Cash Sales Dept. 2 Cr.	General Ledger (Cr.)	Bank Deposit
May	3	Henry Cantor	Payment on account		57 82	58	58 40					
	3	H. F. Kaufman	Payment on account		50 00		50 00					107 82
	8	Jacob Jones	Payment on account		20 00			20 00				
	8	M. Ditmen	Payment on account		100 00			100 00				120 00
	13	Cash Sales		√	356 90				200 00	156 90		
	13	D. E. Milton	Payment on account		95 44	96	96 40					452 34
	20	Notes Receivable	Jones & Merrick		1,000 00						1,000 00	
	20	Notes Receivable	Milroy Jenkins		1,000 00						1,000 00	
	20	Interest Income			10 00						10 00	2 010 00
	31	Cash Sales		√	432 55				232 50	200 05		432 55
					3,122 71	1 54	204 80	120 00	432 50	356 95	2,010 00	3,122 71

FIG. 3-6 Ref. 13

CASH DISBURSEMENTS JOURNAL

Date		Account	Explanation	L. F.	Cash Cr.	Purch. Disct. Cr.	W. H. Tax Payable Cr.	F.I.C.A. Payable Cr. (3%)	Salaries Dr.	Expenses Dr.	Accounts Payable Dr.	Sundry Accounts Dr. Amount Dr.	Sundry Accounts Dr. L. F.	Sundry Accounts Dr. Account
Apr.	10	Kunkle Bros.	Inv. 3/31		388.00	12.00					400.00			
	13	D. & C. Rwy. Co.	Frt. bill 4/12		20.00							20.00		Fr. In
	15	Payroll	Apr. 1-15		1,266.00		286.00	48.00	1,600.00					
	18	Campbell & Co.	Inv. 4/3		80.00						80.00			
	20	Postmaster	Stamps		15.00					15.00				
	24	Valmers Supply Co.	Inv. 3/13		400.00							400.00		Off. Eq.
	28	Jordan Mills	Inv. 2/23		150.00						150.00			
					2,319.00	12.00	286.00	48.00	1,600.00	15.00	630.00	420.00		

FIG. 3-7

PETTY CASH JOURNAL

Date		Explanation of Payment	Petty Cash Paid Out Cr.		Store Expenses Dr.		Shipping Expense Dr.		Postage Dr.		Sundry Accounts Dr. Amount		Sundry Accounts Dr. Account
Mar.	5	Express on purchases	2	78							2	78	Freight and Cartage In
	8	Stamped envelopes	3	30					3	30			
	13	Cleaning supplies	1	95	1	95							
	20	Express on shipping supplies	2	54			2	54					
	27	Cartage on office equipment	3	00							3	00	Office Equipment
			13	57	1	95	2	54	3	30	5	78	

FIG. 3-8

Ref. 13

senting the history of the business, exclusive of customers and creditors. This threefold division covers practically all the accounts which appear in the ledgers. It is also the basis of the expansion of the ledger records as a business firm increases in size and volume. Forms of simple and traditional ledgers are shown in Figure 3-9.[3]

Electronic Data-Processing—Definition

In its broadest sense "electronic data-processing" is 1. the manipulation in any manner of 2. any form of data by 3. electronic means.[4]

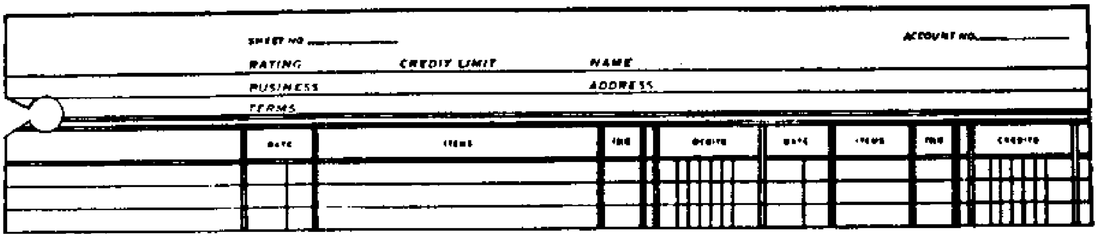
1. "Manipulation in any manner" could include any of the following:
   a) performing arithmetic operations
   b) performing logical operations
   c) recognizing input (source) information
   d) storing information
   e) recording output (result) information
   f) rearranging (editing) information
2. "Any form of data"—basically data can be considered as either of the following:
   a) Analogue information—a continuous flow of information of some physical measurement
   b) Digital information—discrete units of alphabetic or numeric characters.
3. "Electronic means"—various electronic systems can be mentioned:

---

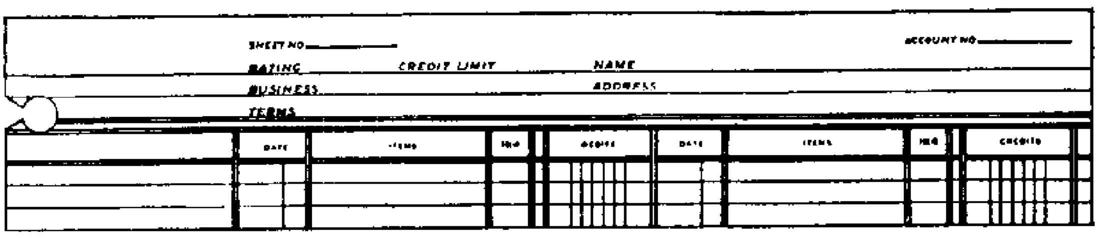
3. Ref. 14, pp. 77-105.
4. Ref. 2, p. 532.

Books of Final Entry—The Ledgers

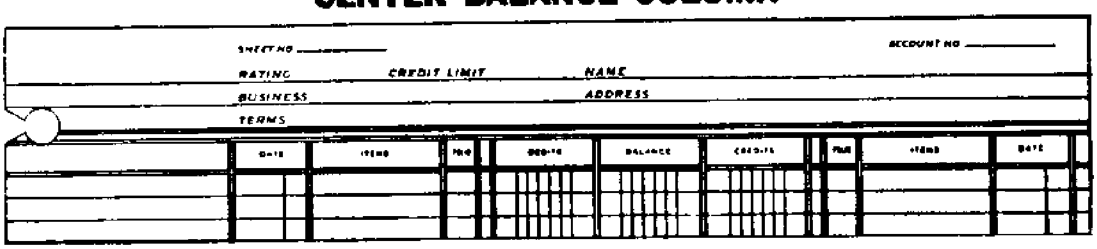
WIDE DEBIT LEDGER



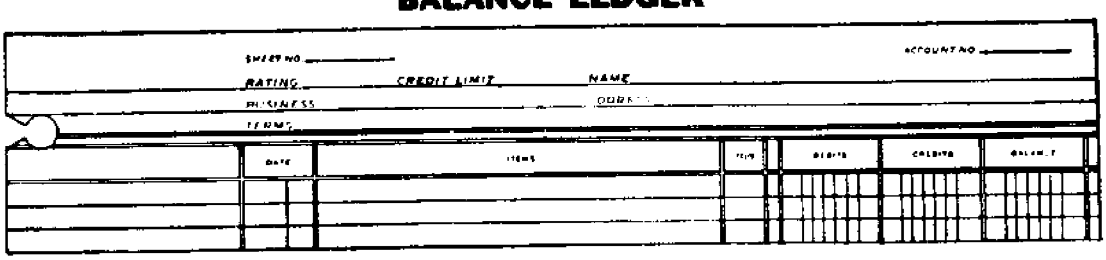
REGULAR LEDGER



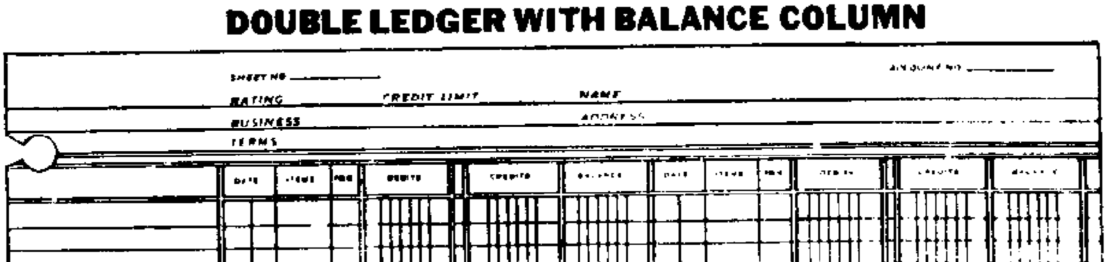
CENTER BALANCE COLUMN



BALANCE LEDGER



DOUBLE LEDGER WITH BALANCE COLUMN



Courtesy of Wilson Jones [illegible]

FIG. 3-9 Ref. 13

a) Teletype transmission

b) Radio or TV transmission

c) Paper handling systems (check sorters in large banks)

d) Scheduling systems (airline reservations systems)

e) Computers or "giant brains"

The Nature and Importance of Electronic Data Processing

Accounting work has basically gone through four stages over the years. At the beginning, the records were prepared manually, using columnar arrangements, posting by hand to ledger accounts, and preparing statements in the same manner. The operation was laborious and time-consuming. For the low volume of transactions, and the low costs of clerical work, this method was satisfactory.

As the volume of transactions increased, business organizations became larger and clerical costs increased, key-driven machines gradually took over the task. Adding machines, calculating machines, and typewriting bookkeeping machines were used due to their higher speeds.

From 1918 on, the use of punched cards to record, sort, and summarize repetitive information has increased rapidly. Thus, through the years, this area has had to develop at a tremendous rate to handle the increased work of the larger business firms, especially firms with need for recording repetitive information, for sorting large volumes of records, and for very rapid preparation of important managerial records.

In the early 1950's, interest developed in the fourth and current phase of accounting and statistical work, namely, electronic data processing, because of the increased speed, simplification, and mechanization that it offered. Again, the necessity for this change becomes apparent when one realizes the tremendous growth of some corporate organizations to the point where they now have several hundred thousand employees to pay each week and millions of stockholders who will receive dividend checks four times a year. Electronic data processing is performed at a speed of 186,000 miles per second. Perhaps the comparative speed of these four methods might emphasize the reason for their need and development. Handwriting is at the rate of 140 characters per minute, typewriting and mechanical methods at the rate of 350 keystrokes a minute, a calculating machine operator at the rate of 740 characters a minute, and punch cards can be read at the speed of 8,000 to 16,000 characters a minute. However, with magnetic tape and electronic devices, it is possible to read one million characters a minute. Thus necessity has been the motivating force behind the progress in accounting work.[5]

---

5. Ref. 14, p. 344.

CHAPTER IV

TAXATION ASPECTS OF FISHERY CO-OPERATIVES

Introduction

All fishery co-operatives performing marketing and purchasing services for member fishermen are required to pay Federal income tax at the corporate rate on any net margin of operating receipts over expenses retained and used for any purpose other than authorized reserves. The net margin which co-operatives are not under obligation to distribute currently to patrons on a patronage basis, either in cash or non-cash form, is retained. Co-operatives pay both Federal and State corporation taxes on the same basis and at the rate, under the same conditions as other corporations.[1]

Corporate Income Taxes

The basic corporate income tax represents a tax of 22% of the first $25,000 of taxable income and 48% of the taxable income above $25,000 per year. Distributions of earnings (after taxes) to shareholders, as owners of the enterprise, constitutes income to the shareholder.

Distributions of its own stock to shareholders of a corporation on the basis of stock held is subject to tax only when sold. If held more than six months before sale, this income would be subject to capital gains treatment.

The investment credit provision allows a corporation a reduction of tax liability equivalent to 7% of the investment

---

1. Ref. 12, p. 21.

cost of new or used depreciable personal property with a useful life of more than four years. Assetsmay generally be depreciated more rapidly than their projected useful life. The effect is to delay taxes rather than to avoid them. It serves as a method of retaining and using earnings without tax for a time.[2]

Limited Partnership

Earnings derived from a limited partnership are taxable at the owner level. The limited partnership limits the liability of partners to their investment in the enterprise. However, limited partners may not participate in the management of the enterprise, and there must be at least one general partner with unlimited liability.[3]

Co-operatives

Co-operatives receive special tax treatment in tax law. The Revenue Act of 1962, approved October 16, 1962, contains two sections, 17 and 19, that deal specifically with the tax treatment of farmer co-operatives and their patrons including important tax reporting requirements. Although not specifically mentioned in these sections of the new Act, fishery co-peratives must meet the same requirements established for farmer co-operatives.[4]

The word patron takes on a special meaning in fishery co-operatives. In a supplying co-operative, the persons buying products from the co-operative are patrons (whether or not they

2. Ref. 18, pp. 17-18.
3. Ibid., PP. 18-19.
4. Ref. 12, p. 21.

are members or equity owners); and in a marketing organization, persons selling fishery products to or through the co-operative are patrons. If a co-operative does both, it may have patrons on both sides of the same product, e.g. fishermen selling fish to the co-operative and buying baits and nets from it.[5]

The essential feature of co-operative tax treatment is that net proceeds earned on patron business are not taxed at the co-operative level if distributed or allocated to patrons on the basis of patronage. A patronage refund must:

1. be paid on the basis of volume or value of business done with or for such patron,
2. be paid under an obligation which existed before the organization received the income and
3. be determined by reference to the net earnings of the organization from business with or for its patrons.[6]

All patronage refunds are deductible for Federal income tax purposes if they are paid in cash, in property, or in allocations of which at least 20% is paid in cash: provided, the patron has the option to redeem the remainder of the cash allocation in cash during a 90-day period after issuance and receives written notice of this option at the time he is notified of the allocation; or the patron consents in any one of three ways to treat this income as being received by him.[7]

The effect of these rules is to treat qualified allocations as a price adjustment or as the final stage of setting the

5. Ref. 18, p. 20.
6. Ibid., p. 21.
7. Ref. 5.

transfer price between patron and co-operative. It makes possible "operation at cost" when costs are not known until the year's business is complete. It also provides the means for the co-operative to retain a portion of earnings to finance itself without incurring a tax liability at the co-operative level. The result is a single tax on income at the patron level.[8]

Under sections 521 and 522 of the old Internal Revenue Code, a fishery co-operative's eligibility for tax exemption is subject to:

1. A maximum of 8% per annum can be declared as shareholders' dividend, and be deducted for income tax purposes; or
2. Each member is entitled to only one vote regardless of the size of his holdings; and
3. Business with members must exceed that with non-members.

Thus a fishery co-operative has to comply with either the first or the second provision, and the third condition in order to enjoy the various tax privileges.

Revolving Fund Plan

Many co-operatives are capitalized under what is known as the "revolving fund plan." This is a plan in which, after sufficient capital has been accumulated, current investments are used to retire the oldest outstanding investments of patrons. There are several advantages to this method of financing.

---

8. Ref. 18, p. 22.

First, it offers greater protection and equity to initial investors who are chiefly responsible for building up the association's capital structure; second, the patron's financial interest is maintained in proportion to the use made of the association; and third, the entrance of new members is made easier and more attractive.

Via this method, capital is usually generated by deferring payment of patronage refunds by the issuance of scripts,or stock options in place of cash. The date of redemption on the scripts is not usually set. Consequently, it allows a cooperative a great deal of flexibility in "revolving" this kind of capital. One other attractive aspect in this plan is the interest-free nature of the scripts.

One major hindrance to this practice is the tax liability of members or patrons, who are liable to pay income tax on the scripts upon their receipts. It may be difficult to get members' acceptance of such paper instruments especially when they are above the 20% tax bracket, in which case the 20% cash they receive will not cover their added tax payments.[9]

---

9. Ref. 12, pp. 21-24.

BLANK

CHAPTER V

ACCOUNTING SYSTEM DESIGN FRAMEWORK FOR A MODEL FISHERY CO-OPERATIVE

A General Approach

Is is important to realize that an accounting system exists not for itself alone, but only as it may be able to serve management in the business of which it is a part. Hence the starting point in designing, or changing an accounting system or any of its parts should be the question of how management can best be served. The nature of the problem emerges through a survey of the organization involved.

Being the first and most essential step to the design of any accounting system, the survey represents and exhaustive investigative process that unveils all the facts of an organization—facts that deal with the organizational structure, policy making, and the financial structure of the organization; and facts that deal with specific procedures within the overall system.

Upon completion of the survey, the task of analysis centers around the identification of the problem centers of the organization. By determining the centers where the greatest improvements are possible, and making sure that good features are not inadvertently sacrificed in the enthusiasm for making changes, the design of the system evolves with the repetitive breaking down of procedures into sub-procedures and the detailed analysis of them.[1]

---

1. Ref. 4, pp. 14-21.

Survey of a Model Co-operative

A survey is to start from the broadest scale and eventually narrows down to specific procedures. On the broad scale, it is advisable to examine the following areas of interest: objectivity, functions, size, organization structure, and finance. Survey of specific procedures mainly covers the operation routine of a co-operative. Below a hypothetical co-operative is described in order to give the reader an understanding of the relevent factors in consideration of a design scheme. It should be noted that actual operations of existing co-operatives will vary from this description to some extent.

Objectivity

A survey in this area should reveal what the objectives are behind the formation of the co-operative in question, and whether these objectives are being met. Attention should be paid to the role the community environment plays in determining the goals of the co-operative.

For a model co-operative, one may find the following: The co-operative is formed due to real economic needs of a group of fishermen. It has to serve the common interests of the fishermen, whose co-operative spirits help to attain certain objectives. These objectives include: a) to provide them with a stable income by dampening the effects of seasonal variations; b) to form a cartel for a better bargaining position; c) to increase the efficiency in the handling and transportation of products; d) to reduce costs of fishing supplies and equipment; e) to enable them to pool resources to finance fishing operations; and f) to provide special harbor and dockside facilities and services.[2]

Functions

A survey in this area should reveal what types of operations the co-operative is engaged in. For the model co-operative, one may find that it is both a supply and marketing co-operative. On the supply side, the co-operative is responsible to provide fishing gears, nets, baits, petroleum products, groceries, etc. for general membership purchases. At the marketing end, the co-operative is responsible for the transportation of products to the appropriate markets or processors, negotiation with buyers on prices, and marketing of members' products. For the purposes of the model co-operative described here, it does not have its own processing facilities, and it leases trucks for transportation purposes.

Size

The survey should reveal the size and the make-up of the fishing fleet. The model co-operative may have 50 member and 20 non-member boats, and its membership totals 120. The boats consist mostly of trawlers with a few pot lobster boats.

Organization Structure

The survey must show the organization chart of the co-operative, and the way power is delegated through the chain of command.

---

2. Ref. 16, pp. 1-3.

The model co-op may be a centralized organization, that is, a fishermen's co-op, and not a federation or a group of co-ops. It is an incorporated organization that provides limited liability to members.

For the purpose of discussion here, membership can be acquired by the purchase of at least one share of common stock in the co-op. Each member is entitled to one vote regardless of the size of his holdings. Common stock yields 5% and preferred stock yields 6% per annum.

The general membership elects a board of 5 directors in an annual meeting. The term of a director lasts for 1 year. The board is responsible for hiring the manager, defining his duties, and setting his salary. The manager is responsible for the day to day operations of the co-op. He controls the daily flow of funds and is accountable to the board of directors for those funds. The manager oversees the accountant in keeping the books. They present periodic reports to the board and members.

The board is theoretically responsible for long term planning and policy making duties, and the manager is responsible to carry out these goals. However, it is normal for the manager to play a major role in the strategic planning of the co-operative.

Finance

The survey should reveal what the basic financial requirements of the co-op are, and what sources of finance are available.

For the model co-op, all the usual corporate financing methods are available—sale of capital stock, sale of debt securities, short-term and long-term credit from banks for co-ops, and retention of earnings.

Capital stock can basically be divided into two types: preferred and common. Preferred stock takes preference in dividend payments; but it has no voting power, and has no right to patronage refunds. It can be bought by anyone. On the other hand, common stock is owned by fishermen only. It is eligible for patronage refunds, and each shareholder is entitled to one vote.

Under tax-exempt status of Section 521 of the Internal Revenue Code, all patronage refunds due to earnings are tax exempt if at least 20% of the declared refund is paid in cash. Consequently, a new concept of finance is available to co-ops whereby the current patrons provide to a great extent the co-ops equity capital. This is accomplished by withholding a portion of the allocated patronage refund in a revolving plan and distributing them in later years.

Operation Routine

The survey on this part can best be accomplished by following the work flow in a procedure. The secret of a successful survey of procedures lies in the good relationship between a systems man and the personnel involved. It is advisable to always contact the supervisory level first, and obtain the permission to observe a particular procedure. When a systems man investigates a procedure, the personnel in that procedure is naturally suspicious of his motives and is usually non-cooperative. It is therefore essential to get them involved to the greatest extent by getting their opinions at every stage of the investigation. The systems man has to get down to their level in order to make progress.

The easiest way of doing a procedures survey is to follow a time sequence of events during the day. For the model co-op, one may start at 4 o'clock in the morning.

4-8 a.m. Boats leave for fishing

The survey may show that most day boats go out during this period. Some trip boats are out at sea, others are docked.

9 a.m. Office opens

The survey should establish the size of the office staff, and the duties of each staff member.

The model co-op may have a general manager, a full time accountant, a salesman, and an office clerk.

10 a.m. - 12 noon Settlements with buyers

While other staff members are finishing jobs left over from the previous day, the salesman starts calling up his buyers to whom some products have been delivered earlier this morning. This is to establish a price for those delivered products. In order to get the best settlement, the salesman calls a number of clients to get a feel for that day's market. After a sequence of askings and biddings, a settlement is finalized, but that check will not be received for another few days.

After all the settlements are accomplished, the salesman tallies the figures and establishes the average price per pound for each type of product. These figures are given to the accountant to credit the boats and debit the buyers accordingly. Fishermen are settled on a weekly basis.

12 noon - 1 p.m. Lunch break

1 p.m. - 3 p.m. Marketing in action

During this period the general manager makes radio contacts with the boats out at sea to get information on the quantity as well as the types of products being caught.

The general manager coordinates this with the sales efforts of the salesman, who is on line with buyers and taking their orders. These orders are approximate in nature, they may or may not be filled.

4 p.m. - 6 p.m. Boats return

All boats come in before the 6 o'clock cut off time. The dockside facilities allow two boats to be unloaded at the same time. A pier foreman supervises eight workers in the unloading operations.

During the unloading process, products are separated by type and weighed. The foreman records all the information to be sent to the office. The products are then packed in wooden boxes to be delivered later.

The boats will resupply periodically, possibly on a weekly basis, depending on the type of boat. Typically a boat could resupply on Friday, laying over on Saturday when the major fish markets are closed.

5 p.m. - 9 p.m. Establish product destination

During this period, the job is to match the actual landings with buyers' orders. If the radio communication was not properly coordinated with sales efforts, this could be a difficult task.

While the boxes are properly numbered or labeled for specific destinations, the office clerk is preparing delivery slips to accompany the delivery. After all this is done, the truckload is ready to go. It usually leaves before 8 p.m.

Note that the fishery co-operative plays the role of a broker handling the fish on a consignment basis. That is, the co-operative does not buy the fish from the fishermen and then try to sell it; instead the co-operative simply arranges for the sale of fish.[3]

---

3. Ref. 15, pp. 1-11.

Analysis of an Accounting System for a Fishery Co-op

The most important part of an analysis is the identification of problem centers, whereby transactions take place relaying certain information that is vital to the decision making of the management.

Again, the technique is from broad to specifics. On the organizational level, attention should be given to the types of the financial reports required by the board of directors, members, investors, and the regulatory agencies. The next step is to focus on the operation routine of the co-op, and to break it down into specific procedures or problem centers. By establishing the objectives of each procedure, one can proceed towards the design of forms to best record the necessary information for management control.

Financial Reports

In the initial design analysis, one should look at some of the pertinent financial statements. Co-op financial reports should contain sufficient information to enable member, patrons, creditors, investors, and other interested parties to understand the financial situation of the organization. These reports are basically the same as those of other organizations, and the generally accepted accounting principles and standards of disclosure are applicable.

Depending upon the basic requirements of the parties interested, the financial reports can include the following: 1) Balance sheet; 2) Statement of operations; 3) Statement of Stockholders' equity; 4) Statement of changes in financial position; and 5) Auditor's opinion

Balance Sheet

The only distinct difference between a balance sheet of a co-op and that of a proprietary concern is in the equity section, since a co-op normally has several equity accounts representing various classifications of allocated patrons' equity, in addition to the retained earnings account. Refer to Figure 5-1 and 5-1A.

Statement of Operations

Except for some differences in terminology, due to some transaction aspects discussed in Chapter IV, the reporting of operating results of a co-op is similar to that of a proprietary concern.

Income tax is charged against operational earnings to arrive at net margins, which then consist of amounts distributable or distributed as dividends and patronage refunds, and additions to unallocated retained earnings. Refer to Figure 5-2.

MODEL COOPERATIVE ASSOCIATION, INC.
Balance Sheet
June 30, 1972
with comparative figures for 1971

Assets	*1972*	*1971*
Current assets:		
Cash	$ 2,005,599	$ 1,662,967
Marketable securities, at cost (quoted market 1972, $1,022,400)	1,018,413	807,429
Receivables:		
Trade:		
Notes	2,454,969	2,349,492
Accounts	5,589,614	5,386,837
Affiliated companies	55,084	42,986
Interest	122,577	84,358
	8,222,244	7,863,673
Less allowance for doubtful receivables	145,864	136,429
Net receivables	8,076,380	7,727,244
Merchandise inventory, at lower of cost (first-in, first-out), or market	4,280,192	3,967,423
Prepaid expenses	172,964	161,820
Total current assets	15,553,548	14,326,883
Investments and other assets:		
Equities in other cooperatives (note 1)	7,423,286	7,222,634
Long-term mortgage contracts receivable	425,000	370,000
Total investments and other assets	7,848,286	7,592,634
Property, plant and equipment, at cost (note 2):		
Land	945,650	945,650
Buildings	7,895,290	7,643,865
Plant machinery and equipment	3,269,843	3,046,587
Office equipment	326,942	310,461
Automotive equipment	946,873	939,472
Construction in progress	576,490	146,503
	13,961,088	13,032,538
Less accumulated depreciation	5,476,422	4,796,965
Net property, plant and equipment	8,484,666	8,235,573
	$31,886,500	$30,155,090

FIG. 5-1 Ref. 20

Liabilities and Stockholders' and Patrons' Equity

	1971	1972
Current liabilities:		
Notes payable to Bank for Cooperatives (note 2):		
Short-term operating loans, unsecured	$ 450,500	425,000
Current maturities on long-term mortgage notes	640,000	640,000
Accounts payable	3,021,724	2,788,092
Accrued expenses	1,148,098	1,004,395
Federal income taxes (note 5)	44,375	42,460
Patronage refund payable in cash	378,900	362,440
Total current liabilities	5,683,597	5,262,387
Long-term debt:		
First mortgage notes payable to Bank for Cooperatives, less current maturities (note 2)	3,560,000	4,200,000
Subordinated debenture bonds, 5¼%, maturing serially $600,000 annually, beginning July 1, 1975	4,200,000	3,600,000
Total long-term debt	7,760,000	7,800,000
Stockholders' and patrons' equity:		
Capital stock:		
Preferred stock, 5% non-cumulative, par value $100 per share. Authorized 100,000 shares; issued 52,300 shares (51,000 shares in 1971)	5,230,000	5,110,000
Common stock, par value $10 per share, dividends limited to 6%. Authorized 200,000 shares; issued 142,690 shares (139,780 shares in 1971)	1,426,900	1,397,800
Patrons' certificates of equity	6,679,154	5,582,429
Patrons' allocated capital reserve, 1960-1968	3,500,000	3,500,000
Retained margins, unallocated (note 4)	1,606,849	1,502,474
Total stockholders' and patrons' equity	$18,442,903	$17,092,703
	$31,886,500	$30,155,090

FIG. 5-1A Ref. 20

MODEL COOPERATIVE ASSOCIATION, INC.
Statement of Operations and Margins
Year ended June 30, 1972
with comparative figures for 1971

	1972	*1971*
Purchases by patrons, net	$27,136,511	27,487,120
Cost of patrons' purchases	23,493,982	23,749,328
Gross margins on patrons' purchases	3,642,529	3,737,792
Grain marketed for patrons	13,363,252	13,315,018
Advances to patrons and processing costs	12,120,321	12,151,419
Gross margins, marketing	1,242,931	1,163,599
Total gross margins	4,885,460	4,901,391
Other operating revenue	134,169	139,607
Gross margins and other operating revenue	5,019,629	5,040,998
Distribution, general and administrative expenses	2,287,094	2,078,838
Net operating margins	2,732,535	2,962,160
Other revenue:		
Dividends on securities	46,500	43,850
Interest	22,464	24,152
Miscellaneous	5,519	2,397
	74,483	70,399
	2,807,018	3,032,559
Other deductions:		
Interest	516,479	567,469
Loss on sale of equipment	43,425	12,436
	559,904	579,905
Net margins before Federal income taxes	2,247,114	2,452,654
Federal income taxes (note 3)	280,000	285,000
Net margins	$ 1,967,114	$ 2,167,654
Depreciation and amortization	$ 695,435	$ 589,451

COMMENT. Although supply and marketing functions must be accounted for separately for income tax reporting purposes, it would not be inappropriate to combine the sales and cost of sales figures of both functions for financial reporting purposes.

FIG. 5-2

Ref. 20

Statement of Stockholders' & Patrons' Equity

As mentioned before, the equity section consists of other accounts not known to a proprietary concern. Besides the preferred and common stock, there are patrons' certificates of equity, patrons' allocated capital reserve, and patrons' margins unallocated. Refer to Fig. 5-3.

Statement of Changes in Financial Position

Here again, except for some difference in terminology, the basic elements in the statement are the same for co-ops and proprietary concerns. Refer to Fig. 5-4.

Operation Routine - Analysis

The operation routine can be broken down into the following areas: 1) Docking and Unloading; 2) Sales; 3) Delivery; 4) Settlement with buyers; 5) Settlement with boats; 6) Supply outlet.

Docking and Unloading

The management is essentially interested in the efficient operation of docking and unloading of fishing boats involved. A proper record keeping system should be devised to provide the management with up to the minute information on the quantity and types of fishery products landed by each boat.

A landing sheet can be designed to include a list of products mostly caught. Each set of sheets should have at least one original and two color copies. One set should be used for each transaction. The original goes to the boat, one copy stays at the pier, and the other copy should be sent to the office. The boats need a copy to record their own landings. The pier requires a copy for two purposes: a) to provide a check for the office of proper landings; b) to provide a check of actual landings versus packaged products for delivery that day. These forms should be numerically coded to provide easy tracing.

Sales

The management desires to sell members' products at the best price at a given day. Naturally, the bigger the market, the less the co-op is susceptible to price fluctuations.

It may be useful to engage the salesman in some sort of incentive program. The idea is to put him to work for himself. If the program involves a commission of the total sales, consideration must be given to seasonal and annual variations in supply and demand. This program should be continually reviewed to suit the market trend.

Sales efforts involve extensive long-distance calls. A budget should be allocated to such sales expenses. Attention must be given to the sales volume versus sales expenses. For example, a drop in sales coupled with an increase in the phone bill may warrant investigation.

Delivery

Most fishery products are transported by trucks. The immediate question is whether the co-op should operate its own trucking facilities. This seems to depend on the nature of the supply and demand of the products. If the supply and demand pattern is quite steady, and the volume handled is large enough, it may be advantageous for co-ops to own trucks. In some cases, the co-op may save money by simply leasing or contracting for the use of trucks.

In the delivery procedure, the objective is to ensure the proper delivery of products to the buyers. To meet this objective, two forms are necessary. A delivery book has to be signed by the driver to acknowledge the amount of the shipment. Upon delivery to each buyer, a set of delivery orders must be signed by the buyer to acknowledge receipt of products. The buyer retains the original, and the driver brings back the signed copy.

Settlement with Buyers

The management is concerned with the prompt payment by the buyers upon each settlement. It may be desirable to use a Sales Journal to update this information. Upon each settlement, the delivery order number and the dollar amount is recorded under the appropriate account. Attention should be given to buyers that consistently make late payments.

Settlement with Boats

The objective here is to properly credit each boat with its landings. A Purchase Journal may be used in this instance to enter the landings. The landing sheets from the previous day serve as inputs. The weekly total is tabulated for each boat so that a pay check can be issued. The pay checks will be recorded in a Cash Disbursement Journal.[4]

---

4. Ref. 7

Supply Outlet

The objective in this operation is to provide the members with convenience in purchasing all the supplies they need, and the ability to charge these purchases against their landings.

Ordinary invoices will be involved, in addition to a general signature book for charge accounts. Inventory valuation can be done at market value or cost, whichever is lower.

FIG. 5-3

MODEL COOPERATIVE ASSOCIATION, INC.

Statement of Stockholders' and Patrons' Equity Year ended June 30, 1972

	Preferred stock	*Common stock*	*Patrons' certificates of equity*	*Patrons' allocated capital reserve*	*Patrons' margins unallocated*	*Total*
Beginning of year	$5,110,000	$1,397,800	$5,582,429	$3,500,000	$1,502,474	$17,092,703
Stock issued for cash	120,000	29,100	—	—	—	149,100
Net Margins	—	—	—	—	1,967,114	1,967,114
	$5,230,000	$1,426,900	$5,582,429	$3,500,000	$3,469,588	$19,208,917
Appropriations, transfers (in) and out and other changes:						
Payment of dividends on capital stock:						
Preferred	—	—	—	—	261,500	261,500
Common	—	—	—	—	85,614	85,614
Net margins appropriated as a patronage refund, payable as follows:						
Patrons' certificates of equity—75%	—	—	(1,136,725)	—	1,136,725	—
Cash—25%	—	—	—	—	378,900	378,900
Certificates of equity redeemed from estates of deceased holders, at face value	—	—	40,000	—	—	40,000
	—	—	(1,096,725)	—	1,862,739	766,014
End of year	$5,230,000	$1,426,900	$6,679,154	$3,500,000	$1,606,849	$18,442,903

COMMENTS

1. The indicated distribution of net margins is made in accordance with assumed by-laws for a taxable cooperative. In this case, it has been assumed that an amount of $1,515,625 has been authorized for distribution to patrons and that the remainder represents margins from non-member business after taking into consideration requirements for the payment of dividends and for the payment of income taxes.
2. The allocated operating capital reserve presumably was built up by allocation of net margins in prior years until it reached the indicated balance of $3,500,000.
3. In place of retained margins, an association may prefer to use such captions as "Earned Surplus," "Undistributed Margins," or "Undistributed Savings." Consideration should be given to the designation which the by-laws place on this account.
4. Appropriate disclosure should be made if common shareholders are not entitled ratably, in the event of dissolution, to the net assets remaining after payment of claims of creditors, the par value of preferred stock, and allocated patrons' equity.

Ref. 20

MODEL COOPERATIVE ASSOCIATION, INC.
Statement of Changes in Financial Position
Year ended June 30, 1972
with comparative figures for 1971

	1972	*1971*
Funds provided		
Net margins	$ 1,967,114	$ 2,167,654
Add or (deduct) items not involving the receipt or expenditure of funds:		
Depreciation and amortization	695,435	589,451
Loss on sale of equipment	43,425	12,436
Non-cash patronage refunds received	(342,670)	(371,940)
Funds derived from operations	2,363,304	2,397,601
Proceeds from sale of debenture bonds	600,000	350,000
Proceeds from sale of preferred stock	120,000	95,000
Proceeds from sale of common stock	29,100	24,300
Proceeds from sale of equipment	87,987	39,628
Equities of other cooperatives redeemed	142,018	163,420
	$ 3,342,409	$ 3,069,949
Funds used:		
Additions to property, plant and equipment	$ 1,075,940	$ 826,495
Reduction of first mortgage notes payable	640,000	640,000
Dividends on capital stock	347,114	340,900
Portion of current year's patronage refund payable in cash	378,900	362,440
Increase in long-term mortgage contracts receivable	55,000	20,000
Redemption of preferred stock	—	15,200
Redemption of common stock	—	960
Redemption of certificates of equity	40,000	32,400
Increase in working capital	805,455	831,554
	$ 3,342,409	$ 3,069,949
Changes in working capital:		
Increase (decrease) in current assets:		
Cash	$ 342,632	$ (54,605)
Marketable securities	210,984	125,800
Receivables	349,136	496,427
Inventories	312,769	112,728
Prepaid expenses	11,144	(5,972)
	$ 1,226,665	$ 674,378
Increase (decrease) in current liabilities:		
Notes payable to bank	25,500	(175,000)
Accounts payable	233,632	(47,369)
Accrued expenses	143,703	48,951
Federal income taxes	1,915	3,552
Patronage refund payable in cash	16,460	12,690
	421,210	(157,176)
	$ 805,455	$ 831,554

FIG. 5-4 Ref. 20

CHAPTER VI

SURVEY OF 3 NEW ENGLAND FISHERY CO-OPERATIVES

For the purposes of this study, surveys were performed on 3 New England fishery co-operatives. They are the Chatham Seafood Co-op, Inc., the Point Judith Fishermen's Co-op Association, and the Provincetown Fishery Co-op.

Chatham Seafood Co-op, Inc.

Objectivity

The co-op was incorporated in 1966 due to widespread fishermen's dissatisfaction over what the fish dealers were paying for their catch. Basically, the fishermen wanted a bigger slice of the pie. Other objectives are similar to that of a model co-op described in the previous chapter.

Functions

Chatham co-op is engaged in two main functions: 1) It markets fresh edible fish to Boston and New York's Fulton Fish Market. 2) It operates a fresh fish market next to the office building.

Size

The co-op handles around 40 boats, all of which are line trawlers of 40 to 50 feet in length. These boats operate on a daily basis with a crew of two to three.

Organization Structure

The management staff consists of a general manager and an accountant.

Finance

The co-op takes 5-1/2 cents per pound for fish marketed to Boston, and 6-1/2 cents per pound for fish marketed to New York to cover operational expenses. The main problem in finance is more of a day to day cash flow type due to fluctuations in supply and demand, and due to late payment by customers. In this respect, the co-op is greatly relieved by the liquidity provided by the income from the fresh fish market. Finance is also done by issuance of common stock, and borrowing from banks. Up to this date, because of marginal overall profitability, no patronage refund has been declared.

Operation Routine

The survey in this area shows that Chatham's mode of operation is generally similar to that of a model co-op discussed earlier.

The cutoff time for Chatham is 4 p.m. The unloaded fish is immediately packed into cardboard boxes of 100-125 pounds each. The catch of a boat varies from 10 to 80 boxes. The wharf foreman records each landing on a standardized set of forms (Figs. 6-1,2,3). One copy is given to each boat, and three copies are forwarded to the office.

With respect to sales, the general manager acts as the salesman as well. Radio communication is not used here, so the exact catch is not known until all boats are in. Then the fish is allocated to the various dealers. During the day,

DATE | TRAPS

	Scup			Squid	Mack.	Black Bass	Fluke	Sea Robbins	Bonita	Tautog	Grays	Striped Bass	Butters	Blues	Flounders	Misc. Species	Name of Boat Captain	Total Weight per Boat
	Small	Med.	Large															
	@	@	@	@	@	@	@	@	@	@	@	@	@	@	@	@		
Total Weight Per Species																		Total Weight for all
Total Price Species																		Total Price

FIG. 6-1

Date | | Handliners | | Trawlers

	COD			Cusk	HADDOCK		Hake	HALIBUT		POLLACK		Cats	Misc. Species	Name of Boat Captain	Total Weight per Boat
	Stk. @	Mkt. @	Scrod @	@	Large @	Scrod @	@	Large @	Small @	Large @	Small @	@			
Total Weight Per Species															**Total Weight for all**
Total Price Species															**Total Price**

FIG. 6-2

Form 2-249

Budget Bureau No. 42-R432.7

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

PURCHASES FROM FISHING VESSELS

FIG. 6-3

Port of .... Date ....

Dealer .... Gear ....

Vessel .... Grounds ....

Date of departure .... Days fished ....

Date of arrival .... Depth ....

ITEM		POUNDS LANDED	PRICE PER POUND	TOTAL PAID Dollars	TOTAL PAID Cents
Cod—large	0811				
market	0813				
scrod	0814				
Cusk	0960				
Haddock—large	1470				
scrod	1475				
snapper	1476				
Hake, white—large	1536				
medium	1537				
Hake, red	1520				
Halibut	1590				
Ocean perch (redfish)	2400				
Pollock—drawn	2691				
Whiting—dressed	5093				
round	5090				
Wolffish "catfish"	5120				
Flounders—gray sole	1216				
lemon sole	1220				
yellowtail	1230				
blackback, large	1200				
small	1202				
dab	1205				
fluke, large	1210				
medium	1212				
small	1214				
Butterfish	0621				
Herring	1685				
Mackerel	2120				
Scallops, sea	8009				
Other, for food	5260				
Other, for reduction	5290				
Lobsters	7270				
Shrimp	7360				
TOTAL					

NOTE.—Individual reports are confidential and only summary data are released.

U S GOVERNMENT PRINTING OFFICE 1960—O-332 071

the manager has been checking on the demand for the products in each market, and the products are usually sent to the market that seem to be able to offer the most. Of course, the actual settlement is not known until the next morning.

Accounting System

Accounting is based on the generally accepted accounting principles' double entry method. Two journals are used for its daily operations: 1) the Cash Disbursement Journal, and 2) the Cash Receipts Journal. Boat settlement checks are done on a one-write system, whereby with the initial entry the check is issued and this entry is simultaneously imprinted on several forms eliminating the need for further posting. (Refer to appendix.) Two financial reports are prepared each year, the balance sheet, and the income & expense statement. All the accounting work is done by the accountant (except for periodic outside auditing). Refer to Figs. 6-4,5 for the forms used in the financial reports.[1]

---

1. Ref. 7.

Chatham Seafood Co-op., Inc.
Balance Sheet
December 31, 1974

Assets

Cash on Hand & In Banks
Savings Bank Deposit
Accounts Receivable
  Local Markets
  New York Markets
  Gear & Bait
  Fuel
  Miscellaneous

Less: Reserve for Bad Debts

Inventory
  Gear
  Fish Merchandise
  Boxes, Ice & Bait
  Fuel

Land
Buildings
Pier Equipment
Office Equipment
Market Equipment
Delivery Equipment

Less: Accumulated Depreciation

Prepaid Interest & Insurance
  Total Assets

Liabilities & Capital

Accounts Payable
Due Fishermen
Accrued & Withheld Taxes
Accrued Payroll
Notes Payable - Truck
  - Fork Lift
  - CCB&T Co.
  - Springfield Bank for Co-ops.
  - Fishermen
Mtge. Payable - CC5¢ Savings Bank
  Total Liabilities
Capital Stock - Common
  - Preferred
Shareholders Equity
  Total Capital
  Total Liabilities & Capital

T. McGuire ?/11/74

FIG. 6-4

Chatham Seafood Co-op., Inc.
Income & Expense Statement
Twelve Months Ending December 31, 1973

Sales:

New York Markets
Boston & Local
Market - Retail
Market - Wholesale

Less:

Local Purchases
Boston Purchases

Gross Profit on Fish Sales 17.71%

Gear Sales (Net)
Less: Cost of Gear Sold

Fuel Sales
Less: Cost of Fuel Sold

Sales: Boxes, Ice & Bait
Miscellaneous Income
Gross Profit on Sales

Operating Expenses

Freight
Boxes, Ice & Bait
Pier Supplies
Casual Labor
Accounting & Legal
Advertising
Bank Service Charges
Bldg. Maint. & Cleaning
Contributions
Heat, Light, & Water
Insurance
Interest
Truck Maint. & Del'y Expense
Market Expense - General
Office Supplies
Rent - Fish Pier
Taxes - Payroll
Taxes - General
Telephone
Dues
Travel
Employee Medical Expense
Wages

Total Operating Expenses
Net Operating Profit Before Depreciation
Depreciation
Net Operating Profit

T. McGuire 2/11/74

FIG. 6-5 Ref.

Provincetown Fishery Co-operative

Objectivity

Provincetown co-operative was incorporated in 1970 out of the growning need of a group of fishermen to pool their catch in order to sell more advantageously than they could do individually. Advantages were also realized by purchasing supplies and equipment on a wholesale basis.

Functions

The co-op is basically involved in two functions: 1) It markets its members' fishery products to New York and Boston markets (with the greatest majority of fish going to New York); 2) It provides the members with the necessary supplies such as gears, wires, nets, and baits. No fuel is supplied. The co-op contracts with a local trucker for transportation arrangements.

Size

About 30 boats operate out of Provincetown. The fleet consists of 8 or 9 long liners and the rest are side trawlers. The membership totals 60. Sales for 1973 amounted to $1-1/4 million.

Organization Structure

16 members are elected to the board for a two-year term. Board meetings are held bi-weekly, and membership meetings are held quarterly.

The management staff, under the direction of the board, is in charge of the day to day operation of the co-op. The general manager also serves in the role of salesman. He is in constant communication with the board directors in carrying out his duties. The only other staff member is the bookkeeper, who does all the accounting work.

Finance

Besides issuing common stocks to its members, the co-op also borrows from banks. The co-op has been taking 6¢ per pound for products handled. This has been marginal in covering the operational costs of the co-op. No patronage refunds have been declared since 1971, consequently not much consideration has been given to the issuance of scripts.

Operation Routine

The survey reveals that the operations are very informally co-ordinated. Most of the boats operate on a daily basis. There is no radio communication with the boats out at sea, which makes the sales efforts all the more difficult. The boats leave the dock before 7 in the morning, and return between 4 and 7 in the afternoon. The actual selling is done after 7 p.m. The manager calls up the dealers from 7 p.m. to 9 p.m. at their homes for their orders. The truck then leaves for delivery. Any excess in supply is cooled by block ice until the next day.

Most aspects of the operations are similar to that of a model co-op, with the exception that Provincetown fishermen sort and pack their fish in boxes before landing their catch. In this manner the time and cost of sorting and packing on shore is saved. Each box is numbered so that any customer complaints concerning the size or quality of fish can be traced to the appropriate fishing boat.[2]

Accounting System

The accounting books and records are composed of the "Safeguard One-Write System" and Fedders computer service. As the term implies, the one-write system has helped to reduce the repetitive nature of journalizing, posting, copying, and proving of the tedious bookkeeping routine down to a "one-write", single entry format. Provincetown employs the services of O. C. Moyer and Company, which provides it with specifically designed forms for record keeping, periodic financial statements, and consultation in accounting matters. For further detail, refer to "Safeguard System" in Appendix.[3]

---

2. Ref. 9.

3. Ref. 8.

Point Judith Fishermen's Cooperative Association

Objectivity

The motive behind the formation of Point Judith Fishermen's Co-operative was to provide an outlet for fish products which would ensure the fishermen a fair return on their investment and efforts. Before the co-op was formed, the fishermen sold their catch to two wholesale fish dealers located at Point Judith, and to the New Bedford, Massachusetts, and Rhode Island Markets. The fishermen were at the mercy of the dealers for their income.

Functions

The survey reveals that Point Judith is mainly engaged in three types of operation. It covers marketing, supplying, and processing activities. Its shoreside facilities include: a filleting plant, a marine supplies store, a lobster plant, an industrial processing plant, an ice making machine for flake ice, a regular ice plant for block ice, and fuel facilities, with assets totalling over $1 million.

Size

It has a fleet of 61 member and 20 non-member boats. They are draggers, side trawlers, and pot lobster boats that vary from 40 to 85 feet in length. The inshore pot lobster boats are manned by a 2-man crew, whereas the day and trip draggers are manned by a 3-man team.

Membership can be acquired by the minimum purchase of $100 of common stock of the co-op plus an entrance fee of $225. Currently there are 129 shareholders.

Organization Structure

The board consists of 7 directors elected to a year term by the members in an annual meeting. Board meetings are held monthly, and membership meetings are held quarterly. The management staff is made up of a general manager, an assistant manager, a salesman or two, and the various plant supervisors. It is under the direction of the board.

Finance

Finance is done by issuance of stocks, retained earnings, revolving fund, and borrowing from banks.

Three types of stocks are available: common, preferred common, and special preferred. Special preferred has top priority and it yields 1% per annum. Preferred common takes precedence over common, and it yields 6% per annum. Common stocks have no specific yield.

The method of retained earnings has been used to a lesser extent than the revolving fund, which involves the withholding of part of the patronage refund by the issuance of scripts or stock options to be redeemed in later years. The co-op has been making patronage refunds on about 80% of total earnings. The refunds were usually made up of 20% cash and 80% in scripts.

Operation Routine

The mode of operation is basically similar to that of a model co-op. The added difference is the operations of the industrial fish plant, and the lobster plant. Radio contacts are frequently made with the boats which greatly help to coordinate the sales effort.

The co-op sell its products to various markets such as Boston, New York, Philadelphia, and Baltimore. Products from the industrial fish plant such as fish meal, solubles, and oil are sold to New England and the Mid-West areas.

In 1973, the total catch consisted of 50 million pounds of industrial fish, 16 million pounds of edible fish consisting mainly of yellowtail, flounder whiting, cod, squid, and butterfish, and 1 million pounds of lobsters. Sales totalled $7 million, of which 80% belonged to members. New York's Fulton Fish Market accounted for about 65% of total sales of edible fish.

<u>Accounting System</u>

Bookkeeping is done in the normal double-entry format. Five journals are used: 1) Cash Receipts; 2) Cash Disbursement; 3) Sales; 4) Purchase; 5) General Journal.

To help evaluate the performance of various branches of the co-op, profit centers are set up on 11 departments:

Fresh Fish	General & Administrative
Processed Fish	Maintenance
Marine	Lobster Supervision
Gasoline	Lobster, Other
Ice	Lobster Overtime
Sales	

Each operating statement points out the profit-loss status of each department, which in turn provides an extremely useful management tool to improve on the overall efficiency of the system.[4]

4. Ref. 5

CHAPTER VII

CONCLUDING REMARKS

The concept of fishery co-operatives is not an end in itself, but a means by which fishermen can get fair returns on their catches. Although fishery co-operatives cannot solve all the fishermen's problems, they provide a framework to deal with most of the problems that arise.

The successful operation of a fishery co-operative hinges on the co-operative spirit of its members. Their understanding and trust in the organizational framework are most essential. The management of a co-operative cannot function properly if members are suspicious of its actions, and if the management is constantly under harassment by the fishermen.

In the surveys performed, it was found that the management often lacks the proper authorities to perform effectively. The problem arises partly from the fishermen's inherent distrust of organizations, and partly from their lack of understanding of most of the accounting practices so essential to the operations of a co-operative.

Even though fishery co-operatives are organized on a non-profit basis from a legal and accounting viewpoint, it is necessary for them to operate efficiently and economically in order to survive. To accomplish this, an adequate accounting system must be designed to suit the nature of a particular co-operative. Such a system has to provide the necessary information for management control and decision-making.

The essence in the design of an accounting system lies in the thorough understanding of the objectives of a business concern, and the nature of its operations. A survey, the initial phase of the design work, serves as the investigative process that reveals all the details of the operations. Then, analyses can be performed on procedures from broad to narrow, and the whole system gradually emerges.

The framework set up for the design of a model co-operative by no means indicates that this is the way a co-operative should operate. It merely serves as a general guideline, that any design work must start from the broadest scale. Only after the major procedures are dealt with, can the details be designed to meet the objectives of the major procedures.

Due to the tax-exempt nature of fishery co-operatives, special considerations with regard to federal income tax treatment should be incorporated in the basic design of an accounting system. Sections 521 and 522 of the old Internal Revenue Code provide the fishery co-operatives with special income tax privileges in that net margins are tax deductible if they are distributed as patronage refunds. Only 20% of such refunds has to be in cash form. The remaining 80% can be allocated in the forms of scripts, or notes payable. This way, the federal income tax liability is transferred from the co-operative to the patrons' level.

This peculiar method of financing, unavailable to other business entities, gives co-operatives an added incentive to expand by reinvesting via the revolving fund plan. Theoretically, expansion reduces costs of operations, hence increases returns to fishermen. However, this method of financing is not commonly used by the co-operatives surveyed.

Of the three fishery co-operatives surveyed, Chatham has an unsophisticated, traditional form of accounting system. Due to the relatively low volume of transaction, all the accounting work is handled by one accountant, without the aid of computers.

Provincetown incorporates computer services into its accounting system. Its "Safeguard" one-write system is claimed to have saved Provincetown considerable clerical costs. The bookkeeper, who does all the recording, doe not need an accounting background. The system is specifically designed to be used by non-accounting fishermen. Provincetown relies on an accounting firm to issue monthly financial reports, and receives the appropriate recommendations.

Point Judith has a rather comprehensive accounting system. Due to its vast scope in operations, separate profit-loss centers are created in order that performance of individual divisions can be readily evaluated, and improvements made accordingly. The accounting responsibilities are spread among several people. No computers are used in the Point Judith system.

The surveys reveal that even in a same line of business, accounting practices can vary a great deal. In each case, the accounting system is tailored to meet the needs of that co-operative. Chatham uses an unsophisticated system for its simple operations. Provincetown utilizes a computer system to cut down the reliance on human elements. And Point Judith has to branch out its accounting system to cope with its expanded operations. Whatever their forms may be, all three accounting systems converge to one principle, that is, to systematically collect all the necessary information to aid the management in control and decision-making processes. (See Table 7-1).

Due to the nature of operations of fisheries co-operatives, there are advantages and disadvantages to the use of computers in accounting systems. On the plus side, computers may cut down clerical costs by taking over the repetitive processes in bookkeeping, and cutting down human errors. Data processing may also eliminate peak loads at the end of each month, and it will provide prompt reports at the end of each period.

The dangers in the use of computers may be the complete reliance on computers, and the neglect of human elements. If the design of a computer system is not comprehensive, the computer outputs may give incorrect signals and hence lead to misinterpretations by the management. It is essential that a computer system is continually readjusted and updated to fit the trend of the business. Frequent consultations with an accounting firm on computer outputs and operational results are not only beneficial to a co-operative, but a necessity.

Co-operatives that incorporate computers in their accounting systems must bear one concept in mind. They should be masters instead of slaves of computer technology.

TABLE 7-1

	Chatham	Provincetown	Point Judith
FUNCTIONS	Marketing & Retailing	Marketing & Supplying	Marketing, Supplying, & Processing
SIZE	45 line trawlers 95 members Fixed assets: $200,000	21 trawlers 9 long liners 60 members Fixed assets: $120,000	60 draggers 20 pot lobster boats 129 members Fixed assets: over $1 million
ORGANIZATION STRUCTURE	7-member board | General manager | Accountant	14-member board | General manager | Accountant	7-member board | General manager | Assistant manager & accountant | Salesman; Plant supervisors
FINANCE	5-1/2 - 6-1/2¢ per lb Common stock Loan from banks Cash from retailing	6¢ per lb Common stock	6¢ per lb Stocks: Common Preferred Special preferred Revolving fund (script) Loan from banks

TABLE 7-1 Con'td

	Chatham	Provincetown	Point Judith
ACCOUNTING SYSTEM	Double entry 2 journals: Cash receipts Cash disbursement Single profit center Financial reports: Balance sheet Income & expenses	One-write system 4 safeguard systems: Cash receipts Cash disbursement Receivables Payables Single profit center Financial reports: Monthly output from computers provides comparative data from previous periods	Double entry 5 journals: Cash receipts Cash disbursement Sales Purchase General 11 profit centers Financial reports: Balance sheet Statement of operations Statement of stockholders' & patrons' equity

APPENDIX

SAFEGUARD ACCOUNTING SYSTEM

Safeguard accounting system is a one-write accounting concept developed by the Safeguard Business Systems in recent years. As the term implies, the one-write method is a rebellion against the conventional double-entry bookkeeping routine. It reduces the repetitive nature of journalizing, posting, copying, and proving of the tedious bookkeeping procedures down to a "one-write", single-entry format. The system requires the usage of forms specifically designed to meet the nature of particular industry together with the Safeguard Folding Accounting Boards.

Due to the time saved in posting, journalizing, and proving, Safeguard Company estimates that up to 50% of clerical savings can be achieved by switching from the conventional accounting to the Safeguard System. The system supposedly can eleminate peak loads, and overtime. Each day's work is a completed job, and all records are kept up to date. Safeguard's "one-write" systems can be adapted to most of the record keeping activities presently requiring repetitive posting. It is a system specifically designed for use by non-accountants, who need not have prior knowledge to accounting work, and who need not have understanding of the inner structure of the accounting system being used. The following systems are available from Safeguard Company: Accounts Receivable, Accounts Payable, Payroll and Disbursements, and Financial Reporting.

Accounts Receivable System

Safeguard's Accounts Receivable System makes it possible to post and prove Statement Ledger and Journal in just one writing. Customer statements are always up to date, and customer credits are easily controlled. It is supposed to provide accurate proof—line proof, page proof, and duplicating proof.
The statements go out in special envelopes with windows showing the name and address of a client.

When payments are received they are recorded on the Statement, Ledger, and Cash Receipts Journal in a one-writing operation. Bank Deposit Slip collates with Journal for complete control of all monies.

Accounts Payable System

The vendor's ledger and the purchase journal are posted simultaneously under this system. Similarly, the check, the vendor's ledger, and the cash disbursement journal are posted in one-writing operation.

As all information is recorded together in each case, one proving of the appropriate journal would automatically prove the other forms for accuracy. This multiple posting is estimated to eliminate about 2/3 of the posting time and all possible errors associated with transposition and omission, etc.

Two forms are used for posting purchases, vendor's ledgers and a purchase register. The difference between the "previous balance" column and the "new balance" column must equal the predetermined total of the invoices posted. The total of all the distribution columns must equal the credit column. Consequently the purchase ledger acts in a dual capacity, as a book of original entry and, equally important, as proof of accuracy in ledger balances and journal entries.

Combination Payroll/Disbursement System

This is a simplified and highly efficient method of combining the paying of bills with the issuing payroll checks. It is most helpful to small business with relatively few employees.

With all forms locked into exact alignment, one single-entry automatically creates all the necessary records. When a check is written to pay a bill, the entry is recorded on the disbursement journal at the same time. When preparing payroll checks, the employee's ledger card is simply inserted beneath the check. The entry to the payroll check will be recorded on the ledger card and the disbursement journal automatically. Because the Earnings Record and Disbursement Journal are NCR(no carbon required) paper, payroll figures will appear in blue, disbursement figures in black. This "color code" is designed to provide fast and easy proof.

This system manages to combine what used to be two separate functions. It insures accuracy, eliminates confusion, and provides the accountant with organized, error-free information for auditing and tax work. Checks may be written at any time, and records are kept up to date.

Financial Reporting

Safeguard provides a Financial Reposting System utilizing computers to summarize and record financial data and printing the related Journals, General Ledger,and Financial Statements.

The speed, accuracy, and economy have permitted the modern data processing to take over the numerous repetitive clerical transcriptions involved in preparing financial information for the clients and integrate the successive operations of accounting from the original entry to end result. In addition, Safeguard's one-write systems are primarily designed as source documents for computer input. A preprogrammed package will provide any kind of financial reports to meet the needs of a client. These reports can also provide the figures of the same period for the past years for comparison purposes. Such reports include: Journal List, General Ledger, Summary Cash Flow, Earnings Statement, Balance Sheet, Consolidated Statements, Accountants Report Letter, Working Trial Balance, 941 and W2 Reports, Automatic Reversing of Accruals, Automatic Recording of Recurring Entries, and Departmental Cost Reports, etc.[1]

---

1. Ref. 10.

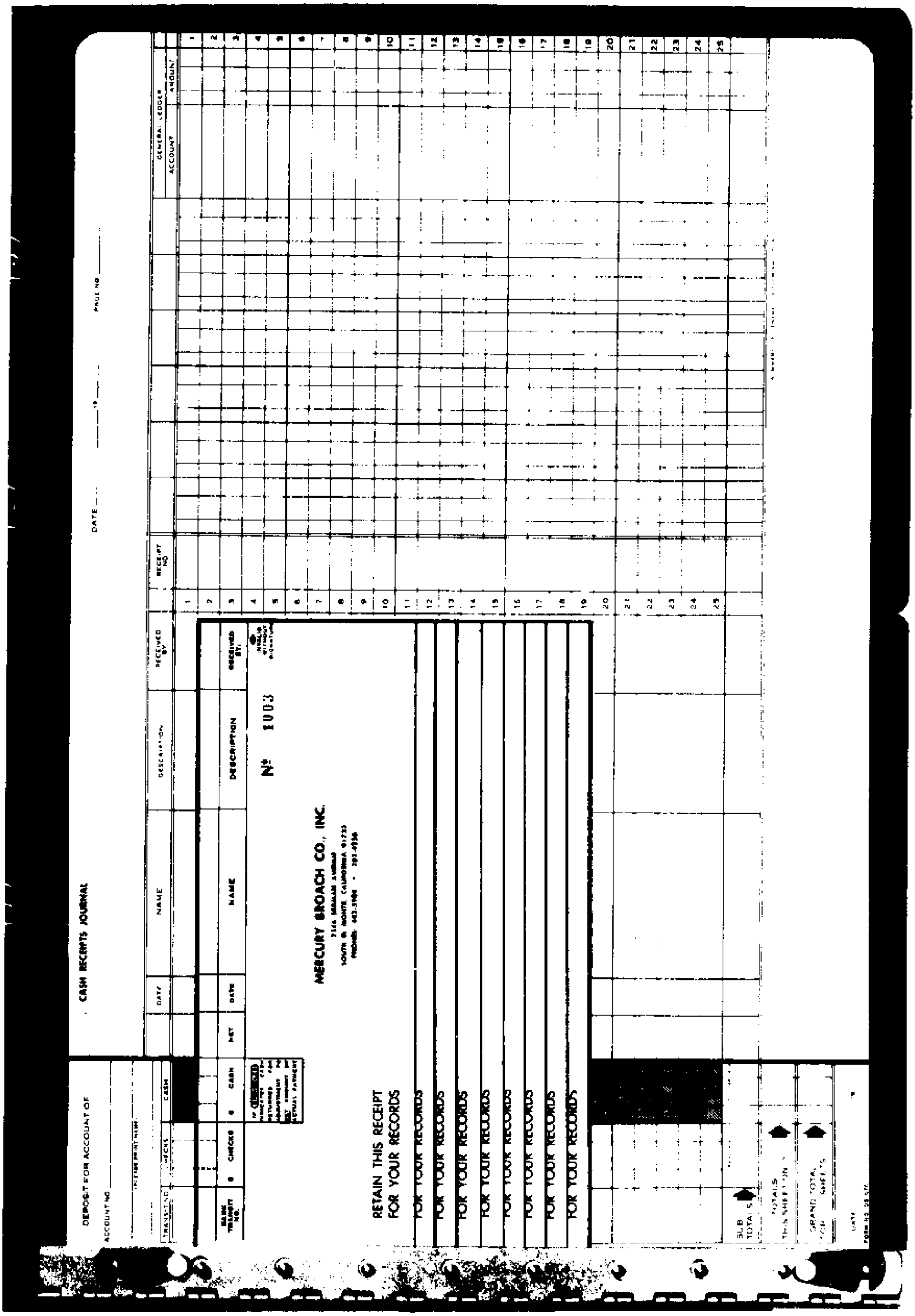
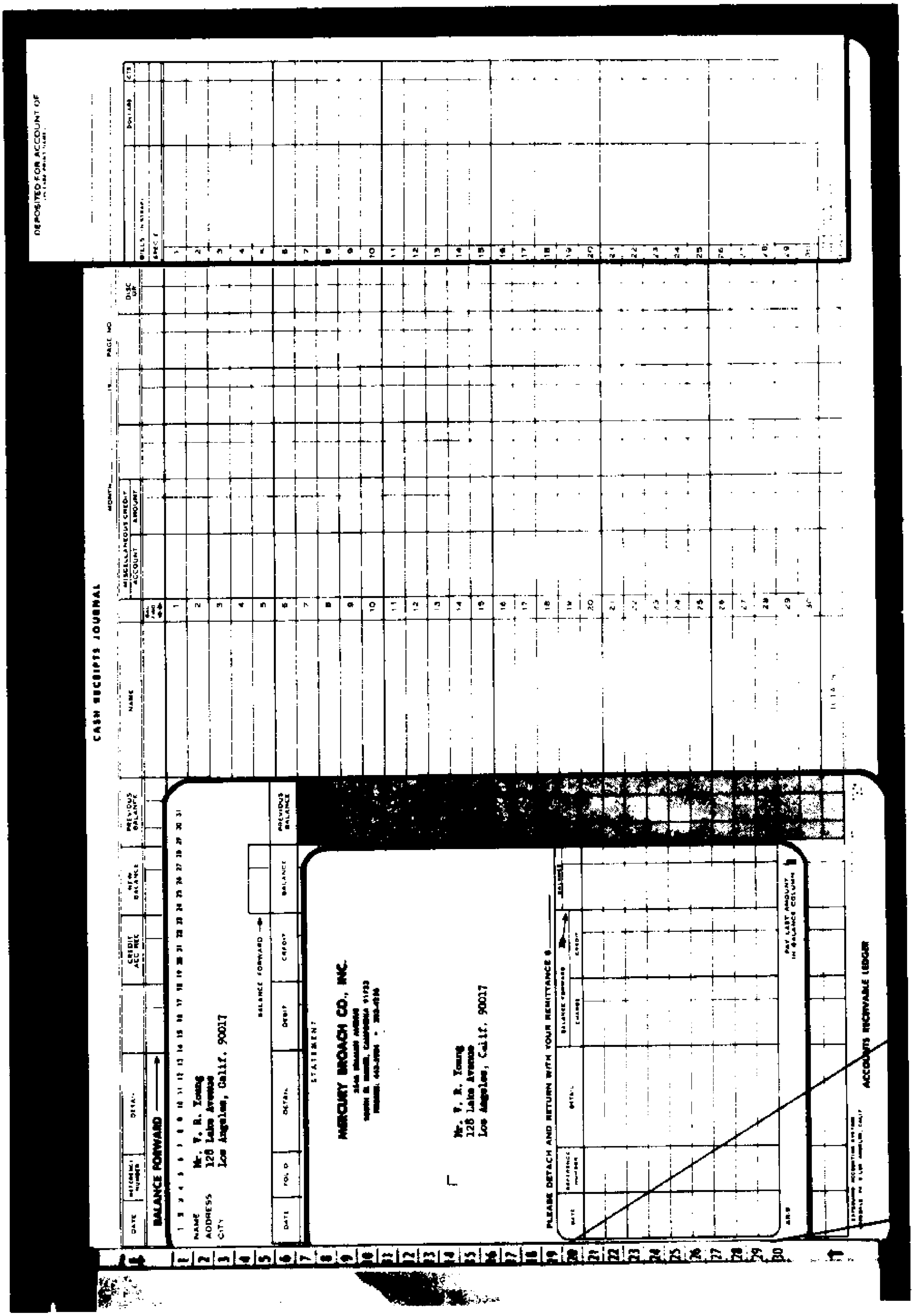

CASH RECEIPTS JOURNAL
DEPOSIT FOR ACCOUNT OF
ACCOUNT NO
DATE
PAGE NO
DATE
NAME
DESCRIPTION
RECEIVED BY
RECEIPT NO
GENERAL LEDGER
ACCOUNT
AMOUNT
CHECKS
CASH
NET
MERCURY BROACH CO., INC.
Nº 1003
RETAIN THIS RECEIPT FOR YOUR RECORDS
FOR YOUR RECORDS
FOR YOUR RECORDS
FOR YOUR RECORDS
FOR YOUR RECORDS
FOR YOUR RECORDS
FOR YOUR RECORDS
FOR YOUR RECORDS
FOR YOUR RECORDS
SUB TOTALS
TOTALS THIS SHEET ONLY
GRAND TOTAL ALL SHEETS

FIG. A-1

Ref. 10



DEPOSITED FOR ACCOUNT OF
CASH RECEIPTS JOURNAL
BALANCE FORWARD
Mr. V. R. Young
128 Lake Avenue
Los Angeles, Calif. 90017
STATEMENT
MERCURY BROACH CO., INC.
PLEASE DETACH AND RETURN WITH YOUR REMITTANCE
ACCOUNTS RECEIVABLE LEDGER

FIG. A-2

Ref. 10

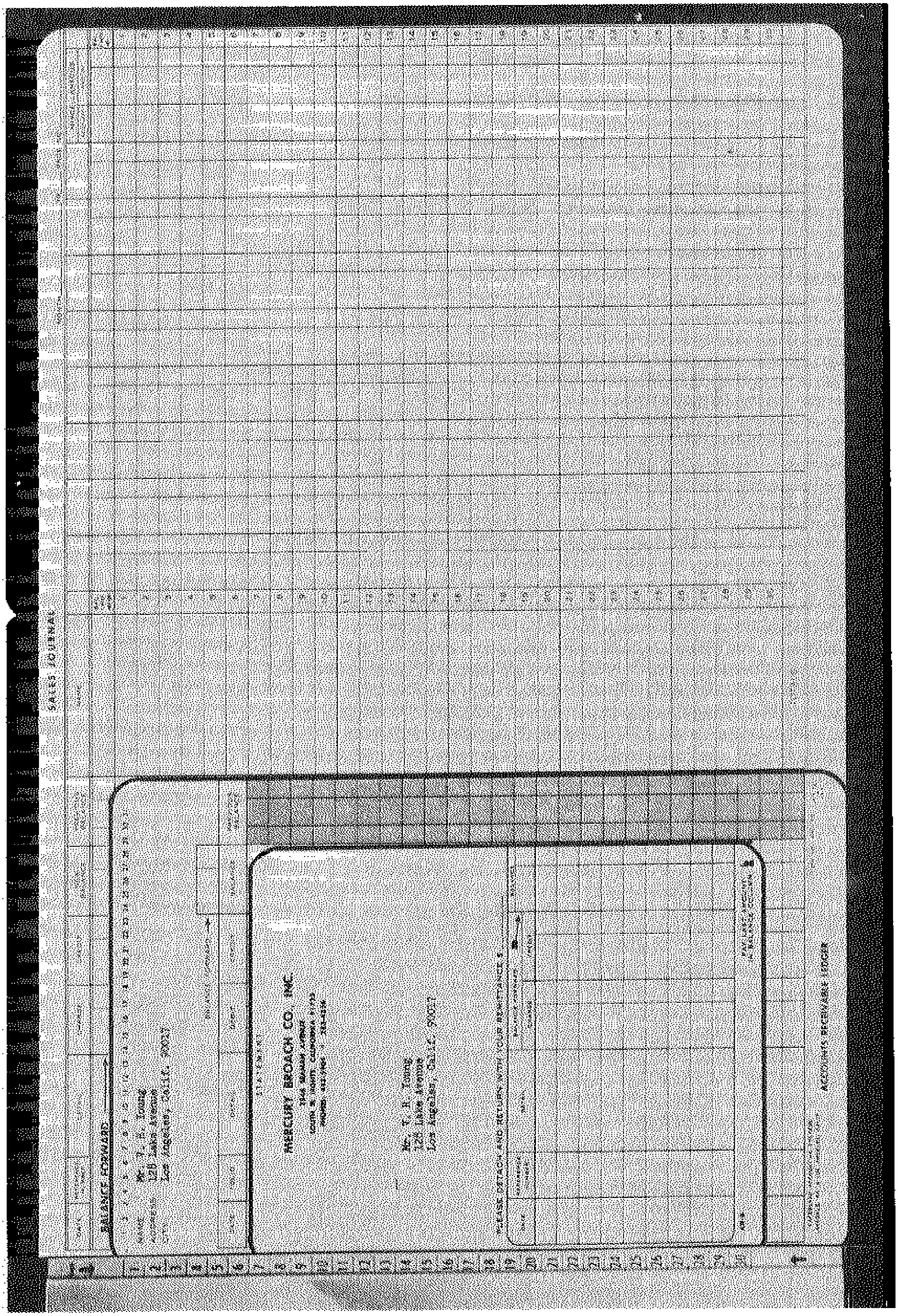

SALES JOURNAL
BALANCE FORWARD
Mr. T. R. Young
128 Lake Avenue
Los Angeles, Calif. 90027
STATEMENT
MERCURY BROACH CO. INC.
PLEASE DETACH AND RETURN WITH YOUR REMITTANCE $
ACCOUNTS RECEIVABLE LEDGER

FIG. A-3

Ref. 10

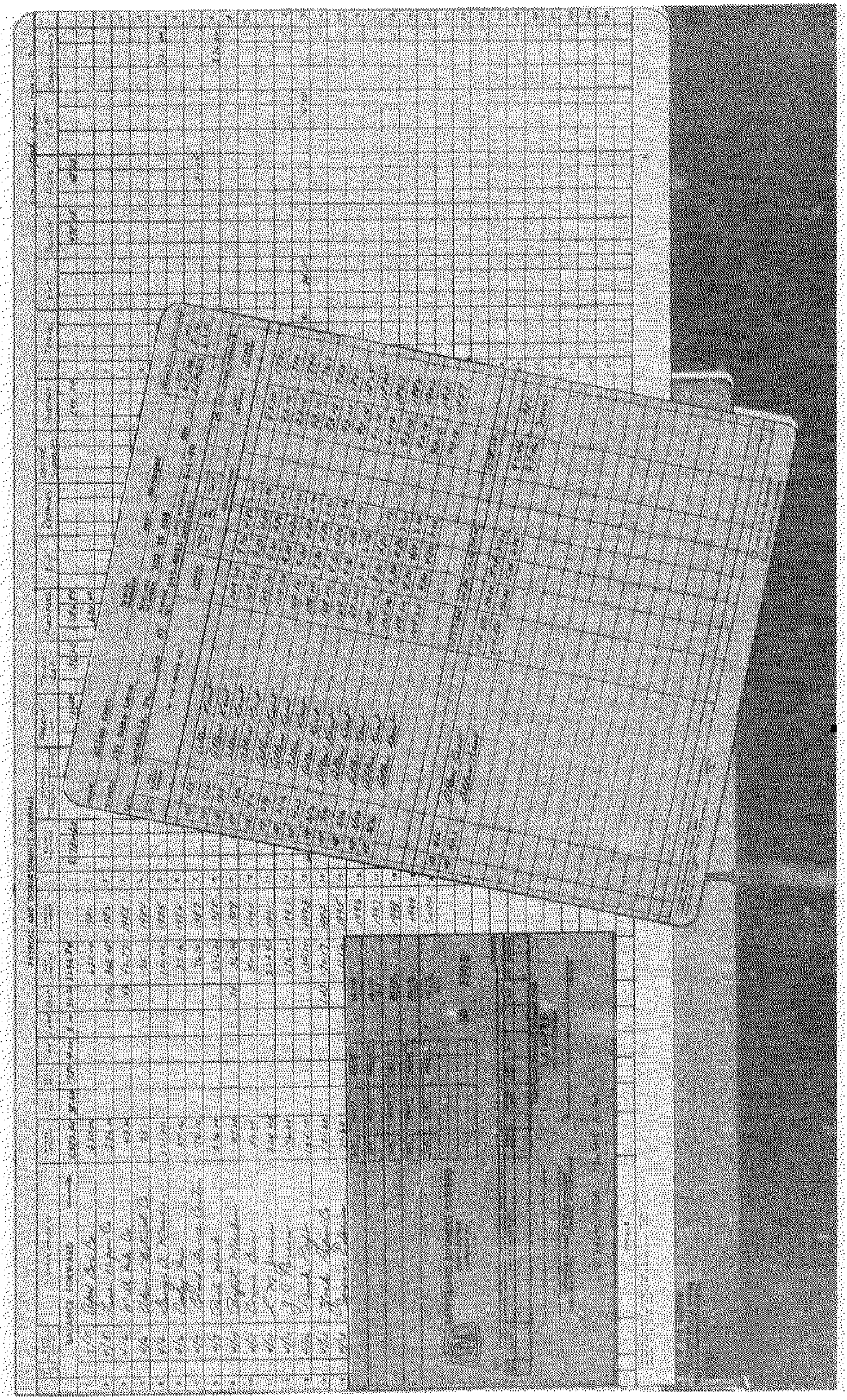


FIG. A-4

Ref. 10

REFERENCES

1. Gersuny, Carl and Poggie, John J. Jr., A Fishermen's Cooperative: Open System Theory Applied , Maritime Studies & Management, April, 1974.

2. Gillespie, Cecil, Accounting Systems, Procedures and Methods , Prentice-Hall Inc., New Jersey, 1961.

3. Gordon, Myron J. and Shillinglaw, Gordon, Accounting, a Management Approach , Richard D. Irwin, Inc, 1964.

4. Heckert, J. Brooks and Kerrigan, Harry D., Accounting Systems-Design and Installation , The Ronald Press Co., N. Y., 1967.

5. Interview with Leonard Stasiukiewicz, general manager of Point Judith Fishermen's Co-op Association, March 29, 1974.

6. Interview with Porter C. Little and Roland W. Hodgdon, business analysts of Springfield Bank for Co-operatives, Nov., 1973.

7. Interview with Thomas McGuire, accountant for Chatham Seafood Co-op, March 12, 1974.

8. Interview with Josheph Taves, C.P.A. for O.C. Moyer & Co., January 31, 1974.

9. Interview with Gayle Charles, former manager of Provincetown Co-operative Fishing Industries, May 6, 1974.

10. Introductory forms from Safeguard Business Systems.

11. Moore, Francis E. and Stettler, Howard F., Accounting Systems For Management Control , Richard D. Irwin, Inc., Illinois, 1963.

12. McMullin, Leslie D., Organizing and Operating Fishery Cooperatives , U.S. Department of the Interior Circular #155, 1963.

13. Napoli, James J., Fisheries Cooperatives: Their Formation and Operation , Marine Advisory Service, U. of R. I. Marine Memorandum 30, 1972.

14. Neuner, John J. W. and Neuner, Ulrich J., Accounting Systems - Installation Methods and Procedures, International Textbook Co., Penn., 1960.

15. Stasiukiewicz, Leonard, "Special Presentation on Fisheries Co-operatives", Sea Grant Conference of March 28-29, 1972.

16. Smith, Frederick J., "Organizing and Operating A Fishery Cooperative," part one, Oregon State Extension Marine Advisory Program, S.G. #19.

17. Smith, Frederick J., "Organizing and Operating A Fishery Cooperative", part two, Oregon State Extension Marine Advisory Program, S.G. #19a.

18. Schrader, Lee F. and Goldberg, Ray A., Federal Income Taxes and Farmers' Cooperatives, Harvard Graduate School of Business Administration, July 31, 1973.

19. Whiteside, Canon Doyle, Accounting Systems for the Small and Medium-sized Business, Prentice-Hall Inc., N.J., 1961.

20. Accounting and Financial Reporting for Farmers' Cooperatives, U.S. Department of Agriculture Publication, 1972.

PART 3

FUTURE PROSPECTS FOR NEW ENGLAND DOMESTIC AND IMPORTED FISH PROCESSING AND HANDLING FACILITIES

CHAPTER I

INTRODUCTION

Most people are aware of the hard times being faced by our New England fishing industry. Decreased landings and rising costs have caused a rapidly decaying fleet and equally poor port facilities. Many people who have been in business for most of their lives have had to leave it or fear that they soon will. The condition of port and processing facilities handling the flow of fresh fish cannot be completely understood without first considering the situation of the supply and the fleets which bring the fish home. (Chapter II)

A much larger industry, but one which is less vocal and taken for granted, is the frozen fish import industry. New England imports frozen blocks of fish and fillets in quantities many times larger than that produced domestically. Our major suppliers are Canada, Norway, Iceland, Denmark and Japan. The port facilities and processing plants which handle and process these imports represent a substantial investment, but the security of this investment depends on an adequate supply. (Chapter III)

The handling and processing of frozen fish is totally different than that of fresh fish. Plants for processing frozen blocks are generally new and modern with a large degree of automation. Cutting and filleting fresh fish requires a great deal of manual labor and is done, for the most part,

in fish houses which are old and run down. The contrast between these two industries is shocking, never-the-less, both supply needed consumer products. (Chapter IV and V)

Once an overall understanding of these two industries is acquired, it is possible to analyze the situation of the existing industry. The ports of Gloucester, Boston and New Bedford handle and process the bulk of both domestic and imported fish entering New England. Each has come to specialize in certain products and each is unique in terms of its port and facilities. Chapter VI analyzes and contrasts the facilities of these three ports, as well as their prospects for the future.

The U. N. Law at the Sea Conferences may have a profound effect on both the fresh and frozen fishing industries of New England. Chapter VII will touch briefly on these issues.

CHAPTER II

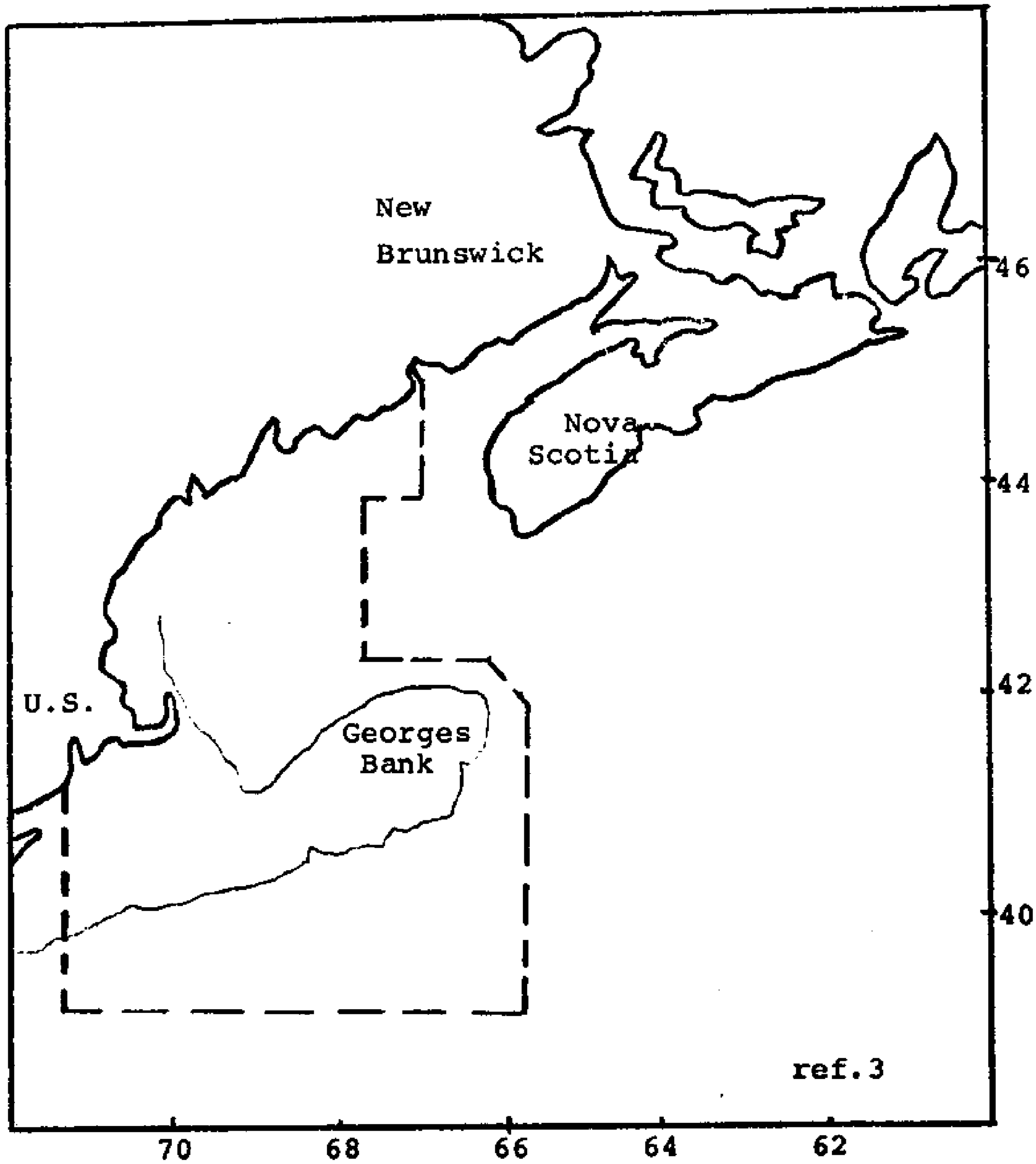
THE SUPPLY OF FRESH FISH

The condition of the domestic fresh fish industry in New England is not at all clear. Various "experts" have different points of view and present a wide range of opinions concerning the present and future of the industry. This chapter, however, attempts to describe the supply segment of the fresh fish industry and lay the groundwork for a more in-depth study of port facilities, processing, and marketing of fresh fish.

Trends in Landings and Price

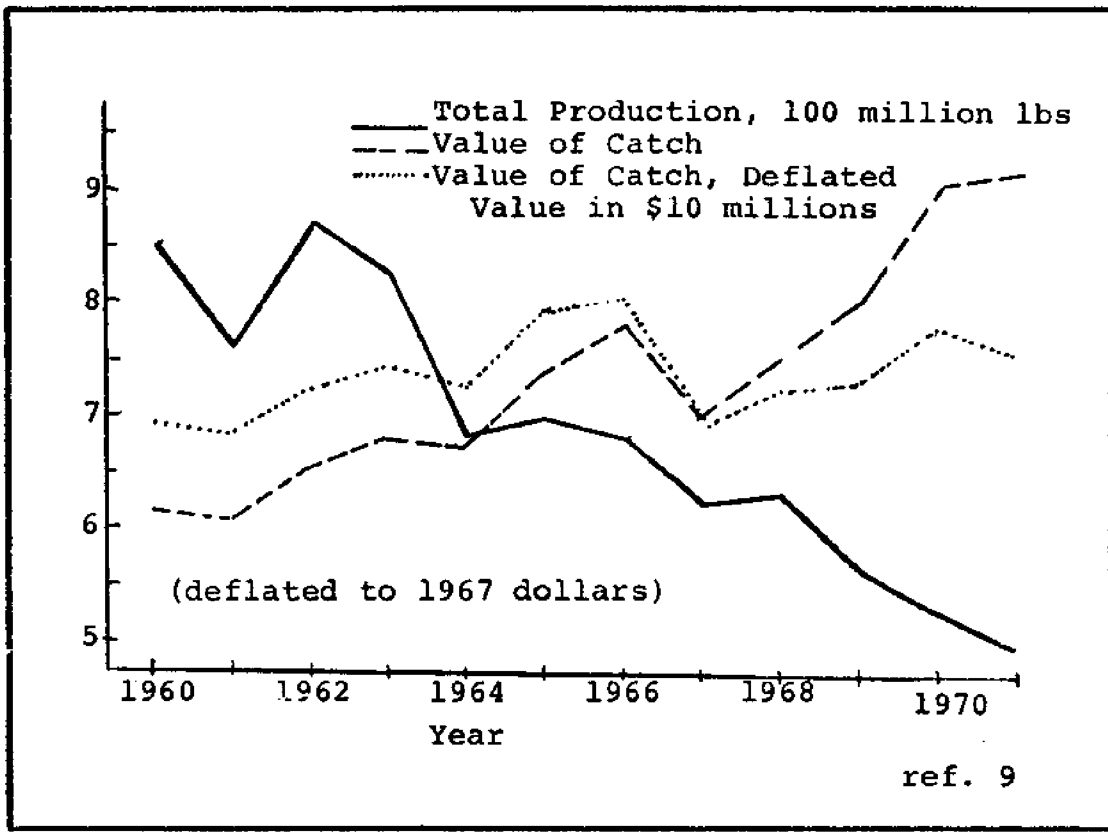
This analysis will consider New England as a whole, and occasionally the ports of Boston, Gloucester, New Bedford and Portland will be considered individually. The fresh fish brought into these ports come primarily from the ICNAF (International Commission for the Northwest Atlantic Fisheries) Commission Subarea 5 (Figure 2-1).

New England catch and value since 1960 are shown in Figures 2-2 through 2-4. Recent statistics by species and port are shown in Tables 2-1 through 2-5. It can be seen in the overall fish landings (Figure 2-2) that although total landings are only 50-60% that in 1960, the increase (in current dollars) of 50%. Adjusted for inflation this still results in a slight increase in actual value. The finfish catch seems to be the main culprit in the decrease in volume and this segment of the industry showed a 20% decrease in deflated



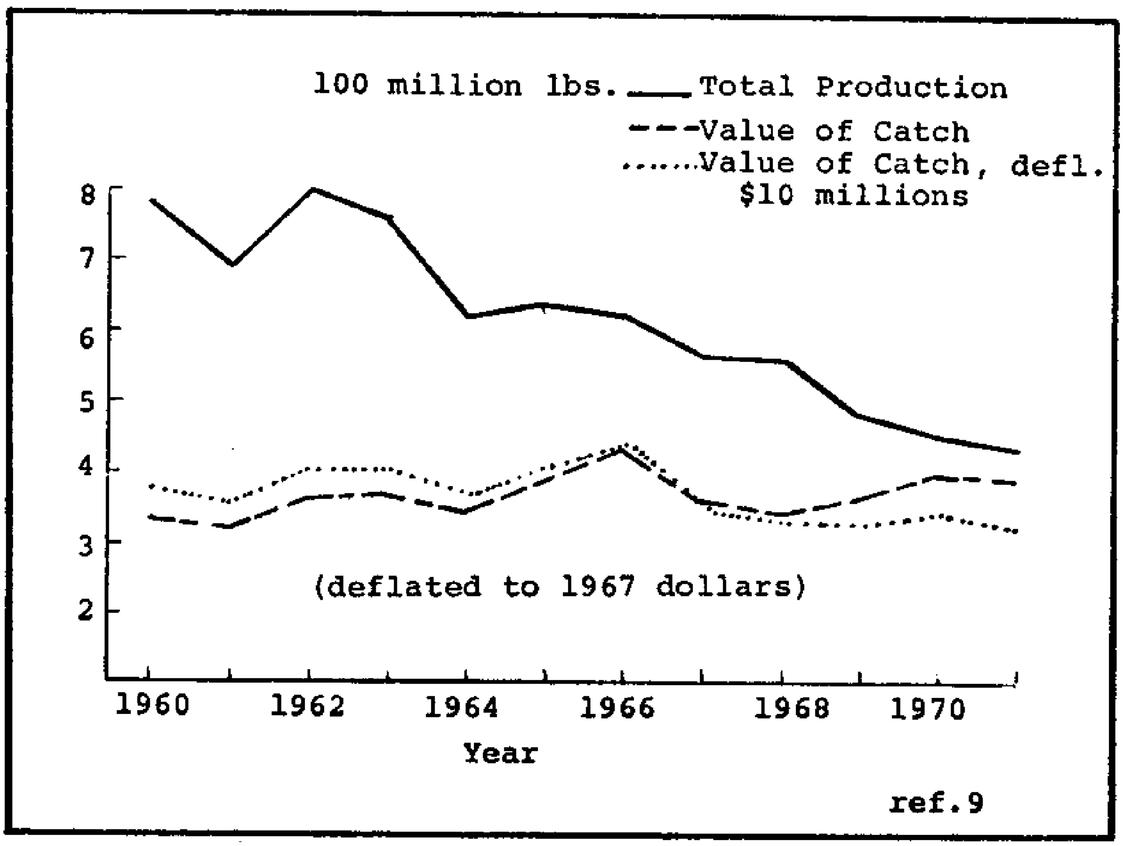
ICNAF Subarea 5 (Circled Area)

Figure 2-1



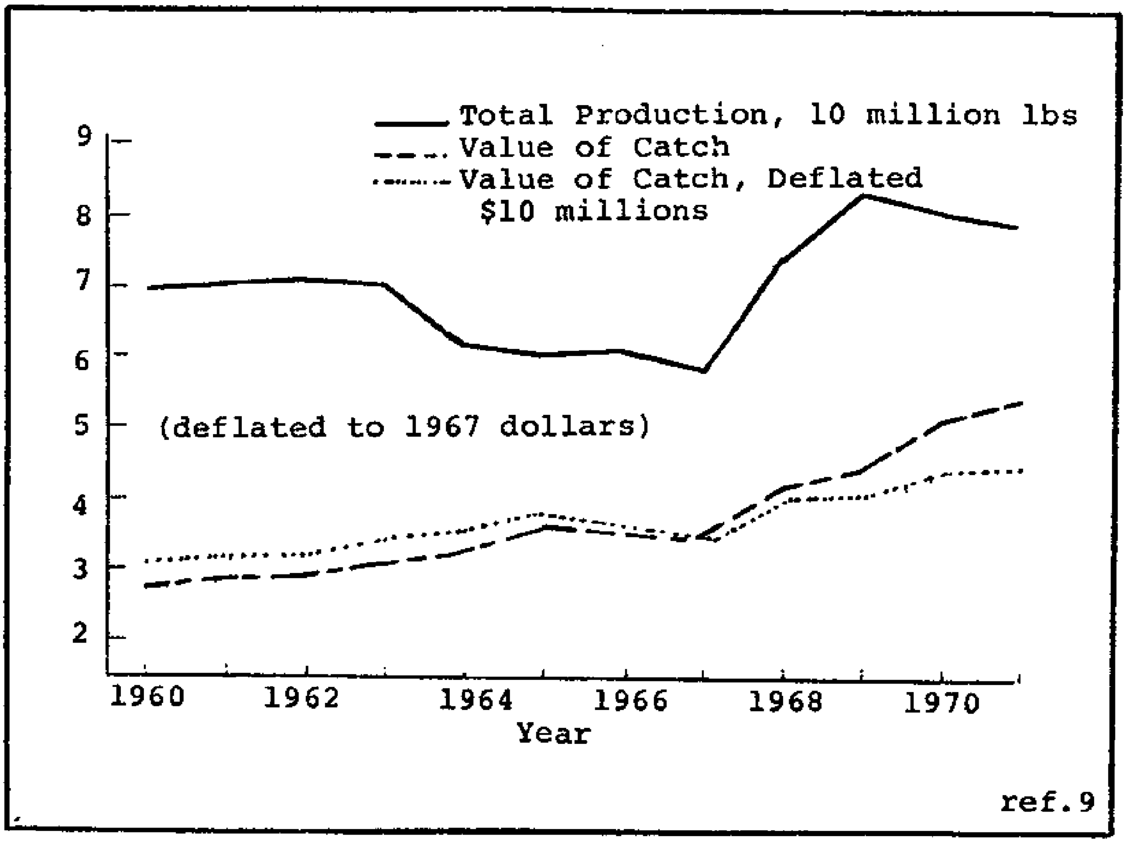
The New England Fish and Shellfish Catch

Figure 2-2



The New England Finfish Catch

Figure 2-3



The New England Shellfish Catch
Figure 2-4

Table 2-1

Boston Landings

	1969			1971		
Species	1000 lbs.	¢/lb.	$1000	1000 lbs.	¢/lb.	$1000
Haddock	20,526	20.27	4,162	9,037	30.00	2,710
Cod	14,439	11.33	1,636	10,989	15.98	1,756
Flounder	4,922	13.69	674	4,362	18.29	798
Pollock	4,532	6.95	315	4,867	9.70	472
Lobster	--	--	--	559	105.55	590
Other	1,289	8.14	105	2,234	9.00	201
Total Food Fish	45,708	15.08	6,892	32,048	20.36	6,528

ref.4

Table 2-2

Gloucester Landings

	1971			1972		
SPECIES	1000 lbs.	¢/lb.	$1000	1000 lbs.	¢/lb.	$1000
Cod	10,000	14.00	1,400	11,500	17.39	2,000
Ocean Perch	12,200	5.16	630	14,500	6.07	880
Shrimp	6,400	15.16	970	7,710	17.12	1,320
Haddock (and Scrod)	4,200	31.9	1,340	3,400	38.24	1,300
Whiting	13,000	5.46	710	9,000	8.16	735
Herring	39,500	1.64	647	33,700	1.86	628
Others	25,700	8.14	2,093	30,200	9.20	2,777
Total Food Fish	111,000	7.02	7,790	110,000	8.76	9,640

ref.4

Table 2-3

New Bedford Landings

SPECIES	1969 1000 lbs.	1969 ¢/lb.	1969 $1000	1971 1000 lbs.	1971 ¢/lb.	1971 $1000
Flounder (Primarily Yellowtail)	68,342	13.88	9,487	46,654	16.73	7,806
Scallops, sea	4,848	110.67	5,365	3,632	148.02	5,376
Haddock	5,129	15.87	814	3,502	26.75	937
Cod	7,857	9.55	750	8,331	14.24	1,186
Tuna	2,464	14.16	349	2,807	16.42	461
Lobster (Offshore)	366	89.39	327	468	102.14	478
Swordfish	106	70.53	75	--	12.00	--
Total Food Fish	89,278	19.23	17,171	65,616	24.76	16,262
Industrial	18,937	1.22	231	7,955	1.70	135
Total	108,215	16.08	17,403	73,571	22.29	16,397

ref.4

Table 2-4

Fish Landings in Remaining New England Ports

(1971)

	1000 lbs.					
	P'town	Portland	Rockland	Pt. Judith	Newport	Stonington
Cod	2,976	1,975	299	717	1,091	147
Flounder	5,866	303	247	7,030	11,607	1,298
Haddock	215	159	175	11	310	--
Herring	40	574	--	85	159	--
Ocean Perch	--	12,890	32,814	--	--	--
Pollock	294	451	286	3	7	--
Scallops	109	--	--	7	8	--
Lobster	--	--	--	2,135	1,449	--
Shrimp	--	3,535	8	--	--	--
Whiting	1,764	3,165	--	2,460	318	167
Mixed	1,458	548	256	2,319	733	879
Ocean Quahogs	--	--	--	--	530	--
Total Food Fish	12,722	23,600	34,085	14,767	16,212	2,491
Food fish ($1000)	2,105	1,871	1,830	4,103	3,738	--
Industrial (1000 lb)	387	864	--	40,803	--	--
Industrial ($1000)	6	8	--	429	--	--
Total ($1000)	2,111	1,879	1,830	4,532	3,738	--

ref. 4

Table 2-5
Total New England Food Fish Landings

	1962			1971		
SPECIES	1000 lbs.	¢/lb.	$1000	1000 lbs.	¢/lb.	$1,000
Cod	43,446	6.8	2,956	52,246	12.0	6,242
Cusk	1,858	5.4	101	1,776	8.9	157
Flounder	86,711	9.5	8,175	90,367	15.8	14,303
Haddock	134,169	8.0	10,903	21,583	26.2	5,648
Hake, white	5,611	3.9	219	5,682	6.0	343
Ocean Perch	123,983	4.2	5,223	59,852	5.1	3,047
Pollock	16,331	4.2	685	10,842	7.6	828
Whiting	97,737	2.1	2,039	27,819	5.7	1,596
Other	231,910	2.5	5,849	110,054	5.6	6,139
Total	742,256	4.8	36,150	380,221	10.0	38,303

ref.4

value. The majority of the finfish landings are made by vessels fishing with otter trawls for groundfish (cod, cusk, flounder, haddock, hake, ocean perch or redfish, and pollock).

At this point we can raise a number of questions:

1. What is the reason for the decrease in fish landings? Is it depleted fish stocks or a lack of quantity and quality in the fishing fleet's effort?
2. What are the economics of New England groundfish vessels in light of their slightly decreasing revenue?
3. What is the effect of decreased volumes of fish at various levels of the industry (catching, unloading, processing, marketing)?
4. How can the industry be helped? Can it survive?

Each of these questions concern critical aspects of the industry and will be discussed individually.

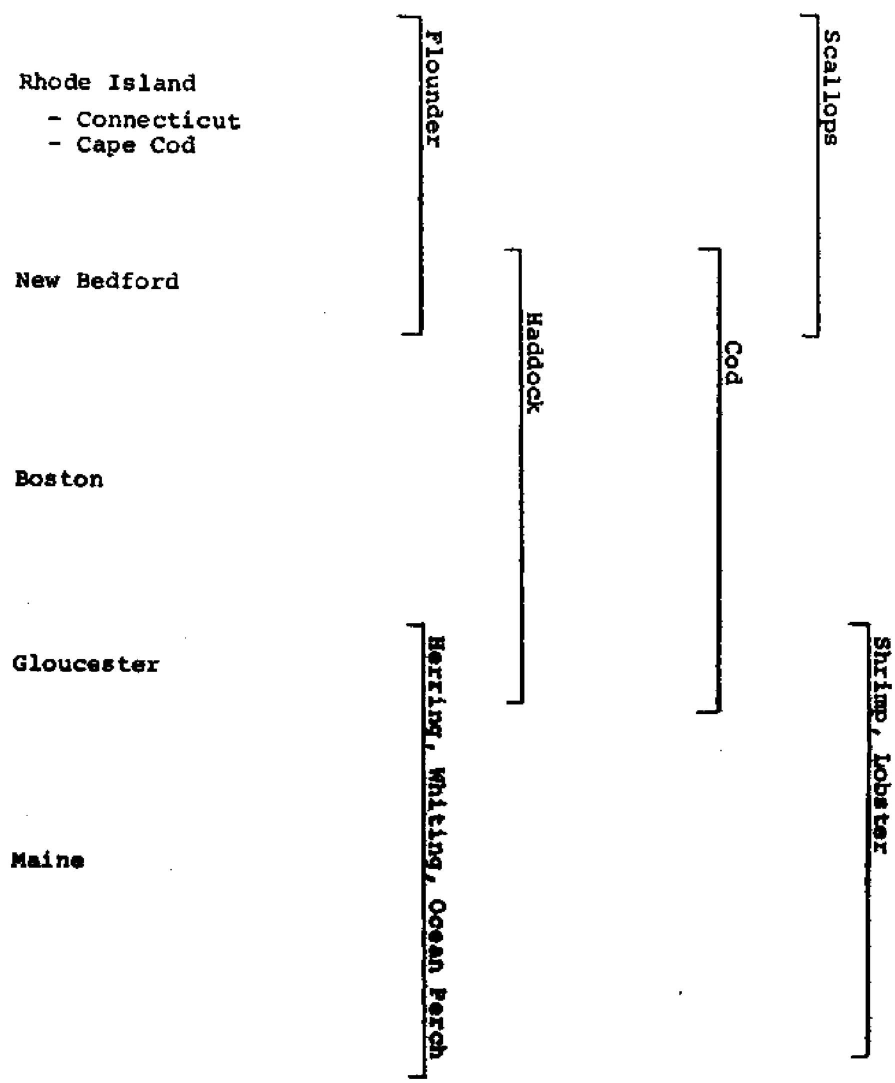
The Fisheries and the Fishing Effort

Important New England fisheries, their condition, and various aspects of the fleets fishing them will be discussed here (Figure 2-5). This discussion summarizes much of the information given in Reference 9.

Massachusetts groundfishing has accounted for over half of New England's fishing vessels and fishermen in recent years. They operate mainly out of Gloucester, Boston, and New Bedford with specialization as shown in Figure 2-5. The main groundfish in this industry are haddock, flounder, and cod.

Figure 2-5

Specialization in New England Fishing



Beginning in the early 60's haddock landings began to decline. In 1965 and 1966 foreign fleets fished the haddock stocks extensively and managed to exceed the U.S. catch. This intensified the already severe depletion caused by unsuccessful spawning. Thus the Haddock Disaster Program was initiated, part of which provided for ICNAF quotas to limit the haddock catch. These quotas are still in effect.

In the face of these quotas a shift to cod and other species is beginning to take place, especially in Gloucester, and this shift has been protected somewhat by ICNAF giving the U.S. two-thirds of a 30 ton quota on cod. Boston has not adapted so easily to this change and its fleet is facing definite financial problems.

Yellowtail continues to be dominated by New Bedford fishermen with less foreign competition. ICNAF has allowed the U.S. 24 tons of a 26 ton quota. Yellowtail like cod is probably being exploited to near sustainable yield.

With the decreasing abundance in groundfish (Table 2-6) the productivity per man, craft, and trawl has declined even in the face of somewhat improved technology. The average age for a New England groundfish trawler is 23 years and ranges as high as 54 years. Rising insurance and other costs have caused a trend towards smaller crews, many within a family. Three out of five fishermen are over 55 years old. Lack of reinvestment has reduced the number and quality of vessels still fishing. The fleet cannot maintain this trend and survive.

Table 2-6

Massachusetts Groundfish Fishing

	1960	1970
Catch quantity (lbs.):	396,402,400	227,410,300
Catch value ($)	23,002,888	27,442,531
Fishermen		
on vessels	2,609	1,887
on boats and shore regular	12	14
casual	--	--
total	2,621	1,901
Vessels		
number	422	343
tonnage	28,664	26,686
average tonnage	68	78
Boats, motor	7	7
Gear, trawls	429	350
Productivity (lbs.)		
catch per man	151,241	119,627
catch per craft	924,015	649,744
catch per trawl	924,015	649,744
Men per vessel	6.2	5.5
Deflated value of catch ($)		
per man	9,894	12,413
per craft	60,451	67,418

ref.9

The Maine ocean perch industry has been marked by an influx of smaller vessels. Landings have decreased, but smaller vessels have allowed lighter hauls to be handled more efficiently (Table 2-7).

Herring has been harvested extensively in Gloucester as of late and has been exported to Europe and used domestically for animal feed.

The extremely high price of sea scallops has kept this industry going, despite a decrease in landings and a migration of smaller dredge boats to catching bay scallops. Value of catch per man has increased substantially (Table 2-8). The industry is at or above sustainable yield.

Maine shrimp harvesting has seen a great boom in recent years which is spreading to Massachusetts. Boats and draggers fish for Northern shrimp both off-season and year round. Stocks tend to fluctuate greatly, however, and shrimp abundance next year is anyone's guess. See Table 2-9.

The Northern lobster fishery consists of three distinct segments:

1. Inshore pot fishery
2. Offshore trawl fishery
3. Offshore pot fishery

The landings of inshore lobster by the many small boats out of Maine and Massachusetts has remained nearly constant in recent years with Maine landing over three-fourths of the total catch. Landings are estimated to be at the maximum sustainable yield. Trawl landings have decreased in recent years and many believe that offshore pot fishing and foreign

Maine Groundfish Fishing
(Ocean Perch)

	1961	1970
Catch quantity (lbs)	102,378,100	70,264,600
Catch value ($)	3,846,781	4,182,581
Fishermen:		
on vessels	469	432
on boats and shore		
regular	42	85
casual	27	53
total	538	570
Vessels		
number	100	139
tonnage	7,884	9,233
average tonnage	79	66
Boats, motor	38	69
Gear, trawls	138	208
Productivity (lbs)		
catch per man	195,192	131,459
catch per craft	741,870	337,811
catch per trawl	741,870	337,811
Deflated value of catch ($)		
per man	8,269	6,728
per craft	31,426	17,291
Men per vessel	4.7	3.1

ref.9

Table 2-7

Massachusetts Sea Scallop Fishery

	1961	1970
Catch quantity (lbs)	22,122,800	4,288,400
Catch value ($)	7,999,180	5,735,304
Fishermen:		
on vessels	843	314
on boats and shore regular	179	2
casual	1,383	--
total	2,405	316
Vessels		
number	81	38
tonnage	6,822	3,556
average tonnage	84	94
Boats, motor	1,153	1
Gear, dredges	2,699	64
Productivity (lbs)		
catch per man	12,911	13,571
catch per craft	17,928	109,959
catch per dredge	8,197	67,006
Deflated value of catch		
per man	5,263	15,606
per craft	7,308	126,448
Men per craft	1.9	8.1

ref.9

Table 2-8

Maine Shrimp Fishery

	1961	1970
Catch quantity (lbs)	67,200	17,530,300
Catch value ($)	13,604	3,563,762
Fishermen		
on vessels		274
on boats and shore regular	10	493
casual		109
total	10	876
Vessels		
number		124
tonnage		4,363
average tonnage		35
Boats, motor	10	298
Gear, trawls	10	422
Productivity, lbs.		
catch per man	6,720	21,339
catch per craft	6,720	41,541
catch per trawl	6,720	41,541
Deflated value of catch ($)		
per man	1,500	3,730
per craft	1,500	7,261
Men per craft	1.0	2.1

ref.9

Table 2-9

incidental catch combined with normal trawl fishing have overfished the stock. Draggers also complain of fouling in pot gear while groundfishing. Despite all this, the high price of lobster has managed to keep this industry alive (Tables 2-10 and 2-11).

Such are the trends in the various New England fishing industries. General trends are towards fewer and older vessels with smaller crews. Rising prices have kept the industry going, but can't continue forever. The best way to understand these trends is to consider the economics of the industry's basic unit, the fishing vessel.

Economics of New England Fishing Vessels

This chapter first considered the nature and size of the New England fish landings. It next described the condition of the fish stocks and the fleet of vessels which fishes them. This section attempts to describe some of the economic reasons for the fleet's condition as they relate to the landings and the stocks, as well as to current costs such as labor, insurance and equipment.

As stated earlier, the groundfish segment of the industry, which comprises over half of the entire New England fishing industry, is having severe financial difficulties due to reduced landings and rising costs.

Reference 8 studies a representative sample of 28 Massachusetts side trawlers with characteristics as shown in Table 2-12 (1967-1968). The average gross revenue per vessel per year is $86,819 (ranges from $23,200 to $193,800).

Maine Lobster Pot and Trap Fishery

	1960	1970
Catch quantity (lbs.)	25,258,800	18,172,200
Catch value ($)	11,018,965	17,201,501
Fishermen		
on vessels	23	36
on boats and shore regular	4,559	3,542
casual	2,011	2,748
total	6,593	6,326
Vessels		
number	23	35
tonnage	205	406
average tonnage	9	12
Boats, motor	6,509	6,289
Gear, pots	709,824	1,180,010
Average gear per boat	109	189
Productivity, lbs.		
catch per man	4,521	3,670
catch per craft	3,867	2,874
catch per pot	36	15
Deflated value of catch		
per man ($)	2,223	2,987
per craft ($)	1,902	2,339
per pot ($)	21	16
Men per craft	1.01	.98

ref.9

Table 2-10

Table 2-11

Massachusetts Lobster Trawl Fishery

	1965	1970
Catch quantity, lbs.	2,154,600	1,072,500
Catch value,($)	1,227,800	992,223
Fishermen		
on vessels	149	102
on boats and shore regular		
casual		
total	149	102
Vessels		
number	22	16
tonnage	2,372	1,710
average tonnage	108	107
Productivity (lbs.)		
per man	14,460	10,515
per craft	97,936	67,031
Deflated value of catch ($)		
per man	8,720	8,364
per craft	59,057	53,322
Men per craft	6.8	6.4

ref.9

Average Statistics for Sample of
Boston Trawler Fleet (1967-68)

		Low profit Vessels	High profit Vessels	All Vessels
1.	Gross Receipts	$87,272	$86,366	$86,819
2.	Costs: crew	$43,450	$44,189	$43,819
	vessel	$48.011	$36,572	$42,292
	total	$91,461	$80,761	$86,111
3.	Profit (or loss)	$4,188	$5,605	$708
4.	Length (ft.)	74	61	67
5.	Gross tonnage	91	54	72
6.	Horsepower	311	275	293
7.	Age (yrs.)	20	20	20
8.	Crew Size	5.8	4.6	5.2
9.	Number of vessels	18	18	36

Table 2-12

ref.8

Vessels are divided into two groups, those with high profits and those with low profits (Table 2-13).

Before these revenue-cost figures can be interpreted it is necessary to understand the revenue-cost breakdown between owner and crew. In general terms, the owner will cover fixed costs and the crew and owner will share in the variable or operating costs (Ref. 10). The agreement between owners and fishermen in Boston provides for the following:

1. Gross stock-Total revenue received from sale of fish.
2. Shared costs include the following:
    a. Wharfage-Landing dock cost; presently $1 per ton of fish.
    b. Scalage-Presently $9 per unloading
    c. Exchange fee- To New England Fish Exchange for auctions, transactions, records, etc.; one per cent of gross stock
    d. Bonuses: (per trip)

       chief engineer $25.00
       second engineer $15.00
       mate $20.00
    e. Sounding machine and radar cost
    f. Watchman cost-when in port; 7-10 dollars per day
    g. Welfare and Pension Funds-- 1 1/2% gross stock
    h. Ice - in 3 summer months
    i. Lumper Cost--for large crews part of this cost will come from crew expenses

3. Net stock--Gross stock less shared expenses
4. Owner's share -- 40% of net stock
5. Crew's share -- 60% of net stock
6. Crew cost:
    a. Ice-in 9 remaining months
    b. Fuel
    c. Lubricating Oil
    d. Icing up-$40 per trip
    e. Groceries and provisions
    f. Cook's allowance - $15 per trip
    g. Cost of water - $12 per trip
    h. Lumpers cost
7. Net crew share - Crew share less crew cost; divided equally among crew members.
8. Owner costs:
    a. Vessel maintenance and repair
    b. Fishing gear
    c. Insurance - Includes vessel insurance which varies with value and age of ship; and protection and indemnity for each crewman.
    d. Payroll taxes - Social Security and Unemployment insurance
    e. Management and office costs
    f. Depreciation
    g. Broker payments - on bad trips must meet guaranteed crew salaries

h. Captain's bonus - 10% of owner's share goes to captain in addition to his crew's share

These arrangements may vary slightly with port and product, but are generally the same.

Given the above description, the situation of an average groundfish fisherman can be analyzed. See Table 2-14.

Groundfish vessels spend an average of 153 days per year at sea, during which the fishermen work about 12 hours per day. This would mean an average wage of $5.12 per hour which is well above that in comparable industries. However, a fisherman's life is not an easy one by any means and requires long periods away from home. It can provide a good living, provided that there are fish to harvest and vessels to harvest them. These are, in fact, the crucial factors in the survival of our domestic fishing industry.

Let us then consider the plight of the vessel owners. Refer to Table 2-13. The most striking information in this table is simply that the average high profit vessel is making a profit and the average low profit vessel is not. The high profit vessels are generally smaller vessels with smaller crews, but achieving a nearly equivalent revenue at a lower cost. The failure of larger vessels to produce more revenue is partly caused by having to cut trips short before being filled to capacity. This is done to prevent spoilage of fish caught earlier in the trip. This combined with reduced catch per haul has caused these decreased economies to scale. Assuming that the replacement cost for the average trawler is around $125,000 (with a 50% subsidy) and that it can expect

Table 2-13

Average Costs and Earnings of Boston Sample (1967-68)

Item	Low Profit $	Low Profit %	High Profit $	High Profit %	All Vessels $	All Vessels %
1. Gross revenue	$87,272	100.0	86,366	100.0	86,819	100.0
2. Cost of operation						
a. Trip expense	18,489	21.2	12,472	14.5	15,481	17.9
b. Net crew share	40,584	46.5	40,909	47.4	40,746	46.9
c. Capt.'s commission	2,866	3.3	3,280	3.8	3,073	3.6
d. Repairs and maintenance	7,022	8.0	6,050	7.0	6,536	7.5
e. Gear and supplies	4,428	5.1	4,456	5.2	4,442	5.1
f. Insurance	5,844	6.7	4,572	5.3	5,208	6.0
g. Payroll taxes	1,511	1.7	1,956	2.3	1,733	2.0
h. Miscellaneous	2,611	3.0	1,811	2.1	2,211	2.5
Subtotal	83,356	95.5	75,506	87.4	79,431	91.5
i. Interest	1,350	1.5	1,144	1.3	1,247	1.4
j. Depreciation	6,755	7.8	4,111	4.8	5,434	6.3
Total	91,461	104.8	80,761	93.5	86,111	99.2
3. Profit before taxes	-4,188	-4.8	5,605	6.5	708	.8

ref.8

Crew Earnings 1970 - 1971

	Low Profit	High Profit	Average
Regular crew share	8,392	10,661	9,396
Captain's commission	3,440	3,933	3,687

ref.8

Table 2-14

a stream of profits amounting to $7,389 per year over a period of 20 years (without interest and taxes), the rate of return is only 1.7%. This is well below an adequate rate of return.

Given this information concerning the economics of New England groundfishing, we can better understand trends in the industry today. The severe financial condition of many low profit owners has caused them to scrap their vessels or at least reduce the size of their crews. Thus the industry has seen their numbers dwindling. Others have kept their profits going by severely reducing their maintenance and repairs. Thus the condition of the remaining fleet is heading for ultimate disaster. Finally, those owners who do remain are often captain for their own ship, thus earning a crew share and keeping an additional 10% of the owner's share.

The Boston trawler fleet is an extreme example, but even the New Bedford flounder and scallop industry is having its problems, although to a lesser degree. It would seem that something drastic has to happen to curb present trends and save the industry. A number of things might help such as cooperative operation, reduced insurance costs, reduced equipment and vessel import duties, or coastal rights legislation. Whatever is done should be done soon.

CHAPTER III

THE SUPPLY OF IMPORTED FRESH AND FROZEN FISH

As our domestic fleet is struggling for survival other countries are supporting, either through subsidy or directly, large, efficient fishing fleets. This effort has certainly affected our domestic supply (as discussed in Chapter II), but it has also created an expanding foreign supply of both fresh and frozen fish to this country. This chapter will attempt to locate this supply, describe its export and sale to this country, and specify the volume and price of the various products imported.

Table 3-1 shows overall statistics for semi-processed imports by type, species, and country of origin. Further breakdown of block imports and totals for all imports are shown in Tables 3-2 and 3-3. Unfortunately, Table 3-1 does not make any distinction between fresh and frozen imports and does not include imports of whole fish. These will be discussed more fully in Chapter IV. The majority of fresh and whole fish imports to New England come into this country from Canada through points of entry in Maine. Fresh imports must be considered separately from frozen for a number of reasons:

1. Processing fresh fish is totally different from processing frozen fish.
2. Much of the imported fresh fish enters the country by truck and may never contact a port.

	Million Pounds				
	1963	1965	1967	1969	1971
Groundfish Fillets:					
Cod:	32.7	33.7	32.1	61.9	80.7
Canada	20.5	22.5	21.5	34.5	28.8
Iceland	9.8	8.5	8.1	20.7	34.1
Norway	0.6	0.1	0.3	3.3	8.3
Denmark	1.6	2.1	1.7	2.4	6.9
Other	0.2	0.5	0.5	1.0	2.6
Haddock:	24.2	20.7	25.7	33.9	34.0
Canada	15.3	13.4	18.4	18.1	9.3
Iceland	6.3	5.9	3.8	3.8	3.9
Norway	1.2	0.4	2.2	6.1	9.3
Denmark	-	-	-	4.1	6.1
Other	1.4	1.0	1.3	1.8	5.4
Ocean Perch	21.6	25.8	36.3	64.2	56.7
Canada	16.2	22.1	33.2	59.0	54.6
Iceland	0.9	1.2	1.0	0.5	1.2
West Germany	3.9	1.7	1.7	0.8	*
Other	0.6	1.0	0.9	1.5	0.9
Blocks:	153.3	166.2	189.5	266.7	311.2
Canada	75.8	119.8	96.0	88.7	96.4
Iceland	31.8	47.1	28.7	53.9	74.2
Norway	17.5	11.4	15.4	73.0	60.9
Denmark	12.0	10.7	11.9	17.8	35.8
Poland	-	1.3	8.9	14.8	12.4
United Kingdom	-	0.2	2.1	0.8	10.1
Greenland	8.0	11.5	16.2	9.4	6.8
Japan	-	-	2.9	2.0	3.4
So. Africa	2.8	0.7	2.0	2.2	1.5
Argentina	-	4.3	0.8	0.2	4.0
West Germany	4.3	4.3	3.0	1.7	2.1
Other	1.1	3.6	1.6	2.2	3.6
Total Groundfish Fillets	231.8	295.0	283.6	426.7	482.6
Flounder Fillets:	16.6	24.1	33.3	48.1	56.3
Canada	15.4	23.2	32.6	46.2	46.9
Other	1.2	0.9	0.7	1.9	9.4
Lobsters:					
Canada	21.8	18.6	15.6	17.4	18.1
Sea Scallops:	13.3	16.6	13.5	14.3	17.4
Canada	13.2	15.2	13.1	13.0	10.3
Other	0.1	1.4	0.4	1.3	7.1

United States Imports of Selected Fishery Products

Table 3-1

ref.4

* Less than 50,000 lbs.
- No information

Table 3-2

U.S. Imports of Frozen Fish Blocks by Species, 1967-71

Species	1967	1968	1969	1970	1971
	Million Pounds				
Cod.........	116.0	176.4	192.6	195.0	193.0
Flatfish....	13.2	14.1	15.0	12.1	22.6
Haddock.....	21.4	22.5	19.7	20.3	28.9
Pollock.....	9.3	8.4	7.7	20.8	20.9
Other.......	28.7	38.7	31.8	24.5	37.8
Total..	189.5	261.1	266.8	272.7	311.2

ref.4

Table 3-3

Imports of Fishery Products, 1960-71

Year	Edible		Nonedible	Total
	Thousand pounds	Thousand dollars	Thousand dollars	
1960..........	1,095,014	310,596	52,685	363,281
1961..........	1,087,175	339,318	61,301	400,619
1962..........	1,255,532	405,832	83,975	489,807
1963..........	1,196,977	399,928	100,784	500,712
1964..........	1,318,099	433,674	130,569	564,243
1965..........	1,398,778	479,412	121,492	600,904
1966..........	1,593,714	568,091	151,611	719,702
1967..........	1,470,437	538,301	169,582	707,883
1968..........	1,741,365	643,165	179,504	822,669
1969..........	1,706,571	704,809	139,484	844,293
1970..........	*1,873,300	812,530	*224,880	1,037,410
1971..........	1,755,823	*872,523	187,131	*1,059,654

*Record. Source:--Department of Commerce, Bureau of the Census.

ref.7

3. Imported fresh fish may come in direct competition with domestic fish. The competition between fresh and frozen is less severe.

4. Frozen fish will generally require some long-term cold storage.

Each of these aspects should become clear in the following chapters.

Import Tariff Structure

Important to the flow of imported fish into this country is the U.S. tariff policy on fishery products. This policy has been changing rapidly in recent years, as the old policy was phased out. The final phase of the Kennedy Rounds (GATT) has now fixed these tariffs. Details of the transition and present policy are shown in Table 3-4.

The emphasis in this tariff schedule seems to be on protecting U.S. processing interests rather than domestic fishing interests. Much of the reason for this lies in the imbalance between domestic supply and domestic demand. Whole fish may enter this country duty-free and blocks which require more processing are also duty-free. Tariffs on cakes, sticks, and portions, however, may run up to 30% and tariffs on fillets and steaks up to 2.5 cents per pound.

The tariff schedule along with rising U.S. demand, the "fish stick revolution", and an abundant foreign supply have brought more and more foreign imports, especially frozen blocks, to this country (Table 3-5), but the supply is beginning to dwindle. Competing markets along with decreased landings have already caused temporary shortages of blocks and fillets with

Item	Product Description	prior rate	1968	1969	1970	1971	1972	column 2
	I. fish: fresh, chilled, or frozen; whether or not whole, but not otherwise prepared or preserved							
110.15	A. Whole, or processed by removal of heads, viscera, fins; but not otherwise processed	.5 ¢/lb	.4	.3	.2	free	free	1¢/lb
	B. Scaled, whether or not processed by removal of heads, viscera, fins; but not otherwise processed							
110.40	1. in bulk or in immediate containers weighing with their contents over 15 pounds each	1.0 ¢/lb	.8	.5	.4	free	free	1.25 ¢/lb
110.45	2. Other	12.5%	11%	10%	8.5%	7%	6%	25%
110.47	C. Skinned and boned and frozen into blocks, each weighing over 10 lbs.	1.0 ¢/lb	.8	.5	.4	.2	free	1.25 ¢/lb
	D. Otherwise processed: cod, haddock, cusk eels, hake, pollack, shad							
110.50	1. For an aggregate quantity entered in any calender year of 15 million lbs. or 15% of average annual consumption over the last three years, whichever is greater. (fillets, steaks)	1.875 ¢/lb	1.875	1.875	1.875	1.875	1.875	2.5 ¢/lb
110.55	2. Other	2.5 ¢/lb	2.5	2.5	2.5	2.5	2.5	2.5
	II. Shrimp, lobster, scallops; prepared or not	free	free	free	free	free	free	free
	III. Fish products							
	A. Fish balls, cakes, puddings, pastes. and sauces							
113.01	1. pastes and sauces	8%	7%	6%	5.5%	4.5%	4%	30%
	2. balls, cakes, puddings							
113.05	a. in oil	25.5%	22.5%	20 %	17.5%	15%	12.5%	30%
	b. not in oil							
	(i) in immediate containers weighing with their contents not over 15lbs each							
113.08	(a) airtight	3%	2%	1.5%	1%	.5%	free	25%
113.11	(b) other	12.5%	11%	10%	8.5%	7%	6%	25%
113.15	(ii) other	1.0 ¢/lb	.9	.8	.7	.5	.5	1.25 ¢/lb
	B. Fish sticks and similar products of any size or shape, fillets, or any other portions of fish which are breaded, coated with batter, or similarly processed or prepared							
113.20	1. Neither cooked or in oil	20%	18%	16%	14%	12%	10%	20%
113.25	2. Other	30%	27%	24%	21%	18%	15%	30%

column 2 applies to communist countries

ref.13

U.S. Import Tariff Policy
Table 3-4

Table 3-5

Imports: Value, Duties Collected, and Ad Valorem Equivalent

1960-61

Year	Value		Duties Collected	
	Fishery imports	All imports	Fishery imports	All imports
1960....	363,281	14,650,000	15,857	1,084,000
1961....	400,619	14,657,000	16,904	1,057,000
1962....	489,807	16,241,000	17,910	1,220,000
1963....	500,712	17,014,000	17,660	1,236,000
1964....	564,243	18,600,300	22,035	1,583,000
1965....	600,904	21,281,800	22,595	1,369,921
1966....	719,702	25,360,330	24,812	1,919,514
1967....	707,883	26,733,200	24,709	2,016,400
1968....	822,669	32,991,700	25,455	2,341,100
1969....	844,293	35,870,400	25,421	2,551,200
1970....	1,037,410	39,767,700	25,175	2,584,100
1971....	1,059,654	45,545,900	1/22,434	1/2,768,000

ref.7

NOTE: "Value" and "Duties Collected" shown in Thousand Dollars.

1/ These calculated duties do not include the temporary surcharge imposed by the President under Proclamation No. 4074, effective August 16, 1971 and terminating on December 20, 1971.

Source:--Department of Commerce, Bureau of the Census.

more predicted for the future. A continuous increase in demand is beginning to cause increased block prices as in other segments of the industry.

The Foreign Supply

As can be seen in Table 3-1, Canada, Iceland, Norway, Denmark, Poland, the United Kingdom, Greenland, and Japan are the major suppliers of groundfish and other fishery products to the United States. Table 3-6 gives a great deal of insight into this import supply situation.

The U.S. is currently landing 300 to 400 million pounds of groundfish annually while it consumes over 1,500 million pounds. The difference in these totals must be made up by imports. The U.S. also has one of the lowest per capita consumptions of groundfish which would indicate the capacity for even more imports.

Complementing the U.S. are such countries as Canada, Denmark, Iceland, and Norway who consume far less than they catch and have a substantial surplus. Denmark, Iceland, and Norway are also saturated in terms of what they can consume as they have very high per capita consumptions. They must sell this surplus somewhere and are selling much of it to the U.S.

Norway

A large portion of Norwegian fish landings are exported. All marketing of fish and shellfish within the country is channeled through the fisherman's own sales organizations which have exclusive rights to negotiate for fishermen. They set

Statistics of the Major Importers to the U.S.

Table 3-6

		*Japan	Norway	Denmark	Iceland	Canada	U.K.	Neth.	U.S.
Groundfish landings: (Million lbs.)	1968	4541.4	1144.6	1586.0	583.0	1070.5	1508.4	253.4	433.3
	1969	5300.4	1320.1	1535.3	728.1	1032.1	1514.8	252.9	387.6
	1970	6176.6	1452.9	1309.1	788.8	950.8	1513.7	250.7	364.7
Groundfish Consumption: (Million lbs.,round)	1967	432	400	341	--	48	1484.0	209	1608.
Per Capita Consumption: (lbs., round)	1967	4.33	70.00	70.39	138.80	5.86	25.67	16.59	8.3
Ex-Vessel Price: (cents, deflated)	1967	5.95	--	2.55	--	3.87	9.13	13.47	7.50

ref.12

groundfish= flounders,halibuts,soles,cods,hakes,haddocks,pollack

* largely Alaskan Pollack

minimum ex-vessel prices and meet with export groups to set prices for export. At present, 13 export groups act as consultants and exporters under government license. These include the following fillet and frozen fish exporters:

1. Frionor Norsk Frosenfisk A/L(Frionor)
2. A/S Findus
3. Nordic Group.

Norway exports about 300 million pounds of frozen fillets annually, a third of which goes to the U.S. Frionor is a cooperative organization of 136 freezing plants in Norway and is the largest exporter. Their facility in New Bedford receives a large portion of Frionor's exports.

Denmark

Denmark ranks second to Norway as Europe's leading exporter of fishery products. Denmark exports about 60 million pounds of cod and haddock fillets annually, nearly half of which goes to the U.S.

Prices to fishermen are set mainly by auction or cooperative negotiation. In some cases minimum price limits have been placed on landings. Private firms negotiate for export prices, but an export committee exists which sets minimum prices. Prices to the U.S. have remained at a level well above these minimums.

Iceland

The situation in Iceland is similar to that in Norway and Denmark. Its two major processing and exporting companies are:

1. Samband (Iceland Products Inc.)
2. Cold Water Seafoods

Samband is a government organized cooperative and Cold Water is privately held. Members of Fishermen's Trade Boards, Owner's Associations, and exporters meet as a price board and set prices for landing and exporting. An Appeal Board exists for situations where the price board fails to agree. The majority of the Icelandic fish is sold processed and frozen. Export prices are critical to Iceland as the fishing industry comprises one quarter of their national product.

Canada

A large portion of Canadian Fishery production is exported and most of these exports go to the U.S. Canada gives much subsidy support to their fishing effort, but, except for some government-cooperative groups, the processing and fishing is done by private businesses. Those companies exporting to the U.S. may operate solely in Canada or own import dealerships in the U.S. Some U.S. companies own or are directly associated with Canadian processing and fish interests (ex.: Booth Fisheries)

A sizable quantity of the fish exported from Canada is not caught by Canadian vessels, but imported from other nations. The primary example of this is import to Canada from St. Pierre and Michèlon. This small island off the coast of New Foundland belongs to France and is a free port. This means that any nation can land their fish there dutyfree and then export dutyfree to any port in the world. Poland, West Germany, Portugal, and Spain are the major countries landing here, with

Poland by far the major contributor. A large portion of these landings are sent processed or whole to Canada, especially the port of Halifax. Once in Canada, the fish may be further processed or sent directly to the U.S. by boat, ferry, truck, or rail. Although specific numbers are not available concerning these imports, reliable sources say that up to 25% of our Canadian imports may originate at St. Pierre and Michelon. This is a significant quantity and must be dealt with when considering the effect of fishing rights policy on U.S. imports.

Fish Prices

Various products exist at each market level and may originate from foreign or domestic sources. Fish are caught and usually eviscerated on board the vessel where the weight of the fish is reduced from its round weight to its landed weight. The fish are then sold off the boats at their ex-vessel price. At this point the fish may be processed further by filleting, steaking, pressing into blocks, packaging, or freezing. The type of processing and the origin (domestic or foreign) determines the weight and price of the product.

Just as evisceration results in a weight loss, so does the removal of head and tail, filleting, and steaking reduce the weight of the final product. Table 3-7 shows typical weight reduction factors for fillets of various New England species. The waste resulting from this processing may be discarded or used for fish by-products. In order to compare prices at various market levels, and for various degrees of

Table 3-7

Weight Conversion Factors For Important New England Fish

Species	Round	Landed	Fillet
Cod	1.00	.8547	.325
Scrod	1.00	.8613	.333
Haddock	1.00	.8772	.351
Perch	1.00	1.00	.280
Pollack	1.00	.88495	.407
Hake	1.00	.7463	.373
Cusk	1.00	.88495	.372
Flounder	1.00	1.00	.355

ref.20

processing, it is helpful to convert landed weight to processed weight using the reduction factors given in Table 3-7. Specifically, prices for small haddock (scrod) will be compared, using a reduction factor of .38 of landed weight. ($\frac{.333}{.861} = .38$)

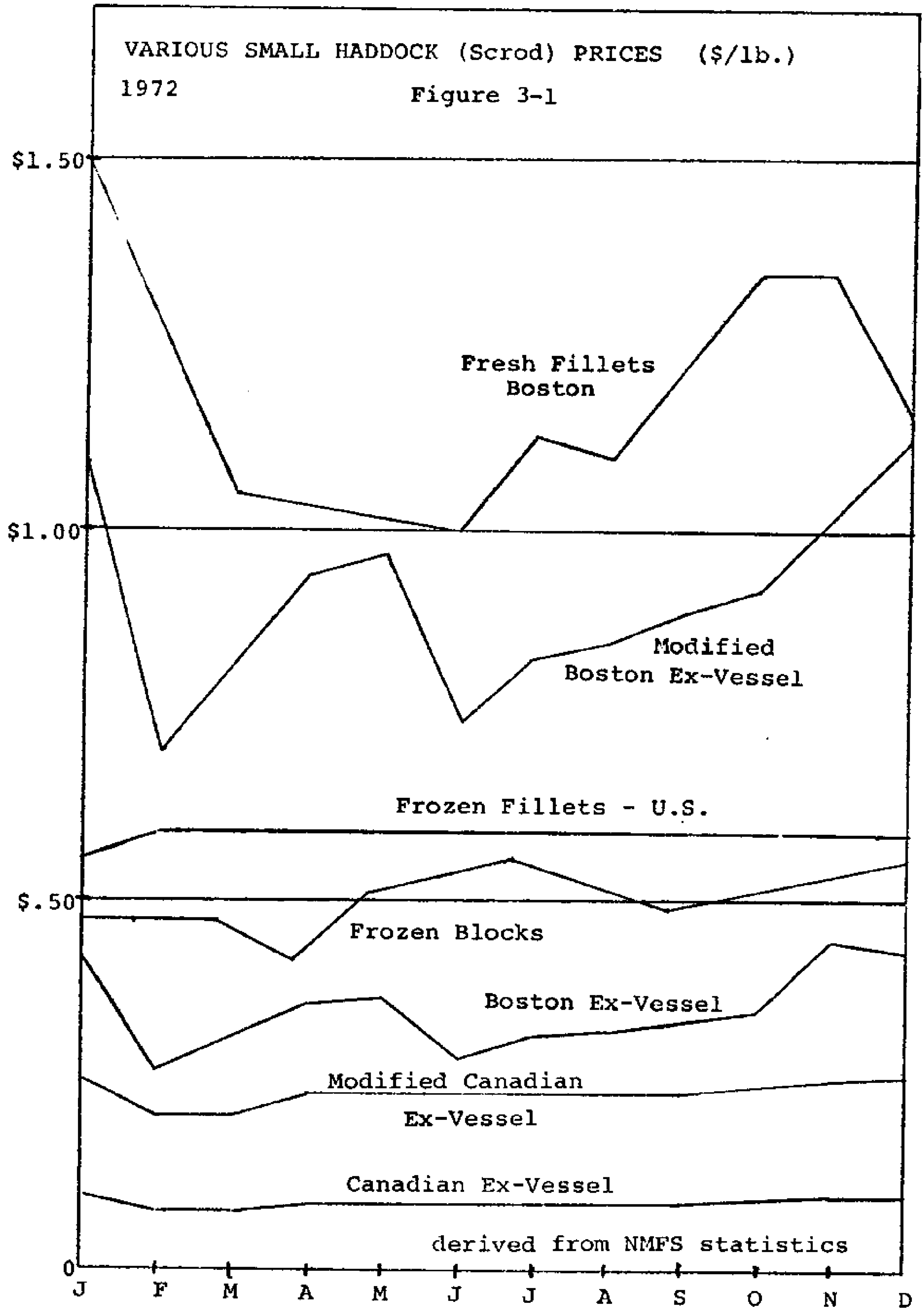
Figure 3-1 shows various small haddock prices for 1972. From this single year's information, a number of interesting characteristics can be observed.

Domestic Versus Canadian Ex-Vessel Prices

One of the most obvious aspects of these prices is the enormous difference between Boston and Canadian ex-vessel prices. The basic reasons for this difference include the following:

1. Lower labor costs - Due to the lower standard of living and lack of alternate employment, labor is substantially less expensive in Canada.
2. Superior productivity - The Canadian fleet is newer and more efficient than the U.S. fleet.
3. Lower ship equipment and insurance costs.

Most of these conditions exist in other exporting countries as well, and similar price differences also exist. The only factors narrowing the price gap between domestic and Canadian fresh fish are transportation costs, import duties, and time. Time is critical as life of fresh fish is short. This single factor tends to distinguish between domestic and imported product quality and makes domestic fresh fish a high-priced delicacy. It also limits any foreign competition for the U.S. fresh fish market to Canada.


VARIOUS SMALL HADDOCK (Scrod) PRICES ($/lb.)
1972
Figure 3-1
$1.50
$1.00
$.50
0
Fresh Fillets Boston
Modified Boston Ex-Vessel
Frozen Fillets - U.S.
Frozen Blocks
Boston Ex-Vessel
Modified Canadian Ex-Vessel
Canadian Ex-Vessel
derived from NMFS statistics
J
F
M
A
M
J
J
A
S
O
N
D

Frozen Fish Prices

For purposes here there is no difference between domestic and imported frozen fish. Also, due to the use of cold storage, frozen fish prices are fairly stable. The final aspect to be observed is the great difference between fresh and frozen fillet prices. It is this great difference that makes domestic suppliers very reluctant to freeze any of their product and, thus, the majority of all frozen fish products are imported. Domestic suppliers freeze only when great, unmarketable surpluses exist. Again, domestic fresh fish is a high-priced delicacy.

Frozen fillets and frozen fillet blocks are normally used to produce two quite distinct consumer products. Generally, fillets are consumed as fillets while blocks are cut up for fish sticks and portions. Due mostly to lower import duties, packaging costs, and transportation costs, blocks run about ten cents less per pound than fillets.

The Effect of Processing on Prices

A final interesting aspect of these prices is the difference between processed and unprocessed fish. In order to compare these two, ex-vessel prices have been modified using the weight factor (.38). The difference between modified ex-vessel prices and the wholesale fillet price must cover the processor's costs and profit. It can be seen that for Boston fillet operations this mark-up varies from 5 to 55 cents per pound and that although processed price varies somewhat with supply price, it must also be affected by demand. Also, it should be noted that the modified Canadian price is far below the domestic price. Again, it must be assumed that superior freshness along with some help from tariffs and transportation costs is protecting the domestic product.

Fishing Grounds

In order to analyze the effect of fishing rights legislation on the supply of fish in various countries, it is necessary to locate the major fishing grounds of these countries. This will be done in the specific case of New England itself and those nations providing imports to New England.

Major fishing grounds located in the Northwest and Northeast Atlantic are shown in figures 3-2 thru 3-7. In the Northwest Atlantic the major grounds are Georges Bank, Browns Bank, Grand Bank, the coast of Nova Scotia, New Foundland, Labrador, and the southwest coast of Greenland. In the Northeast Atlantic are fishing grounds in the North Sea and Norweigian Sea, along most of the coast of Norway, in the Barents Sea, and surrounding Iceland and the Faroes.

These grounds serve as coastal grounds to some and distant grounds to others. In the Northwest Atlantic,Canada and the U.S. fish for the most part along their own coasts. There are, however, numerous other nations fishing here. The U.S.S.R., Poland, Germany, Spain, Portugal, Japan, France, and the United Kingdom are all fishing this area. In the

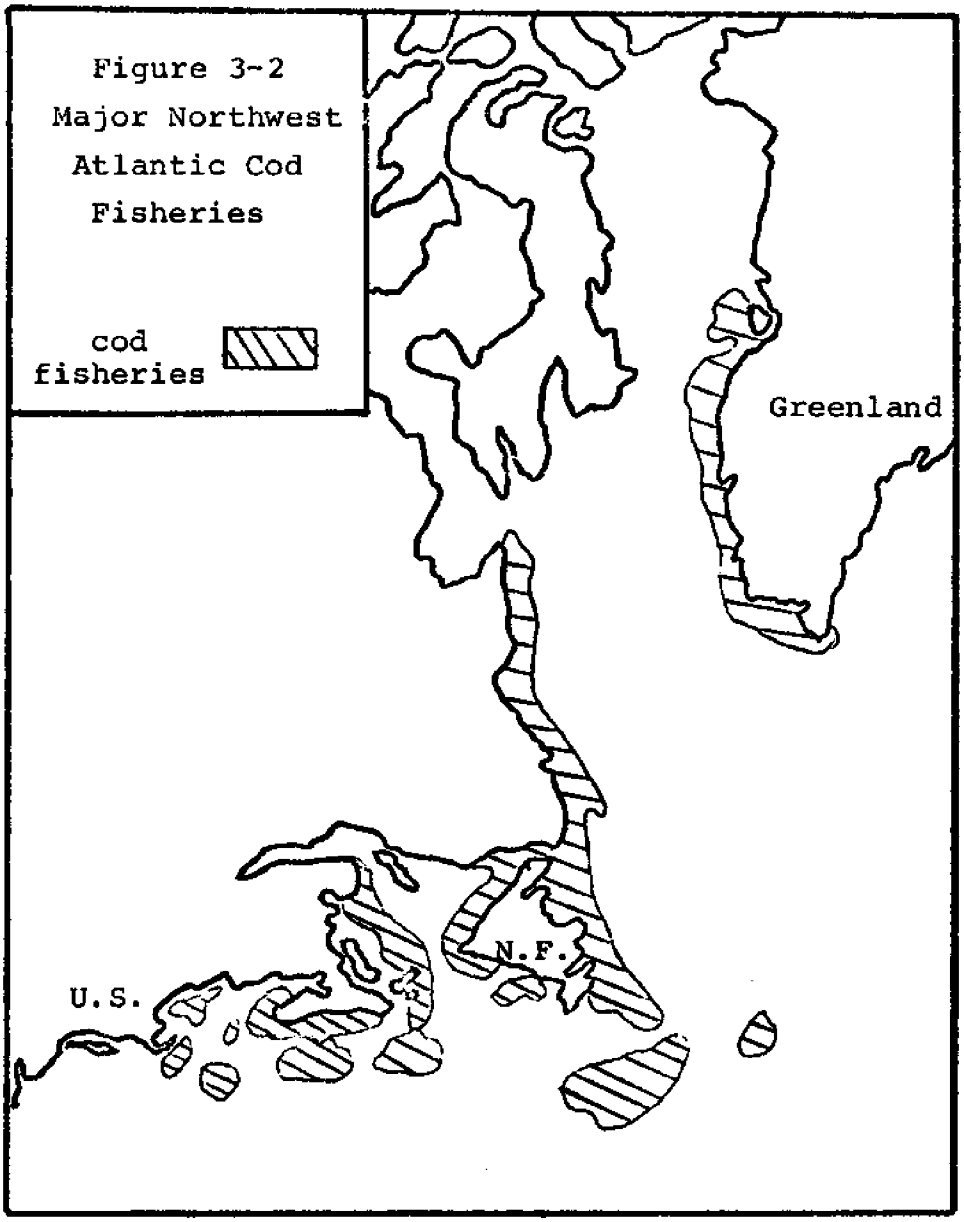


Figure 3-2
Major Northwest
Atlantic Cod
Fisheries

ref.21

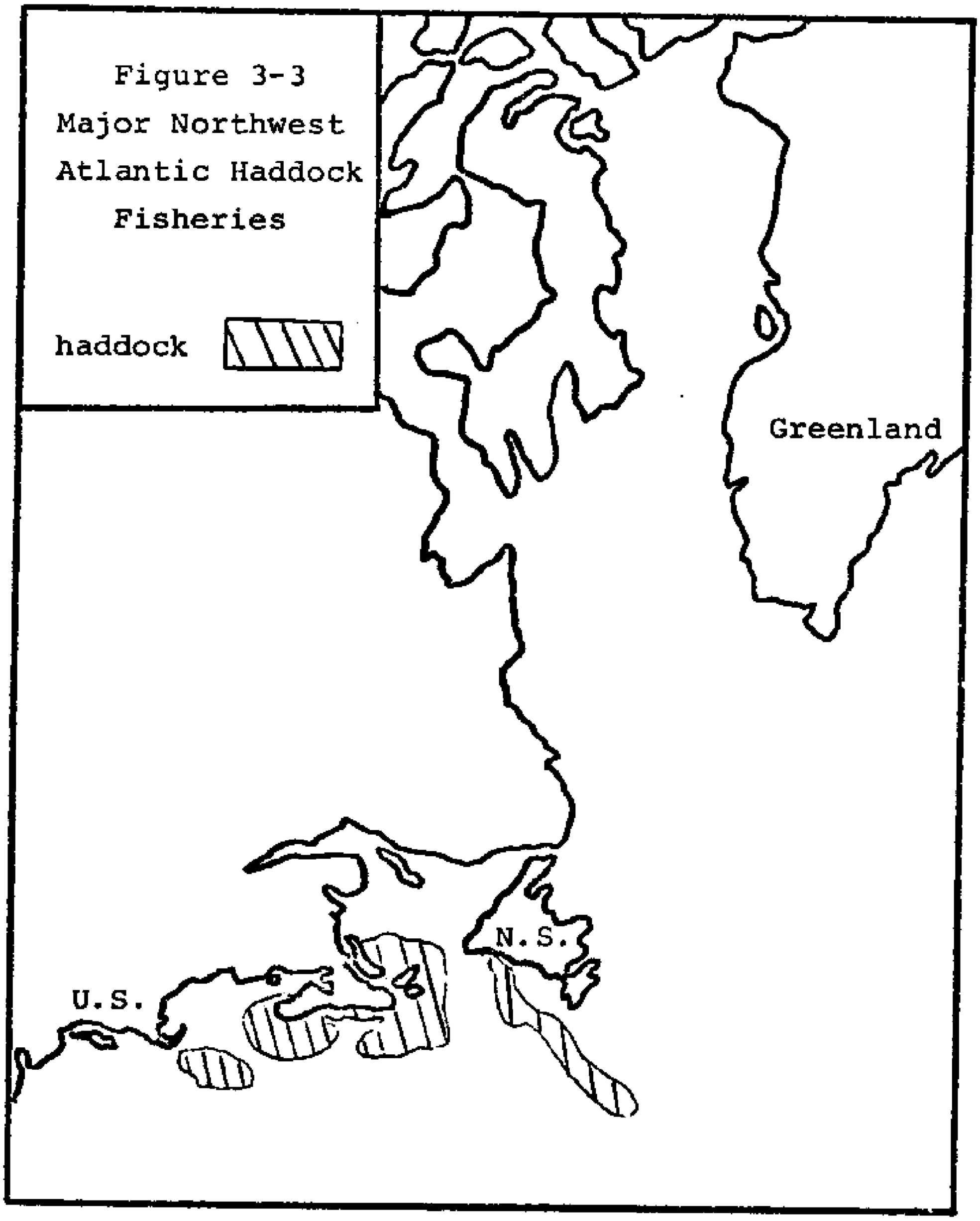


Figure 3-3
Major Northwest
Atlantic Haddock
Fisheries

ref.21

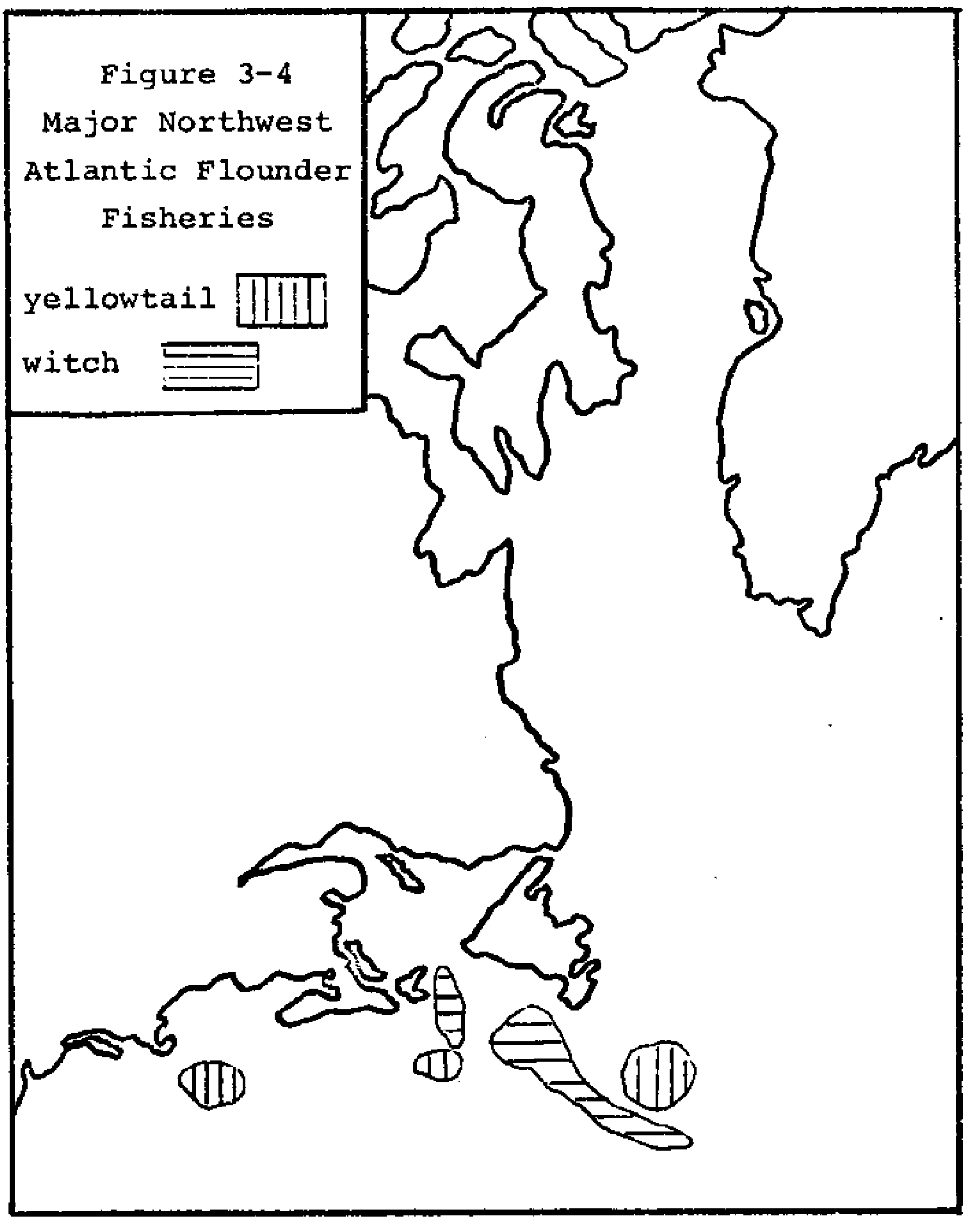
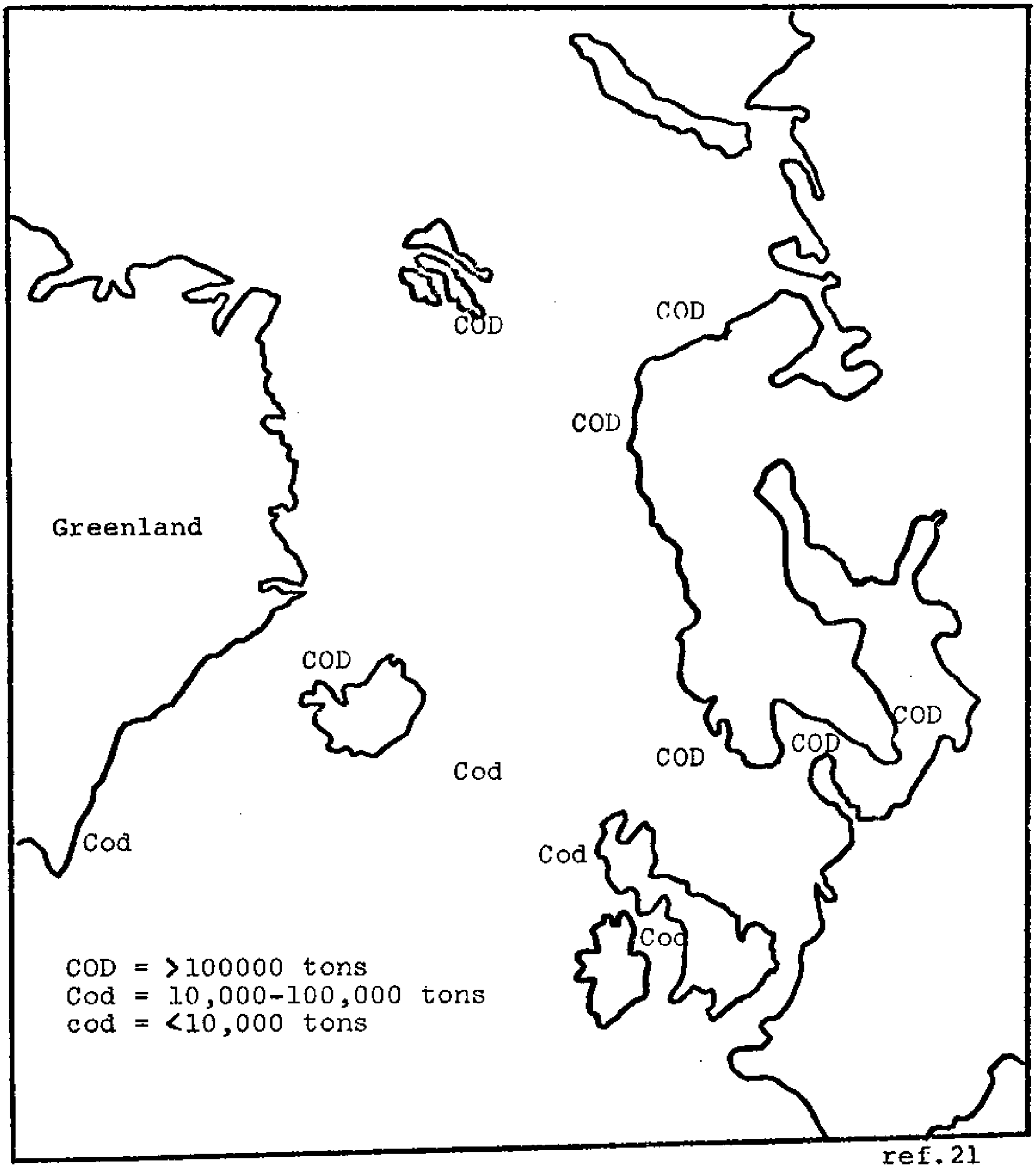


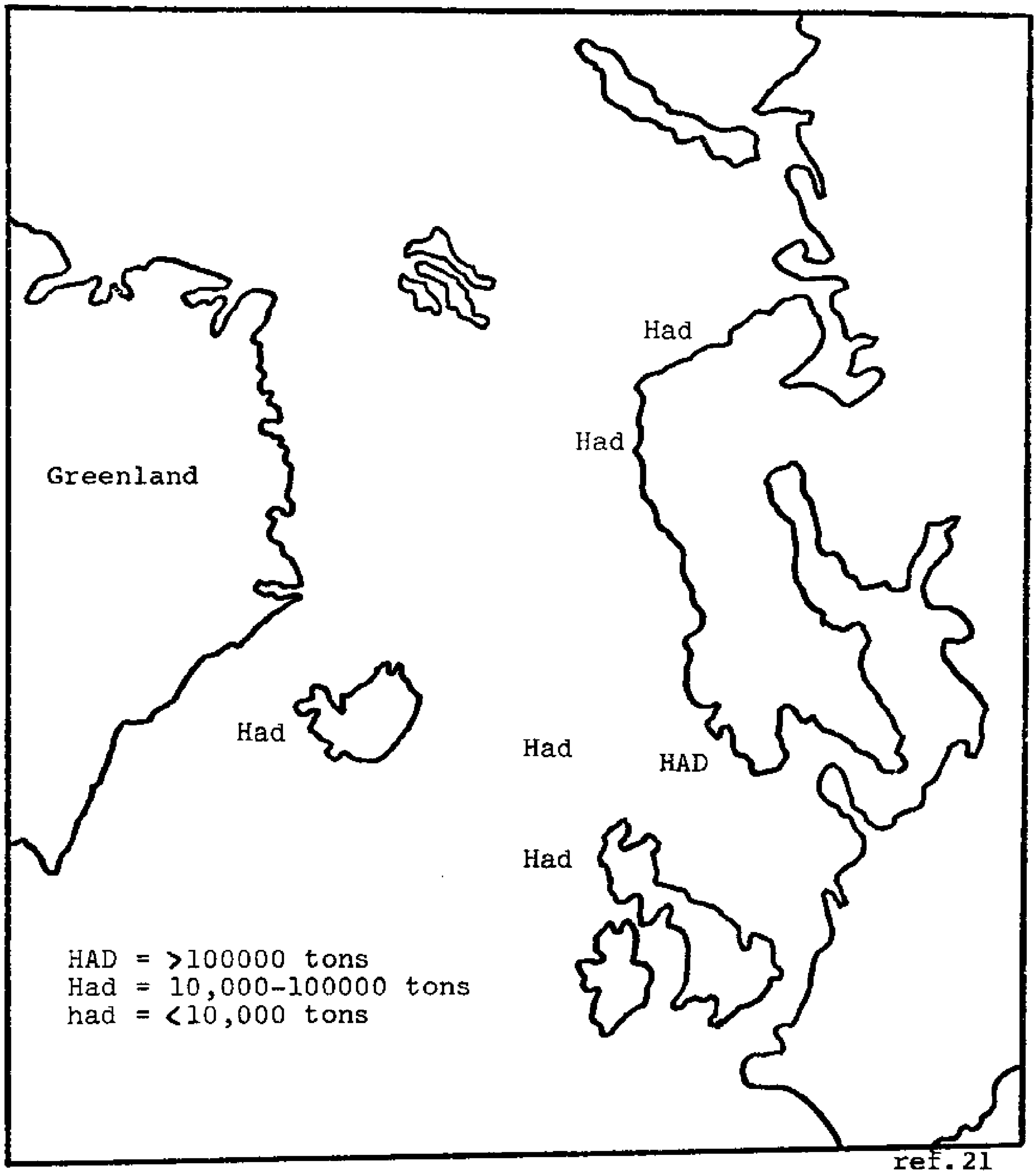
Figure 3-4
Major Northwest
Atlantic Flounder
Fisheries
yellowtail
witch

ref.21

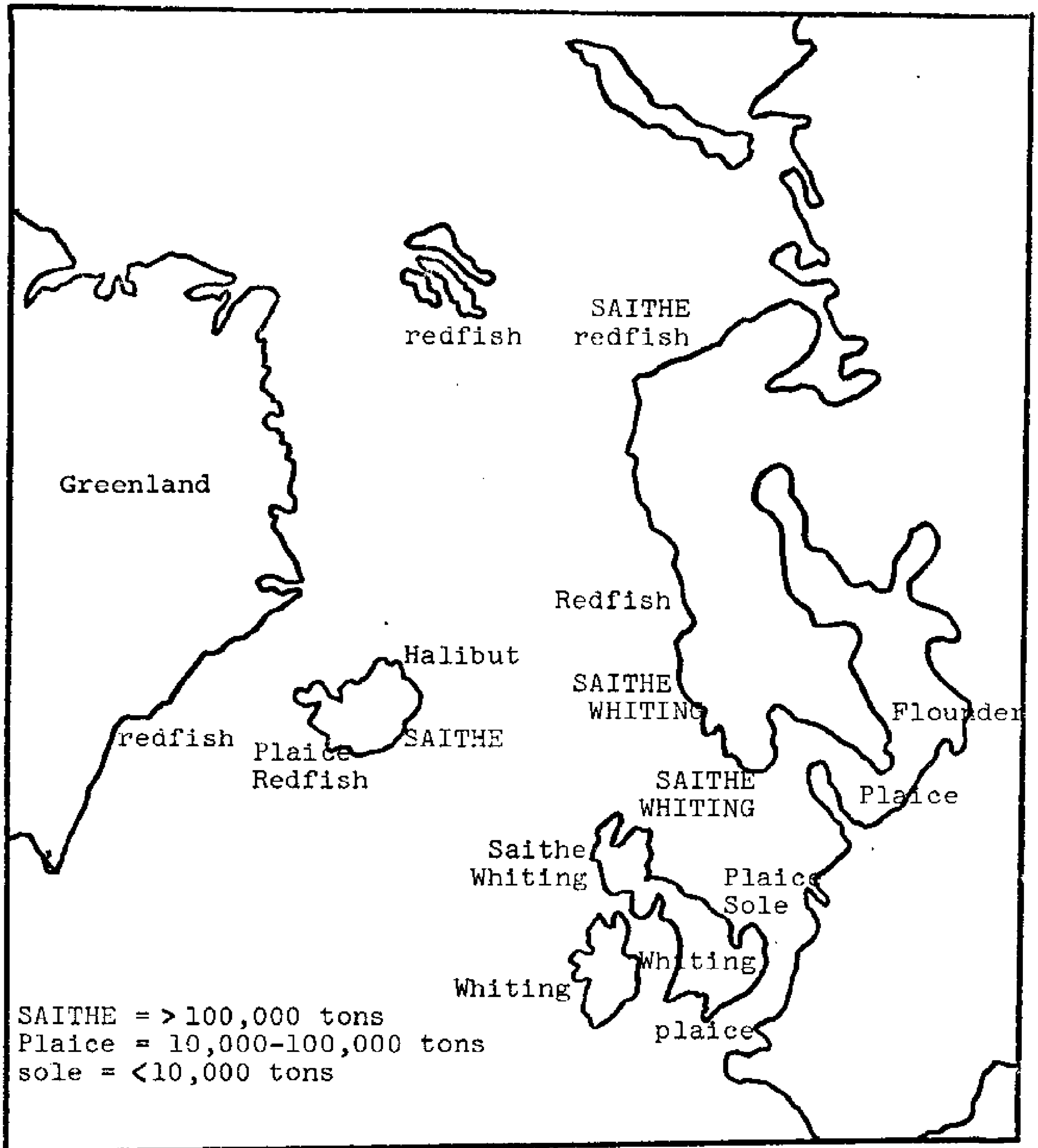


Major Northeast Atlantic Cod Fisheries

Figure 3-5



Major Northeast Atlantic Haddock Fisheries
Figure 3-6



ref.21

Other Northeast Atlantic Fisheries

Figure 3-7

Northeast Atlantic the Scandanavian countries fish primarily off their own coasts as does Iceland, but the U. K., France, Poland, Germany, Belgium, U.S.S.R., and Spain fish all these grounds. In the past, bitter disputes over fisheries have arisen when countries such as Iceland and Norway tried to extend their fisheries jurisdiction beyond 3 miles. Iceland unilaterally proclaimed a 12-mile limit which the United Kingdom met with gunboats and boycott. In 1960 these countries bilaterally settled on gradually extending to 12 miles over the period from 1960-1970. Norway also disputed with the U.K., but over base lines across the mouths of bays, harbors, fjords, rivers, and in some cases between islands. All fisheries within these base lines would belong to Norway. Compromise agreements were made in 1951. Multilateral agreements also exist over North Sea and Faroe Islands rights. If the United Kingdom had failed in all their negotiations, they could have lost up to 9,000 square miles or 50 per cent of their fisheries.

In recent years, Iceland and other countries have proclaimed increased fishing rights off their shores. Negotiations, leading to international agreement on coastal fishing rights are critical. Chapter VII will deal further with this topic.

CHAPTER IV

TRACING FOOD FISH TO U.S. MARKETS

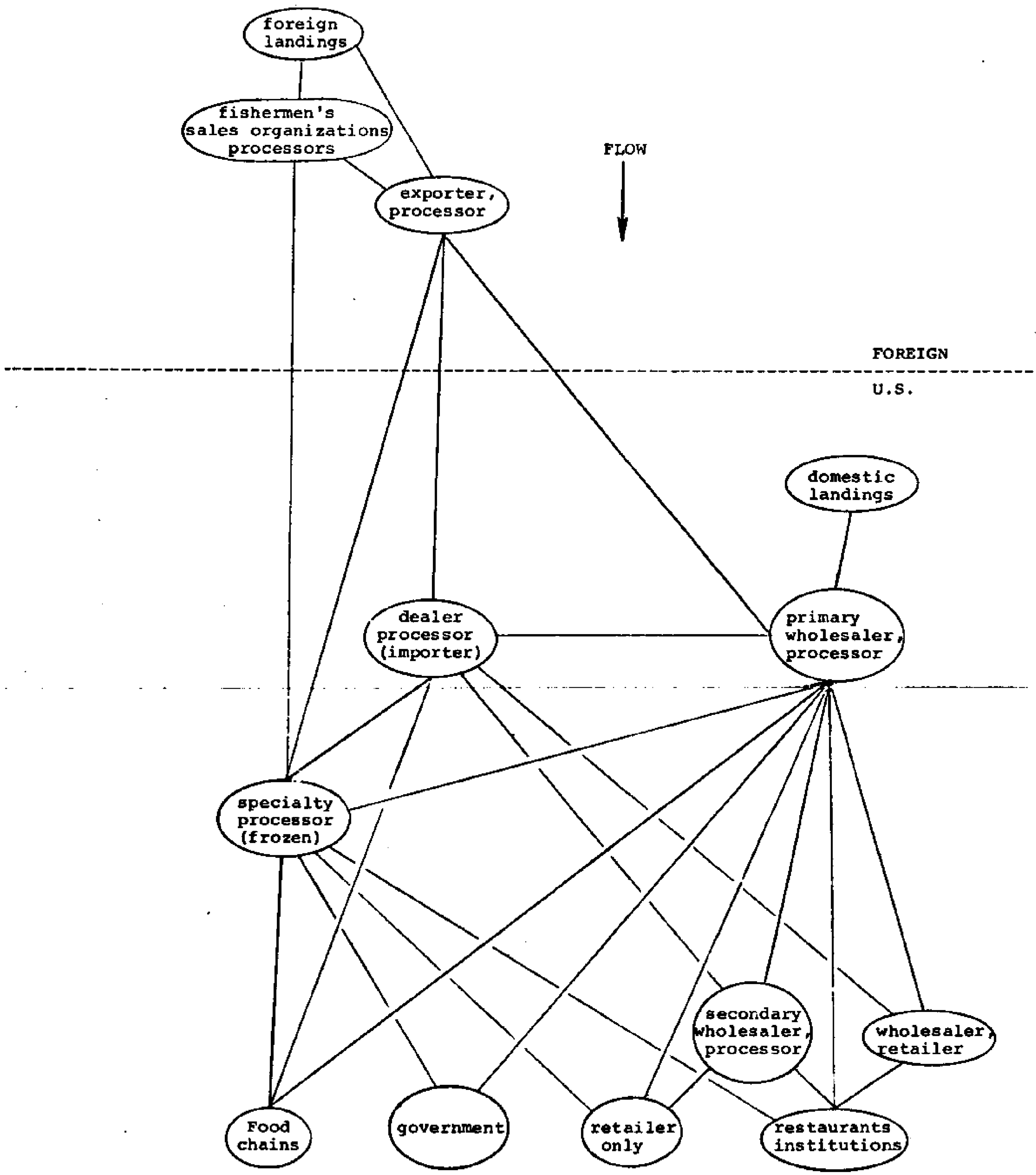
Chapters II and III have described the supply of fish to New England. Before discussing ports, processing, distributing, etc., it is useful to get an overall picture of the flow of fish from supplier to consumer, as well as an insight into consumer markets. Figure 4-1 shows the overall flow. Each level of this flow is worth discussing, especially as it relates to the value of the product.

The Retail Market

The flow of food fish, fresh or frozen, ultimately leads to the consumer. The fish may be in a number of forms at this stage: fresh whole, fresh fillets, fresh steaks, frozen whole, frozen fillets, frozen steaks, fish sticks, fish portions, fish cakes, etc. To define the supply-demand relationships, the cross relationships, or even the geographical location of consumer demand for New England fish products is difficult at best. However, a more qualitative analysis can provide a great deal of insight into this market.

The geographical location of the market for fresh food fish from New England is limited somewhat by perishability in transport. However, the rising value of fresh fish is now making air transport feasible, thus expanding the market to the entire nation. Gaston and Storey (ref. 14) examined the Boston Fish Pier market in 1965. Their results, expanded somewhat

Figure 4-1
Major Flows of Fresh and Frozen
Fish in U.S. Markets

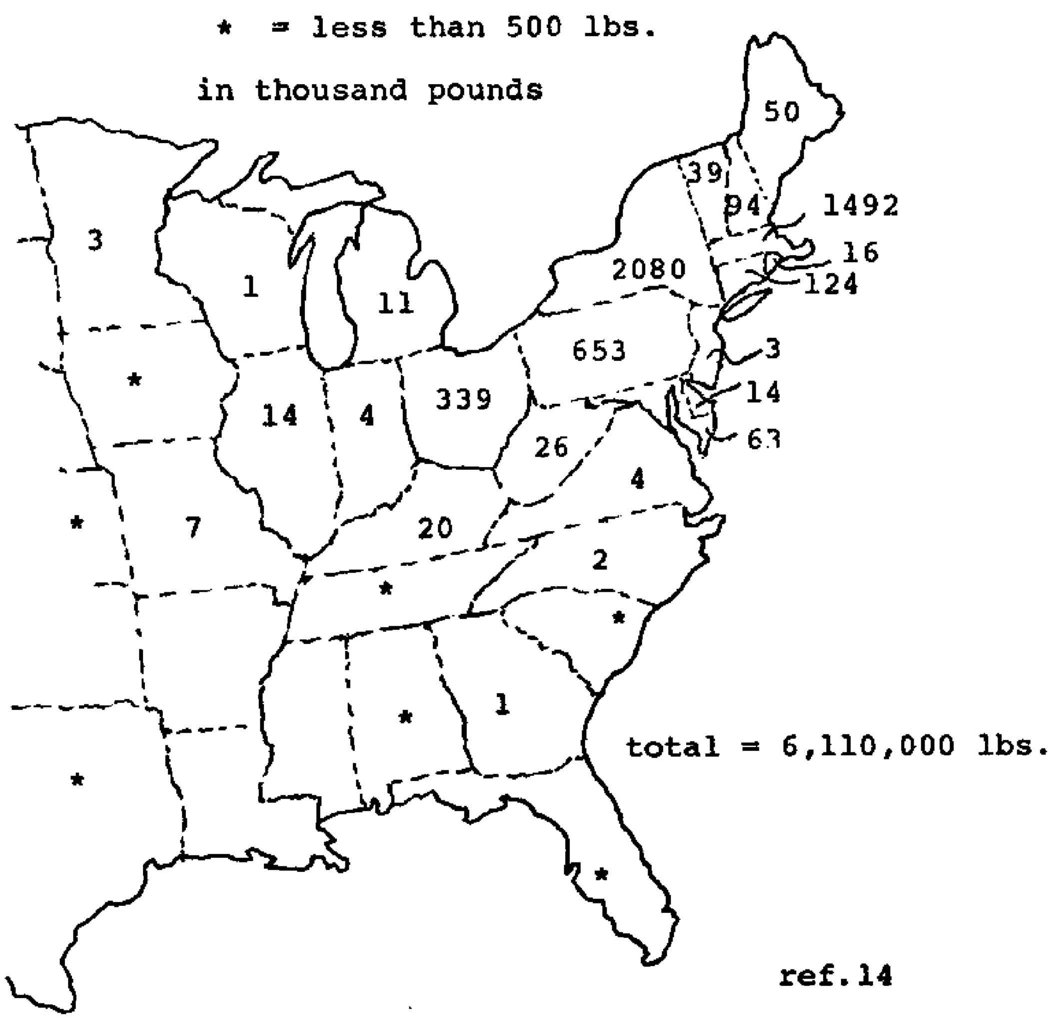


for air transport, still offer a good description of the New England fresh fish market in 1972. Figure 4-2 shows the distribution of Storey's sample. Nearly half of his sample remained in New England, a third went to New York, with some fish going as far as Texas. Today, haddock and flounder fillets may be flown several hundred miles, but the bulk of the market still remains concentrated as indicated in figure 4-2.

Starting with trucking firm fish haul statistics,wholesalers were asked to estimate the breakdown of their fresh fish sales to different types of final recipients. Results are graphed in figure 4-3. Of the 72 per cent sold in retail establishments, it was estimated that 61 per cent was sold in retail grocery stores and most of the remainder in retail seafood markets. Qualitative estimates from Gloucester and New Bedford indicate a slightly higher percentage going to institutions and the government, but generally the distribution is similar to Boston. (New Bedford, for instance, has a large regular market with "Weight Watchers".)

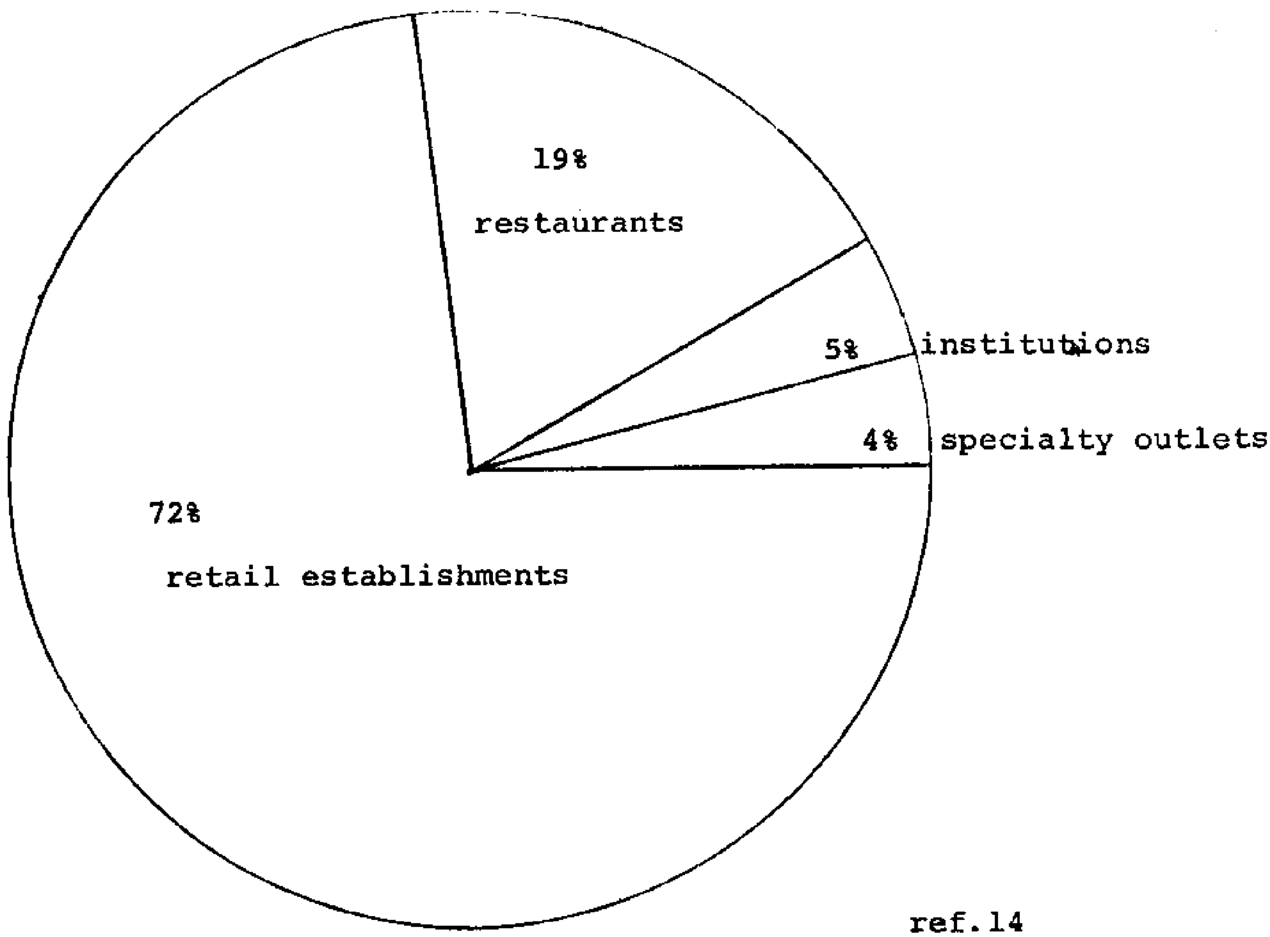
Domestic Landings and Wholesaling

Each of the three major New England ports has its own method of pricing and boat to wholesaler sales, and each warrants discussion here. Those wholesalers receiving fish directly from the boats are called primary wholesalers. All domestic fresh fish are channeled through these. Next in line are secondary wholesalers and wholesale-retailers who eventually distribute to retail markets and the consumer. Variations in domestic fresh fish supply are supplemented with imported fresh and frozen



SAMPLE OF FISH ORIGINATING FROM BOSTON FISH PIER

Figure 4-2



Final Distribution of Boston Fish Pier Landings

Figure 4-3

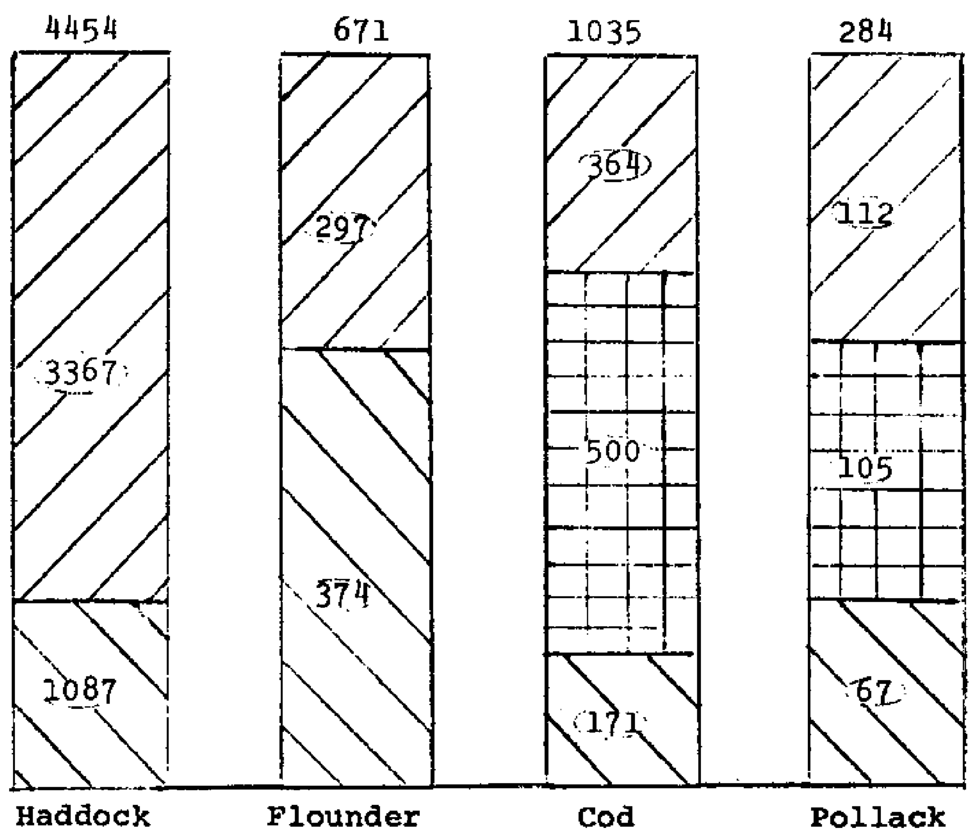


Figure 4-4

Relative Importance of Different Product Forms
*Thousand Pounds

ref.14

at all levels of marketing. In New England, imported fresh fish are trucked to Boston and Gloucester dealers where the various wholesalers may purchase them. These imports may be filleted or whole.

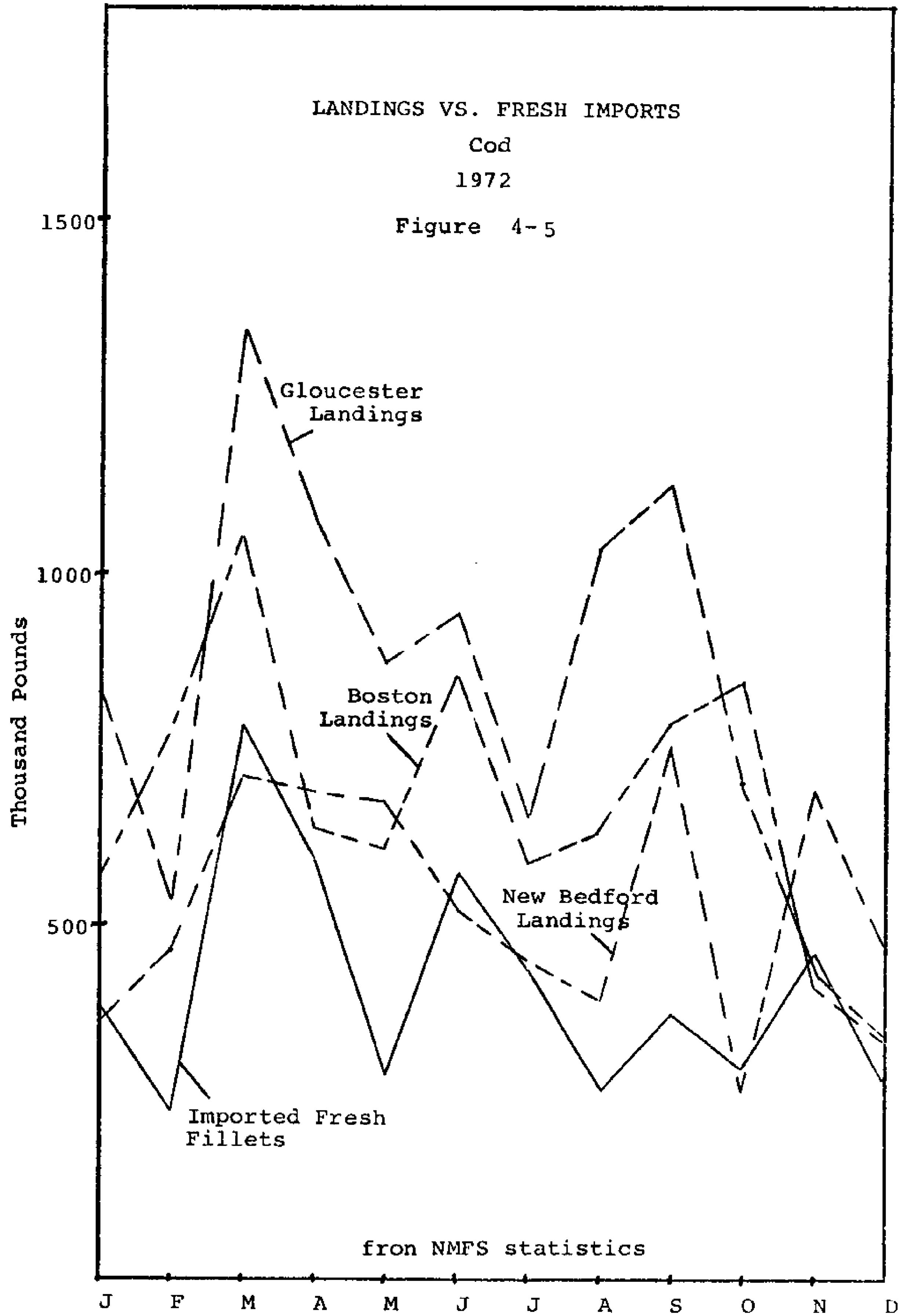
Nearly all fresh food fish landed in New Bedford is sold at its traditional auction. The primary wholesalers participating in this auction are those who have facilities for unloading. The fish are sold by the boatload to the highest bidder. Auctions are held every morning in a small building on Pier 3 in New Bedford and are run by the Fishermen's Union representatives. The boatloads are distinguished by the quantity, species, and size of fish caught. The scallop auction is held from 7:00 A.M. to 7:30 A.M. and the fish auction from 8:00 A.M. to 8:30 A.M. A few vessels sell outside of the auction to specific dealers. The primary wholesaler may then process the product himself or sell some of it to various secondary wholesalers. The various processors in New Bedford are generally quite specialized and handle either scallops, flounder, or other ground fish, although the larger processors may handle all of these. Fillets are usually packed in 10 or 20 pound cans and 8 of these are heavily iced in wooden crates. Scallops come ashore with shell and body removed and packed in linen bags. They may then be packed fresh in commercial or consumer size packages or cooked and breaded for seafood dinners.

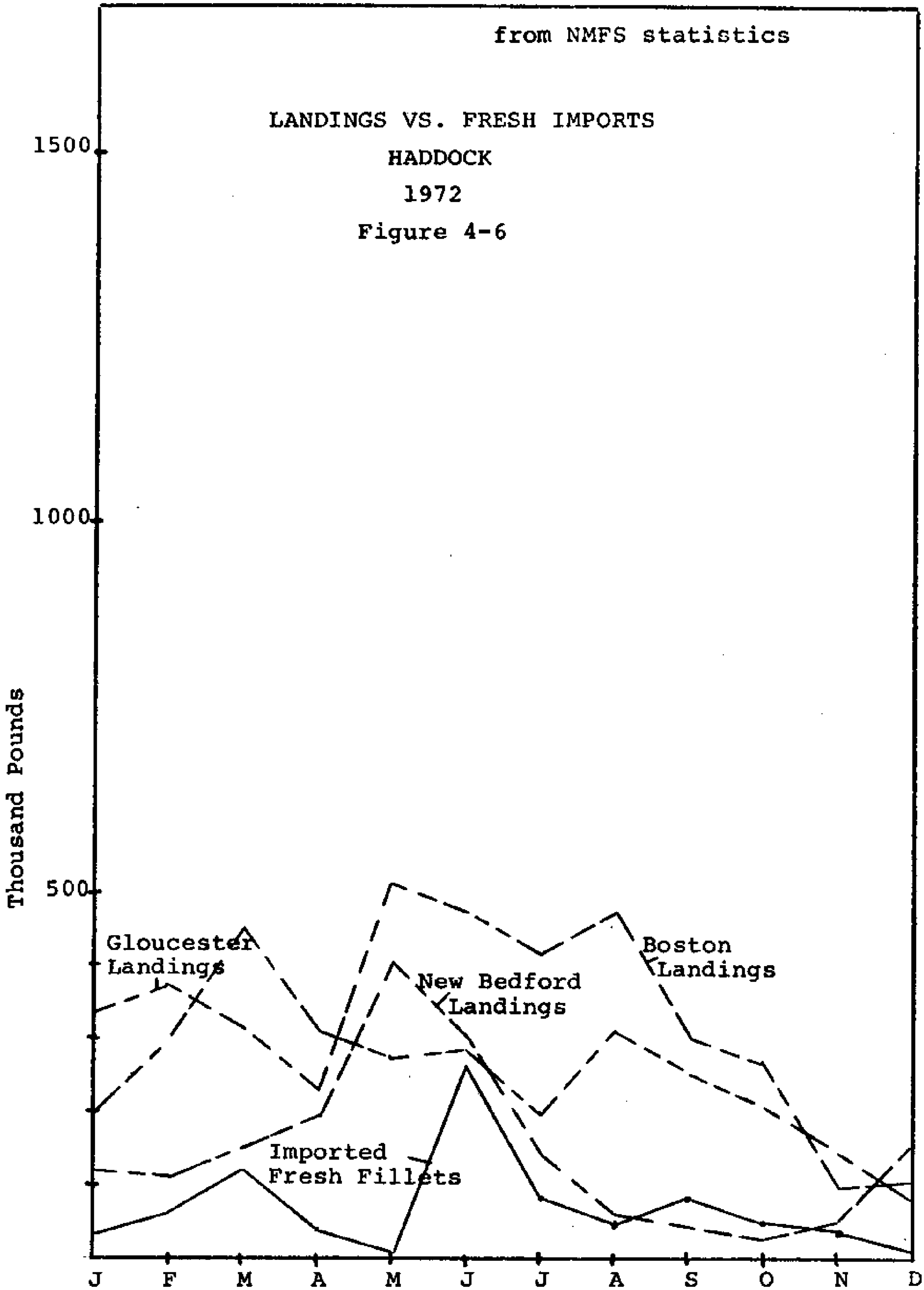
The majority of fish landed at Boston goes through the Boston Fish Pier. Various wholesaler-processors on or near the pier, along with other buyers who own a seat, may then bid for fish, by species, on the New England Fish Exchange. Rather than bidding for entire boatloads, as in New Bedford, Boston buyers bid for smaller quantities of specific species. Fish are sold in units called scales (1000 lbs.) and carted or trucked from the vessel to the various buyers. The houses on the pier buy a good part of the landings, some fish are trucked to near-by houses not on the pier, and the remainder may go to large retail establishments and to other cities.

Unlike Boston and New Bedford, Gloucester does not have a fish auction. Boat owners deal directly with processors and rely on long-standing relationships and contracts for selling fish. Boston or New Bedford prices are often used as a guide for setting haddock, cod, and flounder prices allowing a one cent per pound price cut for delivery to Boston, but this is not at all hard & fast as an individual's supply and demand will affect local price. Also, unlike Boston and New Bedford, Gloucester lands a large quantity of ocean perch. Perch prices are negotiated solely between individuals and depend on good communication between buyers and sellers. Most of the landings are processed in local fish houses, but a fair amount goes whole to Boston.

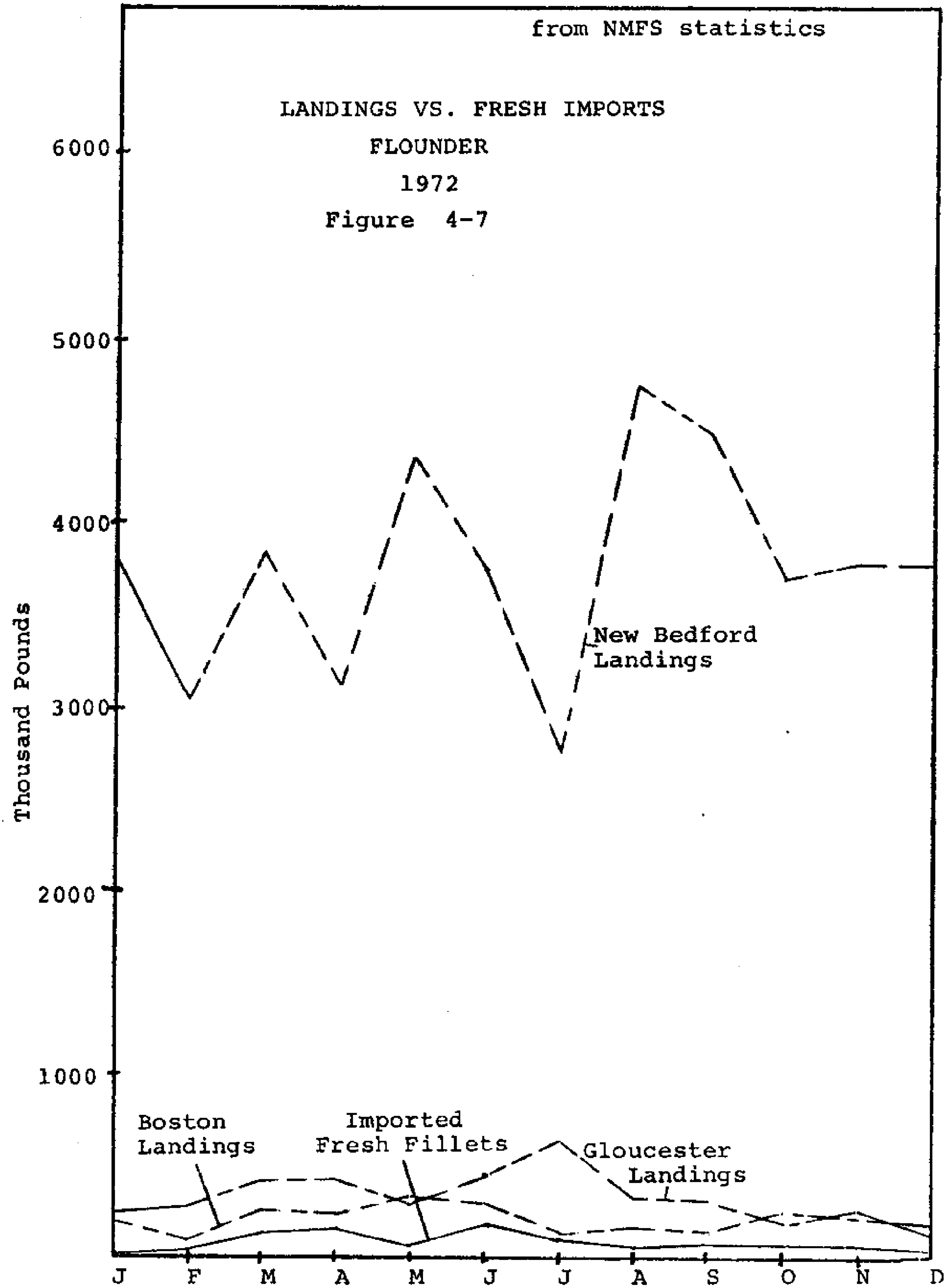
Fresh Imports

The majority of fresh imports enter by truck from Canada. Figures 4-5 through 4-7 illustrate the fluctuating volume of fresh imports entering in 1972. When comparing whole weights to filleted it should again be noted that only about one third


LANDINGS VS. FRESH IMPORTS
Cod
1972
Figure 4-5
1500
1000
500
Thousand Pounds
Gloucester Landings
Boston Landings
New Bedford Landings
Imported Fresh Fillets
fron NMFS statistics
J
F
M
A
M
J
J
A
S
O
N
D



from NMFS statistics
LANDINGS VS. FRESH IMPORTS
HADDOCK
1972
Figure 4-6
1500
1000
500
Thousand Pounds
Gloucester Landings
New Bedford Landings
Boston Landings
Imported Fresh Fillets
J
F
M
A
M
J
J
A
S
O
N
D


from NMFS statistics
LANDINGS VS. FRESH IMPORTS
FLOUNDER
1972
Figure 4-7
6000
5000
4000
3000
2000
1000
Thousand Pounds
New Bedford Landings
Boston Landings
Imported Fresh Fillets
Gloucester Landings
J
F
M
A
M
J
J
A
S
O
N
D

of the landed weight reaches the fillets.

After dividing whole weights by 3, this data reveals the following:

1. The volume of imported fresh cod fillets is 2-3 times that produced domestically by either of the ports.

2. The average volume of imported haddock fillets runs about twice that produced domestically by Gloucester and New Bedford and is roughly equivalent to Boston.

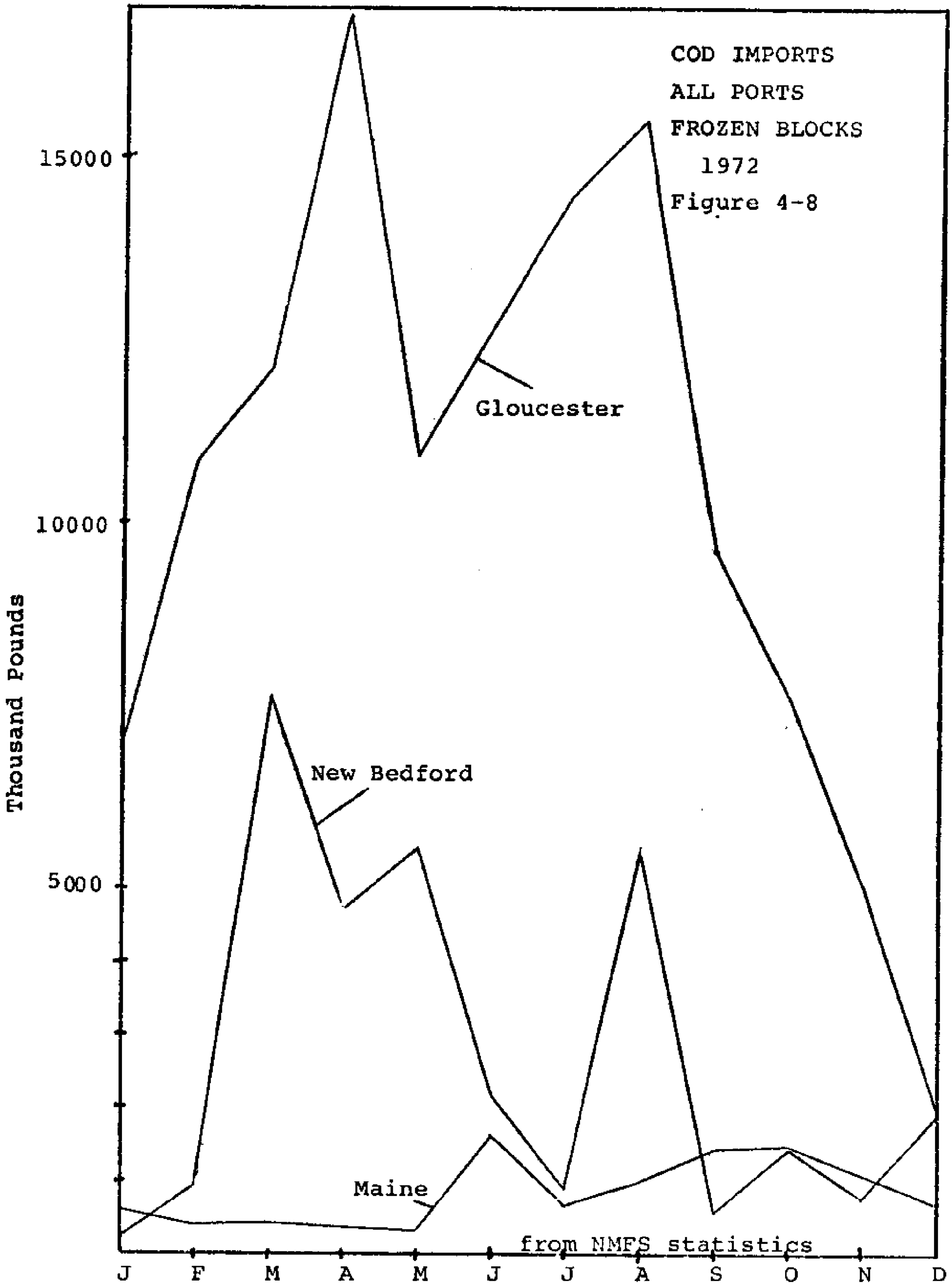
3. New Bedford has a total monopoly on flounder when compared to Boston, Gloucester, and Canadian imports.

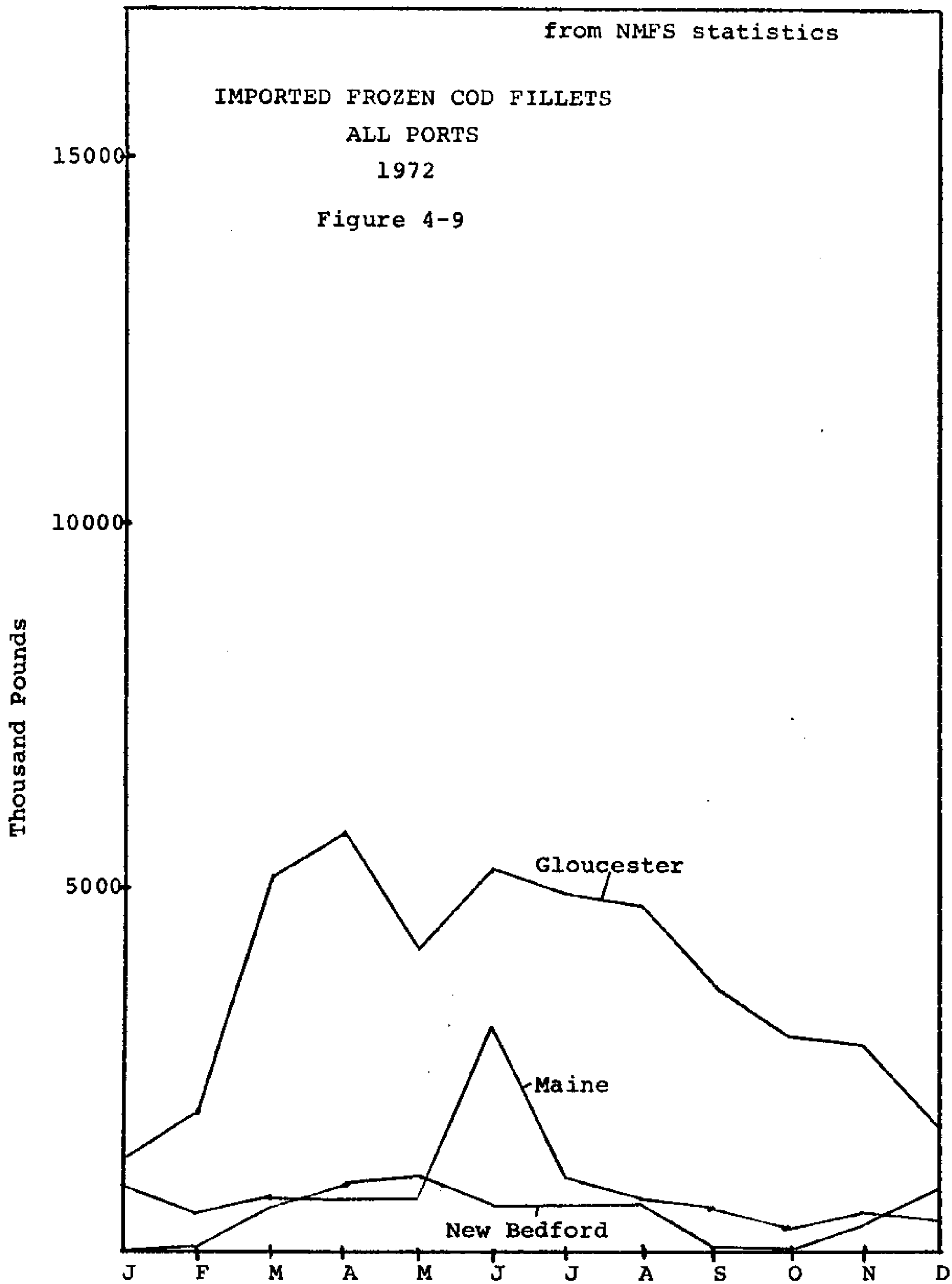
4. On a monthly scale the supply of fresh imports seems to vary seasonally with domestic landings rather than complement them. This could mean that imports are coming into direct competition with domestic landings. Alternatively imports may be used to complement daily fluctuatuions in landings and to keep a steady supply from day to day. Some combination of these two alternatives is most probable.

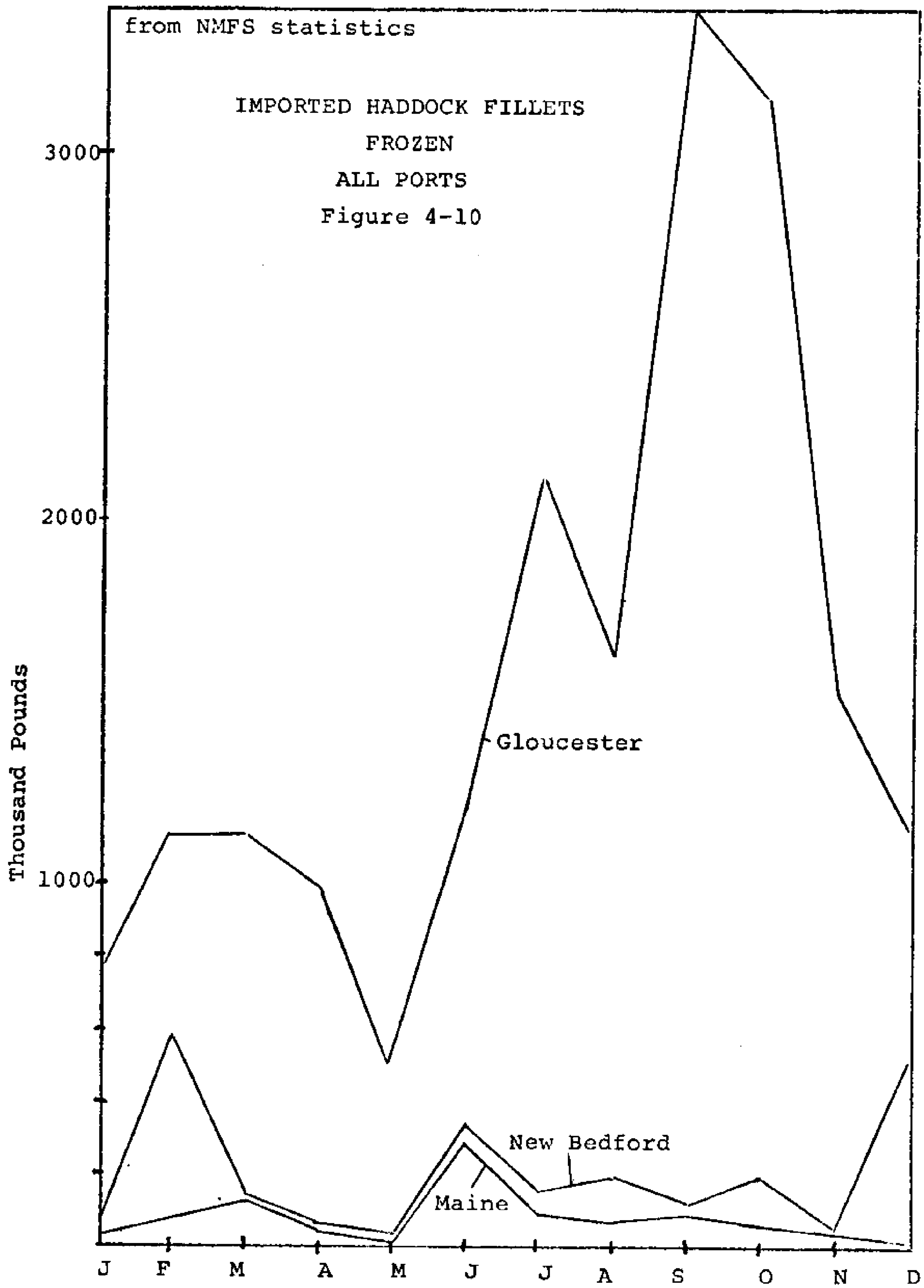
Fresh imports are purchased in a number of ways. Some primary wholesalers buy directly from Canadian sales organizations. Others buy from dealers who import and distribute imported fish. Imports arrive by truck to Boston and Gloucester, by ferry to various Maine ports and then by truck south, by small vessels to Gloucester, and by rail to Boston.

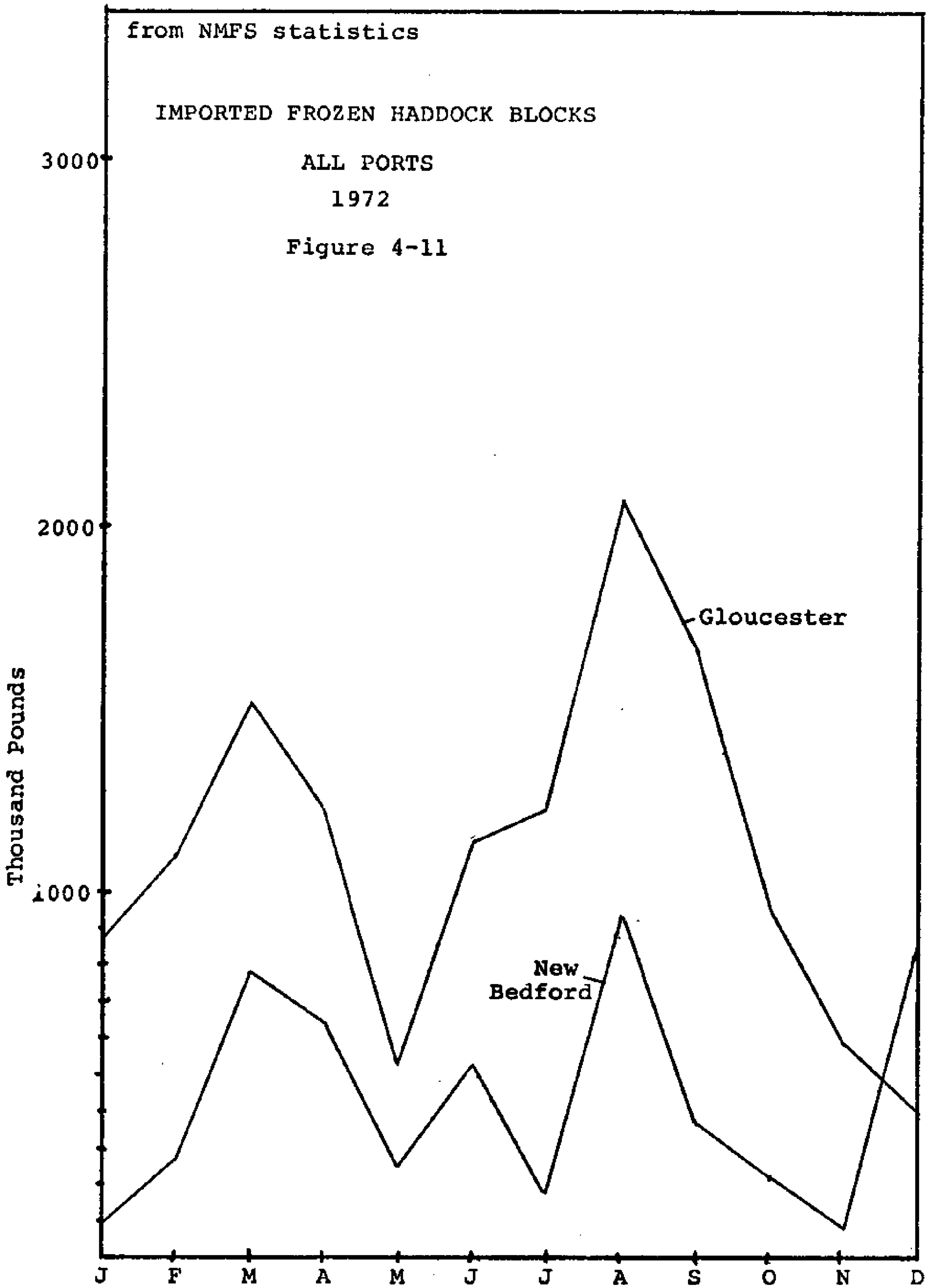
Frozen Imports

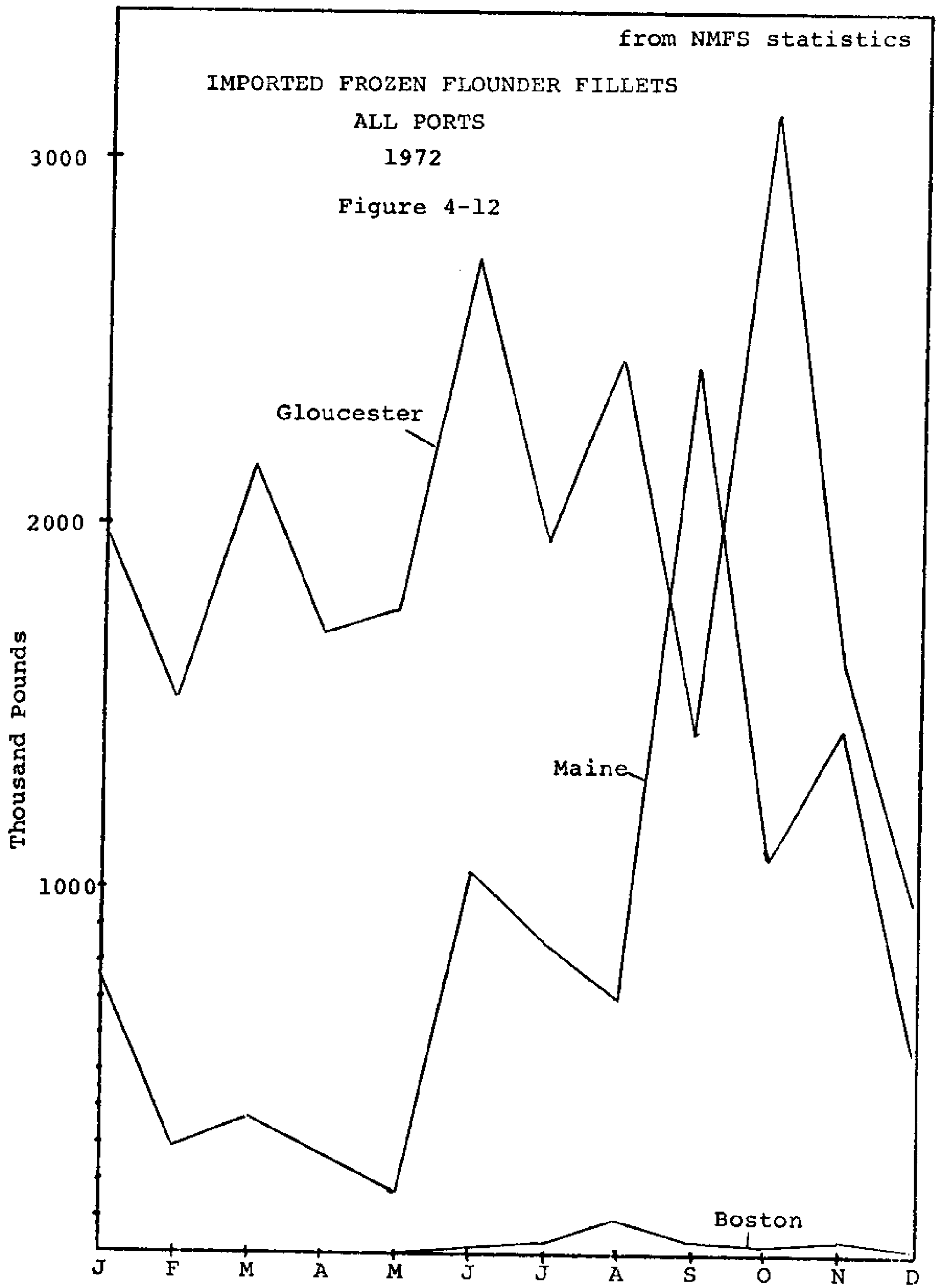
The bulk of frozen fish imports entering New England comes to the port of Gloucester by refrigerated cargo ship although a fair quantity comes to New Bedford by ship and from Canada by truck and rail. Figures 4-8 through 4-13 reveal that Gloucester is by far the leader in frozen cod and haddock imports with New Bedford second. Gloucester and Maine lead in flounder imports with New Bedford, due to its domestic

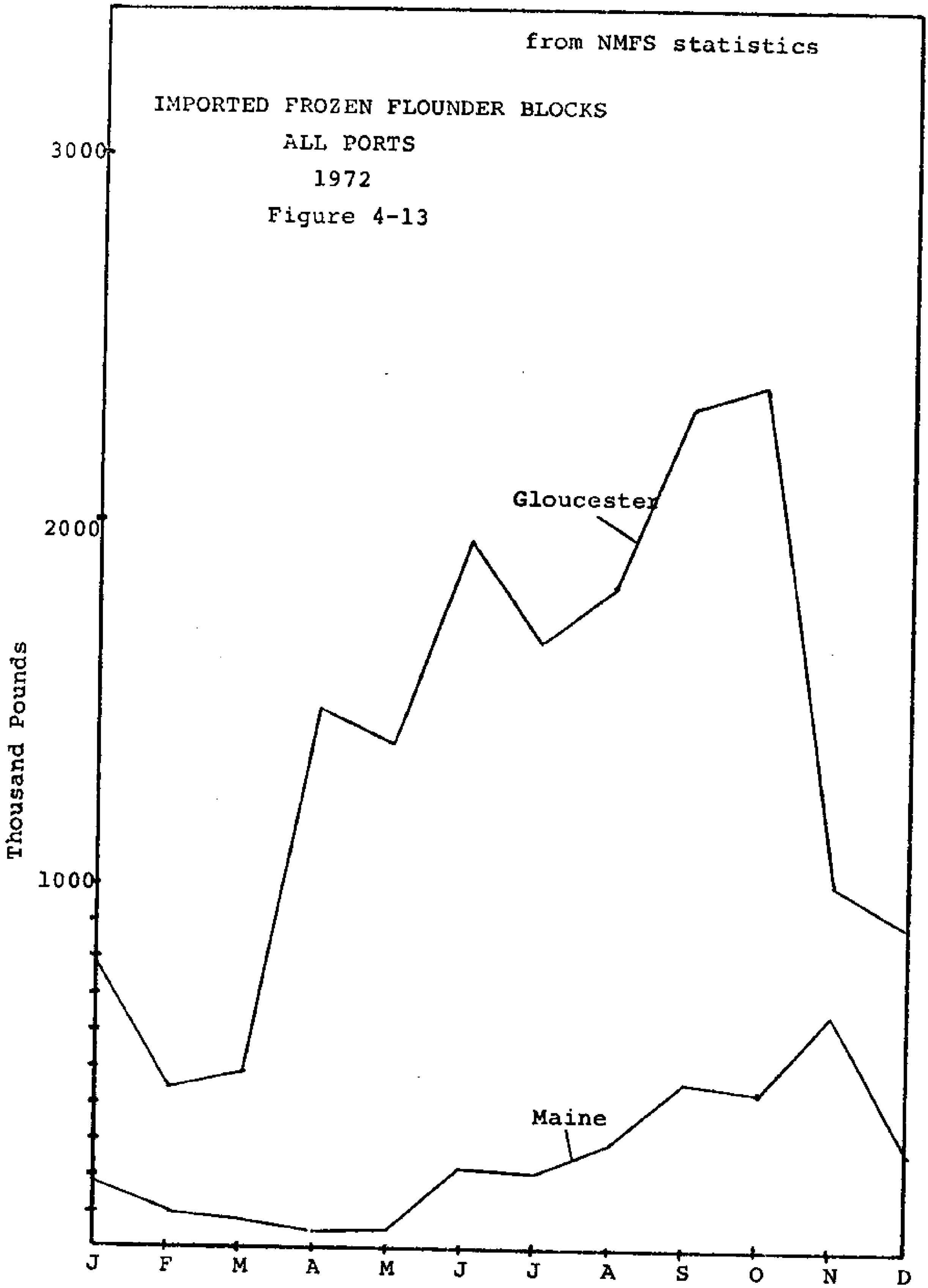

COD IMPORTS
ALL PORTS
FROZEN BLOCKS
1972
Figure 4-8
Gloucester
New Bedford
Maine
from NMFS statistics
Thousand Pounds
15000
10000
5000
J
F
M
A
M
J
J
A
S
O
N
D


from NMFS statistics
IMPORTED FROZEN COD FILLETS
ALL PORTS
1972
Figure 4-9
15000
10000
5000
Thousand Pounds
Gloucester
Maine
New Bedford
J
F
M
A
M
J
J
A
S
O
N
D


from NMFS statistics
IMPORTED HADDOCK FILLETS
FROZEN
ALL PORTS
Figure 4-10
3000
2000
1000
Thousand Pounds
Gloucester
New Bedford
Maine
J
F
M
A
M
J
J
A
S
O
N
D


from NMFS statistics
IMPORTED FROZEN HADDOCK BLOCKS
ALL PORTS
1972
Figure 4-11
3000
2000
1000
Thousand Pounds
Gloucester
New Bedford
J
F
M
A
M
J
J
A
S
O
N
D


from NMFS statistics
IMPORTED FROZEN FLOUNDER FILLETS
ALL PORTS
1972
Figure 4-12
3000
2000
1000
Thousand Pounds
Gloucester
Maine
Boston
J
F
M
A
M
J
J
A
S
O
N
D


from NMFS statistics
IMPORTED FROZEN FLOUNDER BLOCKS
ALL PORTS
1972
Figure 4-13
3000
2000
1000
Thousand Pounds
Gloucester
Maine
J
F
M
A
M
J
J
A
S
O
N
D

supply, importing very little. Boston receives few imports by sea, but rather has them trucked from Canada and Gloucester.

The frozen imports are either bought directly by a processor here, brought in by a company with a subsidiary here (Frionor), or bought through foreign or domestic import dealers here. The frozen fillets are convenience packed and delivered to chain stores and other retail establishments. The frozen blocks are further processed into sticks or portions and delivered to chain stores, chain restaurants (McDonalds, etc), and institutions. When an excess in domestic fresh fish exists frozen processors will sometimes buy fresh. Also, all frozen products processed for the government must come from domestic fish.

The flow of fish products is a very intricate one, although the major exchanges have been discussed. Friendships and dealings of long standing are often all that link the various dealers, but these links are generally effective and efficient.

CHAPTER V

FISH PROCESSING AND HANDLING METHODS

The methods, equipment, and labor used for processing fresh fish are totally different from those used for frozen fish. Fresh fish processing plants are usually small, family-run businesses while frozen fish processing plants are bigger and more automated. The variety in size and shape of fresh fish limits automation as each fish requires different cutting and handling. Frozen fish blocks are uniform as are their products, sticks and portions, so they may be processed by repetitive, automated methods.

Processing Fresh Fish

The most typical type of fresh fish processing pland in New England is a single production line filleting plant, although larger plants exist with more production lines. These plants are small and are often located on a pier where they can unload ships directly. Most plans also rely on a supply of over-the-road fish and have trucking facilities for loading and unloading. Some processors rely solely on over-the-road fish and may not be on the water at all. Small cold storage facilities are usually available for storing about a day's work of fresh or processed fish. The average size of a plant is about 10,000 square feet for both processing and storage, but some plants run much larger and may also have a facility for cooking and handling frozen fish.

Unloading

A certain amount of processing has already taken place before the fish have been landed. The deckhands provide whatever processing is necessary to prepare the fish for storage in the holds of the vessel. Ground fish such as haddock and cod must be eviscerated and scallop meats must be removed from the scallop, washed, and packed in bags before they are stored. The deckhands sort and store fish, properly iced, in the pens below deck.

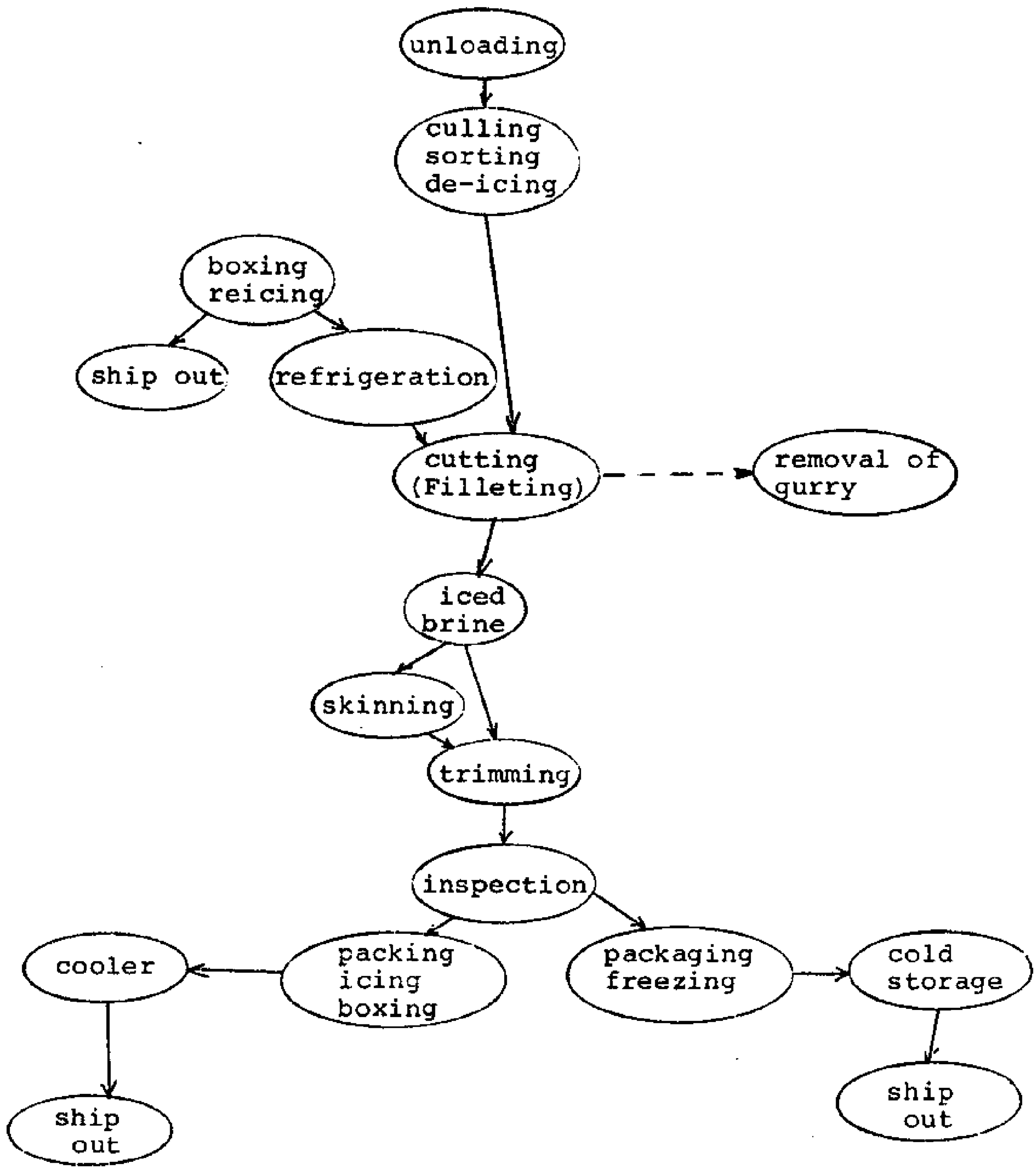
When unloading, men in the hold, using pitchforks, fill two bushel canvas baskets with fish, somewhat separated from ice, and these baskets are hoisted up to the dock and dumped into crates, barrels, chutes, or carts. At this point the product is further sorted, deiced, and then weighed either by placing a container on the scales or driving a cartload onto weighing station scales. If the unloading is taking place at the processor's dock the product is brought in on a hand truck. If not, the product may be trucked or carted to the processor. Unloading is usually performed by fishermen and lumpers.

The Processing Operation

Figure 5-1 illustrates the procedure in a typical filleting operation. After entering the plant the fish may be reiced and boxed for storage or shipping or they may go immediately to processing. The labor for a filleting operation consists of foreman, floorman, cutters, skinners, trimmers, machine operators, inspectors, weighers and packers. The equipment might

PROCESSING FRESH FISH

Figure 5-1



consist of skinning machine, various conveying equipment, brine tanks, filleting machine, cutting boards, packing machine, ice crushers, and coolers. Filleting of flounder and large haddock and cod is still best done by hand, but filleting machines are sometimes used for scrod.

Various degrees of automation occur in processing plants. In a fairly automated plant, the fish are dumped into a chute which delivers the fish to a conveyor and the cutting boards. The cutters fillet the fish, place the fillet in an overhead conveyor or tank which leads to a large iced brine tank and the gurry or remains of the fish are dropped on yet another conveyor which goes back outside to a truck or bin. Fillets are held in the iced brine tank until skinned or packed. Flounder, large haddock and large cod fillets are usually skinned, but scrod haddock and cod are often packed with skins on.

A less automated plant relies on a floorman to place fish in the cutting table trough. After filleting, the cutters place the fillets in brine buckets which are dumped manually into the iced brine trough feeding packaging or skinning. Gurry is dropped into barrels which are also removed manually.

Fillets may be packed by hand into tins or by machine into consumer boxes. Ten and twenty pound tins are most common for fillets bound for institutions, restaurants and secondary wholesalers. One pound consumer packages are often used for chain stores and other retailing. Whole fish are usually packed in 100 pound wooden crates and scallops in barrels. Tins are further packed and iced in wooded crates for shipment.

Fish can be filleted at a rate of about 200 fish per hour per cutter and the skinning machine can skin about 2000 fillets per hour. A look at these figures would suggest about 10 cutters per skinning machine for efficiency, which is a bit high, but reasonable. To package in tins about 3 trimmer — packers are needed per skinning machine. An efficient operation usually requires a total of 15-20 people per line after including machine operators and floormen.

As was stated earlier, fresh fish processing might seem a bit antiquated, but produces a valuable product and provides a good deal of employment.

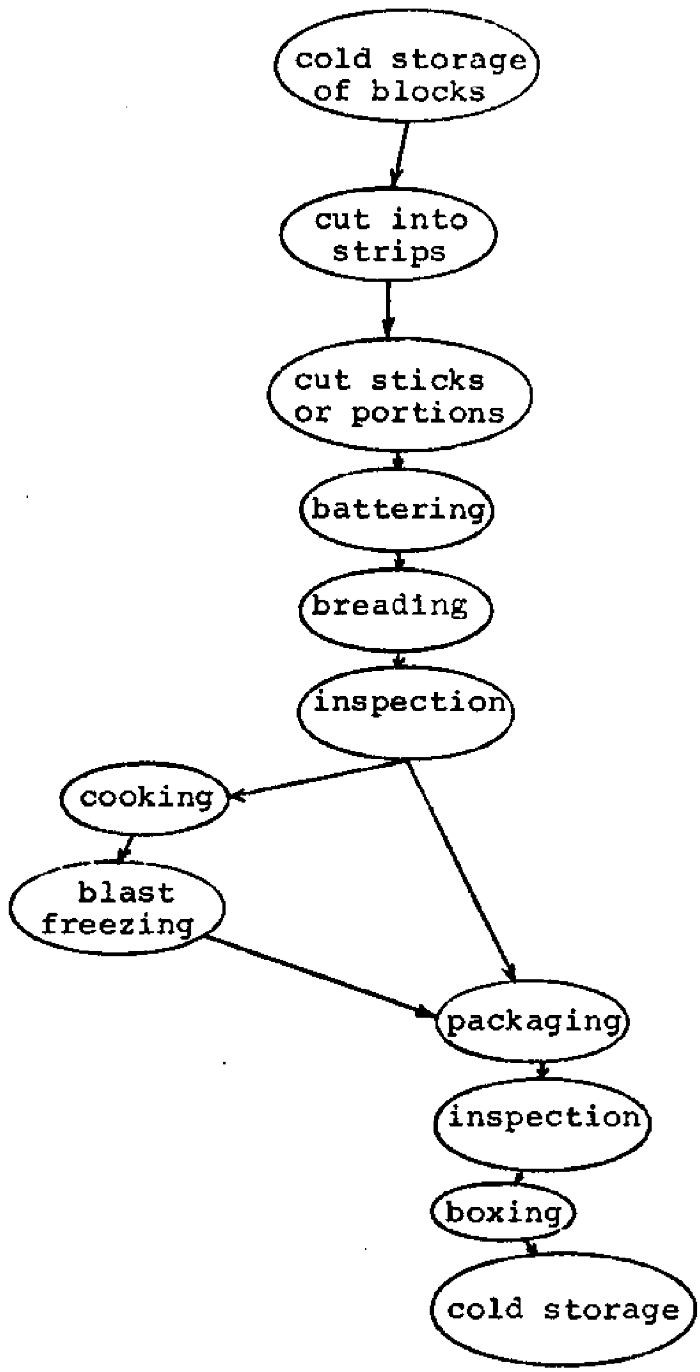
Processing Frozen Blocks

There is little similarity between frozen fish blocks and fish except for the taste. However, blocks of frozen fillets provide the raw material for the largest and fastest growing variety of fish products, convenience-type frozen fish sticks, portions, and dinners. Fish blocks consist of a mass of fish fillets frozen under pressure into a consistent block. The dimensions of a block vary with manufacturer, but they normally weigh about 15 pounds.

The absolute prerequisite for all frozen fish processing plants is adequate and readily available cold storage. Large plants in New England such as Frionor and Gorton's operate immediately next door to a large cold storage facility. Freezing tunnels are usually operated by the processor while cold storage is rented or leased to store raw materials and product.

PROCESSING FROZEN BLOCKS

FIGURE 5-2



This allows the cold storage company to deal in other commodities such as meat, cranberries, etc. and the processor to be free of such dealings.

The machinery used in a typical convenience-type frozen fish processing plant consists of fork-lift trucks, band saws, portion and stick cutters, batter and breading equipment, in-line cookers, in-line freezer tunnels and packing machines. Each production line would require approximately 30 employees with production output for an eight-hour shift varying from 10,000 pounds to 25,000 pounds depending on the product produced. A plant might have up to eight production lines producing various products.

The sticks are cut while the block is still frozen and shortly after it has been removed from cold storage. Cutting is done in two stages. Band saws are used in the first stage to produce thin slabs of frozen fillets. In the second stage these slabs are cut into sticks on stick cutters, which are automatically fed guillotine-type cutting machines. From here the sticks or portions proceed to the battering and breading machines.

Numerous commercial varieties of batter mixes and breadings are available to the processor. Batters normally contain corn-meal, grained corn flour, and non-fat dry milk. Breadings contain cracker meal, potato or soy flour, dryed bread crumbs, etc. Processors often dust the sticks initially with a thin coat of dry batter mix to aid the main liquid batter in adhering to the stick. In operations employing fully automatic breading and battering equipment, the product is next conveyed to an unscrambling device where portions are separated into equally spaced rows. They then pass along a belt beneath a manifold from which the batter flows down in a curtain over the portions. The excess batter collects in a depression beneath the belt and coats the lower side of the portions.

A similar process takes place in the breading machine, where a dry breading compound is applied to all surfaces. Excess breading is removed by passing the portions across a vibrating screen. The portions are next inspected and those to be packed raw pass directly to the packing line, otherwise, they move on to the cooker.

Portions and sticks are cooked in either continuous or batch cookers. In a continuous operation the product moves on a conveyor through the cooker which is essentially a tank about 5 feet wide and 30 feet long containing 250 gallons of oil. The oil is held at about 400°F and the portions pass through for about 30 seconds. Such a process can cook about 2,000 pounds of fish per hour. In a batch process large trays are dipped into a similar tank for about 30 seconds.

Before packaging the cooked product, it must be refrozen and this is done in blast freezers where blasts of cold air (-40°F) are blown through trays of the sticks and portions. The raw product does not have sufficient time to thaw and passes directly from breading to packaging.

The frozen products are next machine-packed into end-loading cartons which are glue sealed. These consumer cartons are then packed into boxes and sent to cold storage which is normally held at -15°F.

This process produces high quality frozen foods which are sold to various types of wholesaling and retail establishments.

New England Fish Processing

Fish processing, especially in Massachusetts is an active industry. Besides the traditional processors of fresh fish, New England has seen a growing number of convenience food processors. (Table 5-1)

The production of sticks and portions has been growing continuously with a recent slight reduction in fish stick production, but continued growth in the somewhat more popular fish portions. (Table 5-2) Frozen processing provides fairly dependable employment, although recent shortages have caused some lay-offs, and this employment has continued to grow along with production. (Table 5-1)

Fresh processors have been sustained in recent years by the growing imports of fresh fish. Although many of the processors only repackage imported fillets, imports have allowed them to maintain their markets under fluctuating and diminishing domestic landings. Unfortunately, this has resulted in gradually decreasing fresh processing employment.

It can be seen in Table 5-3 that Massachusetts is by far the leader in New England fish processing. New Bedford's

Table 5-1

PROCESSING AND WHOLESALING ESTABLISHMENTS

	Plants	Total Employment Average Season	Year	Plants	Total Employment Average Season	Year
New England:						
Maine	250	5534	3233	254	5885	3586
New Hampshire	13	437	396	13	464	391
Massachusetts	233	5843	4991	237	5829	5034
Rhode Island	32	377	304	33	345	391
Connecticut	9	45	36	10	53	45
TOTAL	537	12236	8960	547	12576	9347
Middle Atlantic:	367	6513	5706	370	6295	5690
Chesapeake:	465	10646	7811	556	10265	7260
South Atlantic:	432	7123	5307	431	7601	5608
Gulf:	817	18625	13427	825	18497	12721

ref.7

Table 5-2

U.S. PRODUCTION OF FISH STICKS AND PORTIONS, 1960-71

Year	Fish sticks		Fish portions	
	Thousand pounds	Thousand pounds	Thousand pounds	Thousand pounds
1960	65,142	26,671	49,381	17,517
1961	69,824	30,100	59,847	22,192
1962	77,217	30,076	78,678	28,089
1963	79,302	31,590	94,644	33,980
1964	73,574	29,986	106,313	36,532
1965	82,483	35,778	140,464	56,025
1966	81,415	35,787	147,581	58,013
1967	73,909	32,559	161,313	58,518
1968	91,695	41,454	182,711	68,620
1969	113,369	51,242	217,017	83,719
1970	*115,924	*57,772	234,247	97,930
1971	97,776	56,807	*239,662	*122,842

ref.7

*Record

Note:--A Fish stick, generally cut from a block of fillets, is an elongated piece of breaded fish flesh weighing not less than 3/4 of an ounce and not more than 1-1/2 ounces with the largest dimension at least three times that of the next largest dimension. A fish portion, generally cut from a block of fillets, is a piece of fish flesh generally of uniform size with a thickness of 3/8 of an inch or more, and which does not conform to the definition of a fish stick.

Table 5-3

Processed Fishery Products, 1970

	Massachusetts		Maine		R.I. and Conn.	
	1000 lbs.	$1000	1000 lbs	$1000	1000 lbs.	$1000
Cod:						
Fillets						
Fresh and Frozen	10052	5316	157	64		
Breaded, frozen	10421	6120				
Specialties, frozen	6898	3688				
Flounder						
Fillets						
Fresh and Frozen	27675	18099	148	83	1033	590
Breaded, frozen	4007					
Specialties, frozen						
Haddock						
Fillets						
Fresh and Frozen	8241	6490	373	319		
Breaded	2589	1861				
Specialties	749	419				
Cakes	6466	2572				
Dinners	10680	7488				
Sticks, breaded						
Raw	970	421				
Cooked	43135	21146				
Portions						
Raw						
Not breaded	1287	622				
Breaded	50981	21295				
Breaded and Cooked	18181	8416				

ref.11

processing of fresh yellowtail and scallops, Boston's processing of haddock, and Gloucester's processing of ocean perch have each led the nation. The excellent supply of frozen fish to these ports (mostly through Gloucester) has also encouraged frozen fish processing and distribution. All in all the investment in New England fish processing is significant and due to frozen products, it is growing. Each of these major ports dealing in fish and fish processing will be discussed in detail in the next chapter.

CHAPTER VI

FISHING PORT FACILITIES

This chapter will consider the total facilities for handling fish in the three major New England ports: New Bedford, Gloucester, and Boston. Each of these ports is active in handling both domestic and imported fish which may come into the city by truck, sea, or rail.

Vessel Requirements

The two major categories of fish, domestic and imported, enter these ports by totally different vehicles. The domestic catch is delivered in the same fishing vessels which caught the fish,while imports are usually deliverd by ocean-going refrigerated bulk carriers. In order to understand the port's ability to handle these vessels, we should know something about them.

A large variety of domestic vessels fish off the shores of New England: lobster boats, scallopers, purse seiners, etc., but the most typical and important type of vessel in New England is the dragger or trawler. The dragger may be further classified into three other groups:

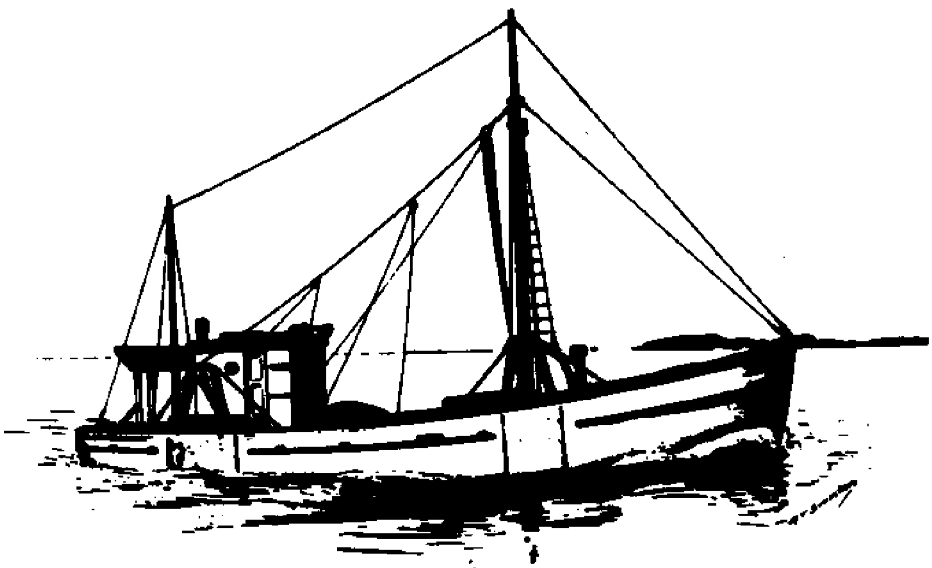
1. small draggers - The vessel tonnage is 50 or less.
2. medium draggers - The vessel tonnage is 50-150 tons.
3. large trawlers - The vessel tonnage is over 150 tons.

The vessels vary in length up to 150 feet with drafts up to 15 feet. They require facilities for repair, unloading,

FIGURE 6-1

ATLANTIC DRAGGER

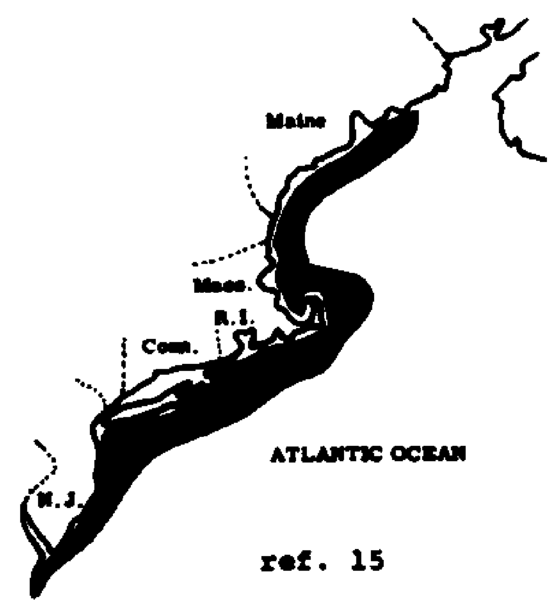
Small



ATLANTIC DRAGGER, SMALL

Length in Feet	30 to 74
Beam in Feet	9 to 20
Draft in Feet	2½ to 9
Net Tonnage	50 or under
Construction	Wood
Engine: Type	Diesel or Gas
Horsepower	50 to 260
Type of Refrigeration	Ice
Cruising Speed	4.5 to 11 Knots
Average Crew	2 to 9
Length of Trip	1 to 8 Days
Convertibility to Other Types of Gear	Gill Net, Clam Dredge, and Purse Seine

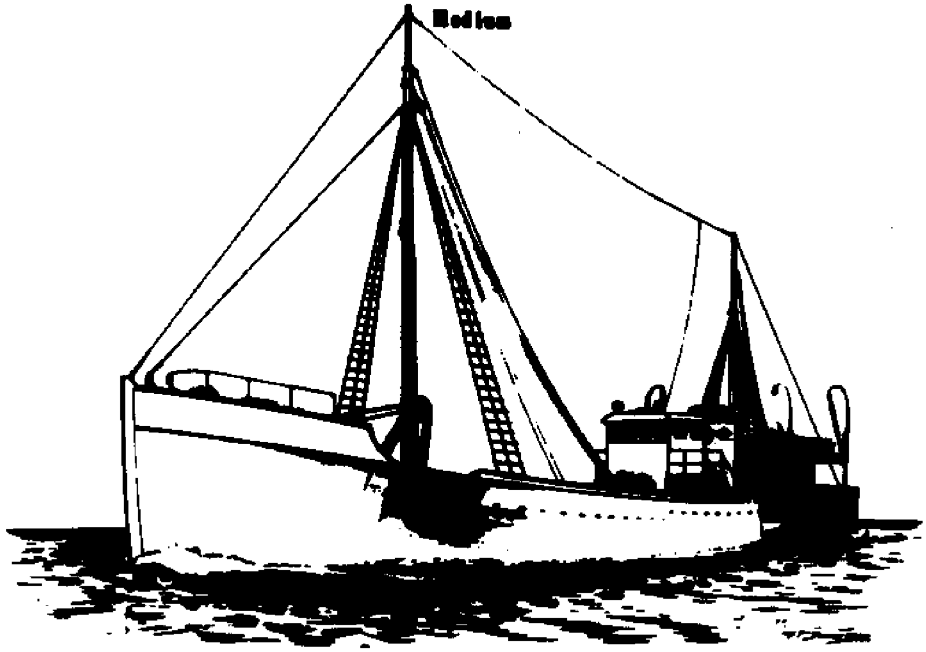
MAIN AREA OF FISHING OPERATION



ref. 15

FIGURE 6-2

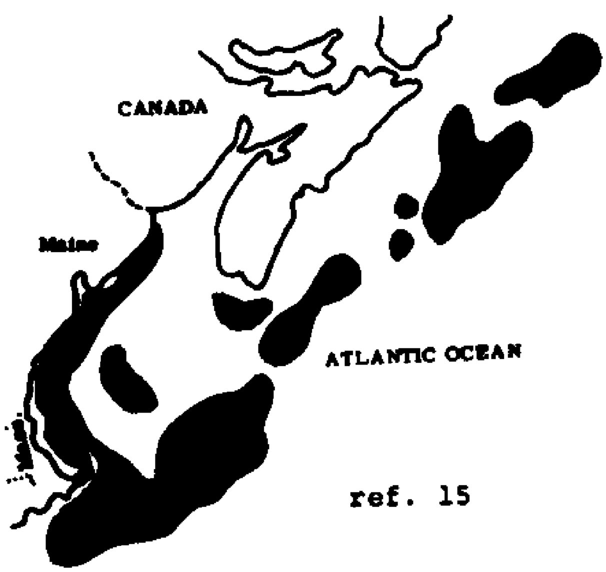
ATLANTIC DRAGGER



ATLANTIC DRAGGER, MEDIUM

Length in Feet	60 to 100
Beam in Feet	14 to 23
Draft in Feet	6 to 13
Net Tonnage	51 to 150
Construction	Wood or Steel
Engine: Type	Diesel
Horsepower	155 to 400
Type of Refrigeration	Ice
Cruising Speed	6 to 13 Knots
Average Crew	5 to 15
Length of Trip	1 to 14 Days
Convertibility to Other Types of Gear	Scallop Dredge, Purse Seine, and Harpoon

MAIN AREA OF FISHING OPERATION

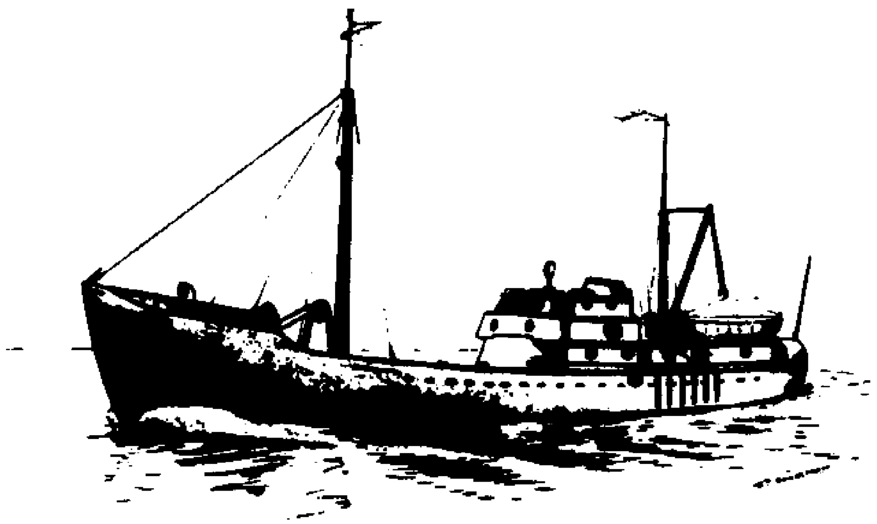


ref. 15

FIGURE 6-3

ATLANTIC TRAWLER

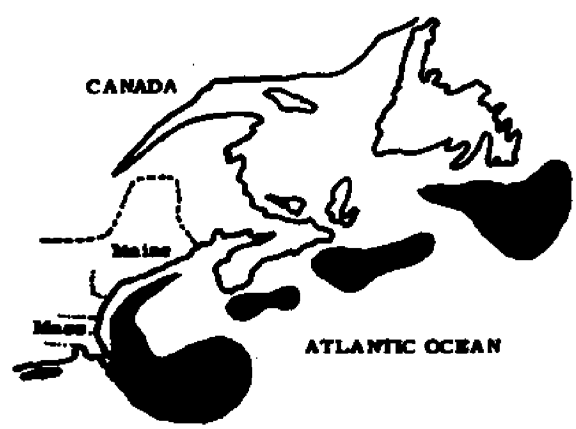
Large



ATLANTIC TRAWLER, LARGE

Length in Feet	85.5 to 140
Beam in Feet	18.3 to 26
Draft in Feet	10 to 15
Net Tonnage	150 or over
Construction	Wood or Steel
Engine: Type	Diesel
Horsepower	320 to 735
Type of Refrigeration	Ice
Cruising Speed	7 to 15 Knots
Average Crew	8 to 17
Length of Trip	5 to 14 Days
Convertibility to Other Types of Gear	None

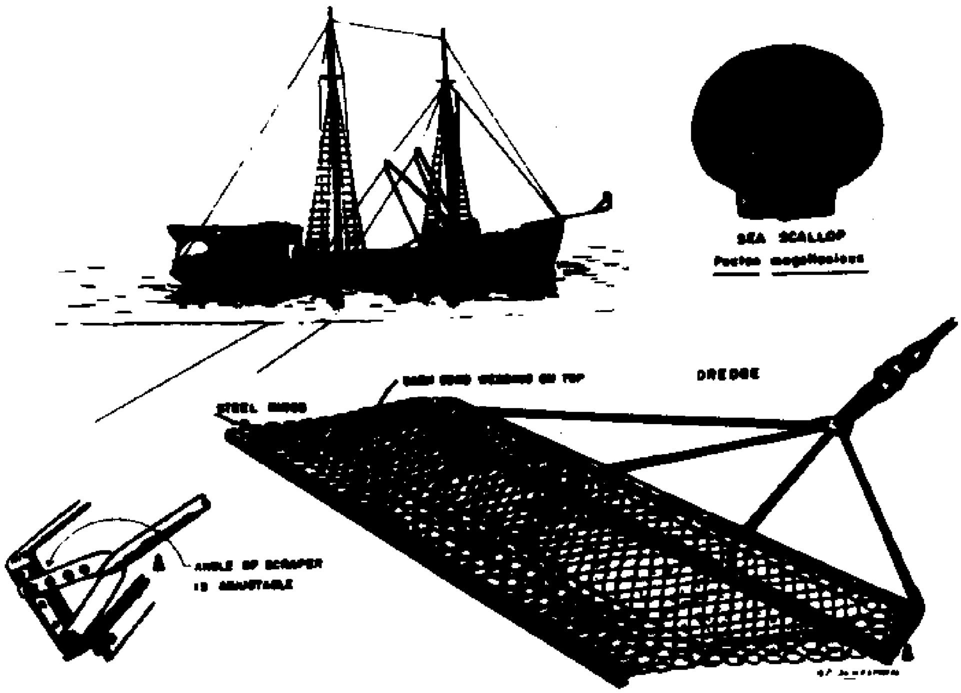
MAIN AREA OF FISHING OPERATION



ref. 15

FIGURE 6-4

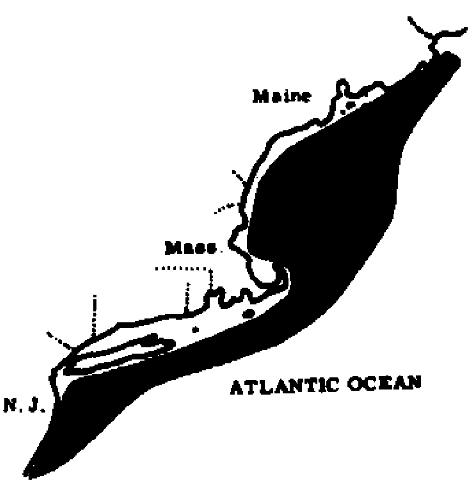
SEA SCALLOP FISHING



SEA SCALLOP DRAGGER

Length in Feet	40 to 100
Beam in Feet	16 to 22
Draft in Feet	6.5 to 11
Net Tonnage	15 to 80
Construction	Wood
Engine: Type	Diesel
Horsepower	110 to 330
Type of Refrigeration	Ice
Cruising Speed	7 to 12 Knots
Average Crew	6 to 12
Length of Trip	6 to 12 Days
Convertibility to Other Types of Gear	Purse Seine, Otter Trawl, and Long-Line

MAIN AREA OF FISHING OPERATION

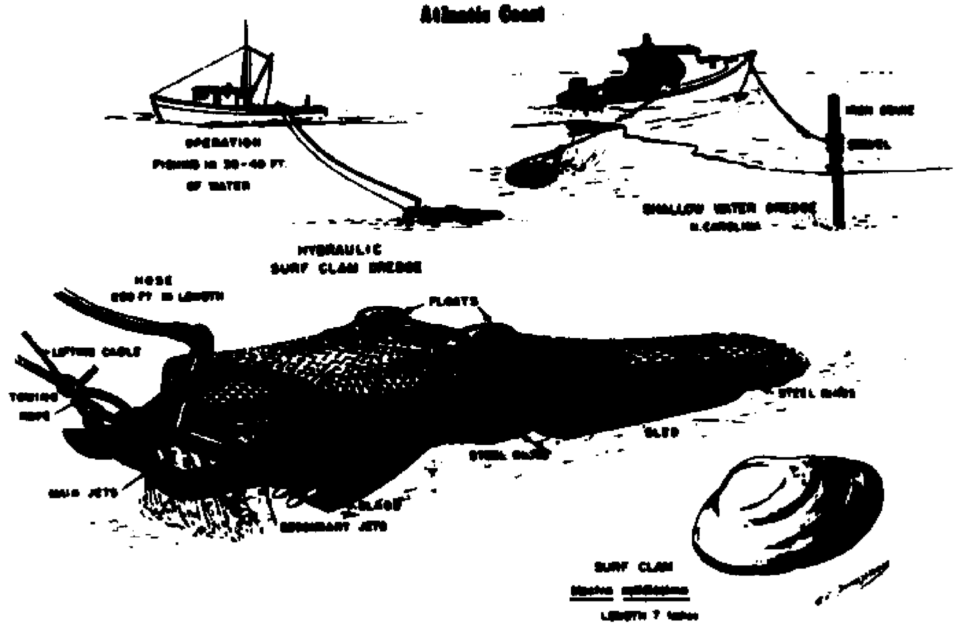


ref.15

FIGURE 6-5

CLAM FISHING

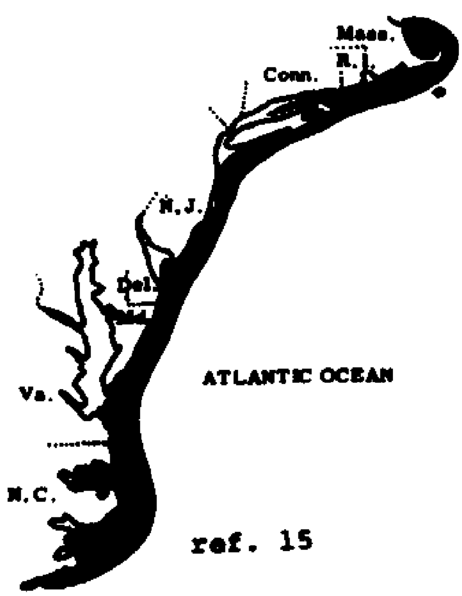
Atlantic Coast



CLAM DREDGER

Length in Feet	31 to 62
Beam in Feet	9 to 18
Draft in Feet	3 to 9
Net Tonnage	3 to 40
Construction	Wood
Engine: Type	Diesel or Gas
Horsepower	25 to 250
Type of Refrigeration	None
Cruising Speed	8 to 11 Knots
Average Crew	1 to 3
Length of Trip	1 Day
Convertibility to Other Types of Gear	Trawl, Gill Net, Crab Dredge, and Trot Line

MAIN AREA OF FISHING OPERATION

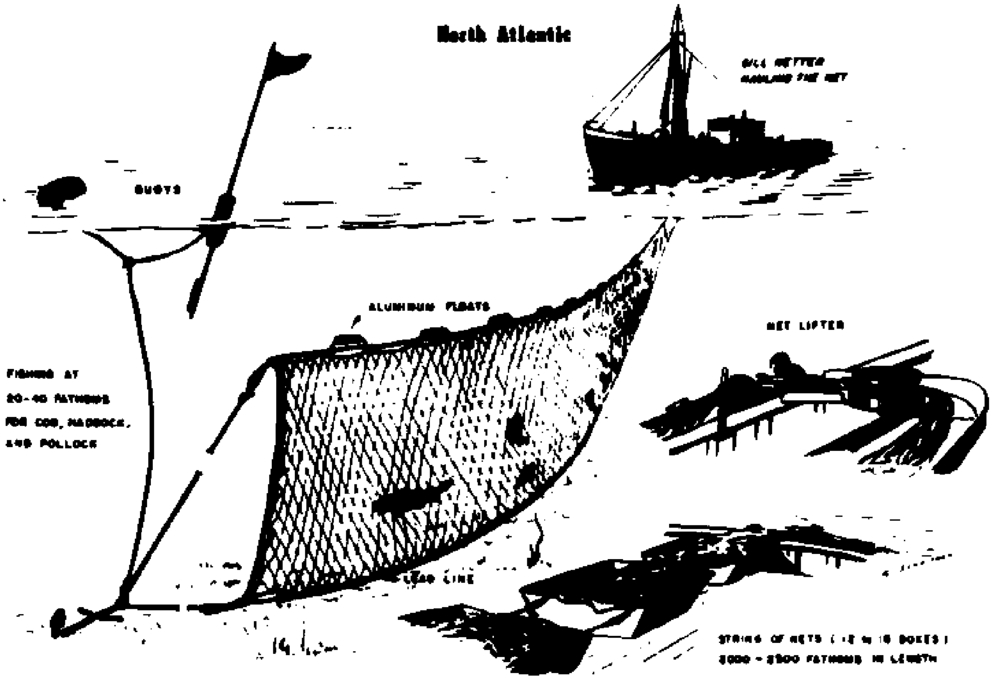


ref. 15

FIGURE 6-6

GILL NET

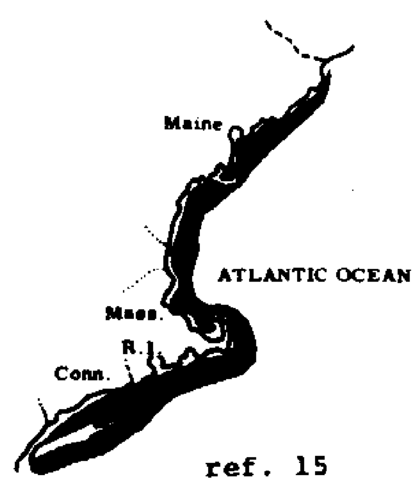
North Atlantic



GILL NETTER

Length in Feet	34 to 69
Beam in Feet	10 to 16
Draft in Feet	4 to 8
Net Tonnage	5 to 36
Construction	Wood
Engine: Type	Diesel, Some Gas
Horsepower	100 to 170
Type of Refrigeration	None
Cruising Speed	5 to 10 Knots
Average Crew	3 to 7
Length of Trip	8 Hours to 1 Day
Convertibility to Other Types of Gear	Lobster Pots, Trawl, Clam Dredge

MAIN AREA OF FISHING OPERATION



ref. 15

berthing, and taking on stores,ice, and diesel fuel. Scallop, lobster, and clamming vessels are usually smaller, but require similar facilities. (see figures 6-1 through 6-6)

Table 6-1 lists a sample of refrigerated break-bulk cargo vessels carrying frozen imports into New England (1972). The size of these vessels is not arbitrarily chosen, but is determined by two major critera:

1. The size limitations at the port of supply.
2. The volume and nature of the product.

Referring to the sample it can be seen that vessel lengths are generally in the range of 200-300 feet, beams range from 30-40 feet and drafts range from 12-20 feet. These dimensions, especially the drafts, reflect the fact that many Newfoundland, Iceland and Scandanavian ports are draft limited. In many of these ports drafts beyond 16 feet become hazardous. The quantity of cargo in these ports is also limited at any given time by their freezer or supply capacity. Thus, regardless of the importing port's facilities, the maximum size of these vessels has been, to a great extent, pre-determined.

How then do the exporting nations and the importers here choose the receiving ports? An analysis of the three major New England ports should answer this question, but generally the following characteristics are sought:

1. Demand and a good distribution network from the port
2. Adequate cold storage facilities
3. Good general port facilities

SAMPLE OF REFRIGERATED BREAK BULK SHIPS COMING TO NEW ENGLAND PORTS

Table 6-1

SHIP	TYPE	FLAG	LENGTH	BREADTH	DRAFT	DEAD WEIGHT
1. African Mercury	SRef	U.S.	572'	75'	30	12728 tons
2. Antartic	MRef	Netherlands	266	40	14	1271
3. Arctic	MRef	Netherlands	243	34	12	950
4. Blue Cloud	MRef	Canada	220	36	14	750
5. Blue Peter II	MRef	Canada	220	35	12	710
6. Blue Spruce	MRef	Canada	213	33	14	703
7. Caribia	MRef	Norway	249	39	13	980
8. Eskimo	MRef	Denmark	188	33	12	733
9. Falcon Reefer	MRef	Panama	253	37	13	1449
10. Frost	MRef	Denmark	188	33	12	709
11. Gelesiae	MRef	Italy	272	39	16	1621
12. Glacia	MRef	Denmark	188	33	12	720
13. Karitind	MRef	Norway	195	30	13	720
14. Lastrigoni	MRef	Cyprus	384	54	22	3680
15. Leo Polaris	MRef	Netherlands	272	40	15	1440
16. Polar Reefer	MRef	Norway	219	33	12	775

refs.6&30

MREF = Diesel, Refrigerated Break Bulk

SRef = Steam , Refrigerated Break Bulk

4. Efficient labor force

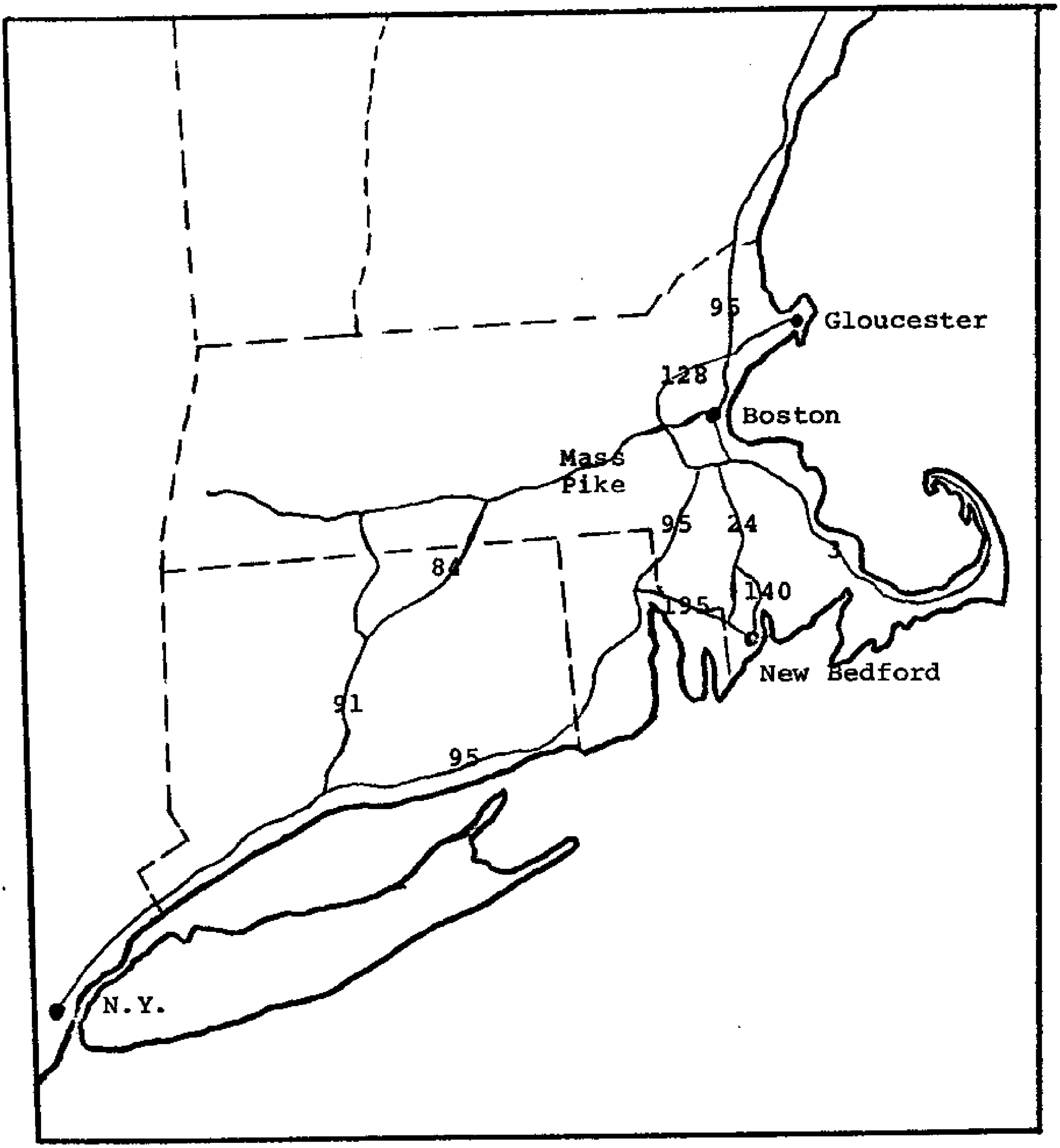
5. Sufficient docking and water depth to handle the vessels

New Bedford, Boston, and Gloucester can all handle most refrigerated bulk carriers in terms of length, beam, and draft. What then distinguishes between these ports?

New Bedford

New Bedford has an active fishing port and receives landings of domestic and imported fish. As can be seen in figure 6-7, New Bedford is slightly closer than Boston to the New York markets and is fed by a newly constructed highway network leading off interstate route 195. However, New Bedford is south of Cape Cod, 90 miles from Boston by sea (via Cape Cod Canal), and is a bit less accessible, at least to the Canadian import traffic. Its harbor approach begins at Buzzard's Bay Buoy and runs 7 1/2 miles direct to the pier facilities (figure 6-8). The channel leads into a moderate size (1000 yards) turning basin after passing through a 150 foot wide passage in the hurricane dike. Continuing north within the harbor leads to the New Bedford-Fairhaven Bridge, which has an opening 95 feet wide into the turning basin serving Maritime Terminal and Frionor Freezer.

Cold storage is directly available at both the Maritime and Frionor Freezer facilities. Six hundred feet of dock space is available on the east side of Maritime and 500 feet on the east side of Frionor (30 feet, MLW). State Pier provides a total of 1,825 feet for 3 ships, but cold storage is not



New England Highway System

Figure 6-7

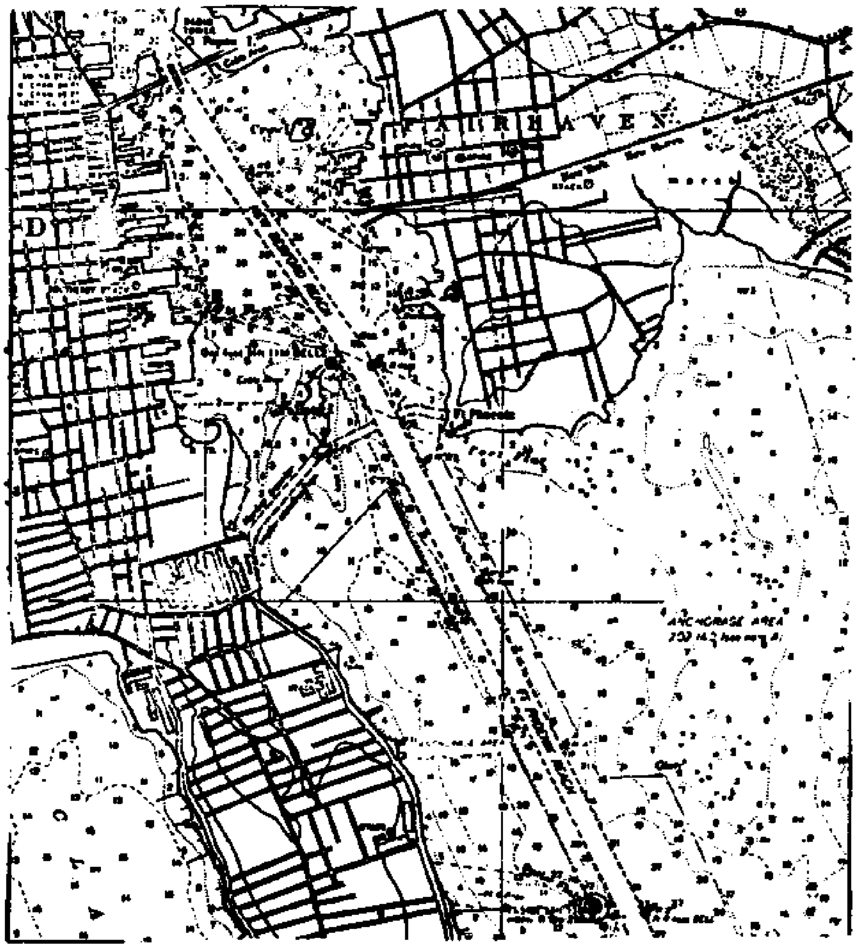


Figure 6-8

Approach to New Bedford Harbor

directly available (figure 6-10).

Docking space for the fishing vessels is not adequate. (Figure 6-9 and Table 6-2). Most of these piers are undermined and many have partially fallen into the water. The New Bedford Redevelopment Authority has recently built the South Terminal Bulkhead and plans to re-build bulkheads on the existing piers. If these plans materialize, the harbor will profit greatly.

Fresh Fish Facilities

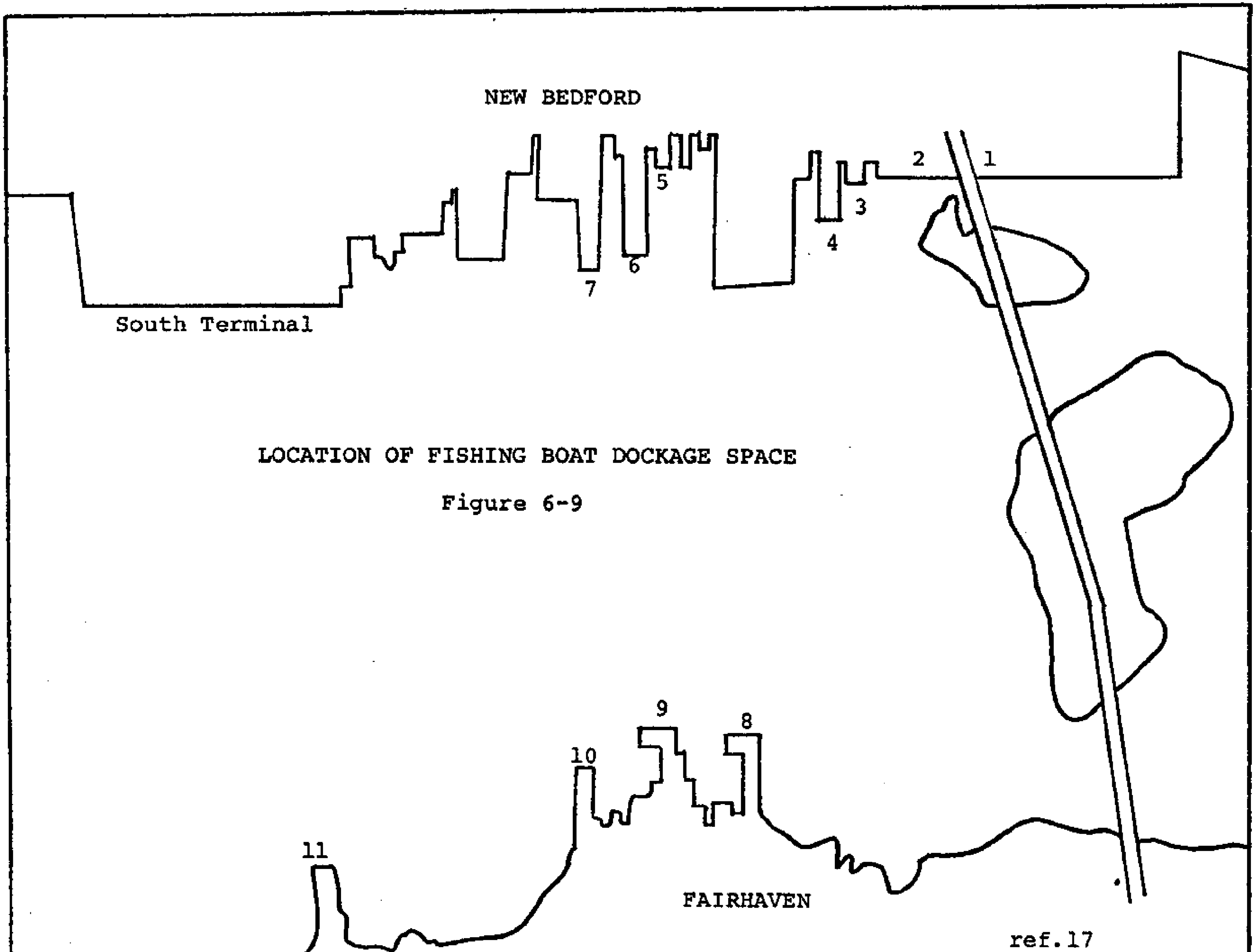
Given this description of the harbor and docking facilities, processing and unloading facilities will next be desribed. Table 6-3 and figure 6-10 show the major fish processing facilities in New Bedford. Local 1749, Fish Lumper's Union, ILA, is responsible for the unloading and weighing operation. The unloading takes place at the various piers of the primary wholesalers involved. From here the product is either processed or packed for shipment. The major products in New Bedford are scallops and flounder and the basic function of the majority of processing plants is filleting. The Tichon plant also has a small kitchen and receives frozen fish to be processed into fish sticks and portions. The new South Terminal has concentrated a half dozen local processors along its bulkhead. A highway link with Interstate 195 is near completion and will make this an excellent facility. Plants and equipment in South Terminal are all new. Quaker Oats Company in the North Terminal processes industrial fish for pet foods and operates its own fleet of daggers. Proces-

Table 6-2

Fishing Boat Dockage
(see Figure 6-9)

		Length(ft.)
New Bedford:		
1.	David Duff's Wharf	340
2.	John Dunn's Wharf	590
3.	City Pier No. 4	540
4.	City Pier No. 3	880
5.	Wood Pier (not totally usable)	290
6.	Homer's Wharf	1,380
7.	Leonards Wharf (little usable)	1,230
	TOTAL	5,250
	South Terminal	1,600
Fairhaven:		
8.	Kelly's Wharf	740
9.	Union Wharf	620
10.	Hathaway Braley's Wharf	780
11.	Fairhaven Marine	330
	TOTAL	2,470

ref.17



LOCATION OF FISHING BOAT DOCKAGE SPACE

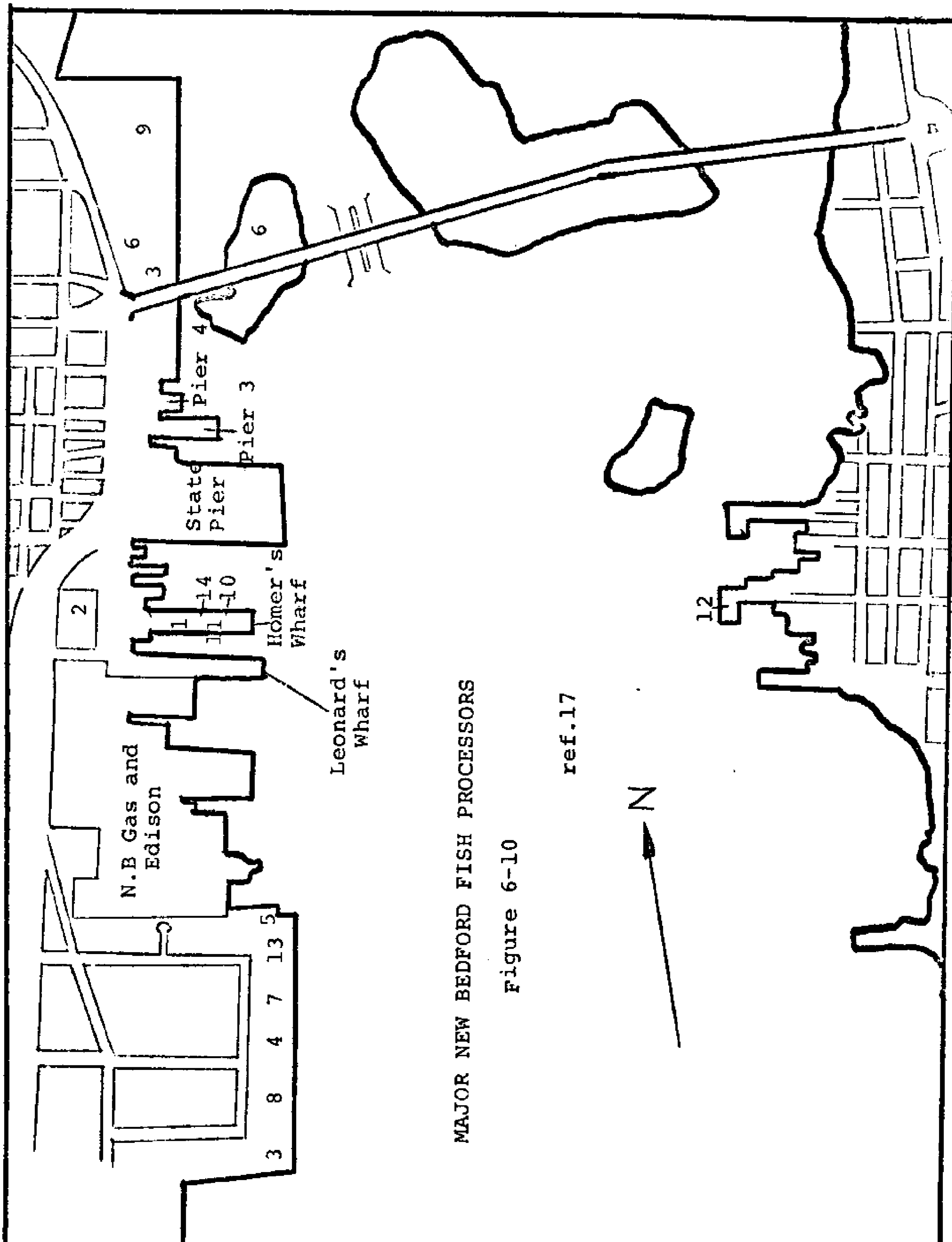
Figure 6-9

Table 6-3

Major New Bedford Fish Processors
(see Figure 6-10)

	Processor	Products
1.	Aiello Bros.	fresh and frozen fillets and shellfish
2.	Capeway Seafoods	prepared fish and scallops
3.	Maritime	cold storage
4.	D Fillet Co., Inc.	fresh and frozen fillets
5.	Ell Vee Dee, Inc.	fresh and frozen fillets and shellfish
6.	Frionor Kitchens	prepared fish, freezer
7.	Pilgrim Fish	prepared fishery products
8.	New Bedford Fillet Co.	fresh and frozen fillets
9.	Quaker Oats Co.	pet food, canned
10.	Quality Fillets Co.	fresh and frozen fillets
11.	Sea View Fillet	fresh and frozen fillets and shellfish
12.	N. B. Coop	fresh and frozen fillets and shellfish
13.	Tichon Fish and Fillet Corp.	fresh and frozen fillets and shellfish
14.	Wes Stan, Inc.	fresh and frozen fillets
15.	Coastal Fisheries	fresh and frozen fillets
16.	Jay Bee Fillet	fresh fillets
17.	Sea Fresh, Inc.	fresh and frozen fillets

ref.17



MAJOR NEW BEDFORD FISH PROCESSORS

Figure 6-10

ref.17

sing in all plants is handled by the New Bedford Seafood Worker's Union.

A cooperative association also exists in New Bedford which is comprised of an ice and fuel division as well as a processing division. The Fishermen's Union is the fishermen's labor organization; Seafood Producers and Boatowners United are boatowner organizations; and the Seafood Dealers Association aids in marketing for the majority of processors. Supplies are provided by a number of private firms as well as through the cooperative. The high price of scallops and flounder has kept New Bedford a relatively healthy fishing port.

Import Facilities

The major fish import facility in the port of New Bedford is the Maritime-Frionor complex. Of all the frozen import processors in New England,Frionor is probably the healthiest because it has its own supply from Norway.Other large processors, such as Gorton's of Gloucestor, are handicapped by having to deal for their supply and have been hurt in the past by shortages.

Refrigerated cargo ships are unloaded at Maritime Terminal and Frionor Freezer by members of the Maritime Stevedoring Corp., I.L.A. The cargo is unloaded on 40" x 48" pallets and brought into the freezers by fork-lift truck.

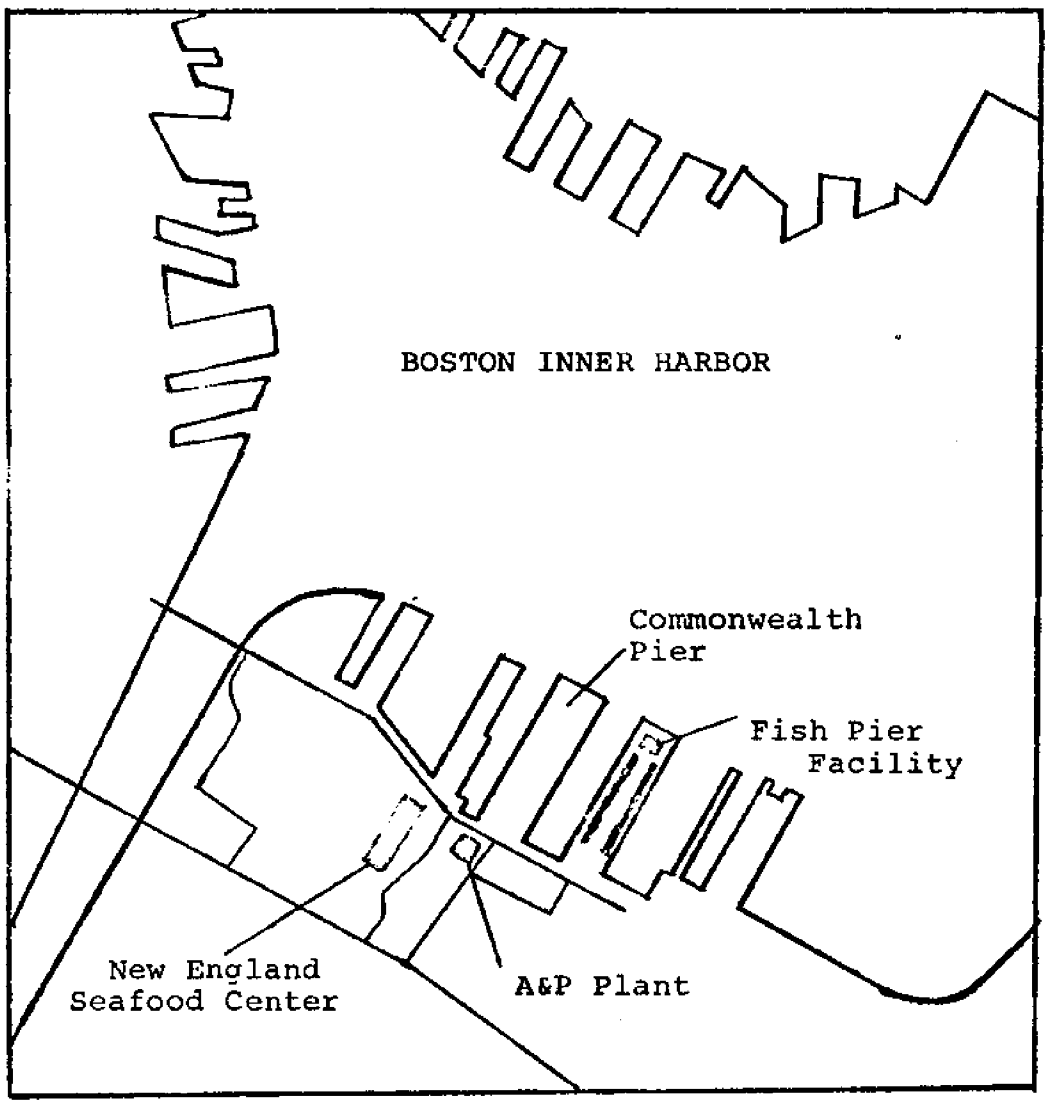
The Frionor Bridge Freezer and Frionor Kitchens has 45,000 square feet of storage with blast freezing units capable of freezing 100,000 pounds of product daily. The Maritime plant is an extremely large complex and can store up to 18 million pounds of fish in its main storage area. Frionor Kitchens has two production lines and employs over 200 people.

Boston

The Port of Boston is a large and many faceted seaport. This discussion will focus on those major facilities which cater to the fishing industry. Most fishing activities in Boston are centered around the Boston Fish Pier. Little need be said here concerning the facilities and capabilities of the Port of Boston. Boston is the hub of a large transportation network and has the deep water and pier facilities for handling most any refrigerated cargo ship and any fishing vessel. Boston is also located north of Cape Cod and in a good spot for shipments from Canada, Iceland, etc. Unfortunately, large port labor problems have diverted much of the import traffic to smaller ports. Reference to Tables 4-8 through 4-13 indicates the great imbalance in favor of Gloucester. This will be discussed in more detail later in this chapter. The largest of Boston's frozen fish processors, A & P and Boston Bonnie, receive the greatest part of their frozen block supply from Gloucester by truck.

Fresh Fish Facilities

Boston's fresh fishing port is nevertheless very active. Figures 6-11 through 6-13 show the Boston Fish Pier and neighboring facilities. The majority of Boston's large trawlers will tie up directly alongside the Fish Pier. Others may dock at various piers in the Atlantic Avenue region, while



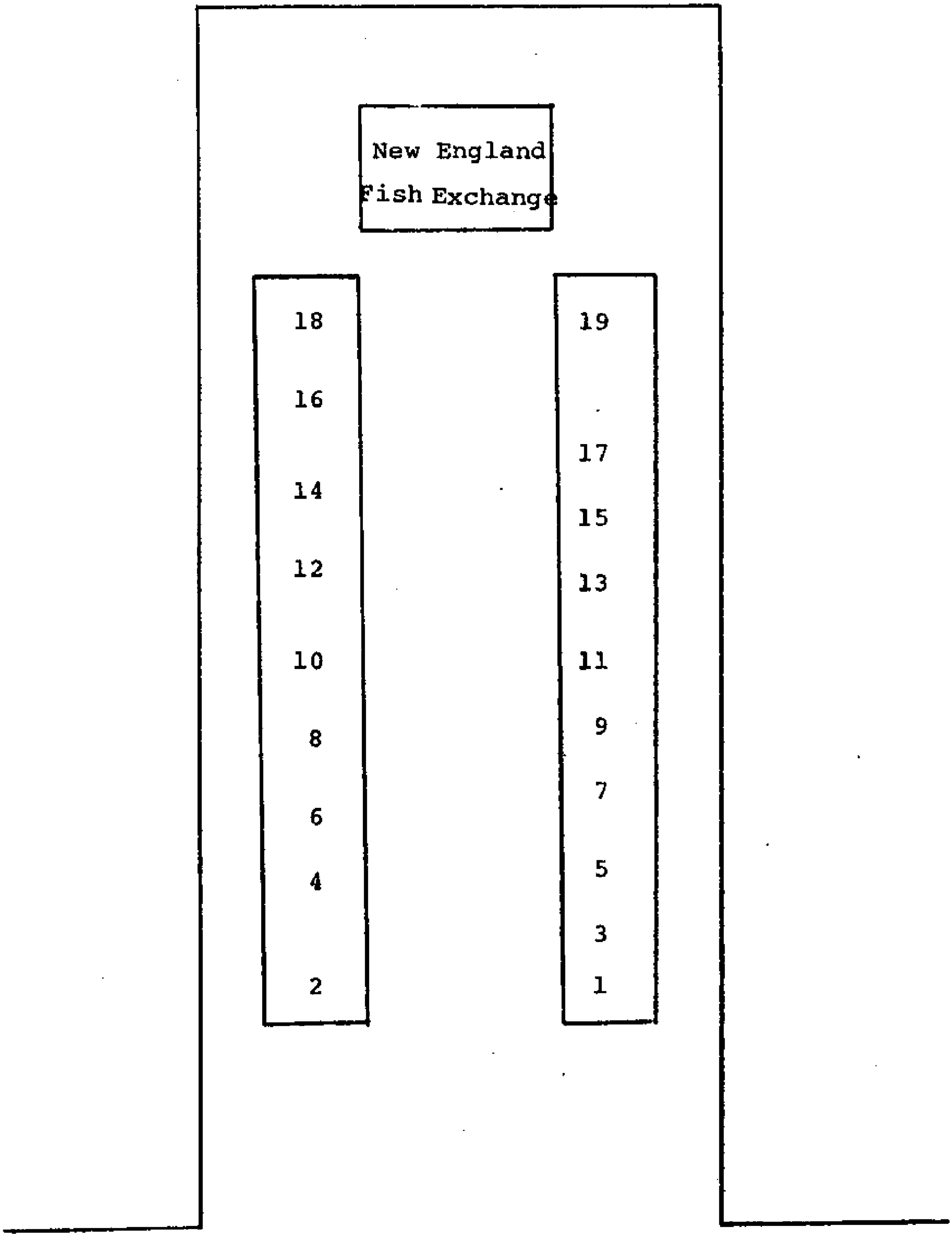
PORT OF BOSTON FISHING & PROCESSING FACILITIES

Figure 6-11

Table 6-4

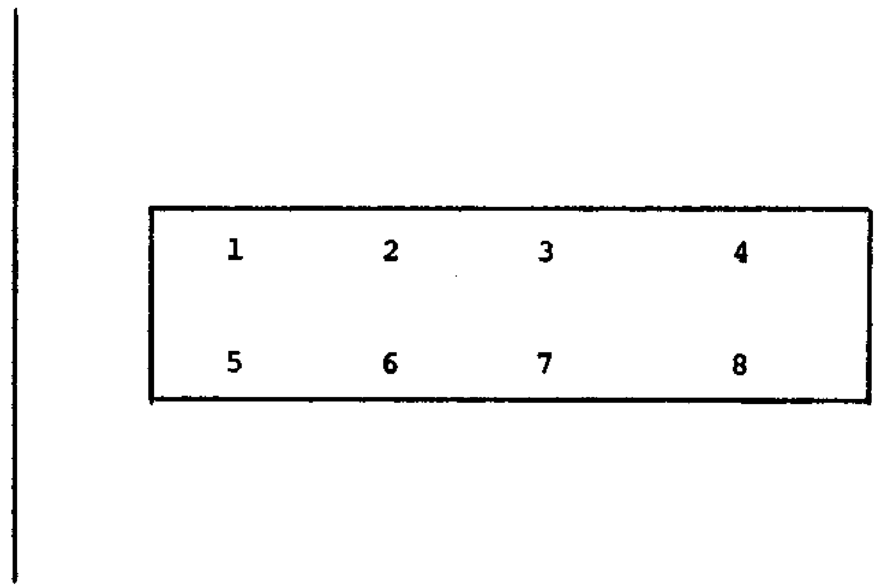
Boston Fish Pier Processors
(see Figure 6-12)

	Processor	Products
1.	Turner Fisheries, Inc.	fresh and frozen fish and shellfish, fillets
2.	A.F. Rich and Co.	"
3.	Crocker and Windsor	"
4.	Deep, Deep Ocean Products	lobsters
5.	F.E. Harding Co.	fresh and frozen fish and shellfish, fillets
6.	Viking Seafood, Inc.	"
7.	Avenue Fish Co., Inc.	"
8.	Blue Sea Fish Co.	"
9.	Puritan Fish Co.	"
10.	T. and J. Busalacchi	"
11.	Super Snooty Seafoods	"
12.	North Atlantic Fish Co.	"
13.	Channel Fish Co.	"
14.	D and F. Fish Corp.	"
15.	John Nagle, Inc.	dealer, fresh and frozen fish, cold storage
16.	Seaside Fisheries	fresh and frozen fish and shellfish, fillets
17.	New England Fillet	"
18.	Bart Tribuna, Inc.	"
;9.	Great Atlantic Fish Corp.	"



BOSTON FISH PIER FACILITY

Figure 6-12



Processor:

1. Abramo Fish Co.
2. Globe Fish Co.
3. Pier Fish Co.
4. Sea Frost Fish Co.
5. Fresh Water Fish Co.
6. B&M Fish Co.
7. H.P. Hale Fish Co. Inc.
8. R.S. Hamilton Co.

Products:

fresh and frozen
fish and shellfish

fillets

NEW ENGLAND SEAFOOD CENTER

Figure 6-13

still others may come from distant home ports, such as Gloucester, unload at the Boston Fish Pier, and then return to their home ports. The majority of the vessels unloading in Boston do come to the Fish Pier, although a few have private contracts with specific dealers not on the pier and unload there.

All of the fish houses on the pier and at the New England Seafood Center have filleting operations except for Deep, Deep, Ocean Products which handles mostly lobster, and John Nagle and Sons which has some cold storage and is exclusively a dealer. The operations on the pier, although they deal in all products, generally produce and distribute fresh fillets. The domestic landings are their primary supply, but in recent years imported fillets have become a large part of their dealings. The processors at the New England Seafood Center receive an even larger part of their supply as imports over the road and have excellent trucking facilities as well as close access to a railroad spur.

Boats are off-loaded by lumpers (ILA) and fishermen. The fish are loaded into carts at dockside and the carts, along with their contents, are weighed and towed by small tractors to their respective processors. Trucks drive onto the pier and load or unload at the front doors of these processors. The New England Fish Exchange is located at the end of the pier and an auction is conducted there every workday morning. The Fish Pier provides 1,200 feet of dock space on each side and 300 feet at the end.

Gloucester

Gloucester is an active fishing port and also imports more fish than any other port in New England. Gloucester is in an ideal location for receiving imports from the Canadian provinces and Iceland. It also has an excellent truck transportation link via route 128. The channel leading into Gloucester's inner harbor has a depth of 20 feet and a breadth of 300 feet. The main channel breaks off into two channels which feed both sides of its State Pier as well as the docks opposite the pier. These channels are 200 feet wide with a depth of 19 feet. Cold storage and dock space for large vessels is available on the north side of the North Channel where the Quincy Cold Storage facilities are located. There is 300 feet of dock space at each of the Quincy facilities on the North Channel.

Docking space for fishing vessels is, as in New Bedford, not adequate. Unlike New Bedford, vessels in Gloucester are not concentrated in one area, but are docked all over the harbor. The major docking spaces are at the Fisherman's Wharf and in the Harbor Cove area.

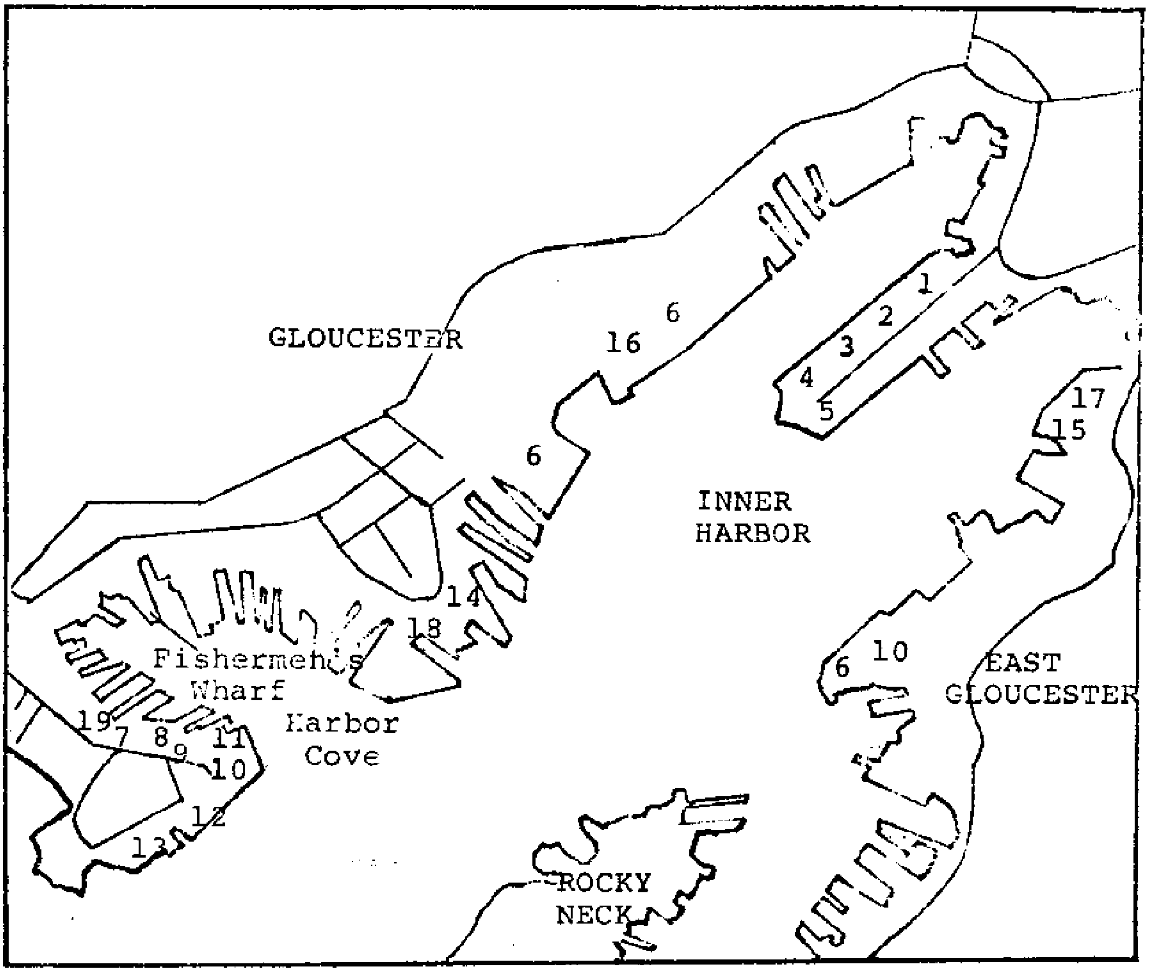
Fresh Fish Facilities

Processing and unloading facilities are also spread all over the harbor. Figure 6-13 shows the location of various fish processing and cold storage facilities in Gloucester. All lumper and fish processing work is handled by the Amalgamated Meat Cutters Union (AFL-CIO), in contrast to Boston and New Bedford who employ ILA lumper and stevadoring labor. The

Table 6-5

Major Gloucester Processing Facilities
(see Figure 6-14)

Processor	Products
1. Boston Frozen Foods, Inc.	shrimp, fresh and frozen
2. American Fillets, Inc.	fresh and frozen fillets
3. Atlantic Seafoods, Inc.	fresh, frozen, and breaded fillets
4. Gloucester Ice and Cold Storage	cold storage
5. Lipman Marine Products, Inc.	fish meal
6. Quincy Market and Cold Storage	cold storage
7. Neptune & Seven Seas, Inc.	fresh and frozen fillets
8. North Atlantic Fish Co.	cold storage, fresh, frozen, prepared fish
9. Ocean Crest Seafoods	fresh fillets
10. O'Donnell-Usen Fisheries	cold storage, prepared fish
11. Quick Freeze Corp.	plate-freezing and cold storage
12. Deep, Deep Ocean Products	lobsters
13. Cape Ann Seafoods	fresh, frozen, prepared fish
14. Star Fisheries	fresh and frozen fillets
15. Capt. Joe and Sons, Inc.	fresh fillets, shrimp
16. Gorton Corp.	prepared seafoods
17. Oceanside Fisheries, Inc.	fresh fillets
18. Empire Fish Co.	cold storage, fresh, frozen, prepared fish
19. Fort Cold Storage	cold storage



MAJOR GLOUCESTER PROCESSING FACILITIES

Figure 6-14

Gloucester labor force has proven generally more reliable and efficient. The bulk of the unloading in Gloucester occurs at the processor's own dock in a similar fashion to that in New Bedford. Ground fish are hand filleted and may or may not be skinned. Most of the fresh processors do have skinning machines. Large quantities of ocean perch are handled in Gloucester,and some of the processors press these fillets into blocks.

One of the major areas for processing is Fort Point. The streets leading to these plants are narrow and congested, making it difficult for truck traffic. Those plants on the State Pier are a bit more accessible. Lipman Marine Products imports fresh herring from Canada as well as landing domestic herring. This herring, along with gurry and other wastes is processed for fishmeal which is then trucked to Maine chicken farms.

Most of the fresh processing plants are small, old, and in bad shape. A number have shut down recently. This is in sharp contrast to the new and modern frozen processing plants located in Gloucester.

Frozen Fish Facilities

Of the three cities discussed, Gloucester handles the most frozen imports. The Quincy Plants alone have a normal capacity for about 80 million pounds of frozen fish. Through the efforts of Frank Elliott and his stevadoring firm, foreign vessels are in and out of Gloucester daily. Imports may be stored for processing in either of the three Quincy Plants, may be stored for distribution by one of Gloucester's import dealers, or may pass right in and right out of Gloucester by truck or rail to Boston and the entire nation.

The Gorton Corporation plant operates in conjunction with Quincy Cold Storage, as does O'Donnell-Usen. Gorton's operates up to six production lines in its main plant and O'Donnell-Usen up to four. Both produce fish sticks, portions, and dinners. Some of the fresh fish processors also run kitchens for stick and portions, but on a smaller scale.

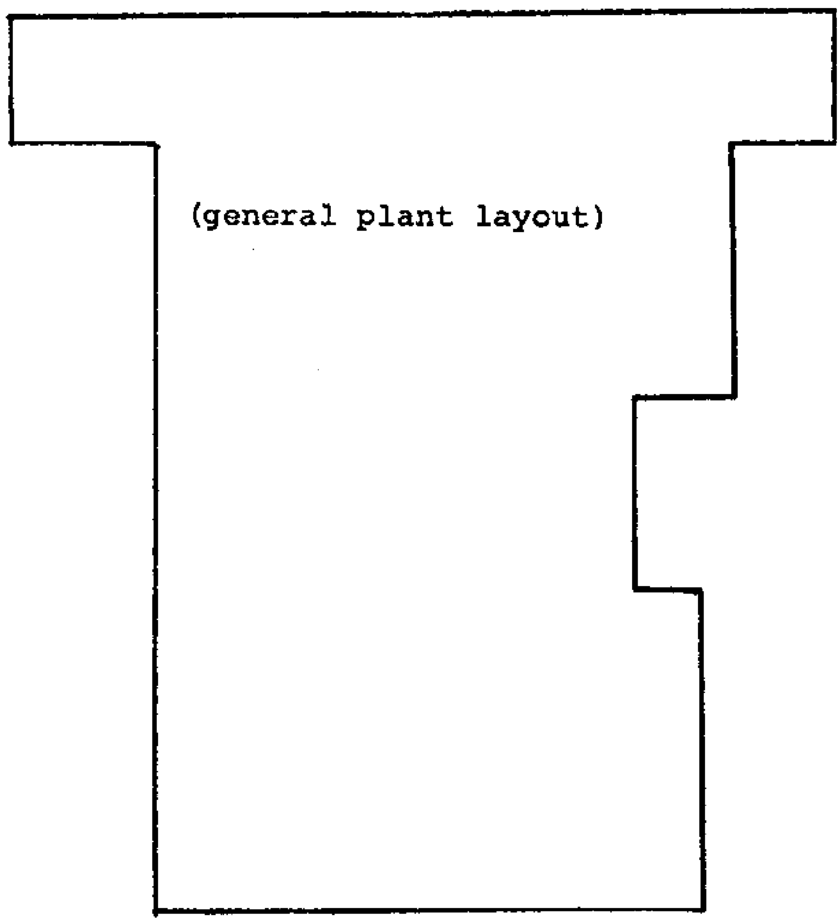
The bulk of the frozen fish imported to Gloucester passes right through. Imports at the third Quincy Freezer (Figure 6-15) deal in frozen blocks and fillets and distribute to the entire nation. Products leave Gloucester by truck and by rail.

Port Analysis

Each of the ports discussed has advantages and disadvantages in certain areas. Each must be isolated and discussed in order to understand the past and implications for the future.

Domestic Fishing

The absolute prerequisite for a fresh fishing port is its supply. In the past, sufficient supply has existed for each of the ports, but this supply has diminished. Boston is in deep trouble due to its depleted haddock stock. New Bedford has been sustained somewhat by yellowtail and scallops and Gloucester by ocean perch, but these supplies are also dwindling. Before any thought can be given to investment in fishing



Companies using this facility:

1. Acadia Fisheries Inc.
2. New England Fish Co.
3. Offshore Fisheries Inc.
4. Sea Pak
5. Fishery Products Inc.

QUINCY COLD STORAGE FROZEN IMPORT DEALERS (Gloucester)

Figure 6-15

vessels or port facilities, there must be some clear indication of a change in this trend.

As of now, New Bedford has the best facilities for handling and processing fresh fish. Its new South Terminal with expected highway link is a modern and well-equipped facility. Boston's Fish Pier continues to function quite effectively and has the potential to continue. The Gloucester facilities are smaller and more run down.

Each of the ports suffer from antiquated unloading techniques and poor vessel docking facilities. Gloucester has some problems with truck transportation in the city due to narrow streets and congestion. Each of the ports suffer somewhat from this problem; but each has excellent transportation facilities once outside the city.

The fishing fleets in each port are run down and aged. Effective operation in the future will depend on using new technology and larger scale operations to increase productivity. Recent efforts with large stern trawlers, however, have been limited by the shortage of fish, even when more capability exists to catch them.

To sum up, there is great need for investment in the New England fresh fishing ports, but this investment can only be justified if the supply takes an up-swing and becomes more abundant. Chapter VII attempts to analyze how international negotiations could affect this supply and subsequently investment opportunities.

Imports

When considering frozen imports it can be assumed that consumer demand will continue at least at present rates. What becomes critical is foreign supply. This supply is affected by two things:

1. The foreign nations' ability to catch fish
2. Competing foreign markets

The present investment in frozen fish imports is fairly large. Modern facilities exist for cold storage and processing at all three of the ports. Boston and New Bedford have excellent ports for handling refrigerated cargo vessels, but Gloucester gets all the import traffic. This must be credited to a preferred labor force and active soliciting for each vessel brought in. Boston and Gloucester enjoy slightly better locations for imports from Canada and Iceland.

New Bedford's imports come primarily to the Maritime-Frionor complex. Frionor enjoys a certain amount of security as they own their own foreign supply. Gorton's, A & P, Booth, O'Donnell-Usen, etc., do not have such security and have felt the pinch recently due to increased competition from foreign markets.

It would appear that present investment in frozen fish processing is due for some harder times even without any change in our foreign supplier's ability to catch fish. Current coastal negotiations could affect this balance in either direction, and this effect will be analyzed in Chapter VII.

CHAPTER VII

THE FUTURE AND CONCLUDING REMARKS

The early chapters of this report described the supply and methods of supply of fish to New England so that the existing facilities for handling and processing this fish might be better understood. Chapters IV through VI described these existing facilities, and this chapter will attempt to conclude by predicting future developments and their consequences in terms of port and processing facilities.

International Agreements

Fishery legislation passed at U. N. Law of the Sea Conferences could have a profound effect on both our domestic and import industries. In order to predict this effect, it is necessary to understand the background and issues of this conference as well as its probable outcome.

Table 7-1 lists the various boundaries and jurisdictions currently held by major coastal nations. Territorial sea is the narrow belt of water adjacent to the coastal state in which it is sovereign and can enforce its own laws and regulations. Until recently, territorial seas were fixed at 3 miles beyond which lay the high seas which are freely open to all nations. However, the blanket 3-mile limit posed problems and special consideration had to be made for straits and passages. Straits are extremely important to military and commercial interests alike. Those connecting the high seas, but less than six miles wide, are still considered international waterways. Straits requiring passage, but within or adjoining a territorial zone, usually allow the right of innocent passage.

More interesting than these standard rights are recent unilateral claims to broader territorial limits or resource limits. Countries desiring to protect seabeds and fisheries contiguous to their coasts chose to extend their jurisdiction. A large segment of most coastal fisheries include regions beyond the 3-mile limit. With more and more long distance fishing, multi-lateral agreements were no longer effective and unilateral claims resulted. Current fisheries claims are also indicated in Table 7-1 and North Atlantic fishing grounds in Figures 3-2 through 3-7.

Rapidly impending conflict led to the 1958 Law of the Sea Conference which did temporarily calm the storm, but did not provide an effective, lasting solution. More recent conferences have been unsuccessful at resolving these complex issues.

Future of the N. E. Domestic Fishing Industry

The future of the New England domestic fishing industry will be greatly affected by the outcome of international agreements (and unilateral actions by the U. S.). A 200-mile limit (combined with an effective resource management program) would obviously be a great aid to New England fishermen.

The early chapters of this report painted a bleak picture of New England domestic fishing. Due to rising owner's costs, fishing vessels are old and in bad shape. The fleet is rapidly

Table 7-1

Breadths of the Territorial Sea and
Exclusive Fisheries Claims in the Northern Atlantic

Limit/Country	Fishing Limits
Three Miles:	
Denmark	12 miles
East Germany	3 miles
West Germany	12 miles
Ireland	12 miles
Japan	3 miles
Netherlands	12 miles
United Kingdom	3 miles
United States	6 miles
Four Miles:	
Finland	4 miles
Iceland	50 miles
Norway	12 miles
Sweden	12 miles
Six Miles:	
Poland	12 miles
Spain	12 miles
Twelve Miles:	
Canada	12 miles
France	12 miles
Soviet Union	12 miles
Portugal	12 miles

Ref. 2

sinking. The scarcity of fish has kept larger and more efficient vessels from obtaining economies to scale thus threatening their success. At the rate ships are being scrapped or sunk, the fleets can't hand on for long. Fishermen and owners are rapidly becoming discouraged with the industry, and young blood is being turned away by bad experiences and the availability of good-paying, "comfortable" jobs ashore. It is not clear that the industry will be able to bounce back.

On the other hand, an abundant supply would allow the new stern trawlers to prove their capabilities and take advantage of economies to scale. Providing competent fishermen could be found to man these ships, new trawlers would find little competition from the present fleet. By 1980 the majority of the aged dragger fleet existing today will be gone. Fishing will be ripe for investment if sufficient labor, demand, and port and processing facilities can handle it.

The port of New Bedford seems to be gearing up for such an upsurge. Six new plants in South Terminal, the hurricane dike, new bulkheads for the major piers, and a new highway system will enable this city to take full advantage of any turns for the better. The city is fairly locked up in terms of future investment and is just lying in wait.

Gloucester and Boston are another story. Their fresh fish processing facilities are, for the most part, old and tired. The waterfront in Gloucester is in bad shape with piers crumbling and boats tied many abreast. These cities could well begin to gear up as New Bedford has done, but their caution is based on a conditioned skepticism which, for this industry, is not totally unwarranted.

Future of the N. E. Frozen Import Industry

Unlike our fresh fish industry, the frozen fish industry is totally dependent on foreign supply. For this reason it is necessary to analyze the resulting situation of each of our major import nations if a 200-mile resource limit were imposed. Norway and Iceland also stand to gain much from a 200-mile limit while Japan and the U. K. stand to lose much. (Figures 7-1 and 7-2)

Like the U. S., Canada stands to gain much from a 200-mile limit: exclusive rights to their rich shores along New Foundland, Labrador, and Nova Scotia, Browns Bank, and a portion of Georges Bank. The imports we could lose from Canada would be mainly those landed in St. Pierre and Michelon by other nations. The exact impact of future international agreements on the N. E. frozen import industry will depend on the amount of fish foreign vessels are allowed to catch and the economic feasibility of serving the U. S. market rather than foreign markets. It would appear that a 200-mile limit combined with a resource management program could result in a temporary set back for the N. E. frozen import industry.

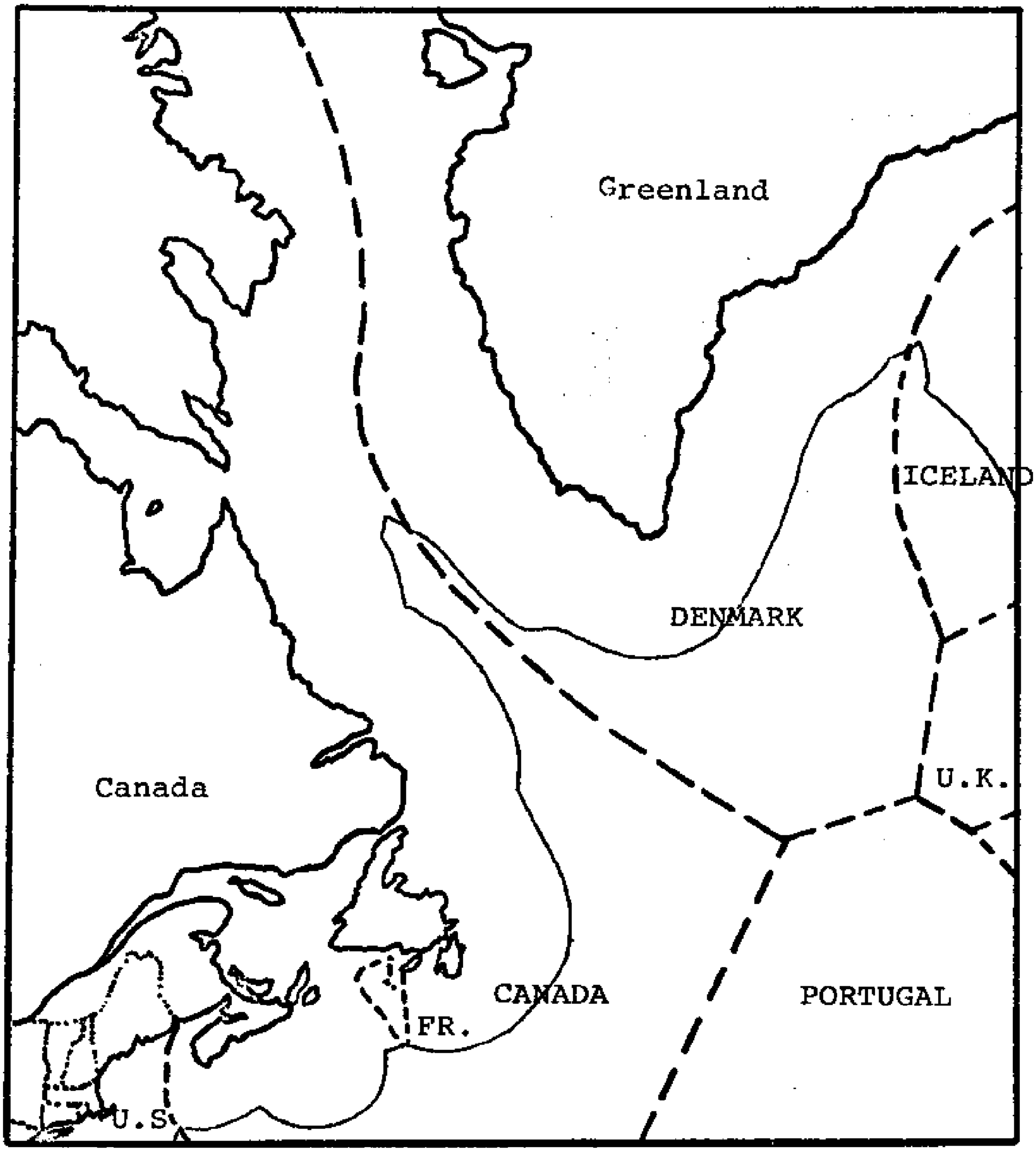
Conclusions

Part 3 has provided an overview of the New England domestic and imported fish processing and handling facilities. This overview has definite implications for New England fishermen and fishing co-operatives. An obvious conclusion is that international agreements (and possible unilateral actions by the U. S.) will have a great impact on both fishermen and co-operatives.

The processing and handling of fresh fish in New England is a declining competitive industry. It would serve no purpose for a New England co-operative to attempt to become a major processor of fresh fin fish. Since the processing of frozen fish is so different from fresh fish operations, fishing co-operatives have neither the capital resources, ability, or interest to enter this field.

Marketing co-operatives interested in the marketing of fresh fin fish directly to retail outlets in New England, must realize that they will face serious problems. Each co-operative handles a relatively small amount of product compared to the overall New England picture. In addition, the supply of this product is relatively unpredictable. Finally, any established market for fresh fish in New England is in danger of being flooded by over-the-road imports of fresh fish from Canada.

ref. 31

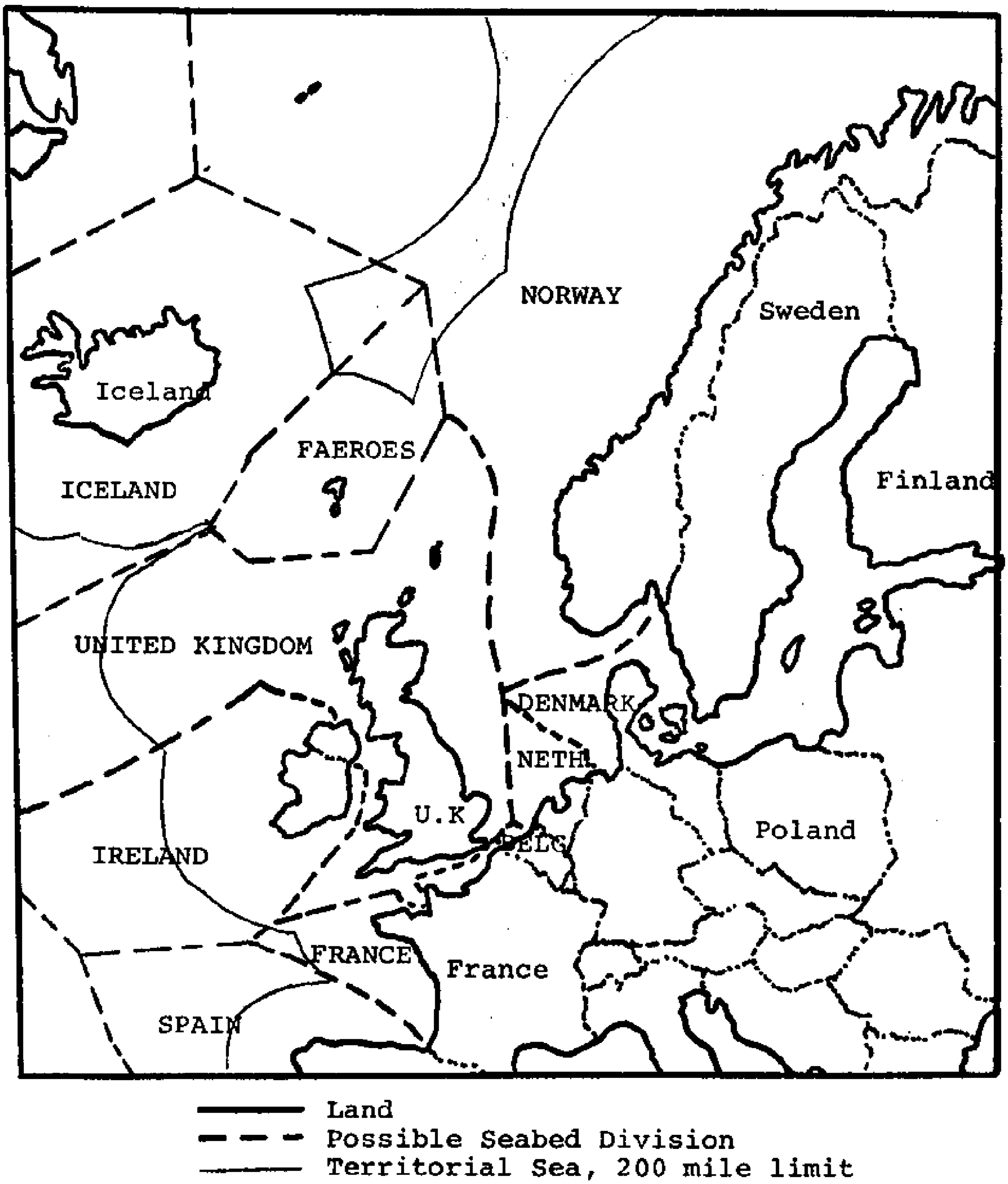


Land
Possible Seabed Division
Territorial Sea, 200 mile limit

200 Mile Limit in the Northwest Atlantic

Figure 7-1

ref. 31



200 Mile Limit in the Northeast Atlantic

Figure 7-2

REFERENCES

1. Food and Agricultural Organizations-U.N., "Yearbook of Fishery Statistics", Vol. 31, 1970.

2. Alexander, L.M., "Indices of National Interest in the Oceans", Ocean Development and International Law Journal, Vol. 1, No. 1, New York, 1973.

3. M.I.T., Offshore Oil Task Group, "The Georges Bank Petroleum Study," Vol. 1, 1973.

4. National Marine Fisheries Service, "Market News Annual Summaries-New England Area Fishery", Boston, various issues.

5. National Marine Fisheries SErvice, "Market News Monthly Summary: New England Fisheries", various issues.

6. National Marine Fisheries Service, "Daily Fishery Market News Report-New England", Boston, various issues.

7. National Marine Fisheries Service, "Fisheries of the U.S., 1971", NOAA NMFS CFS-5900, 1972.

8. Noetzel, B.G., "New England Trawlermen's Struggle for Survival", National Marine Fisheries Service, File No. 105, 1972.

9. Vondruska, J., National Marine Fisheries Service, "Conditions and Recent Changes in the New England Fishing Industry," File No. 115, 1972.

10. National Marine Fisheries Service, "Economics of the Boston Large Trawler Fleet", 1970.

11. National Marine Fisheries Service, "Processed Fishery Products, Annual Summary 1970", Washington, 1972.

12. National Marine Fisheries Service, Division of Economic Research, "Basic Economic Indicators-Atlantic Groundfish", 1969.

13. United States Tariff Commission, "Tariff Schedules of the U.S., Annotated, 1971", TC Publication 344.

14. Gaston, F.L., and Storey, D.A., "The Market for Fresh Fish that Originate from Boston Fish Pier Landings," Research Report, University of Massachusetts, 1965.

15. Salem State College, "Massachusetts Fisheries", Curriculum Source Unit for Elementary Teachers, 1970.

16. Organization for Economic Cooperation and Development, "Price Systems in the Fishing Industries", 1966.

17. New Bedford Institute of Technology, "A Technical Study of the Scallop and Flounder Industry of New Bedford, Massachusetts", 1963.

18. Idyll, C.P., The Sea Against Hunger, T.Y. Crowell Co., New York, 1970.

19. Christy, F.T., "The Common Wealth in Ocean Fisheries",

20. Bell, F.W., "The Economics of the New England Fishing Industry", Research Report to the Federal Reserve Bank of Boston, No. 31, 1966.

21. Food and Agricultural Organizations-U.N., Atlas of the Living Resources of the Sea, Rome. 1972.

22. Rothschild, B.J., World Fisheries Policy, University of Washington Press, Seattle, 1972.

23. Bell, F.W., "Recent Developments and Research in Fisheries Economics," Federal Reserve Bank of Boston, Oceana Publicastens, Inc., New York, 1967.

24. Bell, F.W., and Carlson, E.W., "The Haddock Disaster Program", National Marine Fisheries Service, File No. 89, 1971.

25. Nash, D.A., and Miller, M.M., "Insurance Coverage for U.S. Commercial Fishing Vessels", National Marine Fisheries Service, File No. 74, 1970.

26. Nash, D.A., "Insurance Coverage of U.S. Fishing Vessels", National Marine Fisheries Service, File No. 75, 1971.

27. Cleary, D.P., "Determinants of Actual and Subsidized Competitive Strengths and Weaknesses of U.S. and Canadian Groundfish Fisheries", National Marine Fisheries Service, File No. 67, 1970.

28. Vondruska, J., "Estimated Economic Impact on Fishermen Due to Eliminating the U.S. Import Duties on Fishing Equipment", National Marine Fisheries Service, File No. 98, 1972.

29. Vondruska, J., "Comparison of Government Assistance for U.S. and Foreign Fishermen, with Special Reference to New England and the ICNAF Convention Area", National Marine Fisheries Service, File No. 99, 1972.

30. Bell, F.W., "The Current Status of the U.S. Fisheries", National Marine Fisherdies Service, File No. 82, 1971.

31. Lloyd's Register of Shipping, "Register Book, 1972-1973".

32. Office of the Geographer, Department of State, "Map of Coastal State Jurisdiction Under Various Coastal Policies".

PART 4

A Systems Management Approach
to
Analyzing Distant Markets For New England Seafood: Emphasis on Exporting Fresh Sea Urchin Roe

CHAPTER I

Locating a Distant Market: A Survey in Hawaii[1]

Introduction

Part 4 of this study is devoted to analyzing opportunities for shipping New England seafood to distant markets. To look at the feasibility of any such ventures, both a specific market and a methodology for analysis are needed. Chapter I describes research performed in Hawaii to determine the desirability of air freighting fresh New England seafood there. While lobster is presently marketed in this way, this research was designed to see whether it was economically feasible for other fresh New England seafood also.

The rest of Part 4 presents a systems management methodology for analyzing the economic feasibility of distant markets. This methodology is applied to the potential venture of exporting fresh sea urchin roe to Japan. In this instance, both the Maine Department of Sea and Shore Fisheries and Japan Airlines felt that potential for such an undertaking existed; consequently, there was no need to perform a survey prior to the analysis.

Hawaiian Survey

The objective of this segment of the research was to survey the potential market for fresh New England fish in Hawaii. A

---

[1] All research in Hawaii was performed under the direction of Associate Dean Chuck Y. Gee, School of Travel Industry Management, University of Hawaii, with his students, Sherman Anderson, Amy O. M. Chan, Elaine Hurip, and Susan Runyan.

questionnaire was set up and sent to selected hotels, restaurants, clubs, and major institutions on Oahu. A cover letter to explain the objective of this survey accompanied the questionnaire.

The survey was divided into four major sections--Hotels, Restaurants, Institutions and Clubs. A total of 76 operations either received a questionnaire through mail or were asked the questions during an interview. Phone calls were also used to follow up and help explain this survey. Fifty-three per cent of the questionnaires were returned. However, not every operation actually answered all questions. Some operations do not have or have very limited food service facility; thus they did not answer the questions.

A random sampling was done on hotels and restaurants; all of the country and golf clubs and the large hospitals were surveyed. Caterers and military operations were also randomly included in the sample.

Table 1-1 shows the fresh New England seafood products included in the survey and the price per pound of the processed product delivered in Hawaii. Price includes filleting, packaging, handling, air freight, insurance, pick-up and delivery, administrative cost, and profit. The prices were purposely chosen to be higher than necessary to allow ample room for profit and to permit later negotiations for quantity discounts.

Composite Survey Data

It is readily apparent from Table 1-2 that the most popular seafood items on Oahu are mahimahi, shrimp, lobster, crab, CIF Honolulu

Product	Cost Per Pound (Processed)
Cod	$3.00
Flounder (Sole)	5.00
Large Haddock	3.50
Small Haddock (Scrod)	3.00
Sea Urchin Roe	5.50
Ocean Perch	3.00
Sea Scallops	3.50

Note: The cost per pound of processed product is the price delivered in Hawaii. The processed seafood is packed in 20-1/2" x 15-7/8" x 14" insulated containers (Tech-Pak Type TP-1), with an average of 70 lbs. of product per container. Each container also includes 4 three-pound bags of cooling agent. (Each container costs $3; each bag of coolant, $0.35.) The commodity 300 rate for fresh fish (Boston to Honolulu) of $72.45 per 100 lbs. is used.

Table 1-1

Fresh Processed New England Seafood Used in Hawaiian Survey

SEAFOOD	# of Users	% of Users	Average Price	Price Range
Mahi-Mahi	27	79	83¢	54¢ - $2.00
Butterfish	8	24	97¢	75¢ - $1.40
Octopus	7	21	$1.30	70¢ - $1.75
Lobster	21	62	$5.19	$2.63 - $6.25
Red Snapper	8	24	$1.36	90¢ - $2.75
Halibut	5	15	$1.81	$1.60 - $2.35
Shrimp	26	76	$2.99	$1.64 - $4.10
Scallop	19	56	$2.39	$1.36 - $2.95
Turtle	2	6	$1.88	$1.75 - $2.00
Crab	20	59	$4.80	$1.15 - $6.55
Haddock	2	6	$1.00	90¢ - $1.10
Sardines	4	12	$1.64	20¢ - $2.64
Pompino	2	6	65¢	65¢
Abalone	8	24	$4.86	$1.98 - $5.75
Clams	14	41	76¢	55¢ - $1.35
Tuna	10	29	$1.12	37¢ - $1.75
Oyster	13	38	$1.79	$1.00 - $2.57
Salmon	17	50	$2.35	98¢ - $4.25
Sole	1	3	$2.25	$2.25
Swordfish	1	3	$1.75	$1.75
Cod	2	6	89¢	89¢
Flounder	1	3	81¢	81¢
Perch	1	3	68¢	68¢
Turbot	1	3	70¢	70¢

Table 1-2

Composite Survey Results on Use of Fish in Oahu scallops and salmon. The above are listed in order of popularity and all are used by at least 50% of the operations surveyed. No specifications were given; thus some of the range in price is due to the different forms at which the seafood are purchased. Only the average price of lobster, crab and abalone exceeds $3.00 per pound.

Figure 1-1 deals with the seafood most frequently used by each institution. Again mahimahi tops the list with shrimp following closely. Crab and lobster enjoy moderate usage. From Figure 1-2 it can be seen that there's a wide distribution in monthly allocation for seafood. In general, the greater the allocation, the greater the interest shown.

On Oahu, it appears that seafood is mostly purchased in frozen form, with special interest in fillets, as illustrated in Table 1-3. All operations buy through wholesalers, though some purchase direct and one operation deals with retailers (See Table 1-4). Local varieties of seafood are utilized by all but a few operations. Foreign and mainland seafood enjoy equal usage (See Figure 1-3).

Fifty per cent of those responding were disinterested mainly because the prices quoted are too high. A few mentioned that the seafood listed are unfamiliar in Hawaii. The remaining 50% showed interest in purchasing fresh seafood from New England (See Figure 1-4). Some of those who expressed an interest also felt that the items are too expensive. They also expressed a desire for more information and possibly a larger selection.

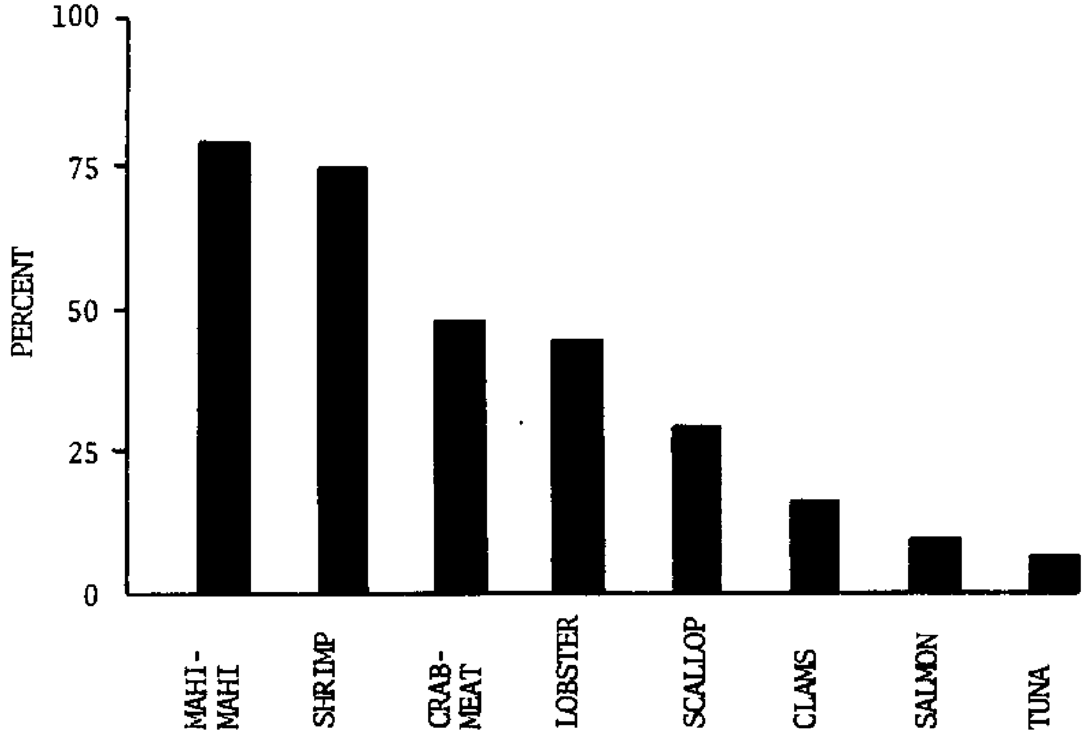


FIGURE 1-1

SEAFOOD MOST FREQUENTLY USED (COMPOSITE)

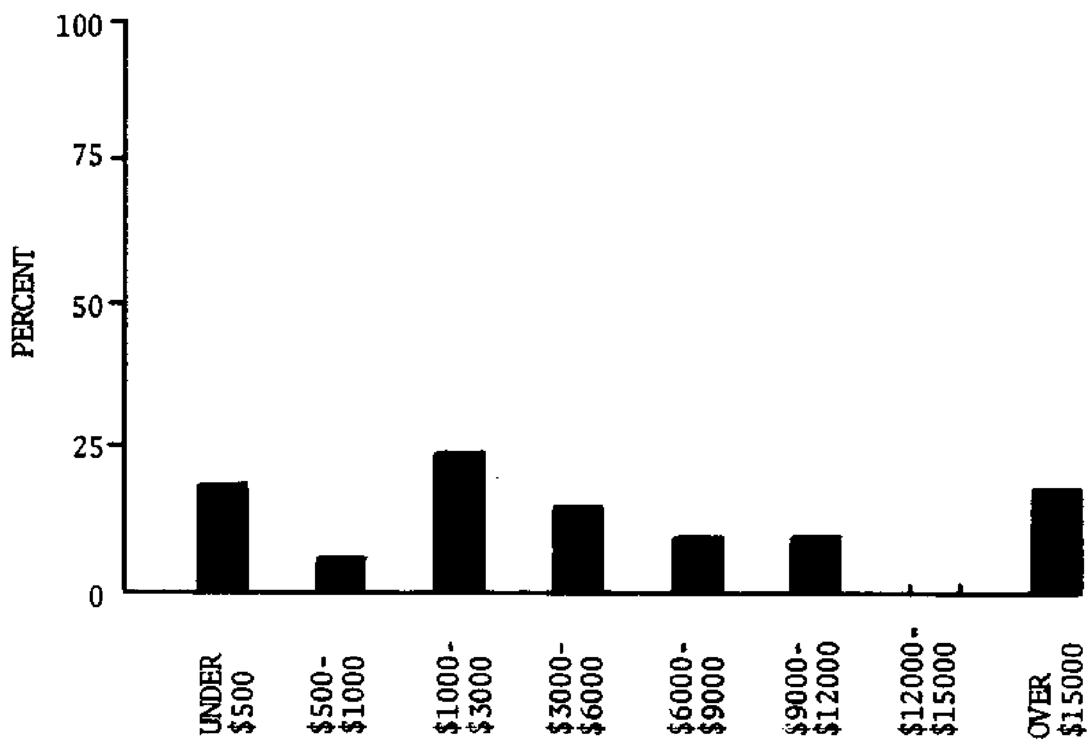


FIGURE 1-2

APPROXIMATE MONTHLY ALLOCATION FOR SEAFOOD (COMPOSITE)

FORMS	LIVE	FROZEN	FRESH	CANNED/SMOKED
dressed	--	41%	26%	9%
fillets	--	68%	24%	3%
whole	18%	44%	26%	12%
steaks	--	41%	9%	3%
drawn	--	29%	12%	3%
sticks	--	38%	6%	3%
chunks	--	18%	3%	24%

Table 1-3

Forms in Which Seafood are Purchased (Composite)

Wholesale Only	76%
Wholesale & Direct	21%
Wholesale & Retail	3%
Retail Only	0%

Table 1-4

Types of Suppliers (Composite)

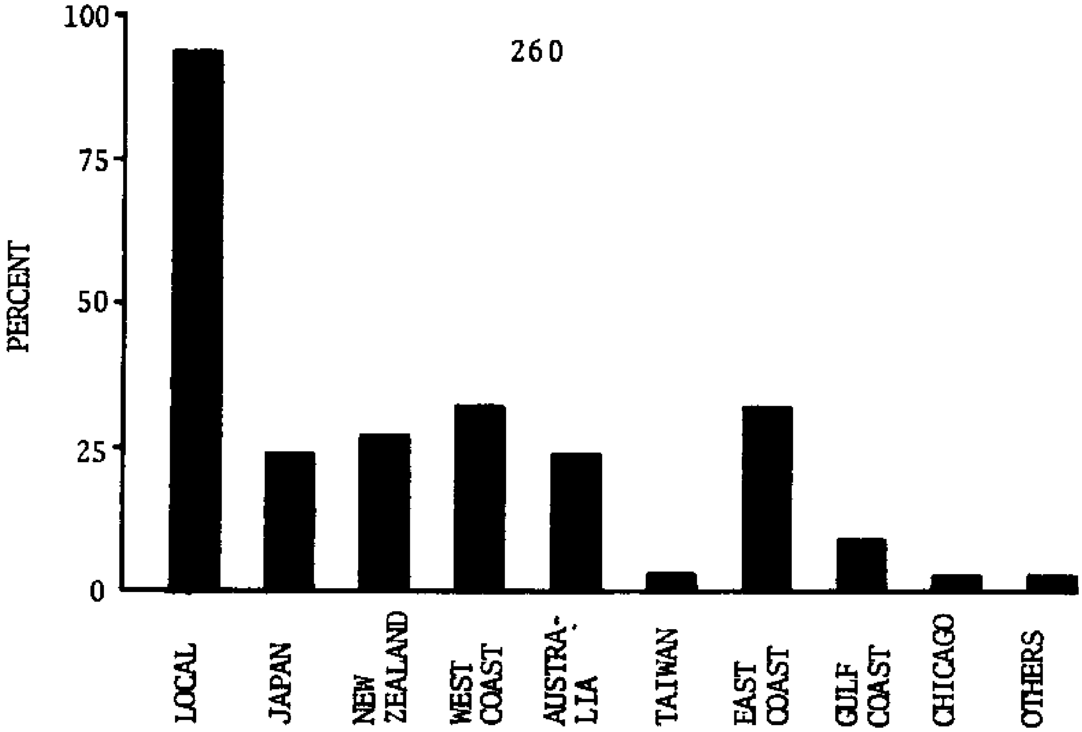


FIGURE 1-3

AREAS OF PURCHASE (COMPOSITE)

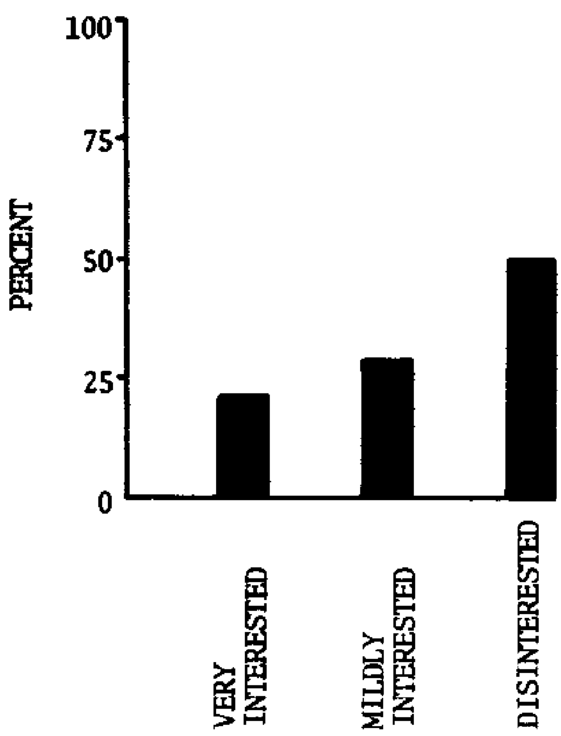


FIGURE 1-4

INTEREST IN PURCHASING SEAFOOD FROM NEW ENGLAND (COMPOSITE)

Table 1-5 shows the frequency of the potential purchase while Figure 1-5 shows the items which they may purchase. Table 1-5 and Figure 1-5 only include those who responded to these questions. For Table 1-5, 28 responded and for Figure 1-5, only 15 responded.

To understand better this composite data, each market segment is now studied independently.

Hotels

A list of hotels from the Hawaii Hotel Guide 1973 and an official membership roster as of December 1973 published by the Hawaii Hotel Association were obtained. Of the 271 hotels in Hawaii, 139 are located on the island of Oahu, 52 in Maui, 43 in Hawaii, 34 in Kauai, 2 in Molokai and 1 in Lanai. This survey is based on a random sampling of major hotels in Oahu. They are selected according to the sizes of their operation.

In order to make this survey more comprehensive, interviews with the purchasing managers, executive chefs, and food and beverage controllers of the hotels were obtained. The results are shown in Table 1-6 and Figures 1-6 and 1-7 based on a 65% return of the survey sent out.

Hawaii has an easy access to seafood due to its location and environment. Mahimahi is the most popular fish and can be caught alive. Its cost per pound is not expensive, varying from \$0.55 - \$2.00. Consequently, it is listed on almost every menu. Shrimp and crabmeat are the runners-up on the popularity list.

Sardine, salmon and halibut are bought from the East Coast and West Coast wholesalers. There is no local supply. Only 8-16%

DAILY	7%
WEEKLY	39%
BI-WEEKLY	41%
MONTHLY	10%
OTHER	3%

TABLE 1-5

FREQUENCY OF POTENTIAL PURCHASE (COMPOSITE)

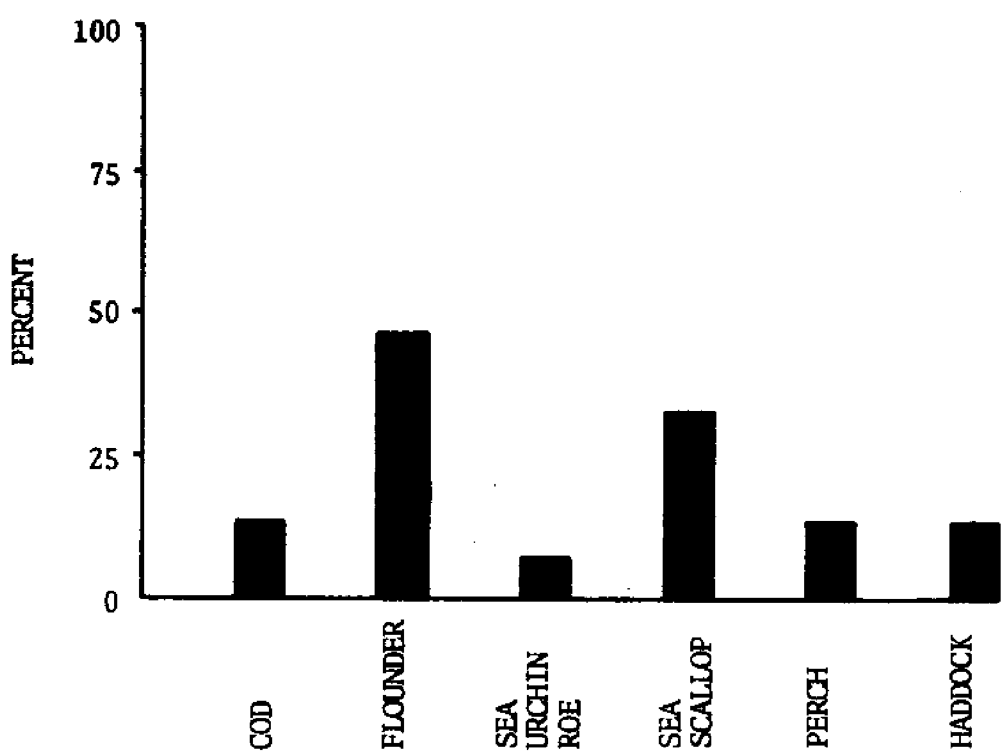


FIGURE 1-5

TYPES OF SEAFOOD DESIRED FROM NEW ENGLAND (COMPOSITE)

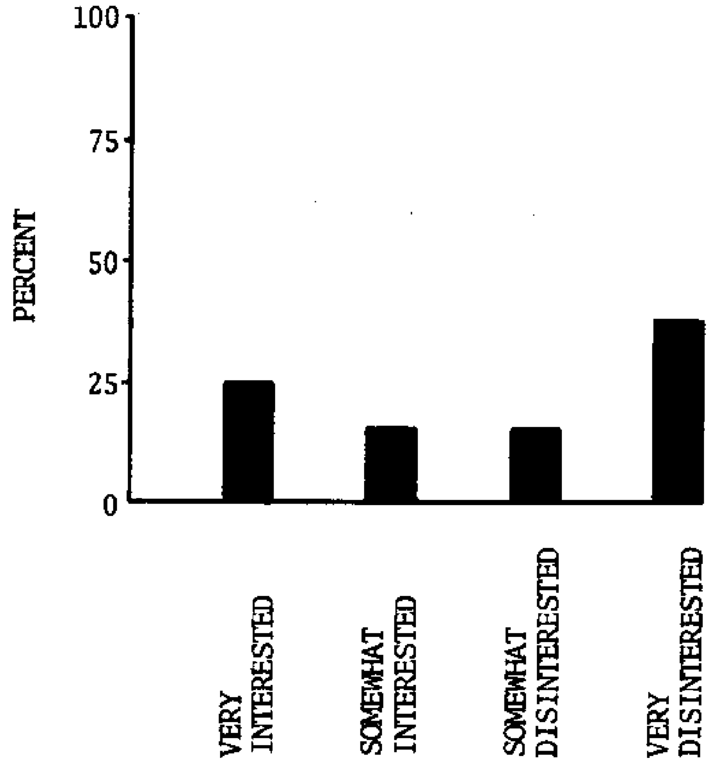


FIGURE 1-6

INTEREST IN PURCHASING FRESH SEAFOOD FROM NEW ENGLAND BY HOTELS

DAILY	15%
WEEKLY	30%
BI-WEEKLY	50%
MONTHLY	0%
OTHER	5%

TABLE 1-6

FREQUENCY OF POTENTIAL PURCHASE BY HOTELS

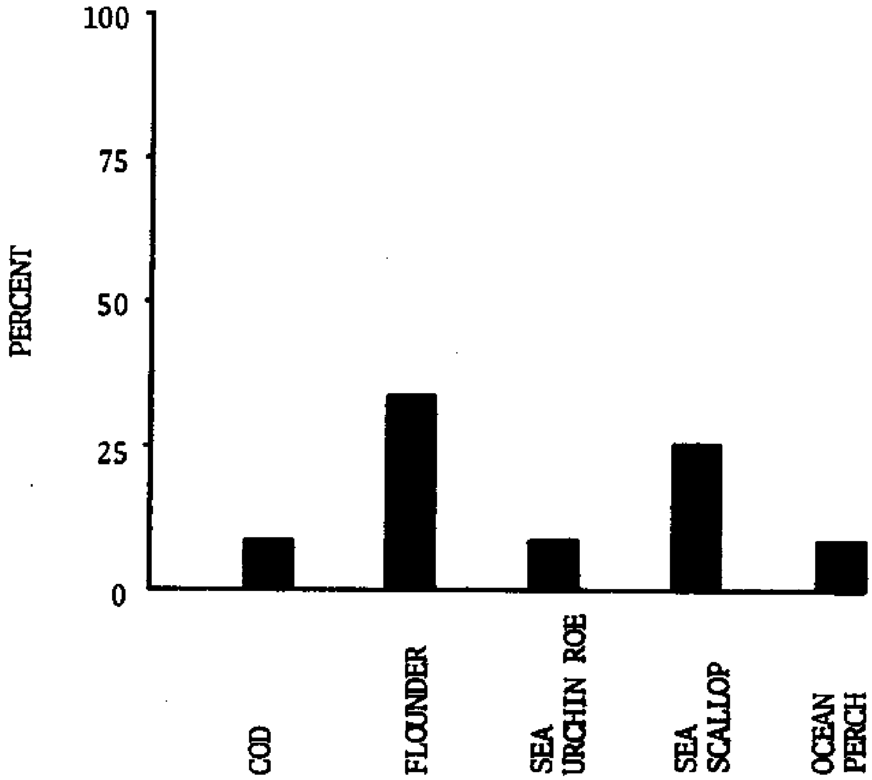


FIGURE 1-7

TYPES OF SEAFOOD DESIRED FROM NEW ENGLAND BY HOTELS IN SURVEY of the hotels surveyed have them on the menu. Shrimp, lobster, crabmeat, butterfish, clam, scallop and mahimahi are purchased on a bi-weekly basis by large institutions and also by weekly delivery in some to maintain freshness.

The seafood are purchased mostly in frozen form rather than fresh. Canned or smoked are nil among the surveys.

One hundred per cent of the returned surveys listed the source of purchase of seafood is from wholesalers of which 84% are local wholesalers. Forty-three per cent of the hotels surveyed have over $15,000 for their approximate monthly allocation for purchase of seafood, and 25% are in the $9,000-$12,000 range.

Many hotels felt that the New England prices are too high, and therefore would not purchase from there. Their degree of interest in this project is shown by Figure 1-6 with frequency of potential purchases represented in Table 1-6. Figure 1-7 shows the types of New England seafood that they would be interested in, particularly if the prices are reduced. In the surveys, those that marked that they are somewhat interested in buying fresh seafood direct from New England also said that they are interested in the weekly delivery of cod, flounder, sea urchin roe, sea scallop and ocean perch.

There is definitely a potential market for the New England seafood. Large scale hotel operations are very interested in pursuing this topic further.

<u>Restaurants</u>

Eighteen questionnaires with cover letters attached explaining the study being conducted were mailed. To ensure a greater number of returns, the restaurants were telephoned first and the names of the managers were obtained. Often discussions were held with the manager himself. Despite these efforts, only 44% return of questionnaires was achieved. Part of the reason for such a low return rate was the time of year the study was being conducted. Questionnaires were mailed just after Thanksgiving when the restaurants were caught up in the holidays. Another reason was the high prices quoted. Despite the seafood being delivered to Hawaii in a processed form via air from the East Coast, many restaurant people dealt with still considered the prices prohibitive.

Eight restaurants, most in the Honolulu area, returned the questionnaires from which Figure 1-8 and Table 1-7 are created. These eight restaurants consisted of the following types: American-2, Seafood-1, Thai-1, Chinese-1, Continental-1, Catering-type-1, restaurant chain-1.

As viewed by restaurants, the most popular seafoods are: lobster, shrimp, crab, scallops and clams. Salmon and oysters are also popular items. Lobster and shrimp are the most frequently used seafood items, followed closely by crab, mahimahi, clams and scallops.

Most questionnaires returned indicated a monthly seafood allocation of under $3,000. One rather large exception to this is the restaurant chain. This chain has a total of 35 restaurants within its scope of operations. There are many different types of restaurants within the chain; however, all purchasing is done from one central office. This office annually accounts for over $200,000 worth of food purchases.

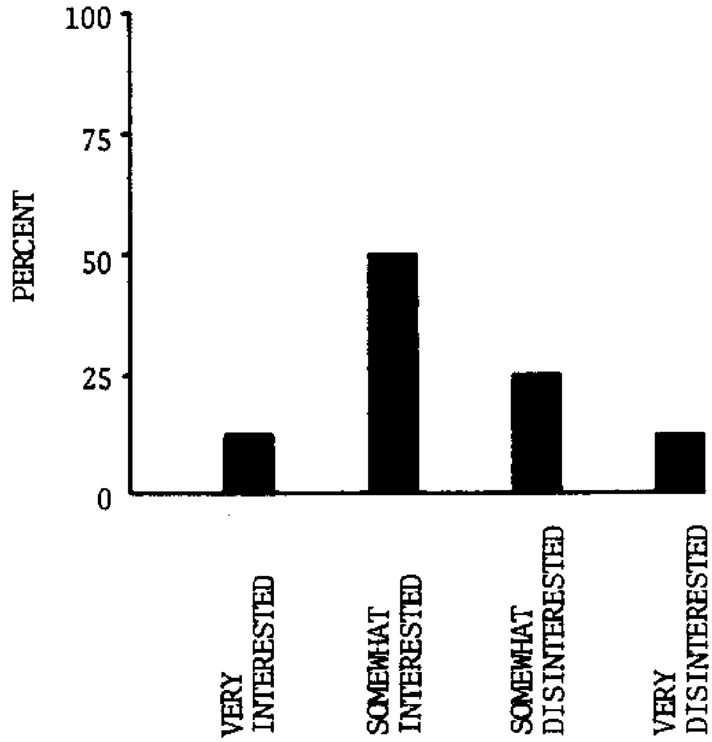


FIGURE 1-8

INTEREST IN PURCHASING FRESH SEAFOOD FROM NEW ENGLAND (RESTAURANTS)

DAILY	0%
WEEKLY	63%
BI-WEEKLY	0%
MONTHLY	25%
OTHER	12%

TABLE 1-7

FREQUENCY OF POTENTIAL PURCHASE (RESTAURANTS)

All restaurants use frozen seafood. While only two restaurants purchase live seafood most restaurants surveyed indicated they would prefer to purchase live seafood if they had proper facilities. Almost all use fresh seafood, supplied primarily by local purveyors. The seafoods in the canned/smoked classification are usually items such as sardines and oysters.

Three out of every four restaurants surveyed reported they bought from wholesale sources only. Lower prices undoubtedly figure in here, but there is another consideration also. Generally a wholesaler will be a steady supplier whereas buying direct can sometimes be a hit or miss affair.

In determining the area of purchase it is hardly surprising to find that every one of those surveyed restaurants "buy local". New Zealand, the West Coast and Australia are also important areas of purchase because of their proximity to Hawaii.

Over half of the restaurants surveyed indicated some interest in purchasing fresh New England seafood as indicated in Figure 1-8, with the majority stating they would buy on a weekly basis (Table 1-7). It would appear that quantity discounts from the prices used in the questionnaire could produce a ready market for fresh New England seafood in Hawaiian restaurants.

Institutions

The types of food service operations that are included in institutions are hospitals, caterers, air line caterers, college cafeterias, and military dining halls and clubs. Twenty-one institutions were either mailed a questionnaire or asked the questions during an interview. Ten institutions responded, but one of these did not serve food so the total answering the questionnaire was nine out of twenty, or a 45% response.

Institutions use quite a variety of seafoods. Mahi-mahi and shrimp are used most frequently. In addition, mahi-mahi, shrimp, and salmon enjoy a high degree of universality. Others are used by only a few institutions. The price ranges are quite large in some cases. It must be understood that specifications on the seafood were not given here and that the prices would vary due to the variety of forms and qualities used. For some items, such as shrimp, several institutions listed more than one price.

Those institutions with a monthly allocation for seafood under $1,000 used less variety of seafoods and were very disinterested in purchasing seafoods direct from New England. Those institutions with higher monthly allocations showed varied responses. Institutions on a very tight budget, namely a college cafeteria and a hospital, expressed no interest. The others in these higher ranges did express some interest.

Frozen forms are the most popular with the frozen fillets being used by the greatest number of institutions. The fresh and canned/smoked forms enjoy equal popularity though considerably less than the frozen. Only one institution uses live seafood. They purchase live lobsters.

One of the caterers uses a retailer. One institution deals direct with the West Coast and another buys live lobsters direct from the East Coast. Wholesalers supply all operations and are the only source of supply for the majority of the institutions.

It can be seen that the market dealt with is an international one. The local varieties are the most popular and are used by all of the institutions responding. Seafoods from other areas of the United States are used by 78% of the institutions and 55% of the institutions also receive seafood from foreign areas. One person interviewed mentioned that he used seafood from foreign areas mainly when mainland sources were blocked. The example he gave was the shipping problems during the West Coast longshoremen's strikes.

Those who were strongly disinterested gave several reasons. The main one was that the prices are too high, that the prices looked more like retail than wholesale in nature. Another factor was that some of the institutions are part of national companies and that these companies contract nationally for many items. This was true in three cases. Two also mentioned that most of the items listed are unfamiliar in Hawaii and would probably not enjoy the popularity of more familiar local items. Most of those responding with some degree of interest still felt that prices were too high. The one who was very interested also deals with retailers and so prices may have less effect on his decisions. This institution was interested in the cod, flounder, large haddock, and sea scallops with weekly delivery.

Figure 1-9 presents the degree of interest shown by institutions in fresh New England seafood. Table 1-8 shows the frequency of purchase desired by those who were interested. Two wanted bi-weekly delivery, one weekly delivery, and one monthly delivery (was somewhat disinterested).

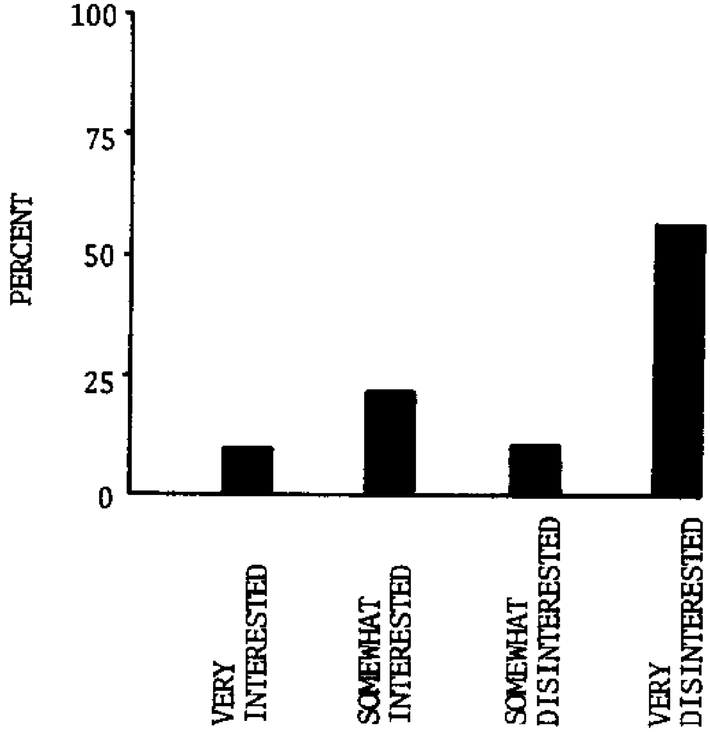


FIGURE 1-9

INTEREST IN PURCHASING FRESH SEAFOOD FROM NEW ENGLAND (INSTITUTIONS)

DAILY	0%
WEEKLY	25%
BI-WEEKLY	50%
MONTHLY	25%
OTHER	0%

TABLE 1-8

FREQUENCY OF POTENTIAL PURCHASE (INSTITUTIONS)

For institutions, interest depends on a number of factors. First was that only those spending more than $1,000 a month on seafood were interested. Second, is the type of institution. Hospitals and college cafeterias were on much tighter budgets and would not even consider the items at the listed prices. Those institutions that have more ability to pass the price on to the customer showed more interest. This would include caterers, military clubs, and to a degree air line caterers. Third, is the actual listed price. Most realize that fresh products would be more expensive than other forms, but the difference between the prices listed and the average prices paid now are too great. Fresh New England seafood is 1.7 to 6.2 times more expensive than the form of the same seafood item being purchased now. In summary, at present quoted prices most institutions feel it is too expensive.

Golf and Country Clubs

Since there are only 17 Golf Clubs and Country Clubs on Oahu, the questionnaire was sent to all the clubs. Only 59% replies were received, out of which 29% do not have any kind of food service facility on their premises.

An interview was also conducted to obtain more information on seafood purchasing in clubs. From this interview it was found that most clubs buy seafood on an Open-Bid basis so as to induce the competitiveness of suppliers. Seafood are purchased from the purveyor with the lowest price quotation. On club menus, seafood are usually featured as the daily special and the nightly special. Great fluctuations in seafood prices take place. This is partially due to the seasonality of seafood as well as the different forms of seafood available for purchase. For example, frozen mahi-mahi can be bought at 65¢ - 85¢ per pound, whereas fresh mahi-mahi costs at least $1.65 per pound. Therefore, some clubs were not able to quote the approximate price per pound for the seafood they purchased.

It appears that clubs use a great variety of seafood. Almost all the clubs use mahi-mahi, lobster, shrimp, crab, abalone, tuna, oysters and salmon. Mahi-mahi, being a local specialty, enjoys great popularity; and so does shrimp. Crab is another popular seafood item.

The majority of the clubs allocate between $1,000 - $9,000 a month for seafood. None of them operates over the $9,000 budget, though some operate below $500 a month.

Seafood are most commonly purchased in the frozen form. However, many of the clubs do purchase fresh-whole seafood. The types of suppliers that clubs deal with are mainly wholesalers and direct sources. None of them is totally dependent on retailers or direct sources.

All clubs on Oahu utilize local varieties of seafood. The area with the second highest percentage of purchase is the east coast, followed by Australia. West coast and New Zealand are the only other areas from which seafood are purchased for club usage.

In Figure 1-10, we can see that 80% of the replies expressed some degree of interest in purchasing fresh seafood from New England. The frequency of such a potential purchase is shown in Table 1-9.

Of the 40% replies that specify the type of seafood which

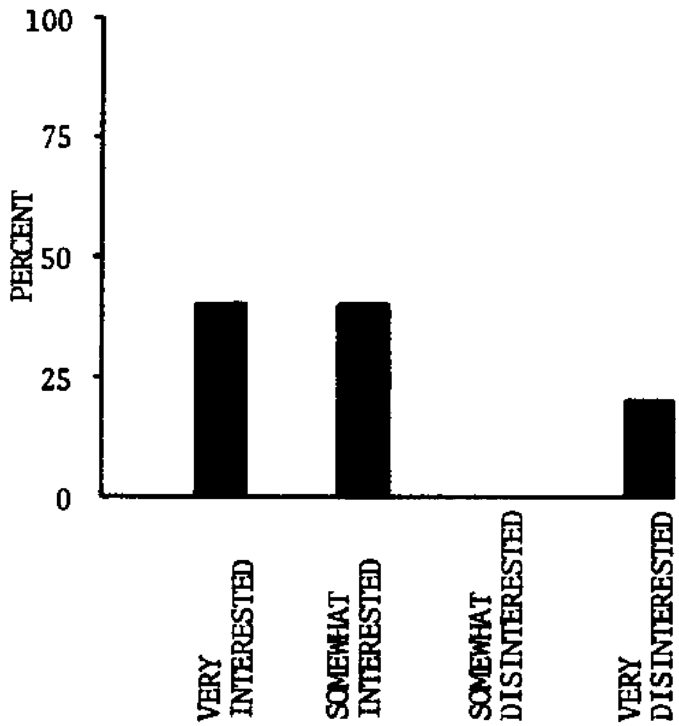


FIGURE 1-10

INTEREST IN PURCHASING FRESH SEAFOOD FROM NEW ENGLAND (CLUBS)

FREQUENCY	PERCENTAGE
DAILY	---
WEEKLY	25%
BI-WEEKLY	50%
MONTHLY	50%
OTHERS	---

NOTE: ONLY 80% OF THE REPLIES ANSWERED THIS QUESITON.

TABLE 1-9

FREQUENCY OF POTENTIAL PURCHASE (CLUBS)

they are interested in, flounder enjoys the greatest popularity. The other items of interest are also shown in Figure 1-11.

Among the comments received, many clubs felt that the prices quoted for fresh New England seafood are too high.

Conclusions

The fact that this survey was done during the holiday season affected the number of responses received. While caution must be used in interpreting specific graphs because of the small number of responses, definite conclusions can be drawn from the survey.

After comparing the data, the consensus is that the prices are too high. Even those who expressed interest would expect the prices to be adjusted for bulk purchase. If the prices were set at a lower level, it would appear that there would be an ample market in Hawaii for fresh New England seafood.

Judging from the data on frequency of delivery desired, two to three deliveries a week would be sufficient to satisfy the majority of buyers. More information should be supplied to prospective buyers before trying to set up a seafood market in Hawaii.

Further Research

Given that prices used in the survey were purposely higher than necessary, the authors are encouraged by the results of the survey. The authors strongly feel that the issue of airfreighting fresh New England seafood to Hawaii deserves further research. Part of such research would consist of a detailed systems management approach as described in the following chapters of Part 4.

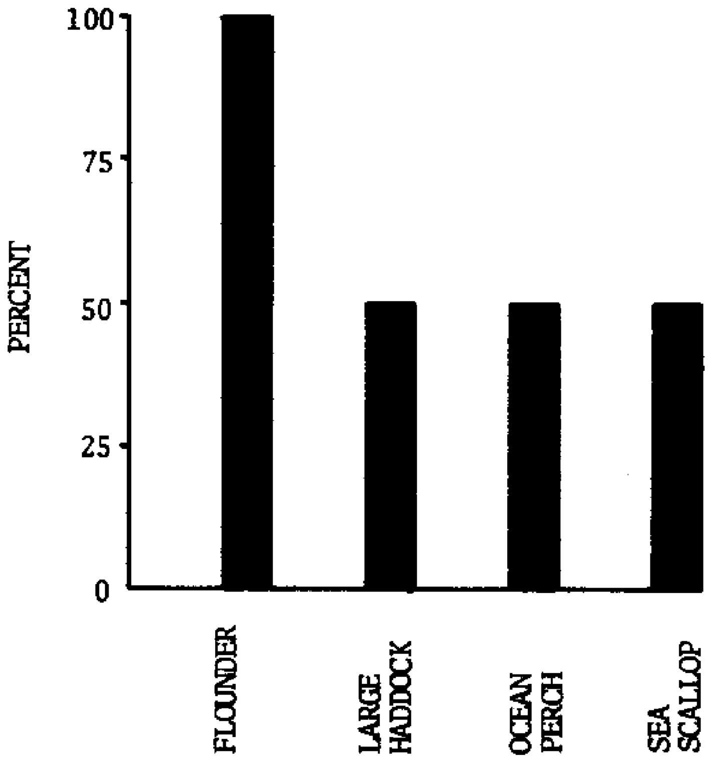


FIGURE 1-11

TYPES OF SEAFOOD OF INTEREST TO POTENTIAL BUYERS (CLUBS)

CHAPTER II

INTRODUCTION TO MANAGEMENT SYSTEMS ANALYSIS

The remaining chapters of Part 4 test the validity of the following hypothesis:

The harvesting and processing of sea urchin roe for export is an economically feasible venture for certain fisheries industries in New England.

This hypothesis is tested through utilization of an innovative managerial decision tool that has been given the acronym of SMART for Systems Management Analysis and Review Technique. The hypothesis serves as the vehicle for developing this new decision tool.

Scope and Limitations

It is not possible to test the hypothesis directly. Parameters cannot be varied under controlled conditions to determine the effect alternative patterns of action and reaction would have on overall system performance. Comparative analyses of similar systems in geographically, functionally, or temporally separated areas are also not possible. Therefore, the systems approach is used to model the various subsystems, and tests are conducted on the models to provide information with which sub-hypotheses can be tested and conclusions drawn. For the purposes of describing this analysis, the specific example of exporting sea urchin roe from Maine to Japan is used.

This presentation and the analyses concentrate on the physical operation and the behavioral, social, economic, and legal influences which occur in the state of Maine. Further, various transportation networks between Maine and Japan are considered and evaluated. Due to lack of sufficient information of the Japanese market and behavior, this aspect is considered superficially. This factor has also necessitated that the scope be limited almost solely to costs. Since very little can be predicted about the potential revenues that should be generated by this venture without actually shipping processed sea urchin roe to Japan for an extended period of time, calculations of expected or potential profits is quite impractical. Therefore, a cost distribution is calculated which states that, given all the factors considered in the SMART model and their interrelationships, the probability of achieving a certain total cost is such and such, with mean so and so. Using the going price of sea urchin roe on the Tokyo market as a bench mark, the distribution of these prices, weighted with some correction factor, can be compared against the cost distribution. From this comparison, the economic feasibility and potential profitability of the venture can be evaluated.

The scope of this report has also been limited to the consideration of existing technologies. A breakthrough on frozen sea urchin roe would have a very definite effect on the feasibility of this venture. The eventual perfection of SST cargo transport would have a similar effect. Yet both have been assumed away for the planning horizon used in this paper.

Lastly, this report is limited somewhat by the lack of quantifiable data and statistics. Since sea urchin roe has never been exported from New England, the actual methods that might be used eventually are largely a matter of conjectural hypothesis and qualitative information, (i.e. guess work). This does not mean that the resultant models are inherently inaccurate. To the contrary they are probably quite accurate. What it does mean, however, is that the accuracy and reliability of the models and the information used in the models cannot be tested. Be that as it may, the models do provide a good "first cut" at evaluating market feasibility and at determining the sensitivity of costs to each of the influencing parameters.

Definitions

Aphasia. "the loss or impairment of the power to use words as symbols of ideas that results from a brain lesion."[1]

Blastula. "an early metazoan embryo typically having the form of a hollow fluid-filled rounded cavity bounded by a single layer of cells..."[2]

---

[1] "Aphasia," Webster's Third New International Dictionary, unabridged, 1968.

[2] "Blastula," Webster's Third New International Dictionary, op. cit.

<u>Calcareous.</u> "1a: like calcite or calcium carbonate esp. in hardness..."[3]

<u>Coelom.</u> "the body cavity or perivisceral cavity of metazoans..."[4]

<u>Decision.</u> An irrevocable commitment to the allocation of a scarce resource.[5]

<u>Dichotomy.</u> "1a: division into two parts, classes, or groups esp. into two groups mutually exclusive or opposed by contradition..."[6]

<u>Echinoid.</u> "SEA URCHIN"[7]

<u>Environment.</u> "2: the surrounding conditions, influences, or forces that influence or modify: as a: the whole complex of climatic, edaphic, and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival - compare HABITAT b: the aggregate of social and cultural conditions (as customs, laws, language, religion, and economic and political organization) that influence the life of an individual or community"[8]

---

[3] "Calcareous," <u>Webster</u>, op. cit.

[4] "Coelom," <u>Webster</u>, op. cit.

[5] Ref. 31

[6] "Dichotomy" <u>Webster</u>, op. cit.

[7] "Echinoid," <u>Webster</u>, op. cit.

[8] "Environment," <u>Webster</u>, op. cit.

Epicyclitus. The continual modification of a poor model to conform to a certain system, as opposed to designing a new and better model to replace the original one.

Epithelium. "1: a cellular animal tissue that covers a free surface or lines a tube or cavity, that consists of one or more layers of cells forming a sheet practically unbroken by intercellular substance..."[9]

Feedback. "1: the return to the input of a part of the output of a machine, system, or process..."[10]

GERT. Acronym for Graphical Evaluation and Review Technique.[11]

Goals. An objective expressed in terms of one or more specific dimensions.[12]

Hierarchy. "5a: the arrangement of objects, elements, or values in a graduated series..."[13]

Homeostasis. "3: a tendency toward maintenance of relatively stable social conditions among groups with respect to various factors..."[14]

---

[9] "Epithelium," Webster, op. cit.

[10] "Feedback," Webster, op. cit.

[11] Ref. 44

[12] Ref. 31

[13] "Hierarchy," Webster, op. cit.

[14] "Homeostasis," Webster, op. cit.

Homeostatic. "related to or characterized by homeostasis"[15]

Interface. "1: a plane or other surface forming a common boundary of two bodies or spaces..."[16]

Madreporite. "a perforated or porous body that is situated at the distal end of the stone canal in echinoderms..."[17]

Management. "...the fundamental integrating and operating mechanism underlying organized effort. Management is defined for conceptual, theoretical, and analytical purposes as that process by which managers create, direct, maintain, and operate purposive organization through systematic, coordinated, cooperative human effort."[18]

Model. An abstract representation of a system.[19]

Oligopoly. "a market situation in which each of a limited number of producers is strong enough to influence the market but not strong enough to disregard the reaction of his competitors..."[20]

Objective. A specific commitment to a desired future situation attained through an organization of certain states or conditions.[21]

---

15 "Homeostatic," Webster, op. cit.

16 "Interface," Webster, op. cit.

17 "Madreporite," Webster, op. cit.

18 Ref. 36, pp.4-5

19 Ref. 31

20 "Oligopoly," Webster, op. cit.

21 Ref. 31

Periproct. "the well-defined area surrounding the anus of various invertebrates (as a sea urchin)..."[22]

Peristome. "2: the region around the mouth in various invertebrates..."[23]

PERT. An acronym for Program Evaluation and Review Technique.[24]

Pluteus. "2...: the free-swimming bilaterally symmetrical larva of a sea urchin..."[25]

Policy. A contingent decision as to what will be done if and when a decision opportunity arises.[26]

Purse Seine. "...a large seine designed to be set by two boats around a school of fish and so arranged that after the ends have been brought together the bottom can be closed,..."[27]

Purse Seiner. "...a usu. power-driven fishing boat equipped or used for fishing with a purse seine..."[28]

Riparian. "...one that lives or has property on the bank of a river"[29]

Roe. "...1...b: the eggs or ovaries of an invertebrate..."[30]

---

[22] "Periproct," Webster, op. cit.

[23] "Peristome," Webster, op. cit.

[24] Ref. 36

[25] "Pluteus," Webster, op. cit.

[26] Ref. 31

[27] "Purse Seine," Webster, op. cit.

[28] "Purse Seiner," Webster, op. cit.

[29] "Riparian," Webster, op. cit.

[30] "Roe," Webster, op. cit.

SMART. Acronyn for Systems Management Analysis and Review Technique.

Stochastic. "...skillful in aiming, proceeding by guesswork,..."[31]

System. An ordered set of elements (objects, concepts and/or activities) whose order results from the exchange of materials, energy and/or information.[32]

Taxonomy. "...2: the systematic distinguishing, ordering, and naming of type groups within a subject field: CLASSIFICATION..."[33]

Temporally. "...2: with regard to time"[34]

Test . "...the external shell or other hard or firm covering of many invertebrates..."[35]

Topological. "...2: concerned with relations between objects abstracted from exact quantitative measurement..."[36]

Transmittance. "...Transmission..."[37]

Trematode. "...of or relating to the Trematoda...a flatworm ...of the class Trematoda"[38]

---

[31] "Stochastic," Webster, op. cit.

[32] Ref. 31

[33] "Taxonomy," Webster, op. cit.

[34] "Temporally," Webster, op. cit.

[35] "Test," Webster, op. cit.

[36] "Topological," Webster, op. cit.

[37] "Transmittance," Webster, op. cit.

[38] "Trematode," Webster, op. cit.

Methodology

This report constitutes a preliminary study into the economic feasibility of harvesting and processing sea urchin roe for export and marketing in Japan. This study is unique in that it (1) deals with a stochastic system that does not yet exist and has never existed, and (2) introduces a new and innovative method of testing the economic feasibility of that system.

The completeness and accuracy required in a study of this complexity necessitate certain methodological shifts throughout the development and presentation. This is accomplished in the remaining chapters of Part 4 which are developed in the following manner:

This introductory chapter contains both descriptive and theoretical information. The preceding descriptive portion has explained the purpose of the research, provided pertinent definitions, and discussed the scope and limitations of the study. This chapter also describes the methodology of the presentation.

In addition, the theoretical portion of the chapter provides a brief summary of systems theory and modeling practices and limitations. It then discusses PERT, DCPM, and GERT, in that order. Each of these techniques represent stepping stones which must be taken in order that SMART be fully understood. The three steps of the SMART approach are then introduced. These are: (1) apply the systems approach; (2) develop models for all subsystems; and (3) construct a GERT network that represents the aggregate system. The chapter concludes with a comparative analysis of SMART and Forrester's Industrial Dynamics.

This analysis serves to bring SMART's explanation into sharper focus.

Chapter III is descriptive. It describes the external and internal characteristics of the sea urchin. It presents the biological and ecological background of the sea urchin concentrating specifically on the urchin's habits and behavior. The characteristics of the species Strongylocentratus drobachiensis, the variety indigenous to Maine's coastal zone, are summarized separately, concentrating on spawning and eating habits.

Chapter IV is descriptive, analytical, and theoretical. Its primary purpose is to provide as much qualitative information as possible relating to the harvesting, processing, transporting , and marketing of fresh, sea urchin roe. Because so little information is available on the Japanese market, its customs and habits, this chapter concentrates on Maine's behavioral environment. The Chapter divides the presentation into legal, economic, and social perspectives then looks at harvesting, processing, and transporting operations from these perspectives. This chapter serves in a secondary role of developing a "feel" for where this proposed sea urchin roe venture fits with respect to other economic areas of pursuit which contribute to the economic and social well being of the state of Maine.

Chapter V is analytical. It represents the actual applcation of SMART to the "sea urchin system." As such, Chapter V is therefore divided into three steps. Step one is the application of the systems approach. Step two consists of the actual modeling of the various subsystems and sub-subsystems that comprise the aggregate system. Step three is the application of GERT for the final solution of the stochastic network.

Chapter VI presents the conclusions of this thesis. It lists areas requiring further research and offers several recommendations. Alternative courses of action are also considered. Chapter VI concludes with a summary of procedures used, analytical findings, conclusions, and recommendations.

Overview of Systems Analysis

This portion of the chapter is derived from theoretical research based on the proposition that all variables that influence any predefined system interact and/or interrelate systematically. That is to say, common threads or patterns exist between concepts or variables which comprise various and possibly diversified, sets of relationships that can be identified, and more importantly "modeled" in some way, after the particular system of interest has been defined.

A general summary of systems theory and modeling practices and limitations is required before the implications of the preceding statement can be fully understood. After providing that summary, a new and possibly innovative approach to the management, analysis, and review of systems' activities is described. This approach, for lack of a better acronym, has been termed SMART (Systems Management Analysis and Review Technique).

Discussion of Systems Theory

What is systems theory?

> There are indications that general systems theory implies the possibility of the "unity" of all science, for it is found as a new frontier in the biological and physical sciences as well as in the work of psychologists, sociologists, anthropologists, economists, political scientists, and management scientists. The systems model is widely useful in developing theories applicable to physical and social events, and to human relationships in large or small groups.[39]

Thus, systems theory, it would appear, is a relatively new concept that seems to hold forth great potential for the future unification of scientific endeavor.

A system has been defined as, "anything that consists of parts connected together."[40] A second, somewhat more complete definition describes a system as a set of objects with a given set of relationships which connect the objects and their attributes.[41] Bringing the definition into sharper focus, a system has been defined as, "An ordered set of elements (objects, concepts, and/or activities) whose order results from the exchange of materials, energy, and/or information.

---

[39]Ref. 36, p. 310

[40]Ref. 3, p.9

[41]Ref. 41, pp. 26-27

[42]Ref. 31

> Systems are identified and described by a number of elements or characteristics. Among these are boundaries, interacting and mutually interdependent parts, feedback and equilibrium.
>
> The boundaries of a system are an important characteristic. A system's boundary may be physical or tangible,..., or it may be abstract and intangible.... The boundary tells us what is inside or outside the system, and can be arbitrarily assigned when we define the system.
>
> The idea of system also implies the interrelationship of its various component parts. The concept of interdependence holds that a change in one element of the system leads to changes in other parts of the system.... The systems concept emphasizes the totality of a set of interrelated parts, conditions or activities.
>
> A system has a tendency to achieve a balance among the various forces operating within and upon it. This balance is called equilibrium or steady state.
>
> Feedback is a central concept in the theory of control, as well as in the theory of systems. ...It is a diagnostic concept for the practitioner in management, for breakdown of the feedback process is evidence of grave difficulty in the operation of an organization or other system. Feedback is a process by which systems gather information about how they are doing, feeding the information back into the system to guide, direct, and control its further operations.

Summarizing what has been presented thus far, a system is a set of elements (e.g. subsystems) that are linked in some ordered pattern by means of purposive interactions. A system is characterized by the interactions and interdependencies of its parts, by indentifiable boundaries, by feedback responses, and by references to some equilibrium or steady state condition.

One, as yet unmentioned, characteristic of systems theory merits consideration. C. West Churchman discussed

---

[43] Ref. 36, pp. 311-312

this aspect of systems theory in the following way:

> The word system has many different meanings in discourse, but all along we are concerned with the design of systems to accomplish a set of purposes. From this point of view, the parts of the system bear special relationship to the whole; namely, in principle it should be possible to evaluate a part in terms of its system effectiveness, that is, in terms of its contribution to the attainment of the system objectives. More precisely, associated with each part we should in principle be able to determine an effectiveness measure; given a fixed state of the rest of the system, the more effective a part becomes (within specified limits) the better will be the whole system. The question of system design is directly concerned with this effectiveness measure.[44]

The preceding discussion serves to emphasize the interdependent relationships of system parts or subsystems. It also hints at the existence of feedback and equilibrium. But most importantly it introduces the system concept of measurement. This concept was best summarized by Dr. D. A. Love when he defined "Love's Law" which states, "If a system does not have an adequate idea of what it's supposed to be doing it cannot have a meaningful performance measurement system. A system with a good performance measurement system, conversely, will have a good idea of what it's supposed to be doing."[45]

Systems theorists have developed systems taxonomies based upon the nature of interrelation and interdependence of these system components, and upon the relative degrees to which each of these components is present in any given system. Figure 2-1

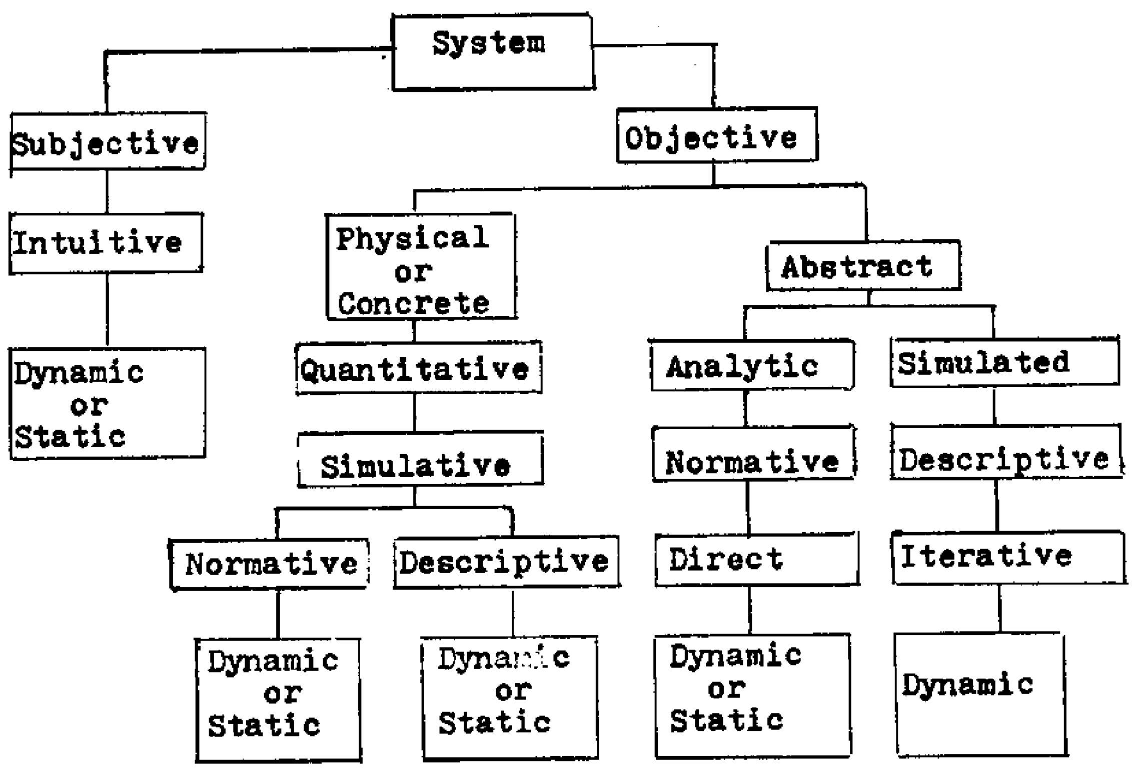
---

[44]Ref. 8, p. 181

[45]Ref. 31

presents one such taxonomical hierarchy which is based upon the purpose served by various systems. That is, if the systems role is defined as seeking order out of chaos, then in a subjective sense, systems fill individuals' needs to identify and/or for identification. In an objective sense they enable purposive objectives to be pursued (e.g. enabling better systems to be devised: more humane systems, etc.).

Systems Taxonomy



Source: Ref. 34

Figure 2-1

Systems are classified by types. The method of interaction and the interrelationships of the system's parts or subsystems define the system under consideration as either probabilistic or deterministic. In a deterministic system the parts interact in a predictable manner. In a probabilistic system the outcome or effects of the part's interaction is not predictable.

Depending upon feedback arrangement, a system may be either open or closed. An open system is one that is unaware of its own performance. Conversely, a closed system is aware of its performance and is usually made so aware by feedback. In conducting a systems analysis, one usually moves from open to closed to open to closed systems, in moving from sub-sub-subsystems to sub-subsystems to subsystems to the total system overview and vice-versa. Drawing an analogy: an engine running without control is an open system. Once a speed governor is attached to the engine, the system under consideration becomes closed. Place the engine in an uncontrolled motorboat and the system being considered is now open. Place a boat operator aboard to steer the boat and control its speed in response to wind and wave actions and the system under consideration is once again closed. Let the boat and operator wander aimlessly on the water and the system is open. Give the boat operator a task to perform, like go from pier A to anchorage B, and the system in question is closed, and so on.

The feedback itself can be either positive or negative. Positive feedback affects system inputs in such a way as to reinforce system output. Negative feedback, on the other hand, affects output in such a way as to diminish output.

A system's relationship to equilibrium determines whether the system is static or dynamic. Quite obviously a system in change is dynamic while one that remains unchanged is static. But equilibrium properties of systems go beyond this rather simplistic definition that is based on change. Some systems are homeostatic and others are not. This means that some systems are placed in a state of disequilibrium from external or internal pressures and seek to return to the same level of equilibrium from which they started. Other systems seek out new levels of equilibrium. Still others exhibit no tendency to equilibrate. Thus, systems may be classified according to the equilibrium properties they exhibit.

System bounds and measurement standards act upon, and are acted upon by the previously discussed characteristics. The arbitrary assignment of bounds, for example, might change an open system to a closed system, or vice-versa. The choice of a measurement standard for systems analysis might determine whether the system being considered is probabilistic or deterministic. The measurement systems utilized in an open system might differ appreciably from that used in a closed system, and so on.

This concludes the rather brief, but vitally necessary summary of systems theory. Modeling practices and limitations are discussed next and should add further dimension to the preceding summary of systems theory.

Modeling Practices and Limitations

Systems theory and modeling practices are inextricably intertwined. A model, by definition, is an abstract representation of a system. Use of systems theory and modeling practices together constitutes what has been termed "the systems approach."

Models serve two classes of role. First, at the objective level, the model facilitates conditional prediction. That is, if such and such is so, then so and so should follow. Second, at the group existential level, the model seeks to eliminate the perceptual differences of group members. This requires some elaboration. Assuming that all important worldly decisions are made by groups, a principle reason for lack of unanimity could be attributed to differences in individual value systems. But even if all members shared the same values, they would still have differing perceptions of reality. In effect, they would hold different models of reality. Therefore, the development and use of an explicit, common model eliminates or helps to eliminate or compensate for this perceptual reason for lack of unanimity.

Models can be dichotomized into systems models or developmental models.[46] Systems models concentrate on system components or parts; boundaries; patterns of interactions;

[46]Ref. 60

specific operations; transferability of operations; response patterns; feedback effects, loops, purposes; imbalance, tension, stress, conflict; and homeostatic properties. Developmental models are concerned more with change and those factors which induce and/or control change. The developmental model concerns itself with: noticeable differences between system states at different times; sequence of states, orderly processes; growth vs. decay, maturation vs. deterioration, gain vs. loss; direction, goal attainment, process and progress; identifiable states; forms of progression (i.e. monotonically increasing, linear, spiral, oscillatory, cyclical, branching, differentiation, speed up or regression, etc.); forces; structural or behavioral limits of the system; and utility of the developmental model to the practitioner.

The last "utility to the practitioner" feature of the developmental model should not be misinterpreted to mean that this aspect is limited solely to the developmental model. On the contrary, it applies equally to both systems and developmental models. It should be noted that a model's value is measured in terms of its utility and not in its conformance to reality. The only difference is that from the developmental model's perspective, this feature is recognized explicitly.

According to systems approach advocates, "the question is never whether or not to model. It is How much? What kind? and How expensive?"[47] This assertion can be substantiated from

[47] Ref. 31

many highly reliable, highly diversified sources. For example:

> Constructing a model helps you put the complexities and possible uncertainties attending a decision making problem into a logical framework amenable to comprehensive analysis. Such a model clarifies the decision alternatives and their anticipated effects, indicates the data that are relevant for analyzing the alternative, and leads to informative conclusions. In short, the model is a vehicle for arriving at a well-structured view of reality.[48]

Considering another source:

> ...Building a model of a process enforces more disciplined thought than does mere discussion, just as a written description usually leads to more careful thought than does a conversation. So model building leads to a better considered and more precise statement of the system description. After a model has been formulated, model simulation shows whether or not the agreed component assumptions can lead to the expected behavior.[49]

From yet another source:

> Experimentation is an essential part of science. But large systems...cannot be brought into a laboratory nor can experiments be conducted on them as a whole in their natural environment. Therefore, since experimentation is necessary to gain understanding and control over such systems and experiments cannot be conducted on them, experiments must be conducted on something other than the system under study. Clearly, if such experimentation is to yield knowledge relevant to the system, it must be conducted on something that is like the system under study. Models are representations of systems that serve this purpose.[50]

---

[48]Ref. 59, p. 10

[49]Ref. 18, p. 414

[50]Ref. 1, p. 10

Despite their many attributes, models also have certain limitations. A clear understanding and awareness of these limitations are of great importance to the study of systems theory and to the ultimate implementation of systems fundamentals. The great importance of modeling limitation's relationship to systems theory application derives from the fact that the modeling practitioner's perception of the actual system (i.e. the "real world") is biased, influenced, and governed by the models he chooses to implement. His perceptions can be no more correct, accurate, precise, etc., than the correctness, accuracy, precision, etc., of the models he implements. One only begins to sense the full impact of this relationship with the realization that the words and phrases with which men communicate are, in actuality, models of feelings and ideas.

The single greatest limitation to modeling practice lies with the practitioner's inability to model the total system. He is forced to deal with a system in parts. As a result, the types of models used and the diversity of systems approaches that result are extremely difficult and more usually impossible to integrate into one representative model of the system, or into one representative approach to understanding or controlling the system. Furthermore, optimizing the activities of each of the subsystems usually produces suboptimal behavior at the next higher level of aggregation.

In many cases the optimal solution prescribed for a certain subsystem becomes infeasible or unrealistic when evaluated in terms of the total system. For example, the optimal production schedule might be developed, by means of a linear programming model, for the production department. Simultaneously, the optimal course of action is dictated, by means of a behavioral model, for the safety department. In this case, faced with the impossible task of integrating two non-integrable models, the decision maker falls back upon some implicit intuitive model of his own to arrive at the actual course that will be pursued by the total system.

Of course, operations research advocates would argue that the constraints imposed by the safety department could be taken into account in the linear programming model for the production department. But this approach has two significant factors going against it. First, because the variables which bear on the safety objective are largely qualitative, the behavioral model would be far superior to a linear programming model for this area of interest. Consequently, any attempt at altering the safety department's objectives to fit as constraints in a linear programming model necessitates the adoption of a clearly inferior model. Such action, in turn, greatly reduces the quality, accuracy, and reliability of attainment of stated safety objectives. Second, the linear programming advocate is faced by the "curse of dimensionality" which maintains that a model's complexity increases exponentially as the number of dimensions considered in the actual system is increased.[51]

---

[51]Ref. 33

Thus far only the problems associated with optimizing decision models have been considered. The optimizing model was chosen because of its direct application to engineering methods. The construction of physical models for purposes of simulation and ultimate system optimization are probably the best known of all modeling techniques. Consequently, the optimizing model provides a convenient vehicle for conceptualizing and exemplifying modeling techniques, relationships, and, of course, limitations. But this approach tends to oversimplify the actual problems which face the modeling practitioner. In the real world optimizing models constitute but a small fraction of all the various models used. In decision making, for example, satisficing models prove more useful than the optimizing models used earlier in decision theory development.[52]

In the management field a great diversity of modeling approaches are used. Many diverse facets of a business enterprise are modeled and considered as separate subsystems. Production models, inventory models, marketing and sales forecasting models, physical flow and information flow models, behavioral models, conceptual models, decision models, simulative models, and so on are but a few examples of the various types of models that are used. The task of integrating any two of these, yet alone all, into a representative model of the total firm is quite impossible at present. The great diversity and dimensionality involved constitutes a very significant limitation, therefore, to the model practitioner.

---

[52]For a more comprehensive discussion of this aspect of modeling theory see Ref. 10, pp. 1-127

The primary limitations to modeling practices, however, rest with the modeling practitioners themselves. These limitations can be characterized in the form of two modeling diseases. These are: epicyclitus and model aphasia.[53]

"Epicyclitus" is a term coined in reference to the Ptolemaic model of the solar system. In his model, Ptolemy placed the earth at the center of the universe with the sun, moon, planets, and stars revolving around it. While the model was functional, it was never completely accurate and required continual modification as new information was discovered, and it required the development of a fairly complex set of relationships to account for relative motion in the system. At the height of its development the Ptolemaic system compensated for the resultant effects of relative motion by modeling epicyclical orbits for all stars and planets as they traveled in their major orbits around the earth. Hence the term "epicyclitus." It should be noted that the Copernican model that replaced it was much simpler in construction, more adaptable to new information inputs, and highly accurate. It is even more interesting to note that the displacement of the highly complex, relatively inefficient Ptolemaic model by the infinitely simpler, highly efficient Copernican model was accomplished by the simple transfer of the sun from a major orbit to the center of the system's model.

Thus, "epicyclitus" can be defined as the continual modification of a poor model as opposed to devising a new

---

[53]Ref. 31

model, through application of a systems approach, etc., to replace the old one. Eric Von Daniken assailed this facet of modeling theory when he bemoaned the inept formulations that have been derived from archeological research. According to Von Daniken:

> Our historical past is pieced together from indirect knowledge. Excavations, old texts, cave drawings, legends, and so forth were used to construct a working hypothesis. From all this material an impressive and interesting mosaic was made, but it was the product of a preconceived pattern of thought into which the parts could always be fitted, though often with cement that was all too visible. An event must have happened in such and such a way. In that way and no other. And lo and behold - if that's what the scholars really want - it did happen in that way. We are entitled, indeed we ought, to doubt every accepted pattern of thought or working hypothesis, for if existing ideas are not called in question, research is at an end. So our historical past is only relatively true. If new aspects of it turn up, the old working hypothesis, however familiar it may have become, must be replaced by a new one. It seems the moment has come to introduce a new working hypothesis and place it at the very center of our research into the past.[54]

Von Daniken's remarks lead nicely into the discussion of the second modeling disease, "model aphasia." In this context, model builders, having gained proficiency in the use of a certain model or models resort more and more frequently to "their" model's usage. They tend to bend reality to fit their models rather than develop a model that fits reality in such a way as to best serve the potential model user's purpose.

Model aphasia is quite commonly exhibited in the work of linear programming advocates. In operations research

---

[54]Ref. 58, p. 13

circles, this second model disease has been termed "the hammer syndrome," in which every problem in the world can be viewed as a nail, and linear programming as the hammer which drives home the solutions.[55] Similar analogies can undoubtedly be drawn in other areas of modeling endeavor.

Developing a Decision Making Approach

The problem of harvesting sea urchins in the state of Maine and transporting sea urchin roe to Tokyo for marketing in Japan can be approached in many different ways. From a linear programming perspective, for example, the problem is essentially that of a classic transportation linear programming problem.[56] From an economic perspective, the problem is largely one of calculating and equating marginal costs and marginal revenues. To the systems analyst or management scientist, the problem may be viewed as a network that requires a network scheduling solution.

Conventional practice would dictate that the modeling approach ultimately chosen would reflect the discipline of the practitioner, be that individual a linear programming operator, an economist, or a management scientist. But are any

---

[55]Ref. 33

[56]Ref. 59, pp. 166-186, 213-224, 387-392

approaches clearly superior to any of the others? Would the results or conclusions of any of these approaches approximate the results of any of the other approaches? How reliable would the results be, given that the chosen approach limits its considerations to a rather select set of subsystems to the exclusion of any others?

Quite obviously a single model of the total system is very much preferred. But won't the diversity of model types and their dimensions prohibit the design of a single representative model? Past experience has proven that there are exceptions to this generalized trend that usually accompanies the development of integrated models. It should be remembered that the Copernican model was far more accurate and infinitely simpler than the model it replaced. Further:

> ... The physical size or scope of a system has but little to do with the complexity of the model necessary to represent that system adequately. The bigger the system, the greater can be the degree of aggregation. A model of an economy need not contain all component companies. A model of a company does not represent each person. A model of human behavior would not reach to the individual cell. A model of dynamics of a cell would aggregate to a much higher level than individual atoms and most molecules. In fact, the models needed in each of these systems would probably be of about the same complexity. [57]

Enumerating the subsystems that make up the aggregate system produces the following breakdown of operations: harvesting, processing, ground transport, sea or air transport, and marketing in Japan. The ideal types of models required for each of these subsystems are quite diversified.

---

[57] Ref. 18, p. 413

The obstacles presented in designing a systems model to integrate the diversity of subsystem models appear almost insurmountable. Behavioral model parameters do not offer any identifiable links with transportation network variables. Methods of delineating system bounds and of establishing subsystem interfaces are not readily apparent. Common standards of measurement are nonexistent. The homeostatic properties and dynamic characteristics of the various models are too diversified. The methods and types of subsystem interactions are not clearly understood.

A cursory examination of an approach utilizing developmental models produces significantly different results. Shifting problem emphasis to concentrate on change and those parameters which influence and/or control change yields a conceptual framework that is quite different from those that would evolve from systems model usage. This resultant framework presents a radical departure from the more conventional modeling methods and represents the essence of SMART. Its acceptance in this particular instance is based upon the following hypothesis:

> The development of Maine's underutilized resources, in this case being sea urchin roe, is completely a management problem. The transshipment of the roe, and its eventual marketing in Japan are also completely management problems.

The eventual impact of this hypothesis pivots upon the definition of the word, "management." This term, therefore, is defined as follows:

> ... Management is defined for conceptual, theoretical, and analytical purposes as that process by which managers create, direct, maintain, and operate purposive organizations through systematic, coordinated, cooperative human effort.[58]

In this case, managers are taken to be any individual or individuals whose actions or inactions can influence the eventual success or failure of this particular venture. The organization referred to is the system by which Maine sea urchins are harvested, processed, transported, and marketed in Japan. The sum of these considerations leads to the development of a decision making approach. The need for this development is dictated by what has been described as "the management process."[59]

The importance of the decision making facet of the managerial process cannot be overemphasized. It is intricately interwoven with the entire management function. This point is easily missed if decision making is viewed only as the final choice among a set of alternatives. Focusing only on the final moment of choice leads to a false concept of decision making and according to Simon, "ignores the whole lengthy, complex process of alerting, exploring and analyzing that precedes the final moment.[60]

Decision making should be viewed as an on-going process where many decisions generate other decisions, passing through

---

[58]Ref. 36, pp.4-5

[59]Ref. 15

[60]Ref. 52, p.1

a sequence of steps, leading to the "final" decision. It is this process character of decision making that has accorded this facet of the management process a central role in the revisionist's theories of management. To them, decision making and managing are synonymous.

Emphasis can also be placed on the after-the-moment-of-choice side of the decision process. According to Ackoff, "Making a decision is only one aspect of what might be called a decision cycle. Such a cycle has...four steps...decision making, implementation, evaluation, and recommendation."[61] Ackoff further stresses that, "It should be apparent that control, decision, and management-information systems are strongly interrelated and are merely subsystems of what might be called the management system."[62]

It is therefore concluded that management and decision making go hand in hand for, according to Drucker, "Whatever a manager does he does through making decisions."[63] But even more importantly, the preceding discussion establishes the concept of a decision flow. Within this framework, a manager becomes one who controls system activities by exerting an influence on a decision stream. This concept of a "decision stream" becomes quite important in the comparative discussion

---

[61]Ref. 1, p 99

[62]Ref. 1, p.112

[63]Ref. 15, p. 351

of SMART and Jay Forrester's Industrial Dynamics approach conducted in the next to the last section of this chapter.

PERT and DCPM

PERT is the acronym for Program Evaluation and Review Technique, and is sometimes referred to as the Critical Path Method (CPM). It is a network approach to planning and scheduling work projects in a system. Developed jointly by the Navy Special-Projects Office and Booz-Allen-Hamilton management consultants, in conjunction with the Fleet Ballistic Missile Program, it was successfully used in producing the Polaris missile.[64] Since that time it has been increasingly used in industry.[65]

> PERT is a system of planning and control involving (1) the identification of all key activities in a project, (2) devising the sequence of activities and arranging a flow diagram, and (3) assigning duration times for the performance of each phase of the work. The sum of the estimated durations along the most lengthy sequence of activities gives the estimated total time span for the entire project. PERT uses time as a common denominator to reflect three basic factors in work projects: time, use of resources, and performance specifications. PERT appears to represent an advance over former systems of planning and scheduling, such as Gantt charts, by the addition of mathematical concepts and the use of computers. ...
>
> The critical path of a program is the longest possible time span along the system flow plan. The critical path is obtained by organizing the events in sequence, beginning with the final event in the total network. ... Observation of the network plan and the critical path makes possible the comparison of progress in each part of the project with the target dates of completion.[66]

---

[64] Ref. 36, p. 278

[65] Ref. 48, p. 57

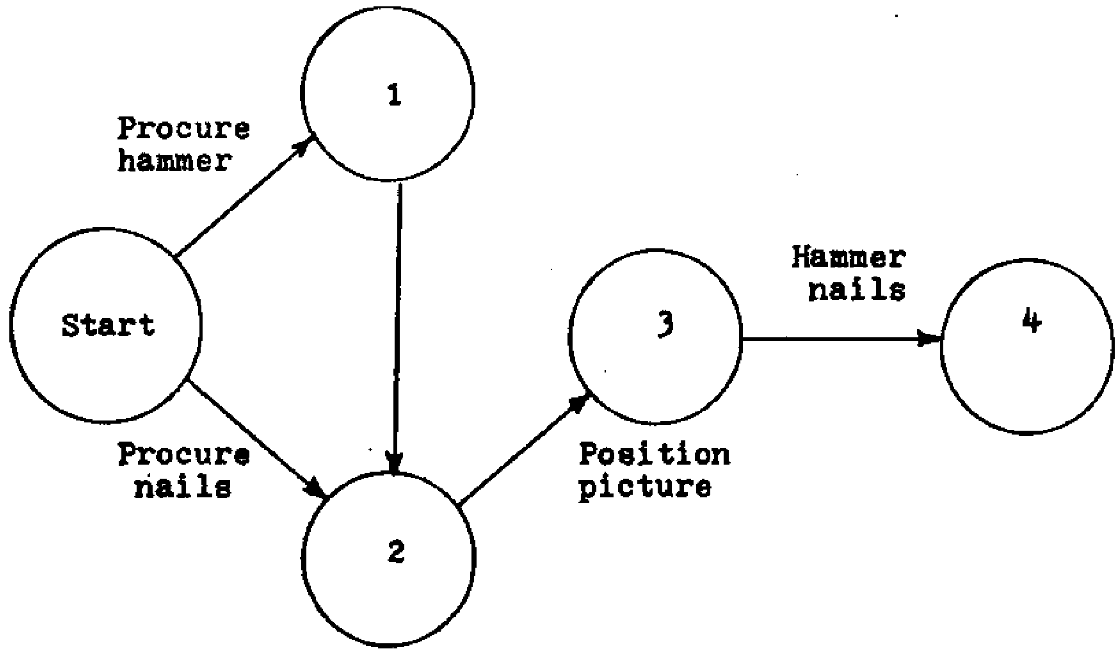
[66] Ref. 36, p. 278

Figure 2-2 shows two examples of PERT flow diagrams. Circles show the key events while arrows represent the priority relationships between the events. The numerical symbols beside the arrows indicate the costs or times associated with the attainment or the respective events. The measurement standard most frequently used is time, measured in units of seconds, minutes, hours, days, weeks, months, etc.

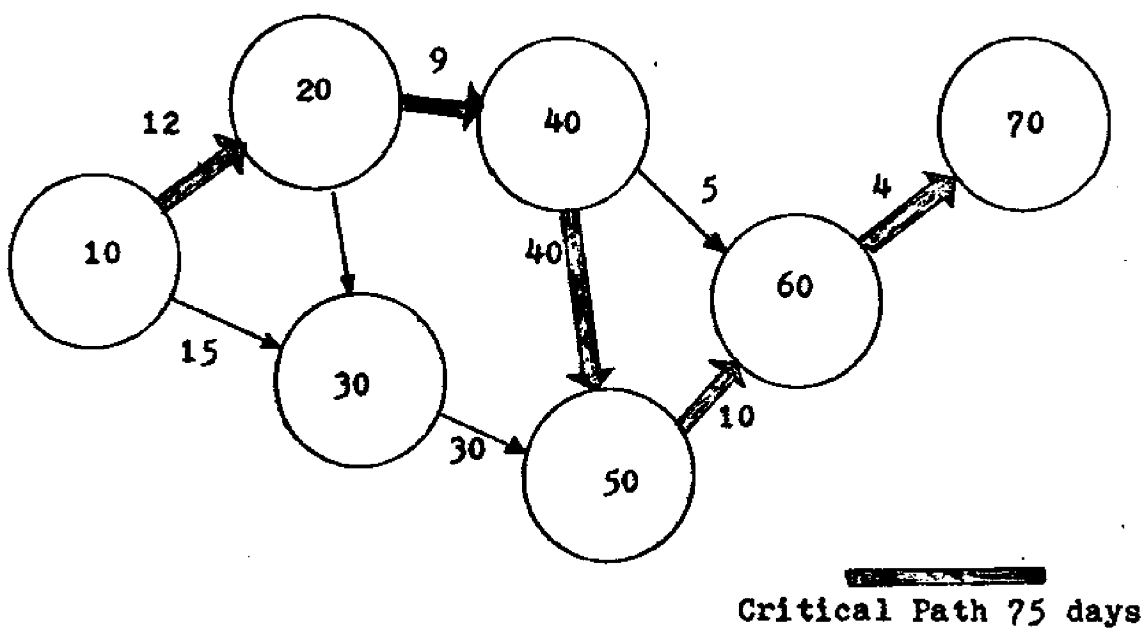
DCPM is the acronym for Decision Critical Path Method. It represents an extension of PERT that provides for the introduction of activity interdependence and alternatives which are required to effect integrated planning, scheduling, and control. By using DCPM, projects can be scheduled in a system where alternative methods exist for accomplishing the same purpose. DCPM diagrams, as in PERT diagrams, depict activities as circular nodes. Triangles are introduced, however, to represent mutually exclusive alternatives of an activity set. If the set consists of non-mutually exclusive activities, it is denoted by a triangle whose base is enclosed by a semi-circle.

Figure 2-3 shows a DCPM network where two activities, 2 and 5, can be performed in two different mutually exclusive ways, which are defined by 51,52, and 21, 22. Figure 2-4 enumerates the alternative paths which are represented in Figure 2-3. This method of enumeration shows that it is a fairly simple matter to solve this DCPM by hand, by simply choosing the least costly alternative. This task, however, becomes increasingly more difficult as the number of nodes and alternatives is increased.

Examples of PERT Flow Diagrams



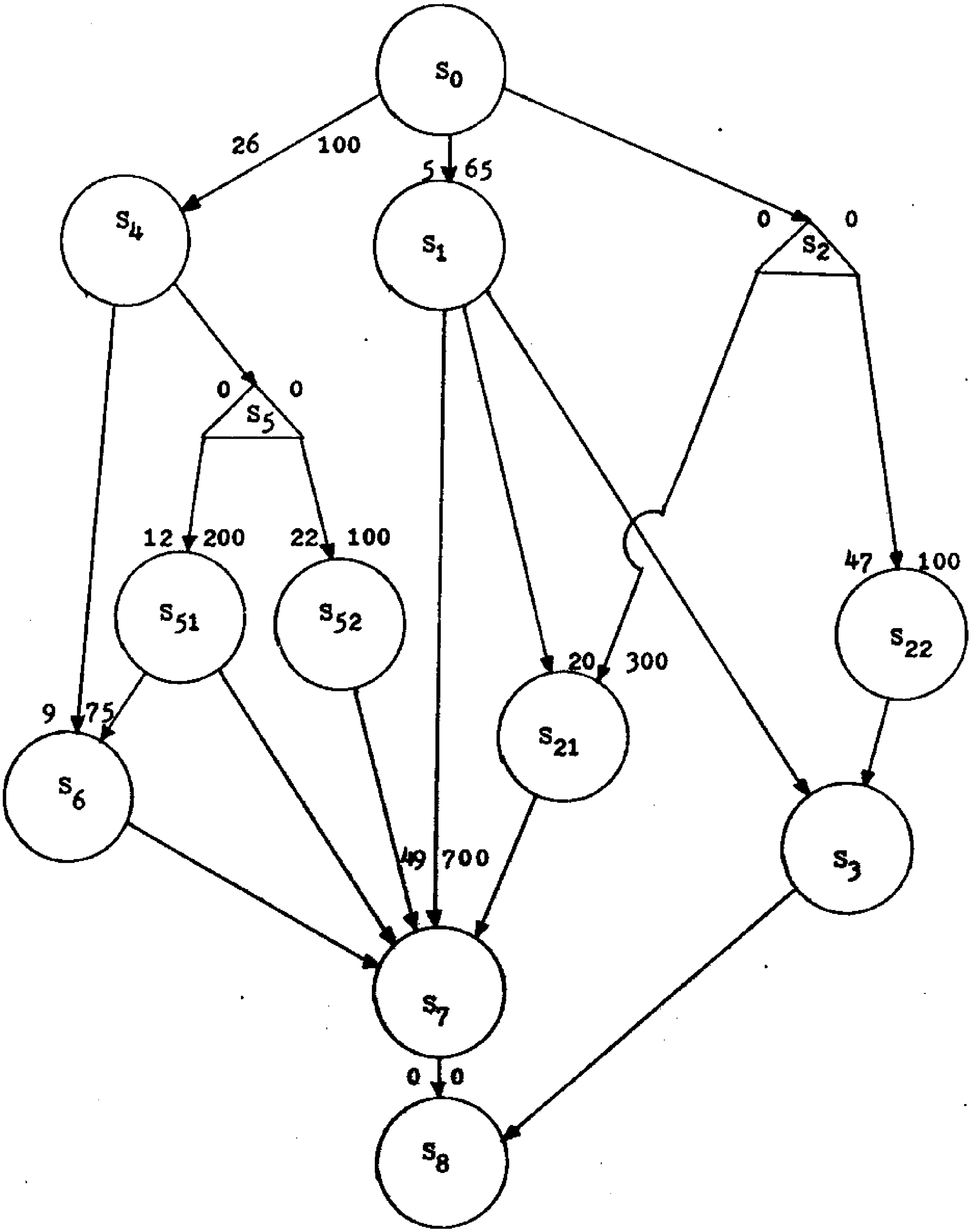
Source: Ref. 27, p. 26



Source: Ref. 48, p. 58

Figure 2-2

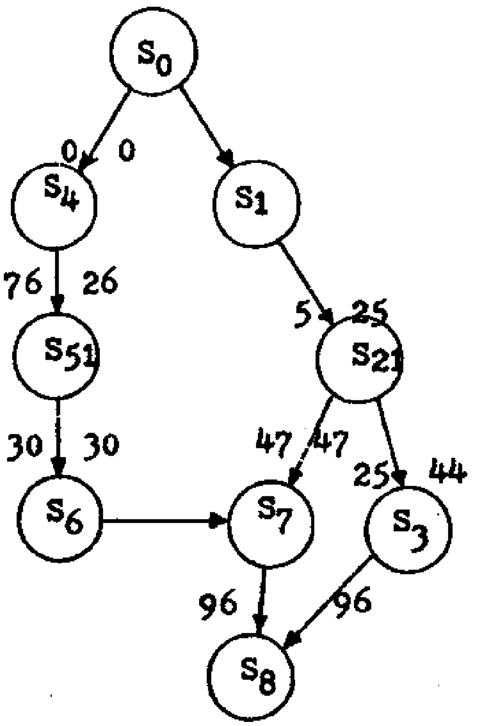
Example of DCPM Network



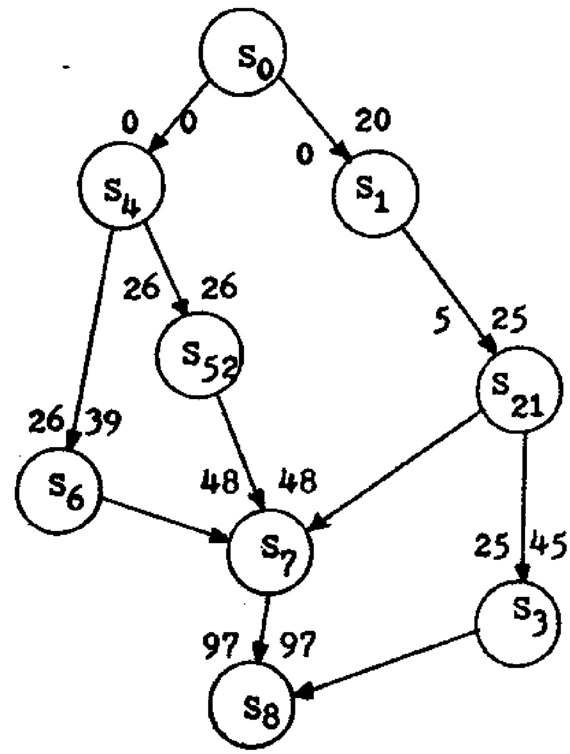
Source: Ref. 20

Figure 2-3

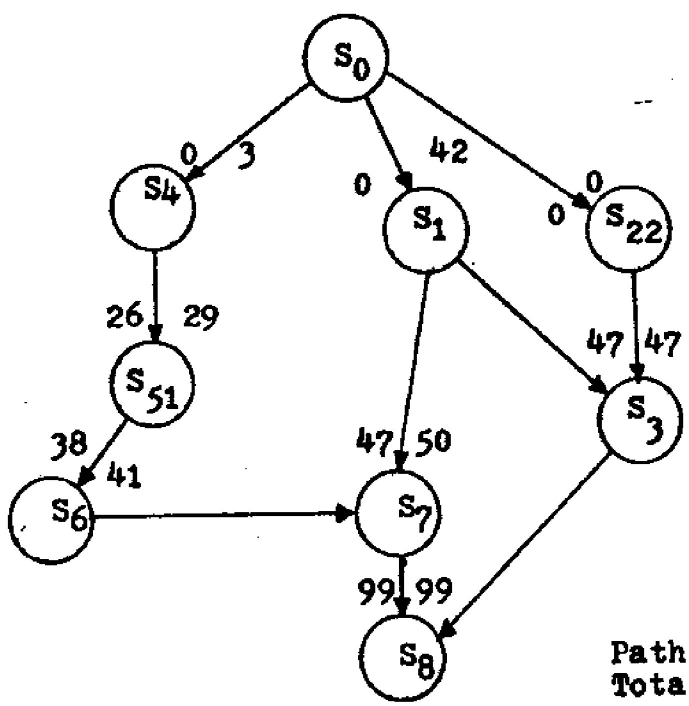
Enumeration of DCPM Alternatives



Path Alternative 51,21
Total Costs = 1600



Path Alternative 21,51
Total Costs = 1500



Path Alternative 22, 51
Total Costs = 1395

Source: Ref. 20

Figure 2-4

PERT and DCPM form the basis from which SMART is derived. But the explainatory transition cannot yet be made. The most important intermediate step in the transition has yet to be mentioned. This "intermediate step" represents a further extension of PERT and DCPM. It is called GERT (Graphical Evaluation and Review Technique).

GERT

GERT was developed jointly be the U. S. Air Force and the RAND Corporation to assist the Air Force in the development of a more comprehensive inventory control program. GERT was used extensively and successfully in the Apollo Space Program by NASA.[67]

> Gert is a technique for the analysis of stochastic networks. Stochastic networks have the following characteristics:
>
> 1. Each network consists of nodes denoting logical operations and directed branches.
> 2. A branch has associated with it a probability that the activity represented by the network will be performed.
> 3. Other parameters describe the activities which the branches represent. These parameters may be additive such as time or multiplicative such as reliability. Time will be used in the generic sense to represent a variable which is additive. ...
> 4. A realization of a network is a particular set of branches and nodes which describes the network for one experiment.
> 5. If the time associated with a branch is a random variable, then a realization also implies that a fixed time has been selected for each branch.
>
> GERT will derive both the probability that a node is realized and the conditional moment generating function (M.G.F.) of the elapsed time required to travel between

---

[67]Ref. 20

any two nodes.

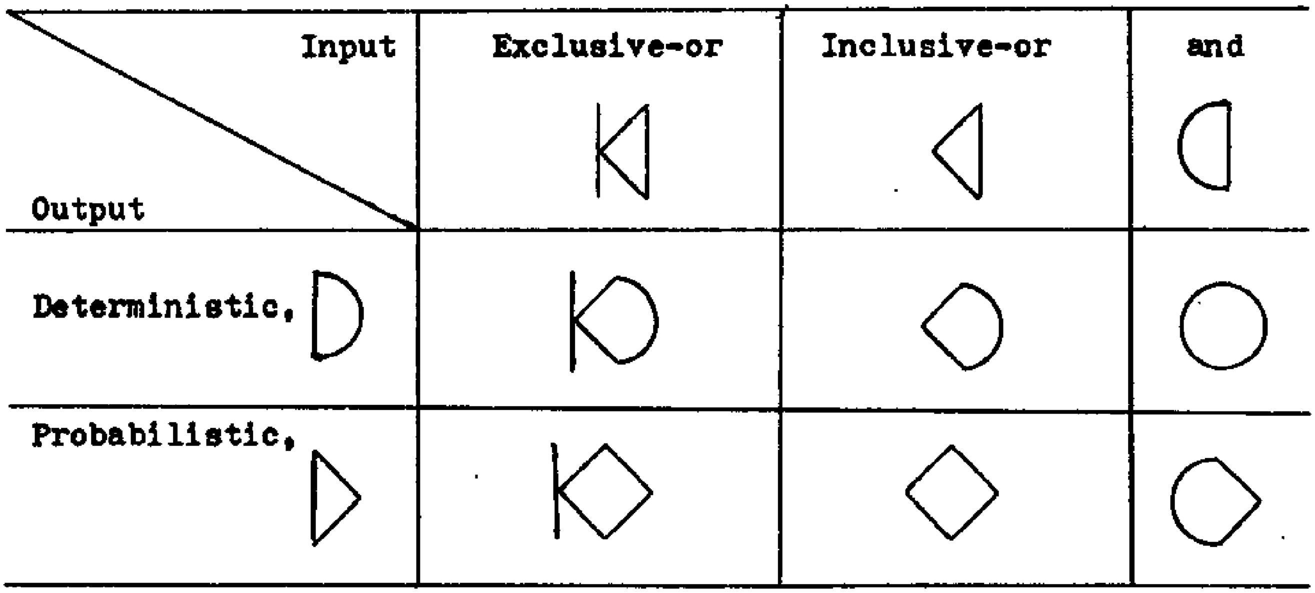
> The GERT approach to problem solving utilizes the following steps:
>
> 1. Convert a qualitative description of a system or problem to a model in stochastic network form.
> 2. Collect the necessary data to describe the branches of the network.
> 3. Determine the equivalent function or functions of the network.
> 4. Convert the equivalent function into the following two performance measures of the network:
>   The probability that a specific node is realized.
>   The moment generating function of the time associated with an equivalent network.
> 5. Make inferences concerning the system under study from the information obtained in 4 above.
>
> The approach combines concepts of PERT type networks with flowgraph concepts. From PERT the concepts are taken that a branch can be used to represent an activity and that the time to perform the activity is a parameter of the branch. From flowgraph theory, the analysis procedure incorporating a topological equation is utilized.[68]

A node in a stochastic network is comprised of an input function and an output function. Table 2-1 depicts six types of nodes which result from consideration of three possible input relations and two possible output relations. Figure 2-5 shows a GERT network which uses this GERT notation. Note the similarity between the GERT network and electrical circuitry networks. This relationship constitutes one of the primary advantages of GERT. It enables the modeling practitioner to implement a vast array of electrical engineering models, tools, and concepts during the formulation and solution of GERT model types.

---

[68] Ref. 44, pp. 267-268

GERT Node Characteristics and Symbols



Exclusive-or -The realization of any branch leading into the node causes the node to be realized; however, one and only one of the branches leading into this node can be realized at a given time.

Inclusive-or -The realization of any branch leading into the node causes the node to be realized. The time of realization is the smallest of the completion times of the activities leading into the Inclusive-or node.

and -The node will be realized only if all the branches leading into the node are realized. The time of realization is the largest of the completion times of the activities leading into the and node.

Deterministic -All branches emanating from the node are taken if the node is realized, that is, all branches emanating from this node have a p-parameter equal to one.

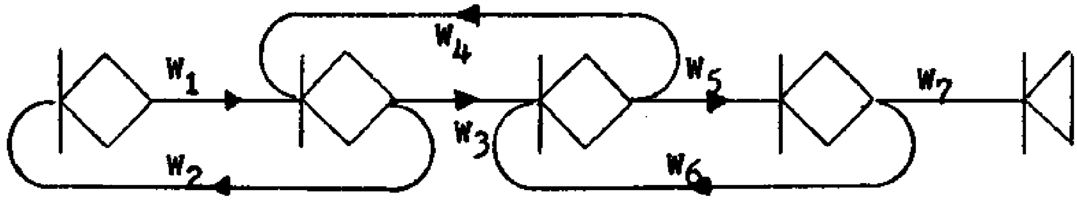
Probabilistic -At most one branch emanating from the node is taken if the node is realized.

Source: Ref. 44, p. 268

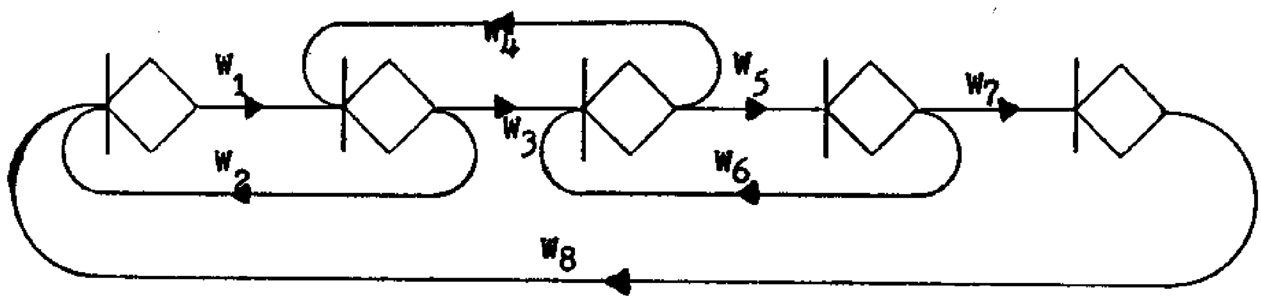
TABLE 2-1

GERT Networks

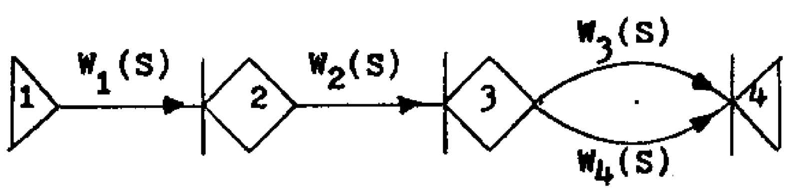
Open System Example



Closed System Example



Electrical Network Flow Graph of a Series Parallel Network



(GERT notation is used at nodes. Flow Graph network does not make such distinctions)

Source: Adapted from Ref. 44, pp. 270-271

Figure 2-5

One of the most flexible tools available to the electrical engineer is the flow graph. Flow graphs are used extensively in the solution of network and control problems. Flow graphs differ from CPM and other additive networks in that they represent a sequence of multiplicative operations.

> Flow graphs can be used to replace additive networks and vice versa by the assumption of a transform representation of activity or transform value. In this case, the value, in the form of an exponent, is added to others when the transforms are multiplied.
>
> Flow graphs have several advantages over other network approaches by their ability to represent feedback as well as feedforward relationships which are of major use in representing or simulating iterative situations.
>
> Similarly, solution methods for flow graph models permit effective sensitivity testing for each activity or transmittance in the network without modifying the overall structure or computational content of the model. This characteristic permits the introduction of a large number of alternatives into complex model structures without reworking the model.[69]

All the advantages of flow graph methods are manifest in GERT. Use of a transform allows multiplicative parameters, like probabilities, to be carried as transform coefficients that are multiplied together as various system alternatives are traced through the network from start to finish. Simultaneously, additive parameters, like time, are carried as transform exponents that are added together as various system alternatives are traced through the network from start to finish. The end result is a transform value with probability of realization coefficient and a mean expected time of completion exponent.

---

[69] Ref. 20

Industrial Dynamics and SMART Comparative Analysis

SMART is GERT modified for management usage. It represents a blending of systems theory, modeling practices and GERT techniques. Its major departure from GERT, in modeling the system for harvesting, processing, transporting, and marketing sea urchin roe, centers around the substitution of a cost parameter in place of the time parameter which usually accompanies the formulation of a GERT network.

While SMART has been derived independently of other modeling and systems analysis techniques, it shares many common characteristics with Jay Forrester's Industrial Dynamics (ID) approach. These similarities are significant and form the basis of this analysis.

Industrial Dynamics and SMART both concentrate on change. Both utilize developmental models primarily, for representing actual systems. In both approaches, these developmental models are used in a simulative capacity, representing changes that are experienced in the actual systems. Both deal extensively with qualitative activities such as the social and behavioral facets of organizations and systems.[70]

Both ID and SMART use a systems approach and emphasize the importance of analyzing the total system.[71] Both concentrate on developing a simulative model of the qualitative activities of a system (i.e. behavioral interactions, peer group pressures, norms, social values, etc.) and both stress

[70]Ref. 19, pp. 608-609

[71]Ref. 19, pp 601-608

the point that quantitative performance data be used in the qualitatively structured model. (In this context, qualitative means that statistical and empirical data are used in model formulation but are supplemented where ever possible with the intangible factors).

The most important relationship between ID and SMART is the emphasis placed on the decision making processes and the concept of a decision stream. In Forrester's words:

> ... The word "decision" is used here to mean the control of an action stream. Such an action stream may be the time devoted to sleeping in response to one's physical state, the effort to improve products in response to market information about product acceptance, the change in interest rates in response to money supply, the change of prices in response to a world-wide commodity shortage, or the rate of consumption of rabbits as a response to the size of the coyote population. As in these and all other decision streams, the action resulting from the decision stream affects the state of the system to which the decision stream itself is responding.[72]

Similarly, SMART maintains that "decisions" are both the cause and result of actions and/or change in a system. In SMART, the term "action stream" and "decision stream" are synonymous.

While these and other comparisons can be drawn relating ID and SMART, significant dissimilarities exist which differentiate the two. These differences fall under one of three headings. These are structure, feedback, and other minor differences.

---

[72]Ref. 18, p. 402

Industrial Dynamics stresses the importance of structure and feedback. The entire ID theory pivots around the concept of feedback in decision processes and in systems. ID therefore limits itself to closed systems. According to Forrester:

> The feedback loop is seen as the basic structural element of systems. It is the context within which every decision is made. Every decision is responsive to the existing condition of the system and influences that condition. This is a statement equally true for the forces that control the flow of electricity into a capacitor, for the conscious decisions of the individual or the manager, and for the selective decisions of nature that fit species to the environment by the processes of evolution.[73]

In similar fashion, ID theory derives much of its impetus from structure and theory of structure:

> Industrial dynamics is a philosophy of structure in systems. It is also gradually becoming a body of principles that relate structure to behavior. The structure which is codified in industrial dynamics has its counterpart in other fields and other bodies of literature. It is in industrial dynamics, however, that the structure has probably been given its sharpest definition and its most rigorous application.
>
> Structure is seen as having four significant hierarchies:
>
> - The Closed Boundary
>   - The Feedback Loop as the Basic System Component
>   - Levels (the integrations, or accumulations, or states of a system)
>   - Rates (the policy statements, or activity variables, or flows)
>   - Goals
>   - Observed Conditions
>   - Discrepancy between Goal and Observed Conditions
>   - Desired Action[74]

---

[73]Ref. 18, p. 408

[74]Ref. 18, p. 406

SMART favors neither open nor closed systems. While ID actively seeks ways to draw arbitrary boundaries around systems in question so as to ensure inclusion of all interacting feedback loops and thereby close the system, SMART does not. SMART concentrates on defining the arbitrary system bounds subject to the single constraint that the resultant model best serve the stated purpose for its construction. This represents a "let the Chips fall where they may" approach which is completely indifferent to whether the resultant model is open or closed. It is assumed that every system is a subsystem of some larger system and, therefore, could be closed but that, from the perspective of what ever purpose the model is to serve, the modeling effort required to close the system might be unduly excessive.

SMART has no particular obsession with structure. It acknowledges that structure is very important but is to be considered as one necessary step taken in applying the systems approach. This is conceptually clearer if SMART is viewed as a three step process. Structure becomes a vitally important consideration in the first stage which is applying the systems approach. The second step is to develop models for each of the subsystems using whatever technique best serves the purposes of the respective subsystems. The third step is to utilize GERT techniques to link all the submodels into one representative model of the entire system.

At this stage in its development GERT is not able to be employed to solve all subsystem models simultaneously. Optimization solutions are derived independently, for example, to determine break points in bulk shipment rates, etc. These results become inputs in the overall GERT model. Simultaneous solution thus far is only possible if all submodels are transformed into a GERT network prior to solution. Otherwise GERT serves as a conceptual shorthand for keeping track of a vast array of interacting factors only. SMART has a long way to go before approaching the sophistication of ID but is offered here, none-the-less, as an effective way of approaching a rather complex problem and as a method which holds forth a great deal of promise for future development.

Summary

This chapter has presented a logical development of the factors required to provide insight and an understanding for SMART. Systems theory and modeling practice where summarized first since the systems approach constitutes the first step of the SMART technique. A discussion of PERT and DCPM was conducted next since these methods form the foundation upon which SMART is based and from which it was eventually derived.

GERT was considered in greater detail because it represents the focal point of the SMART method. This was made readily apparent in the statement that SMART is GERT adapted for management usage.

The comparison of SMART and ID was then conducted to sharpen the focus and impact of the explaination. SMART was described as a potentially effective tool, lacking ID's sophistication, whose true value can only be realized through actual application to many real world problems over time.

CHAPTER III

SEA URCHINS AND SEA URCHIN ROE

General Background

The sea urchin is an echinoderm of the class Echinoidea. Echinoderms are any animals that belong to the phylum Echinodermata, familiar examples of which include the starfish, sand dollar, and sea urchin.

> The echinoderms are divided into five classes: the asteroids (Asteroidea), or sea stars, in which the arms are broadly attached to the disk; the ophiuroids (Ophiuroidea), or serpent stars, in which the arms are narrow, slender, and highly flexible; the echinoids (Echinoidea), including the sea urchins, heart urchins, and sand dollars, having no arms but possessing a globular, oval, or disklike shell; the holothurians (Holothuroidea), or sea cucumbers, having elongate, leathery bodies and a circle of branched tentacles around the mouth; and the crinoids (Crinoidea), including the sea lilies and feather stars, having slender, branched arms bearing side branches or pinnules. The crinoids have few living members; they are remnants of a large fossil assemblage, which included three additional classes now totally extinct.[1]

Echinoderms are characterized by a five-rayed structure, a system of locomotion operated by water pressure, and an internal skelton of calcareous material that supports external spines or tubercles.[2] These can be divided into two general

---

[1] "Echinoderm," Collier's Encyclopedia, Vol. 8, 1971, p. 507.

[2] Idem.

types. In the one type, the body consists of a central disk, from which radiate five or some multiple of five arms. This type is represented by the starfish, star serpent, and the crinoids. In the other type, the body is globular, oval, disklike, or cucumber shaped, showing equally spaced radiating structures which are usually five in number. This type is represented by sea urchins and sea cucumbers.[3]

The term Echinodermata is derived from the Greek "echino," meaning spiny, and "derma," meaning skin. The term appears to have originated with Jacob Klein in 1734 in his treatise, Naturalis dispositio echinodermatium.[4] While Klein applied the term solely to echinoids, the term evolved in its usage to encompass all the animals possessing the characteristics previously listed. The echinoids, however, form the focal point of this discussion since they include marine animals commonly known as sea urchins, heart urchins, and sand dollars.

Including both fossil and living forms, about 250 genera and 4000 species are known.[5] A count in Mortensen's monograph reveals that there are about 750 described existing echinoids.[6]

---

[3] Idem.

[4] Ref. 25, pp. 1-3

[5] "Sea Urchin," Encyclopedia Americana, Vol 24, 1970, p. 477.

[6] Ref. 39, pp. 414-415

Sea urchins are found in all seas and at all depths. They are particularly numerous in warm waters, however, and generally live in shallow waters along the coast. Very few species of sea urchins are found in the shallow waters of the Atlantic Coast. A very common species found along the rocky shores of New England is the green sea urchin (Strongylocentratus drobachiensis). Another North American sea urchin is the purple or deep brown Arbacia punctulata which is found from Cape Cod to the Gulf of Mexico.[7]

Diadema and Toxopneustes are found only in the South Atlantic states while the flat or cake urchins (Clypeasteroidea), the sand dollars (Echinarachinus parma and Mellita testudinata) are North American examples.[8] On the Pacific coast, in the shallow waters of California, the red urchin (Strongylocentrotus franciscanus) and purple urchin (Strongylocentratus purpuratus), are the most common.[9] The species of greatest interest to this discussion is the green sea urchin, Strongylocentratus drobachiensis, which is assumed to predominate the Maine shallow water coastal areas.[10]

---

[7] Encyclopedia Americana, loc. cit

[8] Idem.

[9] Ref. 5

[10] Ref. 5, p.7

External Characteristics

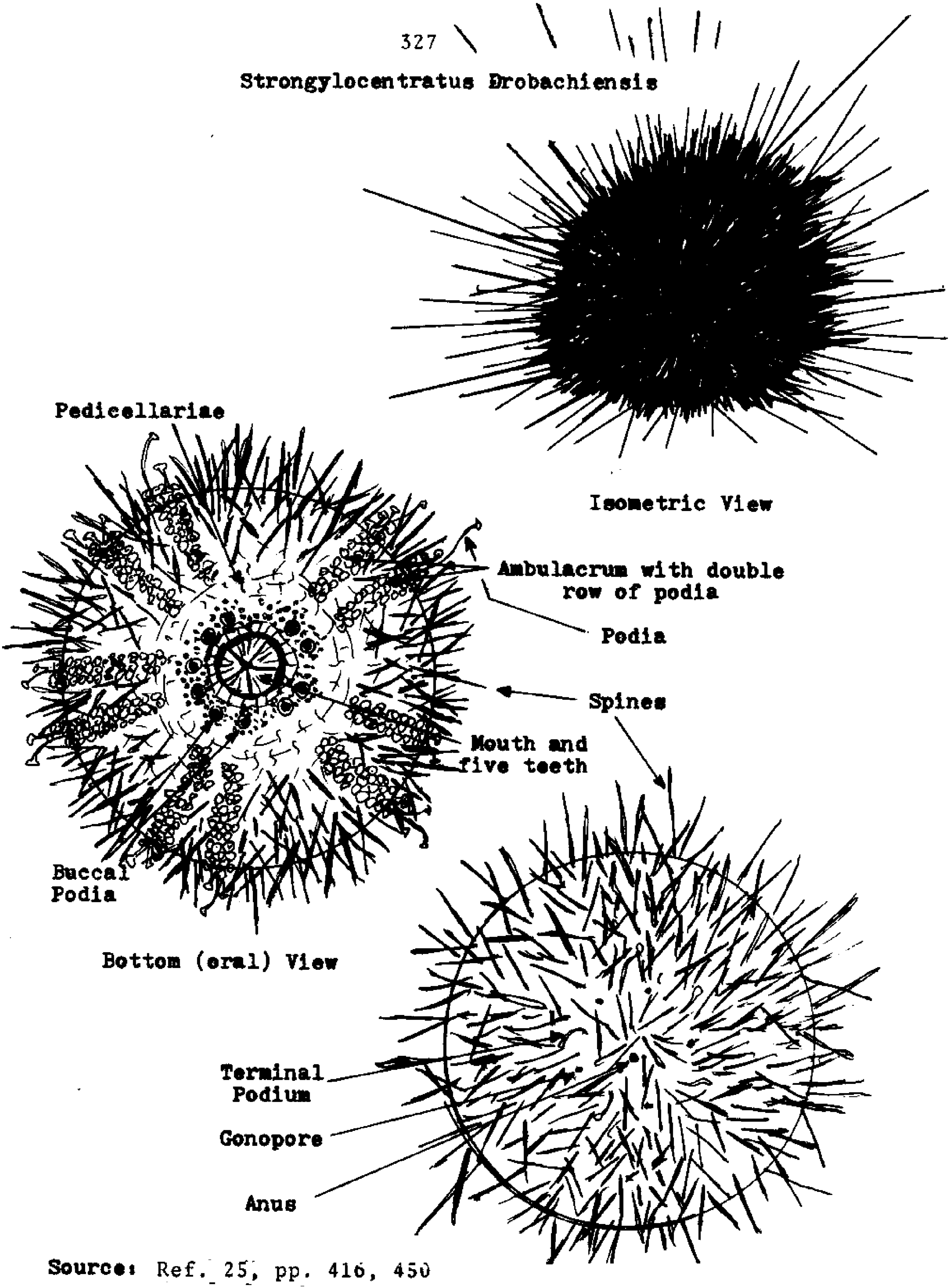
Echinoids (i.e. sea urchins) present differentiated oral and aboral surfaces. They move upon the oral surface, which is consequently flattened or even concave. The aboral surface, on the other hand, is moderately or highly arched.

The most conspicuous external feature of the sea urchin is its bristling armature of thickly placed spines. These spines are usually longer around the urchin's periphery than at the oral or aboral areas. The spines are usually differentiated into two main sizes, the larger, or primary spines (also called radioles) and the smaller, or secondary spines.[11] The primary spines are arranged in meridional rows which extend from the top of the aboral surface to the bottom center of the oral surface (periproct to peristome). The secondary spines are also arranged in similar fashion but are not quite as well ordered as the primary. These patterns are best seen by examining the skeletal plates of the denuded urchin.

Figure 3-1 depicts the sea urchin (Strongylocentratus drobachiensis) from top, bottom, and isometric views. Figure 3-2 depicts the denuded urchin, or "test" which shows the patterns of arrangement for the primary and secondary spines. Of particular interest are the plates, themselves, into which the primary and secondary spines are set. These plates reflect the pentamerous symmetry previously described.

[11] Ref. 25, p. 424

Strongylocentratus Drobachiensis

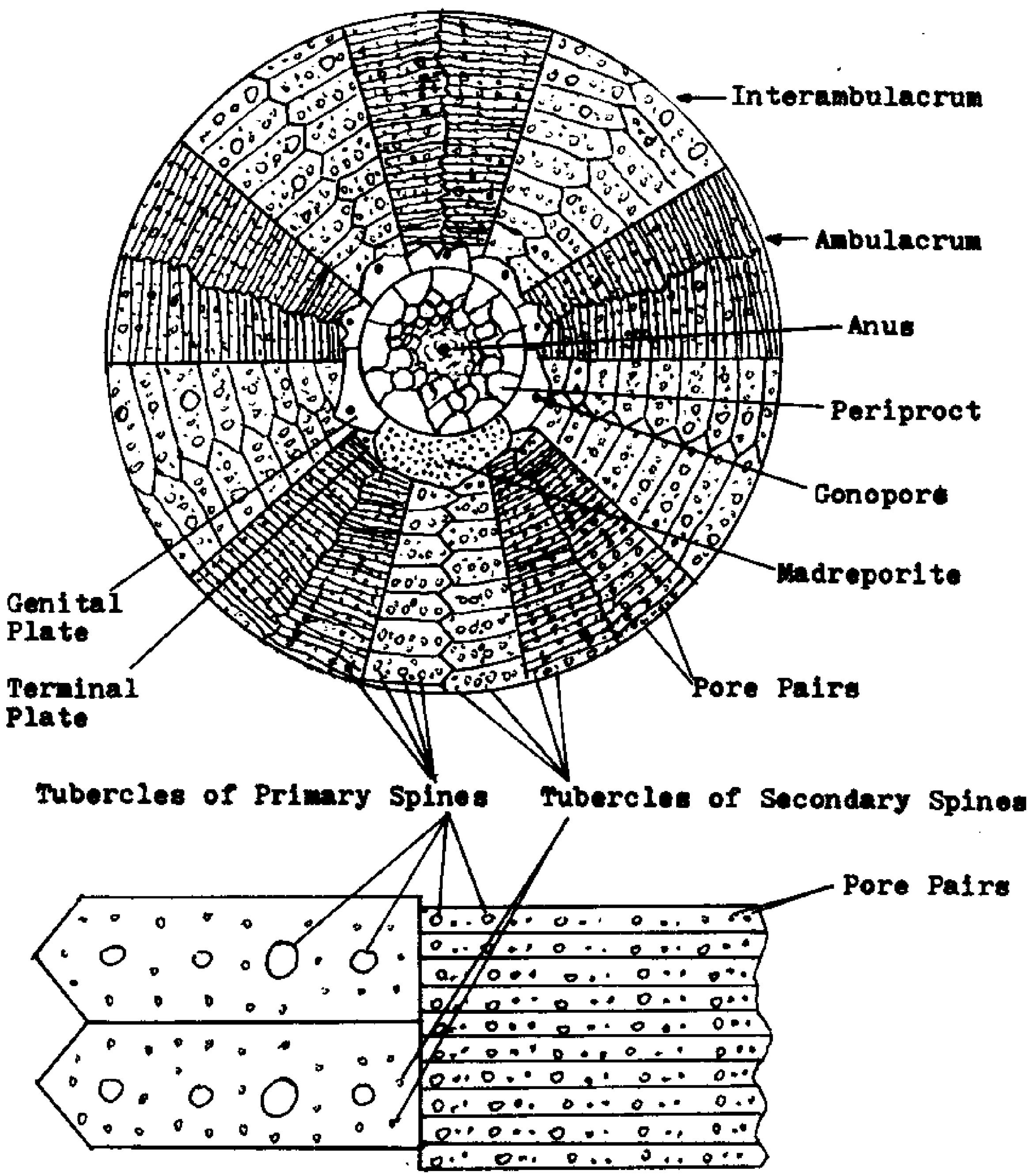


Source: Ref. 25, pp. 416, 450

Figure 3-1

Denuded Test of the Sea Urchin

(Aboral View)



Source: Ref. 25, p. 450

Figure 3-2

These plates are usually largest at the periphery and decrease in size toward the poles. According to Hyman:

> ...They are elongated horizontally and are five-sided with more or less straight horizontal edges. ...The plates of the two rows of each double row alternate, and as their inner edges along which they meet are shaped like an arrow head, the plates dovetail and present a zigzag line of meeting. ... the outer edges are more or less straight. All the plates are rigidly and immovably fitted closely together by ligamentous material....[12]

On the aboral side of the urchin, a special system of plates surrounds the periproct. This consists of five larger "genital" plates, each of which is pierced by a genopore, and five smaller "terminal" plates, each pierced with a single hole through which terminal pediums emerge. Further, "One of the genital plates is larger than the others and is peppered with numerous pores, thus revealing itself as the madreporic plate or madreporite."[13] These are shown in the aboral view of Figure 3-2.

Between the spines on the aboral and oral sides of the sea urchin, and on the peristome, though only sparingly on the periproct, are minute appendages called pedicellariae. These consist of a head composed of three movable jaws mounted on flexible stalks of varing lengths. The jaws are moveable and are provided with sharp serrated edges or teeth. There are four types of pedicellariae, each of which occurs in

---

[12] Ref. 25. p. 445

[13] Ref. 25, p. 445

numerous shapes and sizes. One type, however, the "glandular," is of particular interest in that its teeth are serviced by glandular sacs which secrete a toxic venom.

The pedicellariae serve three apparent purposes. First, they provide a defense mechanism which enables the sea urchin to bite and hold antagonists. Second, they allow the urchin to capture animals that come within reach and in some cases stun the animal, or paralyze it with its venom , so that it can be moved to the peristome region and eaten. Third, they enable the sea urchin to move away unwanted foreign matter that may collect on its plates and spines.

Around the sea urchin's periphery, in the ambulacra region, are "podia," or tube feet. These are usually arranged in five double rows on the ambulacra, extending in symmetrical patterns from peristome to periproct. They are usually long and slender and in most cases have a terminal disk or suction cup at the outer tip. These are used primarily for locomotion while podia without the disks or suckers, which terminate at a blunt or rounded end, serve in a sensery capacity.[14]

Internal Characteristics

Figure 3-3 shows the internal arrangement of a sea urchin that has been split horizontally. At the center of the oral surface is the mouth which is provided with five hard teeth belonging to the chewing apparatus called "lantern of Aristotle." These teeth, which continually grow, are worn away as the urchin

[14] Ref. 25, p.436

chews the feed collected by the pedia.

The chewing apparatus is highly complex, consisting of too many inter-connected and inter-related parts to describe here. Suffice it to say that it is attached to a pentagonal pharynx by membranes, which emerges from the top of the lantern of Aristotle and passes immediately into the esophagus. The intestine is usually arranged in festoons fastened to the inner surface of the sea urchin's test by mesenteries. The intestine winds around to the rectum which passes up to the periproctal surface to the anus.

Figure 3-3 also shows the internal arrangement of the sea urchin's reproductive system which consists of five gonads. These gonads are sometimes fused and are not necessarily spaced as evenly in the pentamerous symmetry as depicted. The gonads are suspended by mesenterial strands along the inner surface of the interambulacra.[15] "At its aboral end each gonad narrows to a short gonoduct that exits by the gonopore in the corresponding genital plate of the apical system."[16] Further, "The gonads consist of an outer coelomic epithelium, a middle layer of muscle fibers and connective tissue, and a lining of germinal epithelium."[17]

The digestive and reproductive systems make up the interior of the test, or body, of the sea urchin, which has been described as a spacious coelom, or body cavity. This coelom is filled

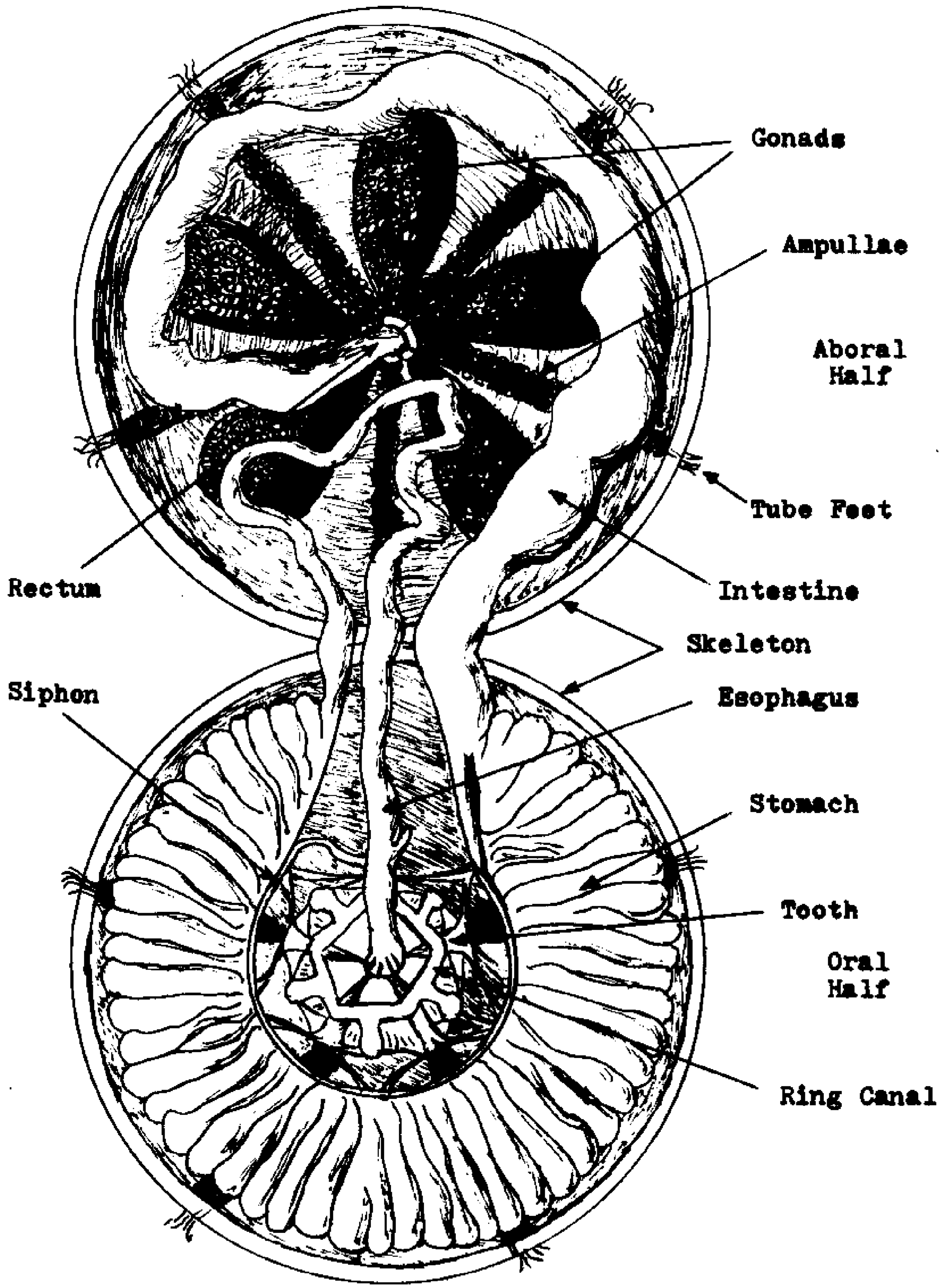
---

[15] Ref. 25, pp. 477-478

[16] Ref. 25, p. 478

[17] Ref. 25, p. 478

Internal Arrangement of an Echinoid, or Sea Urchin



Source: Ref. 55

Figure 3-3

with a fluid that is very similar to sea water. It floats freely throughout the body tissues and organs.

In addition to the digestive and reproductive systems described, the sea urchin possesses a fairly advanced nervous system and water-vascular system. Neither is really critical to this discussion. While the nervous system will be discussed somewhat further under the section on "Sea Urchin Biology," consideration of the water-vascular system is dropped at this point. It serves in the joint capacity of a respiratory and circulatory system to the sea urchin.

Sea Urchin Biology

Sea urchins are usually colored in uniform, plain, dark shades. They are most commonly found in green, brown, purple, and black, though a few are red or even pale white. They are usually of two genders, either male or female, although some have been discovered possessing some combination of male and female gonads in the same body. For all intents and purposes it is impossible to distinguish the sex of an urchin from an external examination.

Sea urchins have a fairly complex nervous system but do not possess a central brain. Besides actuating and coordinating body functions, the system serves in a sensory capacity. Inputs from the spines, podia, and pedicellaria enable the sea urchin to search for and capture food, move from place to place, right itself if turned upside down, and coordinate its efforts by moving itself, its spines, or both toward or away from any source of stimulation.

Reproduction occurs through the simultaneous discharge of eggs and sperm into sea water. Fertilization and development ensue immediately. Cells divide very rapidly and at the eight cell level two separate poles of the developing organism can be readily identified. One pole is defined as the vegital pole, and the other as the animal pole.

> .... After fertilization, the resulting Zygote embarks on a series of cleavage divisions which occur very rapidly (½ - 1 hour per cell cycle) and without intervening growth...
> Subsequent cleavage divisions occur in all parts of the embryo eventually giving rise to a hollow ball of cells; the blastula.... The period of cleave lasts 8 - 18 hours depending on species and temperature. At the end of this time the embryo secretes an enzyme, hatching enzyme, which digests the fertilization membrane and the embryo emerges as a swimming blastula.[18]

Figure 3-4 shows the progress of the developing sea urchin from fertilization through the first four months. As can be seen in this figure, the vegetal pole of the blastula flattens, and the developing cells begin to withdraw to the interior. This commences the gastrula stage which lasts from 1 to 2 days. The gastrula alters into a larva type, the pluteus. After 4 to 6 weeks of development in the pluteus stage, the pluteus undergoes metamorphosis into a young urchin. This final stage of sea urchin development is shown in Figure 3-5. The event usually occurs in less than an hour. The outer wall ruptures and shrinks back

---

[18] Ref. 26, pp. 11-12

Sea Urhins: The First Four Weeks

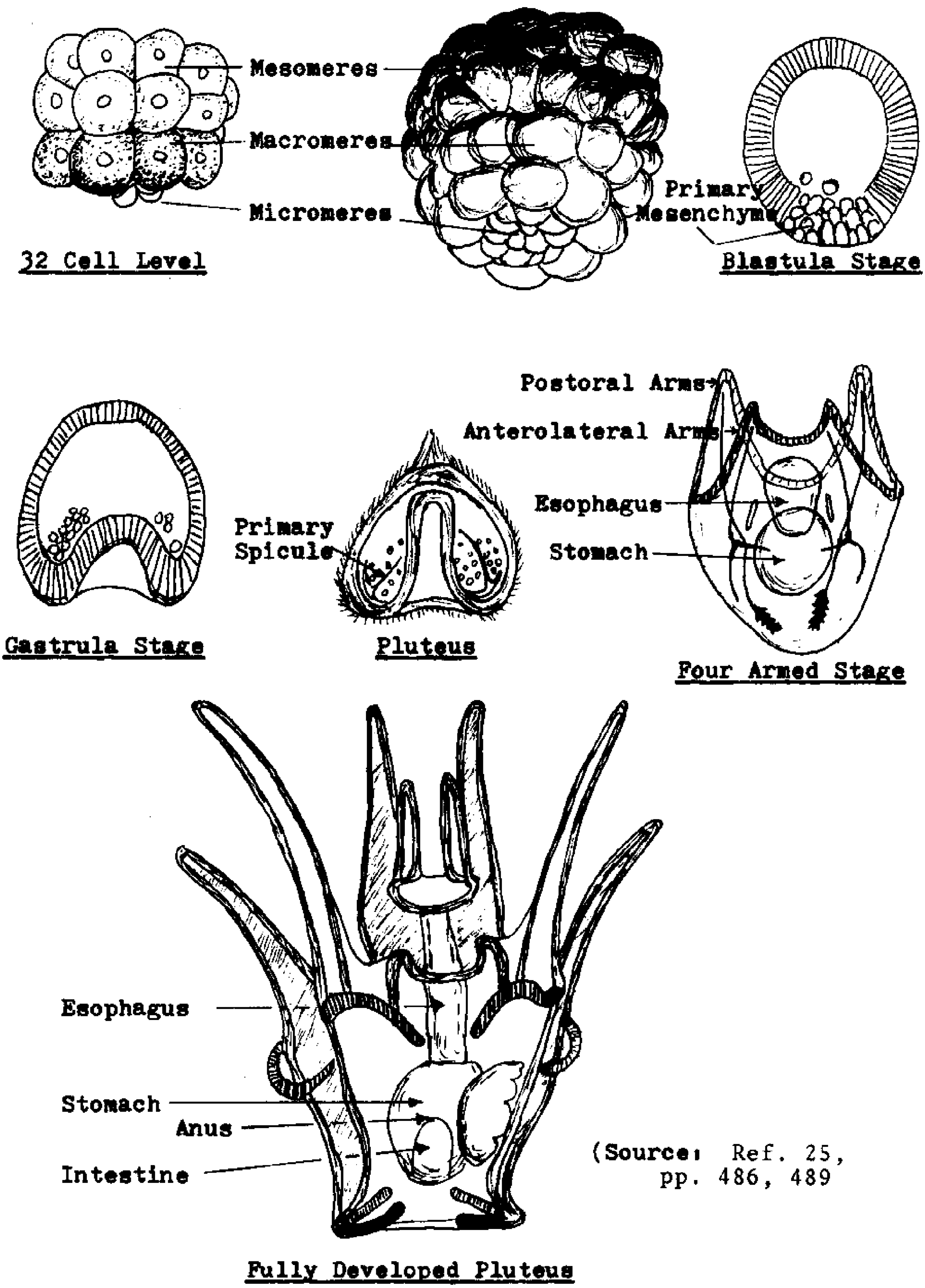
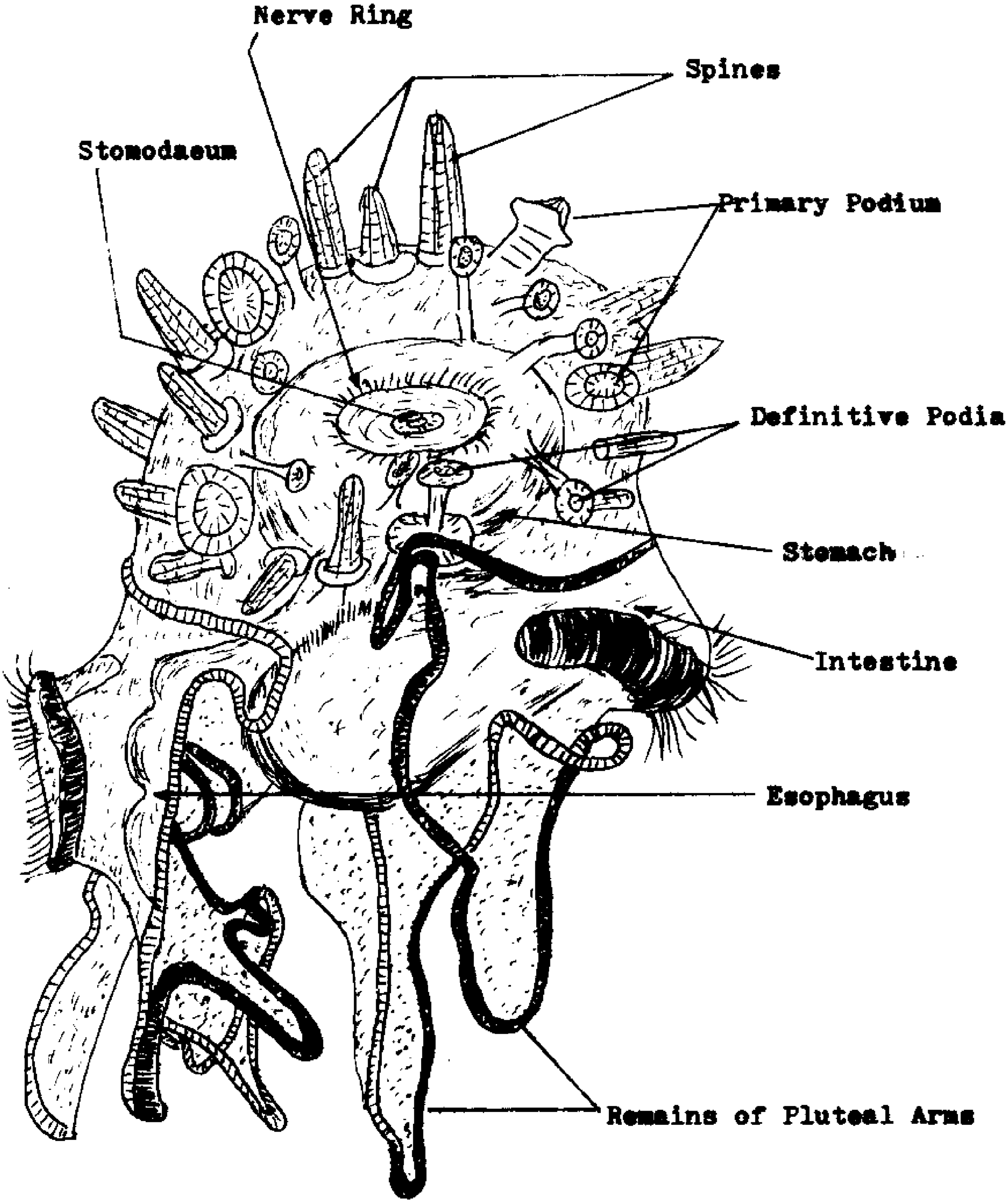


Figure 3-4

Metamorphosis of the Young Sea Urchin



Source: Ref. 25, p. 499

Figure 3-5

allowing primary podia, spines and any additional podia that have developed to emerge to the exterior. The urchin continues to develop after metamorphosis and grows with size as a function of species, temperature, and the food supply. The urchin grows from a body diameter of 1 mm to 10 mm in 8 months, and 20 mm át 1 year. Under laboratory conditions it was found that sea urchins grew to approximately 26.2 mm in diameter at 2 years, 29.2 at 3 years, 30.3 at 4 years, 37 at 5 years, and 38.7 mm at 6 years.[19] It was also found that specimens of Strongylocentratus drobachiensis collected off the Norway coast measured 0.5 mm at metamorphosis, growing to 5 to 6 mm in diameter at 1 year, 15 mm at 2 years, 24 at 3 years, 40 at 4 years, 50 at 5 years, and 60 at 6 years. The largest specimen, 78 mm in diameter, was assumed to be approximately 8 years old.

It can be seen that growth rates are quite erratic in this phylum although it can be concluded that the species under consideration, Strongylocentratus drobachiensis, develops more rapidly. It is also concluded that urchins live for up to 6 years, on the average, and are usually capable of spawning after their first year.

---

[19]Ref. 25, p. 588

[20]Ref. 39, pp. 414-415

Ecology: Habits and Behavior

Echinoids are exclusively marine benthonic animals and all their activities and adaptations occur on the ocean bottom. The oral surface always stays in contact with the bottom as the urchin moves about in search of food. If overturned, the coordinated action of spines and podia serve to return the urchin to its normal position.

Sea urchins generally move over top of food, holding it with spines and podia, and chewing it with the lantern of Aristotle. If food comes in contact with the aboral surface, it is pushed toward the mouth by the coordinated action of spines and podia. Food is detected at distances which average up to 18 inches, at which time the urchin moves in a round about fashion, until it is approximately 12 inches from the food, then in a straight line, over obstacles etc., to the food.

Food for sea urchins appears to consist of almost anything, but some tend to be carnivorous, others herbivorous, and in the absence of preferred items, they ingest bottom material and act as general scavengers.[21] Urchins with carnivorous tastes subsist on sissile and encrusting organisms such as hydroids, bryozoans, barnacles, sponges, dead fish, fish eggs, snails, snail eggs, crustacean legs, etc. Those with herbivorous preferences feed on plankton, kelp and seaweed, sometimes remaining in one spot for the 2 to 3 weeks required to chew and digest a bunch of seaweeds.

---

[21]Ref. 25, pp. 553-554

Sea urehins usually inhabit roeky or partially rooky bottom, or other types of hard bottom, although some may be found on sand. Coral reefs seem to constitute a very favorable habitat for large numbers and kinds or sea urchins. In such suitable spots it has happened that urchins collect in such large numbers as to completely blanket a particular bottom area.

One noteworthy capability of the creature is its boring capacity. Sea urchins dig burrows into hard rock and coral, apparently as a protective measure against waves. In some cases the urchins dig so deep and grew so large that they are unable to get out of the entrance to the hole which they made when younger and smaller. In these cases the urchin must depend on food washed up to it by tidal and wave action. All doubt as to the boring capability of the sea urchin was laid to rest by a study of the boring activities of Strongylocentratus purpuratus, which had caused extensive damage to steel piers on the coast of California by boring deep burrows into the steel pilings in which the urchins were found.

Sea urchins tend to shy away from light, preferring shaded areas and the darkness offered by crevices in coral reefs or by their own burrows. Urchins sometimes cover their aboral surface with plants, shells, etc., holding the debris in place with their podia, in effort to shade themselves from light. In addition to this aversion to strong light, sudden increases and decreases in illumination cause a very definite reflex reaction of a defensive nature. The spines erect themselves and point to the source in the same manner that they would if mechanical stimulation had been applied.

Despite their armature of spines and poisonous pedicellariae, sea urchins fall prey to other animals such as crabs, sea stars, large fish, mammals, and birds. "The gonads when ripe are highly nutritious and are eaten, either raw or after roasting in the half shell, by man in various parts of the world."[22]

Sea urchins serve as hosts to a variety of parasitic animals, internally and externally. The spines being devoid of living tissue can become encrusted with a variety of sissile organisms such as barnacles, algae, sponges, anemones, hydroids, bryozoans, etc. Internally the intestinal tract is often infested with great numbers and varieties of ciliates. Mortensen records that the Japanese Mespilia globulus "is very generally infected with a trematode living in its genital organs and destroying these more or less completely."[23]

Snails feed upon the surface tissues of sea urchins, fastening their egg masses to the test. This is particularly common with Strongylocentratus drobachiensis, which is

---

[22]Ref. 25, p.581

[23]Ref. 39, pp. 414-415

primarily herbivorous.

Summary: Strongylocentratus drobachiensis

The Strongylocentratus drobachiensis is geographically distributed throughout the north European and North American coasts. It is a circumpolar species which inhabits both the North Atlantic and North Pacific, reaching as far north as Discovery Bay, north of Greenland, at 81° north latitude.[24] It is also found in the Bering Strait, north of Russia and Siberia. It is the most common species, if not the only one, off the coast of Maine, and therefore is of greatest importance to this discussion.

Strongylocentratus drobachiensis is primarily herbivorous.

> ...The food habits of S. drobachiensis seem to vary with locality: in Puget Sound it eats mostly seaweeds and resorts to animal material only when plant material is not available (Weese, 1916); also on the eastern Canadian coast this species eats mainly seaweeds and similar material scraped from rocks plus fish refuse from adjacent canneries (Dawson, 1868); but Eichelbaum's specimens from the Baltic contained chiefly diatoms, tube worms, and hydroids, with smaller quantities of other animals.[25]

Its embrological and larval development are the same as that previously described. It was noted earlier that its growth rate is more rapid than that of other species, increasing in size at about 10 mm diameter every year after the first year. It was also noted that it was capable of spawning after its first year.

Spawning usually occurs in late spring or early summer.

---

[24]Ref. 25, pp. 575, 581

[25]Ref. 25, p 554

Spawning usually occurs earlier the more southern the latitude. It is therefore assumed that the Strongylocentratus drobachiensis is entering its spawning season in April or May. In actuality very little is now known about the reproductive aspect of the sea urchin from a macro perspective. There is need for further research in this area to determine number of eggs spawned each cycle, larval survival rate, young urchin survival rate, sensitivity of urchin population to such factors as sea urchin density in any given area, water temperature, quantity of food available, etc. There is a need for more information on where and how the urchin fits into the ecological cycle of the Maine coastal zone. Calculation of a maximum sustainable yield is dependent upon quantifiable information on the sea urchin's reproduction capabilities, behavior, and habits. The harvesting of the Strongylocentratus drobachiensis should not be undertaken until more is known about its own reproductive capacities and its relationship with the ecological cycle.

CHAPTER IV

THE BEHAVIORAL ENVIRONMENT

Introduction

SMART requires vast amounts of qualitative information in the formulation of its developmental models. Such information shapes the design and final conceptual structure of the various networks and the aggregate system. Qualitative inputs also serve to temper the probabilities that would be derived from purely quantitative and statistical data. For these reasons, this chapter discusses and presents as much qualitative information as possible relating to the potential development of Maine's underutilized sea urchin resource.

Before proceeding further, therefore, it becomes increasingly desirable to consider the many facets that comprise the behavioral environment of the state of Maine. For purposes of this analysis, these facets have been divided into legal, economic, and social perspectives. Consideration of each of these in turn provides the necessary insight for building a qualitative data base.

Developing an information base

The Legal Component. The laws of a state frequently reflect the attitudes and values of its citizenry. Maine is certainly no exception. Its laws and court decisions reflect conservatism, individualism, and a high regard for the rights of its individual citizens. The clearest example of these attitudes is provided by the adjudicative proceedings which have served to shape Maine's concepts of a riparian land owner's water rights. Maine's concepts of riparian rights differ significantly from those that have evolved in the other Atlantic coastal states.

The early Maine case of Blanchard v. Baker[1] held that any diversion of water which was not returned was actionable even though there were no actual damages. This interpretation was based on the riparian owners right to the water undiminished in quality or quantity. The difference in this opinion was that in most other states some form of damage had to be shown before diversion of water which was not returned could be considered actionable.

In the Lawrence v. Lockwood case, the Maine Supreme Judicial Court weighed a dispute between two riparian owners. In this case, Lockwood, a downstream riparian textile owner, attempted to enjoin Lawrence, an upstream and chronologically earlier saw mill operator, from discharging sawdust edgings, shavings and other material into the river which hindered the textile mill's operations.[2] The court did not grant the injunction on the grounds that the lumber mill provided a greater economic service to the community.

The results of these two cases had a profound impact on the decisions rendered in many cases that followed. These decisions, in turn, continued to shape Maine's concepts of

---

[1] 8 Me. 253, 1832.

[2] 77 Me. 297, 1885.

riparian rights.

In Kennebec Water District v. Maine Turnpike Authority, the water district sought remuneration for damages to its ability and right to take water from a brook and distribute it for public use.[3] The district claimed that the Turnpike Authority had constructed a bridge over the brook, mudding the waters, making it unfit for distribution. The court referred to the Lockwood case and interpreted the phrase, "the rights of the owners are not absolute but qualified, and each party must exercise his own reasonable use with just regard to the like reasonable use by all others who may be affected by the acts."[4] In this case, however, it was held that reasonable use pertained to reasonable "riparian" use. Therefore, because the water district was not a "riparian" user, no remuneration for damages was granted.

In the Stanton v. Trustees of St. Joseph's College case, the courts continued to develop the reasoning laid down in the Blanchard v. Baker and Kennebec Water District cases.

> ...The private college, located at some distance from a non-navigable brook, proposed to build a new dormitory which would necessitate the emission of 50,000 gallons of liquid residue per day. The college acquired a small parcel of land adjacent to the brook as well as easements permitting it to lay sewer pipes from the dormitory site to the riparian parcel, to discharge into the brook. The effluent was to be treated so as to leave the quality of the water virtually unchanged while only slightly increasing its quantity. The proposed discharge of effluent had been licensed by the Environmental Improvement Commission.
>
> The court held that the plaintiffs, downstream riparian proprietors, had a right to have the waters

---

[3] 145 Me. 35, 71 A. 2d 520 (1950); 147 Me. 147, 84 A. 2d 433 (1951).

[4] Ibid., p. 44.

> of the stream unchanged in quantity or quality except by reasonable riparian uses of other riparian owners; that riparian uses are only those uses of water which benefit adjacent land; that the waste disposal use contemplated by the college, not being for the benefit of the small riparian parcel, was not a riparian use, and thus was unreasonable as a matter of law. The Court took notice of the license issued by the Environmental Improvement Commission, but held that the agency was incompetent to rule on rights as between private individuals....
>
> The decision in the St. Joseph's case is an unfortunate one. By giving the riparian owner injunctive relief when there was no actual harm to the quality of the water and only a slight augmentation of the quantity, the Court placed technical private rights above the public interest in sewage disposal.[5]

The most important point brought out by these cases, is the emphasis placed upon private riparian rights. Maine apparently places a very high value on the private rights of its citizenry to the point where private rights are to be maintained even to the detriment of the public good.

The Economic Component. The primary interest of this study centers upon Maine's coastal fisheries. It is useful, therefore, to develop a feel for how and where Maine's fishing industry fits economically into the rest of Maine's economic coastal environment. In January of 1970, for example, Maine's Department of Sea and Shore Fisheries estimated that Maine's fishing resources accounted for an annual landed value of $26 million.[6] Assuming these figures remain fairly constant from year to year, where does Maine's fishing industry fit in relation to its other coastal industries?

---

[5] Ref. 46, pp. 461-462

[6] Ref. 42

Recreation is Maine's second largest industry.[7] Since timber and forest products constitute Maine's largest industry, recreation could be identified as its largest coastal zone industry. It has been estimated that tourism brought $348 million to Maine in 1967 and $400 million in 1968. This represents a significant competing use for Maine's coastal resources since the great majority of out-of-state vacationers congregate in the coastal towns and along the shore. A very significant factor is that only 34 miles of Maine's 2,162 miles of shoreline with recreational potential is now in public ownership.[8]

Maine's mineral industry brought in revenues of $17 million in 1968. Sand and gravel accounted for $6 million of this figure. Maine's activities in the mining area in the past have included quarrying for building rock for export, limestone, copper, lead, zinc, gold, silver, molybdenite, mica, serpentine, and grinding pebbles. While quarrying and other mining activities are fairly dormant today, copper and zinc mining in Penobscot Bay are still quite active.[9]

---

[7] Ref. 45, p.37

[8] Ref. 46, p. 507

[9] Ref. 28, p. 77

Maine's coastal areas, like that of most of the coastal states, have suffered from developmental pressures. Real property valuations in coastal towns rose 57% from 1960 to 1970 representing a total market value of $3.2 billion. The estimated median value of year-round homes in coastal towns rose 63% over this period. The number of homes used as permanent residences in coastal areas increased from 137,000 units to 146,000 units over this period leaving 23,000 or 39% of the states total seasonal homes in the coastal area.[10]

The economic implications for power generation and use in the state of Maine are quite profound. Projected demands for electric power nationally, in New England, and in Maine, are staggering. At the national level, it has been estimated that with little or no increase in population, power requirements over the next 30 years will grow to 2½ times present consumption levels.[11] In New England, where the growth rate has been a traditional 7%, projected demands are expected to quadruple in the next 20 years.[12]

It has been estimated that 70% of the power produced in New England by 1990 will be by nuclear power plants. These plants will require approximately 1 million tons of cooling water per day per megawatt generated.[13] Maine's coast,

---

[10]Ref. 32, p. 106

[11]Ref. 28, p. 114

[12]Ref. 45, p. 59

[13]Ref. 45, p.59

with its year-round cold waters offers an ideal location for the siting of power plants. The temperature of Maine's water is 60 degrees F or lower during the summer. Presently, only one nuclear power plant is in operation in Maine, in Wiscasset. This facility is expected to serve as a pilot project to test the feasibility for siting other nuclear plants in Maine's coastal zone.

It is interesting to note that approximately 65% of Maine's electric power is generated from fossil fuel sources, the remaining 35% being attributed to water power.[14] It is also interesting to note that Maine's cost of electricity is as much as 30% higher than the national average. This seems quite illogical at first when it is realized that the value of petroleum products crossing Maine's borders each year is estimated at $541,000,000. Portland Harbor is the largest crude oil handling port in New England, and the second largest in the nation. The reason for the higher costs becomes evident when it is realized that 80% of Portland's imported crude is transshipped to Montreal and the 20% that is left is generally marketed for refining purposes. Ninety to 95% of Maine's energy requirements are then imported from outside sources. It should also be noted, however, that this oil transhipment industry accounts for approximately $27 million in revenues annually.[15]

---

[14]Ref. 32, p.84

[15]Ref. 42

The Social Component. Social factors will play the dominant role in determining the ultimate success or failure of the sea urchin processing and marketing venture. The Japanese social values and norms will affect the sale and marketing of the processed or bulk roe. The social values and norms of Maine's citizens, however, will shape the ultimate processing, harvesting, domestic and international transport network. Both are important. Unfortunately, little information is currently available about the socio-cultural norms of the Japanese and/or the buying habits of the Japanese housewife. Consequently this section is limited to consideration of Maine's social characteristics only.

That same single characteristic that was exemplified in the discussion of the legal component stands out just as noticeably in the social perspective. The Maine citizen seems best typified under the general category of "staunch individualism." A discussion of the attempt to introduce aquacultural enterprise into the state of Maine best serves as the vehicle for developing this point. According to a recent study on the subject:

> A formidable obstacle inhibiting the development of an aquaculture industry in Maine is the individualism of Maine's coastal inhabitants. Although the independent manner of these taciturn citizens enthralls tourists, it has also dislodged many attempts to gain a foothold for even minimal aquaculture development on the Maine coast.
>
> Efforts to introduce aquaculture have often failed because aquaculture requires the cooperation of large numbers of people...Although ignored by public relations men, the individual's preference for self-reliance is usually tightly interwoven with a keen distrust for organization. The changes in laws, traditions and personal hierarchies requisite for

> aquaculture do not come easily in this environment. Many coastal organization failures can be attributed to this problem, and each failure increases the individual's conviction that he is wise to labor alone.[16]

Of course, aquaculture is not the only industry to suffer from this social constraint. According to Ivan W. Fly, President of Seafoods U.S.A. of Damariscotta, "We cannot indefinitely continue to operate in the 1970's as we did in the 1930's. Petty jealousies and a lack of willingness to help anyone but yourself is what is killing the infant marine industries of Maine."[17] It stands to reason that the social and cultural elements of the Maine coastal industries must be thoroughly considered when formulating any overall plan for harvesting, processing, transporting, and marketing sea urchin roe.

The Maine Fishing Community

General Background. U.S. domestic fisheries have maintained an annual production level of 5 billion pounds despite increasing national needs. Per capita consumption has increased steadily over the last 25 years while total landings of fish and shell fish has steadily declined. Looking at Maine's fishing history provides insight into how and why this trend has developed in Maine and in all the New England coastal states.

The Gulf of Maine is bounded by the Maine coast, Nova Scotia, Cape Cod, and Georges Bank. This relatively shallow basin of water is continually stirred by the warm Gulf stream

---

[16]Ref. 32, p. 39

[17]Ref. 32, p. 39

making it one of the most fertile and rich fishing areas in the world. Since the beginning of colonization of the New World, fishing industries have flourished along the Maine Coast. In the early 1800's an extensive mackerel fishery sprang up in Eastport and herring catches continued to grow until the turn of the century, when over two hundred smoke houses operated along the Maine coast.

> As smoked herring faded in popularity, a process was devised to package sardines in hermetically sealed containers, giving birth to the sardine industry. By the early 1900's fourty-five sardine canneries packed herring caught in the Gulf of Maine. Until only recently, when the industry has been forced to import sardines from Nova Scotia, the production of the sardine industry was greater than any other Maine fishery.
>
> Technological innovations in canning and shipping methods greatly expanded markets accessible to the fishing industry. The processing and sale of several species such as menhaden flourished and then failed. The menhaden fishery, after growing to a multi-million dollar industry in fifteen short years, crumbled suddenly when the fish disappeared from coastal water in 1878.[18]

After the collapse of the menhaden industry, fishing emphasis shifted to the lobster which grew from a half million dollar industry in 1880 to a 16 million dollar industry in 1969.[19] Northern shrimp fishing was the most recent industry to develop in Maine where heavy catches from 1965 through 1969 prompted heavy capital investment in boats, gear, and processing plants. In 1970 the catch of both shrimp and lobster failed leaving both industries heavily

---

[18] Ref. 32, p. 4

[19] Ref. 32, p. 4

overextended in capital and labor.[20]

This brief summary of Maine's history in the fishing enterprise serves to identify two trends which account for the current lack of success of the New England fishing fleets. First, while total landings of fish and shell fish have continually declined, the levels that have been sustained have resulted from shifts from one fishing resource to another. Second, any success encountered in a particular fishing resource has resulted in a flood of capital and labor intensive investments, resulting in over-fishing of the resource, producing poor catches in the following years, leaving many failing industries struggling for their very existence. The ultimate result of this unfortunate sequence is the extreme hesitation that is expressed by members of the fishing community to explore and enter new areas of endeavor. This precludes such activities as researching species to be harvested, coordinating efforts among competitors, planning, innovating, etc. This, in turn, carries some grave implications for the potential management and development of any new coastal resource.

Future Promise for Maine Fisheries? In an industry plagued with uncertainty and unpredictability, one innovative solution has been singled out as being the most likely method for salvaging the Maine fisheries industry. This method has been termed aquaculture and involves the growing, harvesting,

---

[20]Ref. 32, p. 5

and processing of seafoods under controlled conditions. Thus aquaculture would introduce a great deal of certainty and predictability into the fishing industry. This topic has a very decided impact on the topic at hand. The aquacultural development of sea urchins, as can be seen with reference to the model and problem solution offered in Chapter V, could greatly reduce the overall costs of the venture.

As has been mentioned earlier, the development of aquaculture enterprise in the state of Maine would not be without difficulty. Despite the promise offered by this fisheries innovation, obstacles to the development of aquaculture in the state of Maine are quite formidable. An enterprise of this type would require legal protection in the form of some type of regulating mechanism that would provide short or long term leasing arrangements, zoning laws to prohibit encroachment and deleterious effects of domestic or industrial activity, permission to conduct experimentation in polluted areas, etc. Unfortunately these activities touch upon areas already covered in Maine fisheries laws which were developed around conventional fishing philosophies and technologies of a by-gone era. These existing laws are quite inflexible to the interpretations that aquacultural enterprise would require. In addition, the sanctions that might be required go against the interpretation of riparian rights as it has developed in the state of Maine. Existing state health requirements, residency requirements, zoning requirements, etc. all pose problems that would have to be overcome for any aquaculture enterprise to be developed in the state of Maine.

This has not been to say that aquaculture is an impossibility in Maine, nor that laws do not exist which make provisions for aquacultural activities in the state. There are indeed provisions in Maine law for the aquaculture of clams, quahogs, and mussels.[21] These laws, administered by municipalities provide for one fourth of the total area of all flats and tidal creeks to be leased for periods of from five to ten years. In unorganized towns this responsibility falls upon the Department of Sea and Shore Fisheries.[22] Provisions have also been made for the aquaculture of oysters. These provisions do not rely upon the Department of Sea and Shore Fisheries or Municipalities since the legal arrangements for the aquaculture of oysters predates the Department of Sea and Shore Fisheries. The right to use waters for these purposes is subject to the assent of adjacent riparian owners.[23]

National demand for lobster, oysters, clams, shrimp and other seafoods certainly justifies the required research needed for establishing domestic aquacultural enterprise on an economic basis. According to Dr. Robert Dow, Director of Research for the Maine Department of Sea and Shore Fisheries, "There is no valid reason why the production of food and

---

[21]Ref. 54, pp. 343, 349-350

[22]Ref. 47, pp. 673-674

[23]Ref. 47, p. 674

pharmacologicals from the sea cannot become Maine's primary industry, employing more personnel at higher salaries than any other industrial activity."[24]

The uniqueness of Maine's coast, situated near, and fed by the Gulf Stream, with its meandering shoreline and indentations of bays, coves, and estuaries, with its bottom conformation, tidal range, and general water circulation system, make it, "...one of the outstanding places in the world for the development of aquaculture."[25]

> The development of an aquacultural industry, even at a level which would produce raw materials valued at $20 billion a year, would not be incompatible with many other coastal activities, nor would it interfere with the continued use of the wild resource for recreational and subsistence fishing, nor even for limited commercial fishing as, for example, the resource is used at the present time. An aquacultural industry in effect simply develops a viable food, pharmaceutical, and light industrial complex based on the use of naturally occurring resources which are then increased in yield through such means as selective breeding and modified or controlled environment. It is in effect divorcing the coastal food industry from the concept of welfarism, the public domain, and primitive hunting practices. [26]

New England Fisheries-The "Real World"

If it seems incredible that the "staunch individualism" of the Maine native could be responsible for the failures and calamities experienced by the Maine fisheries industry, consider the following account from a highly reliable source.

---

[24]Ref. 14

[25]Ref. 47, p. 771

[26]Ref. 47, p. 784

"The fisheries business in Maine is probably the most competitive business in the world.... It is more than competitive...competitor's actions are vindictive.... A man will go to work every morning knowing that he's going to lose two dollars...just to keep a competitor from making money."[27]

Ralph Stevens of Stinson Canning Company, Bath, Maine stated it this way: "My father used to say that a man will throw away the whole loaf just to be sure that no one else would get a slice."[28] It is within this framework of reality that the sea urchin roe harvesting, processing, and transporting must function.

In the actual operation various combinations of fishing vessels and techniques would be employed. The harvesting operation would be carried on by independent operators. Each fisherman would make a determination every morning of every day as to whether or not to go for sea urchins or for some other catch which is more profitable. His decision will usually be based upon the per pound value offered for the respective catches. For example if the going price for sea urchins is $1.00 and shrimp is $1.20, per pound, the fisherman will go out after shrimp in most instances. This means that the processor faces an highly probabilistic input of the raw product and/or an highly probabilistic cost for the material.

---

[27]Statement of an executive of a Maine processing company, personal interview, May 1973.

[28]Statement of Mr. Ralph Stevens, Stinson Canning Co., Inc., Bath, Maine, personal interview, 6 July, 1973.

Maine processors are very much aware of this fact. They also realize that the fisherman are, in most if not all instances, completely unaware of the interdependent nature of their respective activities. Fishermen do not seem to realize that their livelihood is dependent upon the processor as well as vice versa. The combination of these two factors necessitates that the processor travel to various drop points along the Maine coast each day to negotiate for the bulk product. The processor is also aware of the fact that the going price for sea urchins, which is currently fluctuating between $4 to $5 per bushel will go up to at least $6 per bushel if the enterprise is successful and starts to generate any volume.[29]

The factors to consider in the processing plant itself are also quite significant. One Maine processor, drawing upon experience gained from previous endeavors in processing new marine products, estimated that his company could reasonably expect a proficiency gain of 2.5 on the processing of sea urchin roe. This means that if the plant personnel manage to process 100 lbs of roe during the initial test runs, an expected yield of 250 lbs of roe should result during the same period of time once the processing operation was fully established.

It was also anticipated that the current wage rate of $1.80/ hr would be increased in the near future to $2.20/hr. Using the $2.20 figure as the evaluation base, it was fully expected that all initial sea urchin roe processing would be

---

[29] This information, and the information that follows represents a condensation of material provided by several Maine processing companies through personal interviews conducted during May, June and July of 1973.

initially costed at the hourly rate. It was speculated that if the venture turned out to be profitable, the processing companies would most probably shift to piece work rates. This would result in a wage increase of up to $3.00 to $3.40/hr with at least a doubling of production. Therefore, the processing cost per pound would be reduced. The cost of supervision would be increased, however, since piece work usually generates sloppy production. This realization is quite important however in view of the fact that the workers realize that the per unit cost figures, which determine the wage they receive once the shift is made to piece work rates, are based upon production results at the hourly rates. It is therefore anticipated that plant personnel will deliberately "drag their feet" during the hourly wage rate phase.

Shifting attention to the marketing aspect, one might question the Japanese interest in Maine seafoods. The interest is apparently quite real and based upon several factors. First, the Japanese consumer is becoming more sophisticated and much wealthier. The market for such delicacies as sea urchin roe, therefore, is expanding. Second, U.S. Government officials have made it clear to the Japanese that new ways must be found for reducing the trade deficit between these two countries. The Japanese Government, therefore, has stimulated its large trading companies to search for and help develop American products which could qualify for sale in the Japanese market. Third, the revaluation of the yen has made American products appear less expensive to the Japanese consumer, and therefore, appear more attractive. Fourth, the Japanese, who rely heavily upon seafoods for one of the country's principal source of protein have witnessed a serious scarcity of preferred seafoods.[30] The sea urchin falls into this category.

The Japanese sea urchin roe market is subject to wide price fluctuations each day. It is also a very seasonal market. The market price for sea urchin roe is lowest in the summer, picking up in September and reaching its peak in December and January. By early March the price begins to drop rapidly, returning to the summer low. These prices can fluctuate from $2.00 to $10.00 per pound in a season.[31]

Maine sea urchins begin to ripen in October, hitting their peak in January and February. By March and April they are ready to spawn and their value at that time begins to decrease. It is very much to Maine's advantage that their sea urchins ripen conincident with Japan's peak seasonal demand. One further advantage accrues to Maine's sardine processors specifically. Sardines are also seasonal and their availability reaches its peak during the summer, tapering off to practically nothing by late fall. Processing facilities then lie dormant during most of the winter, switching over to shrimp processing in late winter or early spring, then back to sardines in late March or April. Obviously the sea urchin roe venture is an attractive countercyclical enterprise that would enable the sardine processor to utilize his facilities and provide employment for his workers during what would otherwise be a slack time.

---

[30]Ref. 5, p. 9

[31]Ref. 5, p. 3

Looking to the international transport problem, one finds three airlines Pan Am, TWA, and Japan Airlines with the facilities to service the New York to Japan market. of the three Japan Airlines offers the best scheduling and handling package. Surprisingly, however, Japan airlines, or any of the other airlines for that matter, would not be overly excited at the prospect of handling and shipping sea urchin roe. As it turns out, the winter season is the airlines busiest time of year. It is also the time of year when the airlines receive their greatest quantity of high dollar density, "hard" non perishable items. Perishable items, and particularly highly perishable items like sea urchin roe require more careful handling, much closer observation, and generate larger amounts of paper work than their non perishable counterparts. As a result, the airlines would much rather be handling something else. To further complicate matters, the airlines are plagued at this time of year for vacation requests from their employees which means that they are somewhat under-staffed at this particular time of year, not to mention over-time expenses, etc. which they encounter during their winter months of operation.

This concludes the "real world" presentation of behavioral factors that directly or indirectly affect the sea urchin roe venture. It is now time to commence structuring a model of the system based upon these behavioral factors, statistical data, and available cost information. Once this is done, the overall feasibility of the venture can be evaluated.

CHAPTER V

CONSTRUCTING THE MODEL

Step One: The Systems Approach

Establishment of Boundaries. The system must encompass all the factors that influence the eventual success or failure of this particular investment opportunity (i.e. to develop Maine's underutilized sea urchin resource). This includes all five stages of the potential operation, harvesting, processing, domestic transport, international transport, and marketing. Therefore, the system's boundaries are established as follows:

The legal geographic borders of the state of Maine and the coastal waters which extend from Maine's shore to the designated outer limits of the contiguous zone bounds the harvesting and processing stages of the system. This boundary also includes all the labor, capital, and other monies subject to the direct control of Maine's local, regional, and/or state governments, agencies, organizations, or businesses. More specifically, all people who reside or derive all or any part of their income from the state of Maine within these designated bounds, including their socio-cultural norms and values, habits, and any other characteristics which make up the behavioral aspect of the state's activities are included in these bounds.

The domestic transport stage consists of several transportation branches, each of which is bounded by the physical path covered by the transport vehicles. This includes all major and minor roadways, railways, sea lanes, and/or air corridors outside of the state of Maine, extending from Maine's boundaries to Boston and/or New York. This further includes the property boundaries of all scheduled road/rail/sea/or air service agencies, storage, and trans-shipment facilities. Also included are all personnel outside the state of Maine who transport, load or unload, or inspect the transported commodity, including the transport vehicles, and all behavioral factors which typify or are characteristic of each of the respective transporting industries. Not included within system bounds are the transport companies, their owners and operators, other commodities carried on the respective transport vehicles, state and federal regulating industries and agencies, and any other activities not directly involved with sea urchin or sea urchin roe movement.

The international transport stage consists of several transportation branches, each of which is bounded by the physical path covered by the transport vehicles. This includes all sea lanes from Portland, Boston, and New York harbors to Tokyo harbor in Japan, and all major airways from Kennedy International Airport in New York to Tokyo and Osaka airports in Japan. These boundaries include all scheduled airport stops, all scheduled seaport stops and the Panama Canal, all transport vehicles and their crews, and the behavioral characteristics of the transportation companies and their crews. These boundaries also include U.S. and Japanese Customs Agencies.

The marketing stage is limited to the personnel that make up the Japanese trading companies, the trading companies, and the transportation companies, vehicles, and personnel that distribute the product to the consumer in the market place. Unfortunately too little data is available about this facet of the operation to permit an in-depth analysis of the factors which contribute to the marketing of fresh or frozen roe in the Japanese markets.

Establishing System Taxonomy. The system has been conceptually divided into the five stages of: harvesting, processing, domestic transportation, international transportation, and marketing. System interfaces, therefore, are located between harvesting and processing, processing and domestic transportation, domestic transportation and international transportation, international transportation and marketing. This taxonomy is both functional and logical.

It should be noted that the system could be divided in several other ways. For example, the system could have been divided into the three functional categories of sales, transportation, and production. Or it could have been divided according to the firms involved, i.e. each individual trading company, airline, ship operator, trucking company, sea food processor, and fishing groups. Or it could be left as it is and not be divided at all. In this case each cost could be considered as an individual expense, each alternative could then be totaled, and the least costly route through the system at any one time could be chosen. But none of these methods exhibit any characteristics that are inherently superior to the five stage method that has been selected. In fact, the five stage method is more flexible in that it will enable a very diversified set of parameters (i.e. costs, social values, work habits, cultural norms, etc.) to be integrated into the problem solution.

Statement of Purpose. The purpose of the system is to develop one of Maine's underutilized resources, the sea urchin. The purpose of the model is to structure all the parameters that influence the eventual outcome of the system, to impart understanding as to how these factors interrelate, to determine the costs associated with their interrelations, to assess the potential return on investment that could be expected from the venture, to predict the ultimate success or failure of the system.

Enumeration of Alternatives. To simplify the presentation, alternatives are listed as they occur in each of the five subsystems (i.e. harvesting, processing, domestic transport, international transport, and marketing). The various subsystem combinations that can be structured in the aggregate system, are then considered in the final model.

In the harvesting subsystem there appear to be five possible alternatives. These are: (1) Use small boats, scuba divers and boat tenders, (2) Use a relatively larger boat, suction pumps, and possibly one diver to guide the suction outlet on the ocean bottom and/or to scout for sea urchin clusters, (3) Drag the bottom using an intermediate size boat with a scallop type dredge, (4) Use a skiff and scoop the sea urchins up from the bottom with a long handled net device, (5) Use no boats and wade for them, picking up the sea urchins by hand, or any combination of the five.

The processing subsystem is faced with three alternatives. (1) Don't process the urchin but ship it in bulk instead, (2) Process the urchin and ship the fresh roe, or (3) Process the urchin, freeze the roe, and ship frozen roe. If alternative one is chosen, the processor is faced with the two sub-alternatives of shipping bulk to Japan or developing and shipping to domestic markets. If alternatives two or three are chosen, the processor is faced with four sets of sub-alternatives. These are: Set 1, (1) Ship to Japan, or (2) Develop and ship to domestic markets; set 2, (1) Use conventional labor intensive processes or, (2) Concentrate on developing some technological innovation that will permit automation of the process in whole or in part; set 3, (1) Use an assembly line processing approach or, (2) Organize small task oriented work units; set 4, (1) Use an hourly wage rate or, (2) use a piece work wage rate.

Both the domestic and international subsystems are faced with the same sets of alternatives. Further, they are both somewhat dependent upon the alternative selections made in the processing subsystem. The only exception to this general statement is the obvious exclusion of truck transport from the international subsystem. If the processor chooses to ship sea urchins in bulk, or to ship fresh roe, he is limited to truck and/or air transport in the domestic subsystem, and to air transport in the international transport subsystem. Frozen roe, on the other hand, could be shipped by land, sea, or air domestically, and by sea or air internationally. Quite obviously the frozen roe processing alternative is the most flexible from the processor's point of view and, as it turns out, the least risky. The technological feasibility of this alternative remains to be proven, however.

Unfortunately very little is known about the available alternatives in the Japanese markets. There appear to be two which are: (1) Sell to Japanese trading companies, or (2) Sell to small independent merchants. This applies to both bulk and processed shipments. It should be noted, however, that the second alternative has a very low probability of attainment since the Japanese trading companies represent huge oligopolies which market most, if not all, of Japans imports.[1]

Much better information is available on the domestic markets but none has yet been collected in quantifiable form. The possible alternatives appear to be as follows: (1) Ship in bulk to the various ethnic markets that exist in major east coast cities, or (2) ship processed, fresh roe to restaurants and restaurant chains in the major east coast cities. Interest has been expressed in Maine sea urchin roe by representatives from Japanese restaurants in New York City.[2]

---

[1] Ref. 5, pp. 4-5

[2] Ref. 5, p.2.

Assumptions

Operations.

1. Maine sea urchin roe is comparable to the Japanese product (Some Japanese sources claim that it is slightly inferior to theirs but of "good" quality, while other Japanese food experts have stated that Maine's sea urchin roe is of "superior" quality[3]).

2. Maine sea urchin roe is comparable to or of higher quality than that of California, Mexico, or Canada, Maine's potential market competitors.

3. Harvesting season will start in November, reach its peak in December and January, and end in March.

4. Because sea urchins' potential harvest yield is closely related to kelp's five year cycle, a good planning horizon is assumed to be five years.[4]

5. Traffic from Maine to Tokyo during the first five years will not be sufficient to justify a commodity rate.

6. Technological and/or marketing break throughs for frozen roe will not occur during the five year planning horizon.

7. Domestic transport rates, salaries, wages, and other costs, are assumed to be in accordance with Table 5-2.

8. All probability distributions are normal distributions, except where noted.

9. Initial harvesting operations will not approach the maximum sustainable yield.

---

[3] Ref. 5, p.2

[4] Ref. 5, p. 10

10. Fishermen will follow traditional work patterns and schedules.

11. Processing plants will operate 8 hours per day, 5 days per week.

12 Pan Am, TWA and Japan airlines will remain the only feasible carriers to serve from Maine to Japan and will not significantly vary their flight schedules or rates from those shown in Tables 5-3 and 5-1, respectively.

Decision Making. Neo-classical theories of decision making and decision behavior usually assume:

(1) Men are rational and as such will follow their rational self interest once this is revealed to them.[5]

(2) Organizations are autonomous extensions of man, pursuing goals, acting rationally, making decisions just as an individual man would do.[6]

(3) Organizations operate with perfect knowledge.[7]

(4) Organizations consider all possible alternatives when making decisions.[8]

---

[5]Ref, p. 34

[6]Ref. 10, pp. 4-8

[7]Ref. 10, p. 10

[8]Ref. 10, pp. 44-82

These assumptions are gross at best. Yet most of the models currently in use in American society are based upon these presuppositions. To state these decision behavior assumptions and attempt to develop a model in the next section of this chapter that accurately portrays the decision process as it relates to the organization (i.e. system) that is to develop Maine's underutilized sea urchin resource would be counterproductive. Therefore, the model developed in this chapter is based upon the following assumptions:

13. Men are not always rational and will not always follow their rational self interest once this is revealed to them.

14. Individuals have goals but collectivities of individuals do not.[9]

15. Organizations operate with imperfect knowledge.

16. Organizations actively search for information.[10]

17. Organizations consider only a limited number of decision alternatives.[11]

18. Variations in short run decision making will cause the system to behave probabilistically in the long run.

19. Decision rules implemented in the first two years of operations will remain in effect during the last three years of the planning horizon.

---

[9] Ref. 10, pp. 26-44

[10] Ref. 51, pp. 99-118

[11] Ref. 10, p. 83

Thus, the decision model used in SMART is representative of an adaptively rational system rather than an omnisciently rational system.[12]

Standards of Measurement. Essentially there are only two measurement standards used. The first is probabilistic and represents the percentage of times a particular activity occurs as compared to the percentage of times some alternative activity occurs. Probabilities are either based upon statistical data, or more qualitative forecasting techniques which could include: Delphi method, Historical analysis of comparable systems, Priority pattern analysis, Input-Output analysis, and/or Panel consensus.[13] The second measurement standard is completely quantitative and represents activity costs measured in dollars. A greater depth of understanding can be realized through digression to a general discussion of GERT.

In GERT there are two parameters associated with any branch: (1) the probability that a branch is taken, p_a, given that the node from which it emanated is realized; and (2) a time, t_a, required to accomplish the activity which the branch represents.[14] In this report the time parameter, t_a, is replaced

---

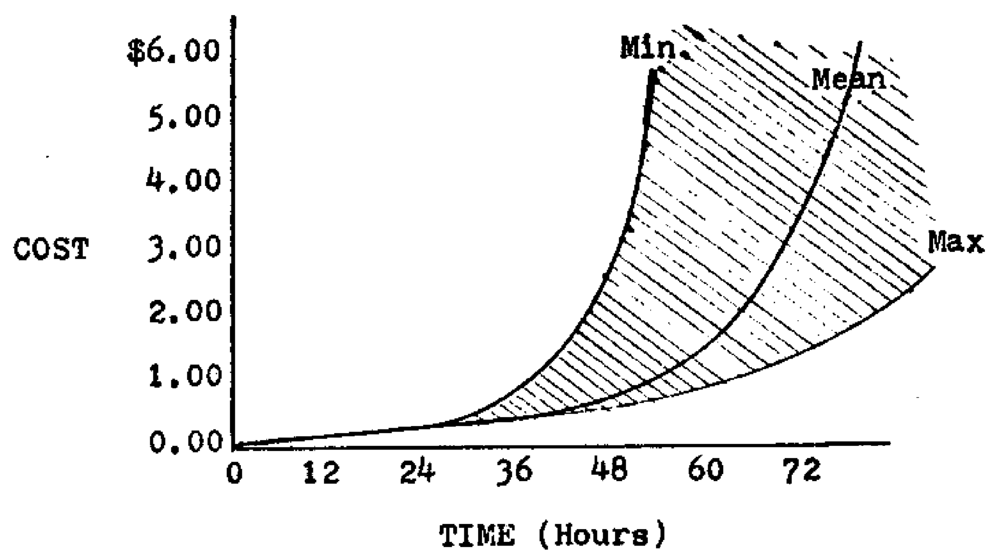
[12]The distinction between "adaptively" and "omnisciently" rational decision systems is treated in Ref. 50.

[13]Ref. 7

[14]Ref. 43, p. 5

with a cost parameter, c_a. This cost parameter varies with time in accordance with Figure 5-1 shown below. Time and cost are analogous, therefore, but this conversion increases the model's flexibility. The costs of independent activities can now be introduced as step functions anywhere within the decision network. Probabilistic data can be evaluated directly as it relates to overall system profitability. Hence, an action taken by a Maine fisherman as a result of traditionalism, habit, personal preferences, peer pressures, economic factors, etc., can be evaluated in terms of its incremental cost or benefit (profit) to the entire system. Figure 5-1 is derived from the assumption that any decrease in wholesale value of the roe due to freshness loss over time, can be treated as an increase in costs seen by the system that supplies the roe.

Cost/Time Relationship for Fresh Processed Roe



Source: Adapted from information supplied in Ref. 5, personal interview with Mr. W. Watson Taylor, Japan Airlines, Boston Office, 9 July 1973.

Figure 5-1

Air Cargo Rates For All International Carriers		
Type	Weight	Rate
General Cargo	100 lbs or less	$2.15 per pound
	100 - 220	$1.60 per pound
	221 - 440	$1.51 per pound
	441 - 660	$1.35 per pound
	661 - 880	$1.24 per pound
	881 -1100	$1.10 per pound
	1100 lbs or more	$0.97 per pound
Type 3 Pallet (125"x88" x86")	2300 Kilos or less	$3780
	2301 Kilos and up	$ 164/100 Kilos
Type 4 Pallet (108"x88" x86")	1900 Kilos or less	$3145
	1901 Kilos and up	$ 164/100 Kilos
Type 5 Pallet (125"x88" x64"	1900 Kilos or less	$3145
	1901 Kilos and up	$ 164/100 Kilos
Type 8 or 9 Pallet (62"x92" x64")	900 Kilos or less	$1595
	901 Kilos and up	$ 177/100 Kilos
Insurance Rate: 30¢ per $100 valuation		

Table 5-1

Source: Pan American Airlines, Cargo Information, Boston, Massachusetts.

Domestic Transport Costs, Wage Rates, and Other Expenses		
Item	Specific Description	Rate
Common Carrier	Truck from Pick-up Point to the Fulton Fish Market in New York	$0.04 per pound
Common Carrier	Truck from Portland to the Fulton Fish Market in New York	$0.03 per pound
Common Carrier	Delta Airlines flights from Portland or Bangor to Kennedy	$0.06 per pound
Handling Fees	Fulton Fish Market extra handling charge	$0.25 per package
Driver Rate	Private Vehicle Operator	$2.50 per hour
Crackers	Person who cracks open the shell	$2.20 per hour
Cleaners	People who separate roe from the shell and other internals	$2.20 per hour
Graders	People who separate roe by grade	$2.20 per hour
Packers	People who soak roe and package the final product	$2.20 per hour
Cedar Boxes	Boxes required for Japan's market	$0.20 a piece

Table 5-2

International Transport Flight Schedules				
Carrier	Flt. No.	Dep.	Arr.	Frequency
J A L	041	0400	0845	Wednesday, Friday, and Sunday
J A L	031	0540	1445	Tuesday, Thursday, and Saturday
T W A		0055		Wednesday and Friday
T W A		1415		Wednesday, Thursday, and Saturday
Pan Am	Same Flight Schedule as TWA.			
All three also offer service on passenger flights but these flights are subject to seasonal rescheduling, etc.				

Table 5-3

Step two: Modeling the System

Each of the five subsystems are modeled separately. Each subsystem alternative is considered independently. The GERT structure remains unchanged for each of the alternatives because the activities and their relations to each other do not change. What does change, however, is the parametric value for each of the network branches. That is, the costs and probabilities associated with each activity change as attention shifts from one alternative in a subsystem, to the next. For this reason, GERT networks are structured for each subsystem, and each subsystem activity is labeled W_{ab}, where W represents the "transmittance" or cost and probability parameters for each activity, and ab represents the node from which the activity emanates and to which the activity leads respectively.

Harvesting Subsystem. Figure 5-2 depicts harvesting activities and their relationships.

HARVESTING

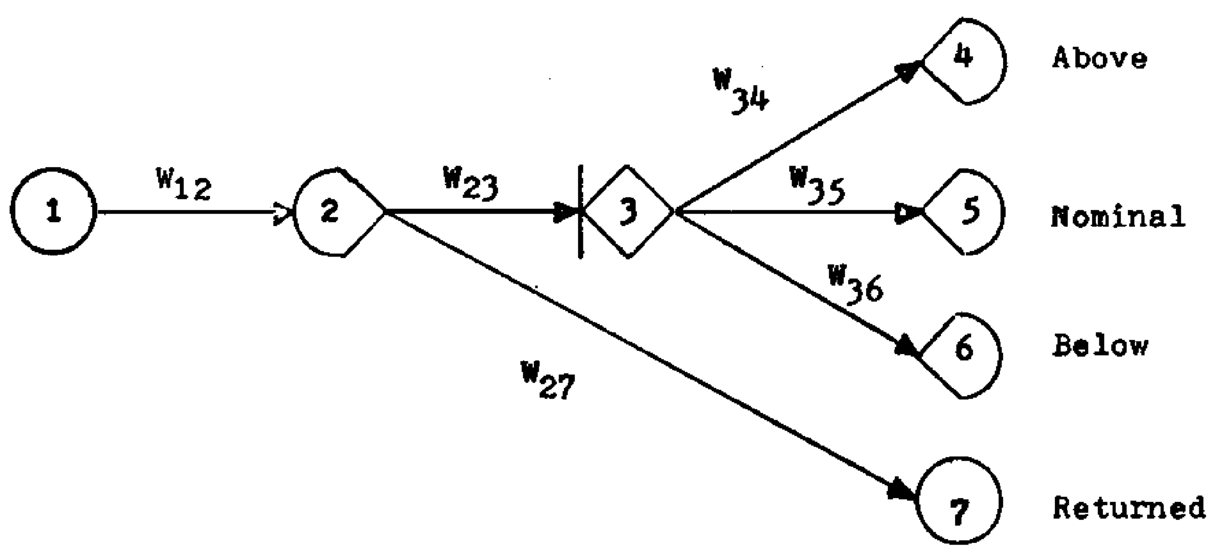


Figure 5-2

W_{12} is the transmittance representing the costs associated with the particular alternative or mix of alternatives used in harvesting the sea urchins. The costs associated with a one man skiff operation are quite different from those associated with a 70 to 90 foot vessel outfitted with a purse seiner rig. The parametric value of W_{12}, therefore, is calculated from the total operating costs of all the various vessels that might be involved over the five year planning horizon. Obviously, actual operating data should be used that is gathered from actual experience with the harvesting operation to revise the values assigned to W_{12}.

The probability associated with W_{12} is always 1. It is assumed that the harvesting operation must be undertaken before any costs are incurred in the rest of the system. Overhead is not a consideration in this case because the sea urchin venture is being evaluated as a potential method for utilizing seasonally underutilized capital and equipment. Since the overhead expenses of the various firms involved would be incurred, regardless of whether or not the sea urchin venture was undertaken, these costs are not considered as long as they remain less than those that would normally be experienced. Any costs above the norm, however, would have to be treated as overhead expenses.

W_{23} represents the percentage of sea urchins that are brought to shore while W_{27} represents the percentage of sea urchins that are returned for one reason or another (i.e. undersized). W_{34}, W_{35}, and W_{36} represent daily yields which are above expected, nominal, and below expected or normal amounts, where nominal refers to the mean or average amount.

Processing Subsystem. Figure 5-3 represents the transshipment network which relates the various costs incurred by the processor in picking up the bulk sea urchins at the various drop points along the Maine coast and in delivering them to the processing plant. $W_{48'}$, W_{58}, and $W_{68''}$ represent the costs associated with transshipping yields which are above expected or normal, nominal, or below expected or normal amounts, respectively.

TRANSSHIPMENT

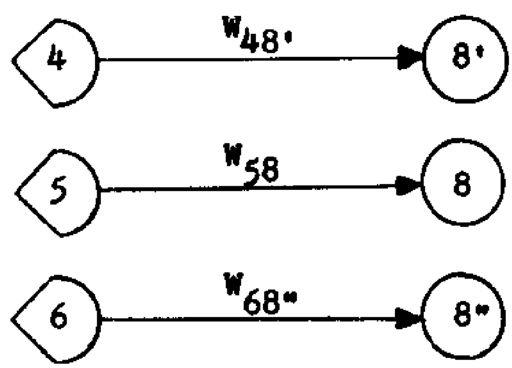


Figure 5-3

Figure 5-4 shows the decision alternatives which the processor faces at plant delivery.

DECISION

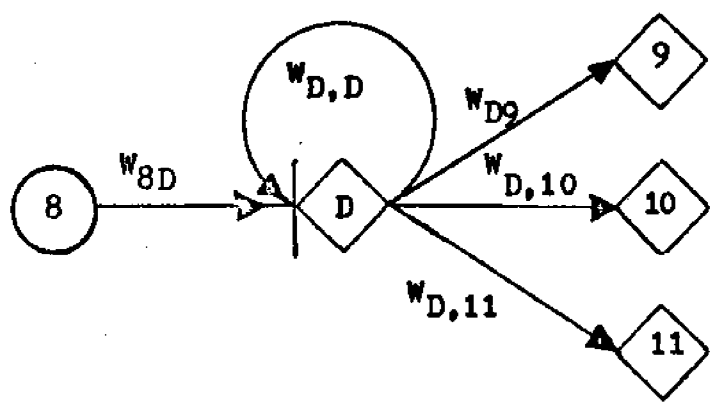


Figure 5-4

Figure 5-4 is a highly simplistic decision model wherein $W_{D,D}$ represents the decision to hold one day's catch of sea urchins over for the next day, assuming that facilities are available for keeping the urchins alive for that period. W_{D9}, $W_{D,10}$, and $W_{D,11}$ represent the decisions to package the sea urchins in bulk, to process the urchins, or to discard the urchins, respectively. In actuality, however, the relationships between alternatives are quite complex as shown in Figure 5-5.

PROCESSOR DECISION MODEL

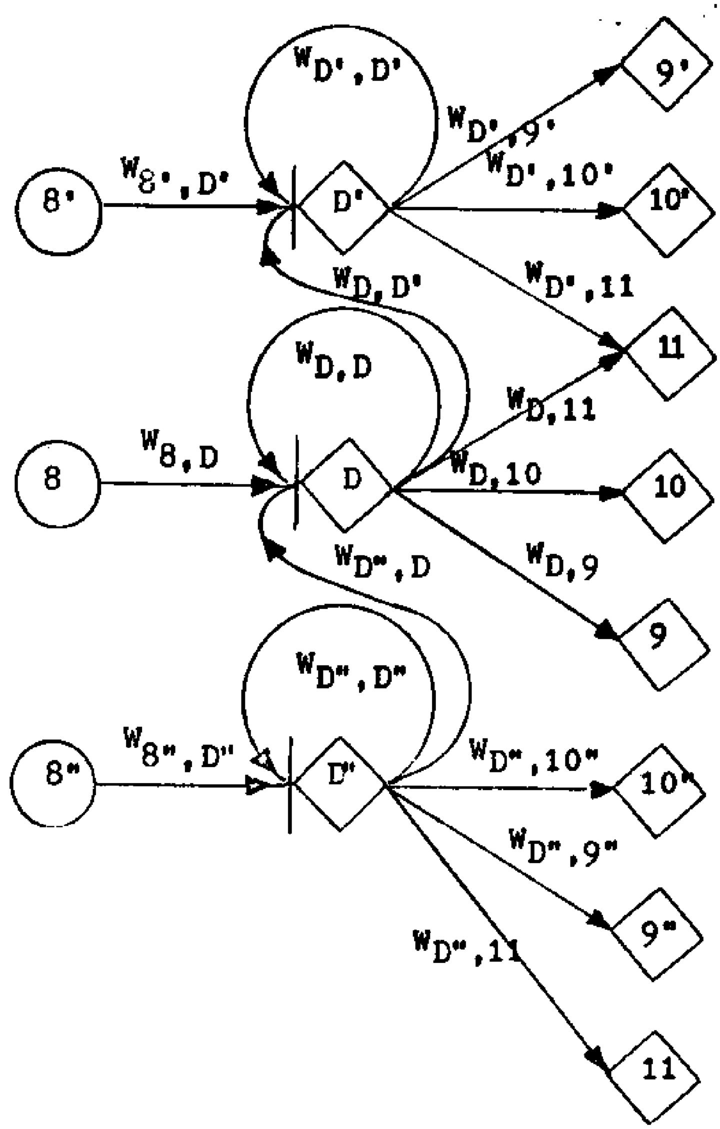


Figure 5-5

The transmittances for Figure 5-5 are as follows: All single prime superscripts refer to decisions made with respect to a daily yield that is above the normal or expected amount. All transmittances without superscripts represent decisions made with respect to the normal or nominal daily yield. All double prime superscripts refer to decisions made with respect to a daily yield that is below the normal or expected amount. The decision to hold in the nominal or below expected yield categories produces two possible results. Either the quantity of urchins held over does not sufficiently augment the next day's yield to enable the processor to take advantage of any economies of scale that exist in the next higher processing and shipping category, or the hold over decision does boost the supply over the necessary "break point" to enable the processor to take advantage of economies of scale. Transmittances $W_{D',D'}$, $W_{D,D}$, and $W_{D'',D''}$ are examples of the former while $W_{D,D'}$, and $W_{D'',D'}$ represent the latter. All other transmittances are the same as those described for Figure 5-4.

Figure 5-7 shows the packing in bulk alternative for the nominal case. The network is the same for the above and below nominal cases. Only the transmittance values change.

PACKING

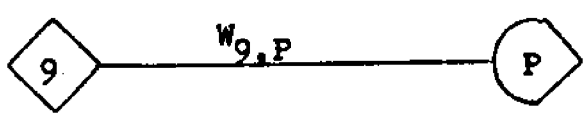


Figure 5-7

Figure 5-8 depicts the processing alternative. Once again only the nominal category is considered. Both the above expected and below expected yield categories are the same. Transmittance values constitute the only differences.

PROCESSING

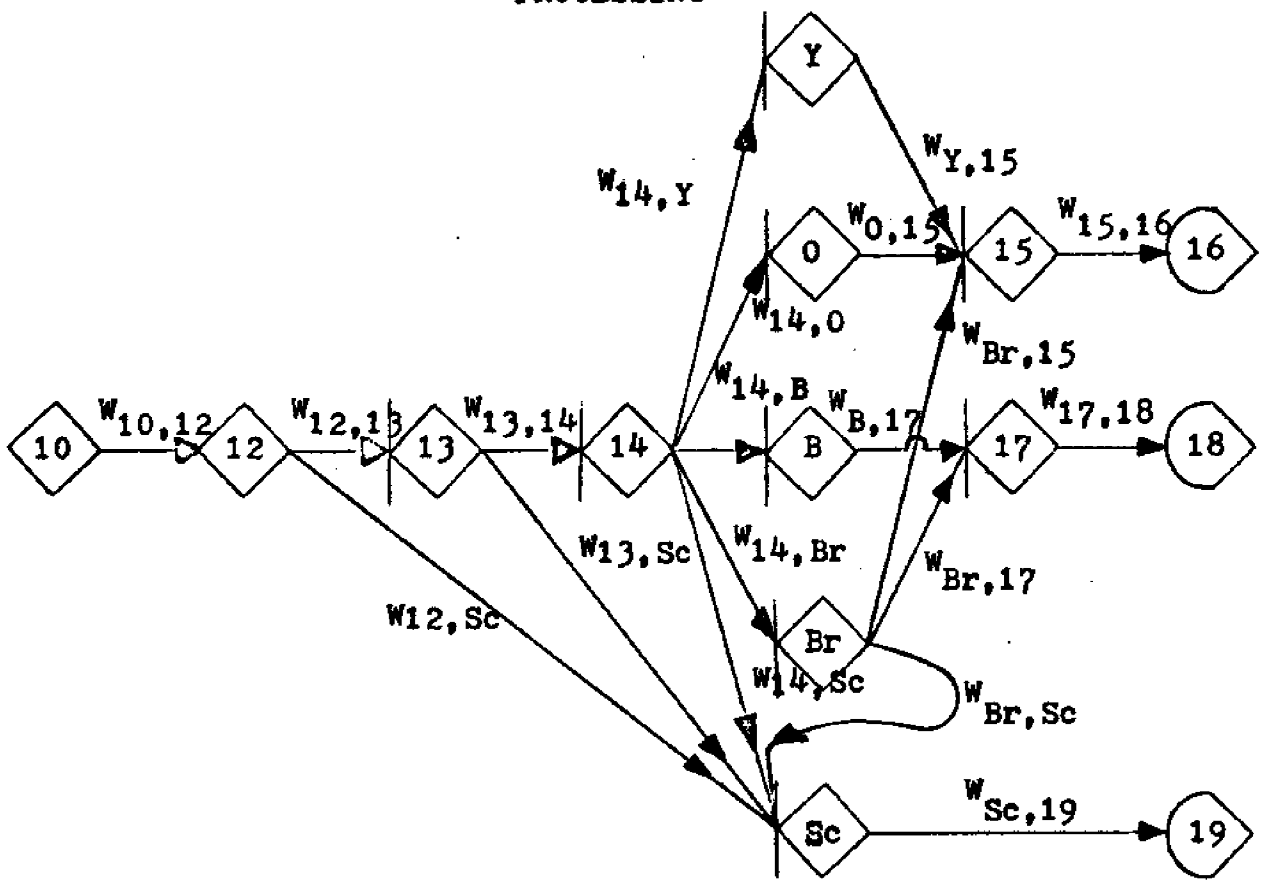


Figure 5-8

Transmittances represent the following activities:

$W_{10,12}$ represents cracking the shell. $W_{12,13}$ represents extracting the roe, washing it in sea water of same or comparable salinity, and placing the roe in an alum solution for a minimum of 20 minutes. $W_{12,Sc}$ represents the spines, shell, and other body parts that make up the sea urchin. $W_{13,14}$ represents the finished product after soaking while $W_{13,Sc}$ accounts for any roe that was damaged during the extraction or soaking phase of the processing operation. $W_{14,Y}$, $W_{14,O}$, $W_{14,B}$, $W_{14,Br}$, and $W_{14,Sc}$ represent the grading operation where Y is Yellow or highest quality, O is Orange or pink and of average quality, B is broken roe, and Br is Brown and of poor quality, and Sc is scrap, respectively. $W_{Y,15}$, $W_{O,15}$, and $W_{Br,15}$ represent roe that is packed into wooden trays for shipment to Japan. $W_{B,17}$ and $W_{Br,17}$ represent roe that is intended for domestic shipment for use in other foodstuffs, fertilizers, etc. $W_{15,16}$ is the packing or wooden trays into nests and nests into insulated boxes. $W_{17,18}$, is the packing of jumbled roe into appropriate containers. $W_{Sc,19}$ is the disposal of waste material.

<u>Domestic Transport</u>. Figure 5-9 shows domestic transport alternatives and possible consequences for each.

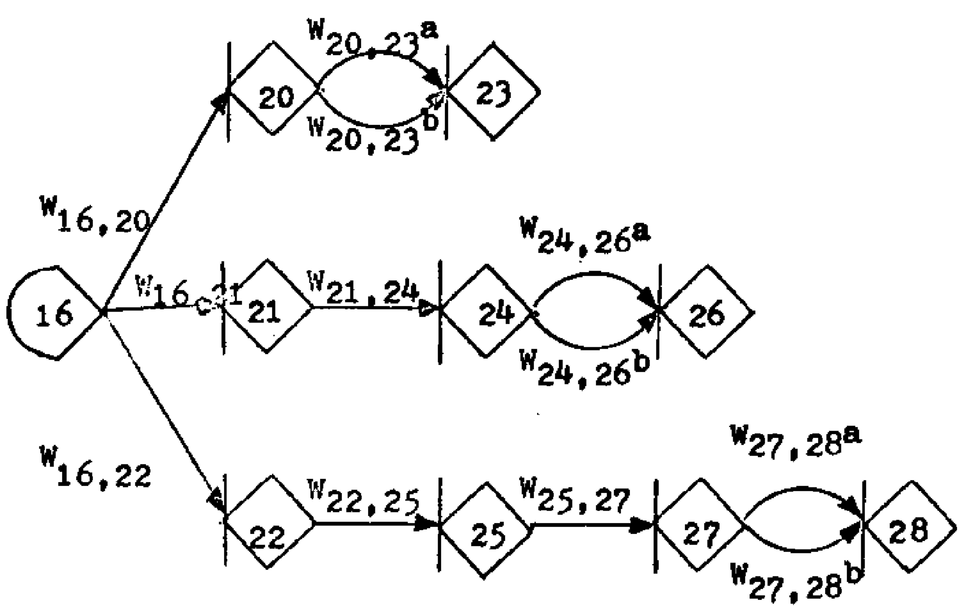


Figure 5-9

Transmittances for Figure 5-9 are as follows: $W_{16,20}$, $W_{16,21}$, and $W_{16,22}$ represent the processor using his own vehicle or vehicles for shipping the fresh roe to Kennedy International Airport in New York, to Portland Airport in Maine, or to a trucking pick-up point or points in Maine which are located near the processing facility or facilities processing the sea urchin roe. $W_{21,24}$ represents Delta Airline flights from Portland to Kennedy International Airport in New York. $W_{22,25}$ and $W_{25,27}$ represent truck shipment from the pick-up point to Fulton Fish Market in New York and transshipment to Kennedy Airport, respectively. Fulton Fish Market serves as a collection point for all commercial carriers trucking fish produce into the New York City area.

$W_{20,23a}$, $W_{20,23b}$, $W_{24,26a}$, $W_{24,26b}$, $W_{27,28a}$, and $W_{27,28b}$ represent the various arrival conditions for each of the domestic shipment alternatives. The "a" and "b" differentiate cargo into the categories of that which arrives undamaged and that which arrives damaged or impaired in quality in some manner during domestic transport handling and/or transporting operations.

Figure 5-10 shows the international transport alternatives that could occur. Unlike the preceding figures, Figure 5-10 depicts the above expected and below expected yield alternatives in addition to the nominal alternative. Because the network structure remains the same for each of the three alternatives, only the nominal alternative is considered in explaining transmittance meanings. Transmittances for the nominal alternative of Figure 5-10 are as follows: $W_{23,30}$, $W_{26,10}$, and $W_{28,30}$ represent freshness losses associated with each transport

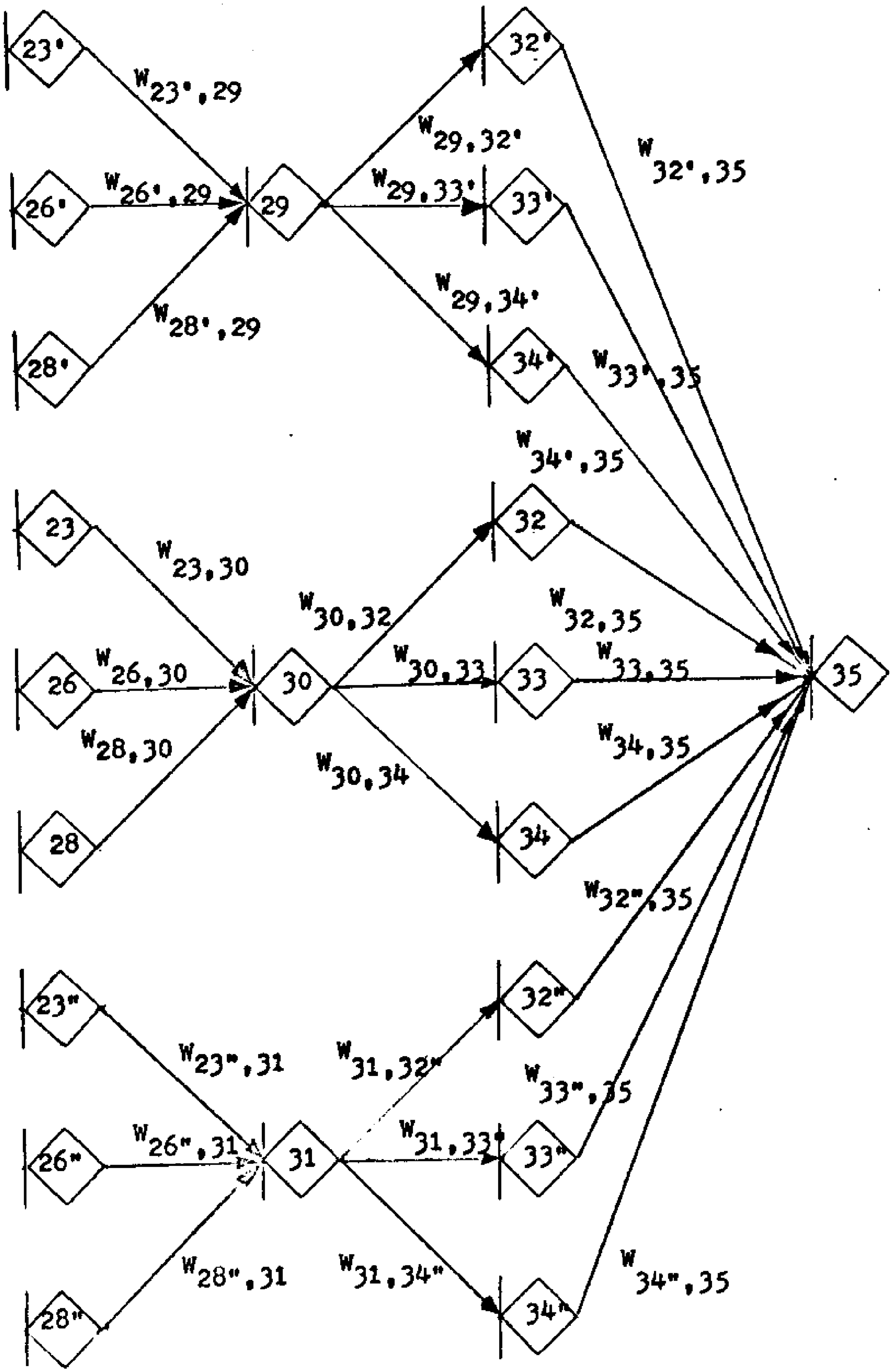

23'
26'
28'
29
32'
33'
34'
W23',29
W26',29
W28',29
W29,32'
W29,33'
W29,34'
W32',35
W33',35
W34',35
23
26
28
30
32
33
34
35
W23,30
W26,30
W28,30
W30,32
W30,33
W30,34
W32,35
W33,35
W34,35
23"
26"
28"
31
32"
33"
34"
W23",31
W26",31
W28",31
W31,32"
W31,33"
W31,34"
W32",35
W33",35
W34",35

Figure 5-10

method. $W_{30,32}$, $W_{30,33}$, and $W_{30,34}$ represent higher, nominal, and lower rate levels that might be charged by the airline in accordance with the weight of the shipment that is received.

The last stage of the system, the marketing stage cannot be considered further in this analysis, either domestically or foreign, due to a lack of quantitative and qualitative information. For purposes of this analysis, transmittance $W_{16,20}$ in Figure 5-9 is used to represent the costs associated with the shipment of the fresh roe to the domestic market. It should be noted that these projected costs overstate the actual costs that would be incurred in the processing subsystem. Packaging costs could be reduced significantly for domestic shipments of sea urchin roe. The wooden trays that are required for the Japanese markets could in all probability be replaced with plastic trays, etc. at a considerable cost savings.

Step Three: Utilizing GERT Techniques

Assigning Parametric values. Behind every assigned value there is a certain amount of facts and there are some assumptions. Both are enumerated explicitly during the discussion of each parameter.

The first parameter W_{12} represents the costs associated with operating a fleet of mixed vessels. It is anticipated that approximately 50% of the season's catch would be contributed by by one man skiffs producing 7 bushels per day (current range is from 5 to 11 bushels per day per one man skiff) at a price of from \$4.50 to \$5.50 per bushel. Approximately 40% of the seasonal catch is anticipated to be produced by two man draggers which range from 35 to 40 feet in length and operate at a total cost of from \$150 to \$200 per day. These figures represent the low end of the operating range so it is estimated that a sea urchin harvesting operation would result in a cost of approximately \$6.50 per bushel on a seasonal average. Finally, it is anticipated that 10% of the seasonal catch would be brought in by 70 to 80 foot purse seining vessels which operate with three or four man crews at a total average cost of from \$250 to \$300 dollars a day (again, estimates are in the low range). Because of the high operating costs of the purse seining vessel, it is assumed that it would only be used in conjunction with a suction apparatus when deep areas of ocean bottom are discovered to be densely carpeted with sea urchins. In this case it is assumed that sea urchins could be harvested at about \$4.00 per bushel. Therefore, the estimated seasonal cost of producing sea urchin yields is: $.5\times \$5 + .4\times \$6.50 + .1\times \$4 = \$5.50$ per bushel. However, since this data is based upon low cost estimates the cost per bushel is assumed to be \$6.00.

Since 1 bushel yields approximately 40 sea urchins and 40 sea urchins yield approximately 4 pounds of roe, the cost of harvesting the roe is \$1.50 per pound. This is represented in the GERT network as: $1e^{1.5s}$. The s is a mathematical notation that indicates that the calculations are being conducted in the "s" domain. A probability coefficient of "1" is used because it is assumed that some fishing has to be done for the urchins before any can be harvested. In other words, the urchins will not mysteriously appear at the processing plant. At least one fisherman must go out after urchins before the rest of the operations which make up the system can be realized.

All other costs in the harvesting subsystem are considered to be zero since the \$1.50 figure was based upon the total cost of the harvesting operation. The probabilities assigned to the remaining harvesting transmittances are based upon a consensus of opinions of individual's who have harvested and/or eaten sea urchins. These probabilities can be, and should be, refined through actual tests that should be undertaken to determine what the percentages are for harvesting the Maine sea urchin, using regional techniques and regional personnel. Thus, the remaining transmittances for the harvesting operation are: $W_{23} = 0.95$, $W_{27} = 0.05$, $W_{34} = 0.10$, $W_{35} = 0.75$, $W_{36} = 0.15$.

In the processing subsystem a 450 pound per day processing level of production is assumed for the first five years of operation. Transshipment costs are based upon a 12¢ per mile rate and a \$2.15 per hour rate for the vehicle driver. Assuming that an above expected yield would be nominally represented by a 650 pound yield and a below expected yield would be nominally represented by a 250 pound yield, $W_{48'} = 162.5$ bu., $W_{58} = 112.5$ bu., and $W_{68''} = 62.5$ bu.

$W_{8',D'}$, $W_{8,D}$, and $W_{8'',D''}$ are represented by: $1e^{0s}$ which merely designates the fact that the decisions which follow are realized when node 8', 8, or 8" are realized. Other decision transmittances are: $W_{D',D'} = 0.01$, $W_{D',9'} = 0.01$, $W_{D',10'} = 0.97$, and $W_{D',11'} = 0.01$; $W_{D,D} = 0.04$, $W_{D,D'} = 0.02$, $W_{D,11} = 0.01$,

$W_{D,10} = 0.90$, $W_{D,9} = 0.03$; $W_{D",D"} = 0.15$, $W_{D",D} = 0.45$, $W_{D",10"} = 0.30$, $W_{D",9"} = 0.15$, $W_{D",11} = 0.05$.

Packaging costs, represented by transmittance $W_{9,P}$ are approximately 11¢ per pound of bulk sea urchins. This is based upon a packaging cost figure of \$3.75 for bushel (including insulation material, cartons, and handling), and 40 pounds of urchins per bushel.

In the processing operation, $W_{10,12}$ =\$0.07 per pound based upon past experience where 1 man cracking open the shell can process 250 pounds of urchins in one 8 hour day. His salary, in accordance with Table 5-2, is assumed to be \$2.20 per hour. $W_{12,13} = 0.1\ e^{0.35s}$. The 35¢ cost figure is derived from having five workers process 250 pounds in an eight hour shift at the \$2.20 hourly rate. Comparing $W_{12,13}$ with $W_{12,Sc}$ which equals $0.9\ e^{0s}$, the 0.1 probability indicates that only 10% of the bulk urchin is roe, 90% is everything left over. Consequently, the cost of processing the 0.9 scrap is zero.

The costs of the grading operation are based on one worker grading 250 pounds of urchins in two hours. At an hourly rate of \$2.20 the cost equals 2¢ per pound. The percentage of grades shown are purely hypothetical. Only data gained through actual tests and operations can be used to refine or replace the figures used.

Transmittances $W_{Y,15}$, $W_{0,15}$, and $W_{Br,15}$ have a cost of 53¢ per pound based on a cost of 20¢ per cedar tray, 250 pounds of roe being packed by one person in four hours at \$2.20 per hour, and that 2.5 cedar trays hold one pound of fresh processed roe.

$W_{15,16}$ = 0.01 based on projected packing time of 1½ hours by one man at the $2.20 rate for 250 pounds of processed roe. $W_{17,18}$ = 0, based on a packing time of ½ hour. $W_{B,17}$, $W_{Br,17}$, and $W_{Br,Sc}$ = 3¢ per pound.

For the above and below nominal yield transmittances, the hourly wage rates remain unchanged, the size of the work groups remains the same, and the sequence of operations remains the same. The only change assumed is that an above nominal yield operation would result in a 285 pounds per hour basis as opposed to the 250 pound figure used in the nominal operation, and a 200 pound per hour basis would best represent the below nominal level. Utilizing these figures, the following transmittances are derived: $W_{10',12'} = 1\ e^{.06s}$, $W_{12',13'} = 0.1\ e^{.31s}$, $W_{13',14'} = 0.95\ e^{.01s}$, $W_{13',Sc'} = 0.05\ e^{.01s}$, $W_{Y',15'}$, $W_{O',15'}$, and $W_{Br',15'}$ retain their costs of 53¢ per pound, $W_{15',16'}$ = \$0.01, $W_{17',18'}$ remains zero, and $W_{B',17'}$, $W_{Br',17'}$, and $W_{Br',Sc'}$ = 3¢ per pound. Continuing, for the below nominal yield, the costs incurred would be: $W_{10'',12''} = 1\ e^{.09s}$, $W_{12'',13''} = 0.1\ e^{.44s}$, $W_{13'',14''} = 0.95\ e^{.02s}$, $W_{13'',Sc''} = 0.05\ e^{.01s}$, $W_{Y'',15''}$, $W_{O'',15''}$, and $W_{Br'',15''}$ become 54¢ per pound, $W_{15'',16''}$ = \$0.01, $W_{17'',18''}$ remains zero, and $W_{B'',17''}$, $W_{Br'',17''}$, and $W_{Br'',Sc''}$ = 4¢ per pound.

In the Domestic Transport subsystem, anticipating a 600 mile round trip and 16 hours of driving time, $W_{16,20} = 0.9\ e^{.25}$. $W_{16,21} = 0.08\ e^{.02s}$ and $W_{16,22} = 0.02\ e^{.00s}$. These values were calculated as follows: $W_{16,20}$ = 600 mi. x 12¢ per mi. + 16 hr. x 2.50 per hour = \$112 for 450 pounds of roe, or 24.8888¢/pound.

For $W_{16,21}$, 40 mi. (to Portland) x 12¢ per mi. + \$2.50 per hour x 2 hr. = \$9.80 for a 450 pound shipment or, 2.1777¢ per pound. For $W_{16,22}$, 5 mi. (to drop Point) x 12¢ per mi. = \$2.50 per hour x 0.25 hr. = 0.27222¢ per pound.

For above and below nominal yields the rates remain the same with only the total shipping weight changing to 650 pounds for above nominal and 250 pounds for below nominal. The resultant transmittances are: $W_{16',20'}$ = 0.172318, $W_{16',21'}$ = 0.015077, and $W_{16',22'}$ = 0; $W_{16'',20''}$ = 0.448, $W_{16'',21''}$ = 0.0392, and $W_{16'',22''}$ = 0.0049.

$W_{21,24}$, $W_{21',24'}$, and $W_{21'',24''}$ carry the same transmittance values since the airlines charges on a per pound basis. It should be noted that the shipping weight has been increased by a factor of 1.5 in the calculations which follow for all airlines involved and for domestic trucking commercial carriers. This is because each package of sea urchin roe weighs 60 pounds of which 24 pounds is roe and 36 pounds is packaging. Each cedar tray weighs approximately 1.6 oz and these trays are stacked 10 high and the top tray is covered with a dry cedar top. The total weight of these 10 high stacks or nests is approximately 18.5 oz. without roe and 82.5 oz with the roe, or the weight of roe per 10 trays is 4 pounds. The ten tray nests are then packaged in groups of 6 or 8 into insulated boxes. This increased shipping weight due to packaging produces the following per pound calculations: At Delta's rate of 6¢ per pound, a nominal yield of roe would weigh 450 x (36/24 = 1.5) = 675 pounds. Above nominal would weigh 975, and below 375. Therefore, the transport cost would be: 975 x .06/650 = 9¢ per pound in the above, nominal and below nominal cases. Similarly, trucking costs for transmittance $W_{22,25}$ are calculated as: 675 x .04/ 450 = 6¢ per pound. This applies for all three cases. $W_{25,27}$ entails shipment from Fulton Fish Market where a 25¢ to 30¢ per package handling cost is incurred, to Kennedy International Airport. Because various alternatives are available for the transhipment, the total cost involved is assumed to be approximately 3¢ per pound.

In the "a" differentiated transmittances the values reflect the percentage of roe shipments which arrive at the airport unharmed with a cost incurred due to freshness loss during transit time. Once again, these freshness loss costs are merely estimates that should be refined or replaced with actual test data. The "b" differentiated transmittances represent the values which reflect the percentage of roe shipments which arrive at the airport damaged or impaired in quality. The cost figures associated with this branch, therefore, account for the freshness loss incurred during transit, plus the value loss in product due to quality decrease. The transmittance values are as follows: $W_{20,23}a = 0.95\ e^{.10s}$, $W_{20,23}b = 0.05\ e^{.65s}$, $W_{24,26}a = 0.65\ e^{.04s}$, $W_{24,26}b = 0.35\ e^{.5s}$ (note that it is assumed that the airline route will be used only when seasonal schedules changes permit an easy transfer of cargo from domestic to international carrier with lay-over not to exceed 6 hours. One reason for the low probability associated with taking this particular shipment branch is the fact that this "ideal" state does not occur very often). These values do not change for above nominal, nominal, and below nominal cases.

$W_{27,28}a = 0.75\ e^{.25s}$ (the 25¢ cost due to freshness loss in this case is due to a 12 hour lay-over encountered in the Fulton Fish Market). $W_{27,28}b = 0.25\ e^{.65s}$.

In the International Transport subsystem, transmittance values are based upon (1) a flight time of 19 hours with a 1½ hour delay period tagged on each end, (2) the flight rates depicted in Table 5-1, or (3) a freshness loss incurred in the Tokyo Wholesale Market due to an 18 to 24 hour operating delay. The transmittances, therefore, are as follows: $W_{23',29} = 1\ e^{.3s}$, $W_{26',29} = 1\ e^{.25s}$, $W_{28',29} = 1\ e^{.4s}$. The values for the nominal, and below nominal cases are the same.

$W_{29,32'} = 0.2\ e^{1.65s}$ (Calculation of $1.65 figure: Shipping approximately 700 pounds of processed roe results in a total package weight of 700 x 1.5 = 1050 pounds. This puts the shipment in the $1.10 per pound rate bracket. Therefore, 1050 x $1.10 = $1155 for 700 pounds of roe, or $1155/700 lbs = $1.65 per pound), $W_{29,33'} = 0.6\ e^{1.65}$, $W_{29,34'} = 0.2\ e^{1.86}$, $W_{30,32} = 0.1\ e^{1.86}$, $W_{30,33} = 0.8\ e^{1.86}$, $W_{30,34} = 0.1\ e^{2.02}$, $W_{31,32''} = 0.2\ e^{2.03}$, $W_{31,33''} = 0.7\ e^{2.26}$, $W_{31,34''} = 0.1\ e^{2.37}$.

Because so little information is available with respect to the Japanese market and since the information that is available suggests that there is a 24 hour delay in the normal operating procedures of this market, reference is made to Figure 5-1 and an arbitrary value is chosen. Assuming that the mean time spent in transit from Maine to Tokyo is 30 hours for the average time in transit for the sum of the three domestic transport methods, adding 24 hours brings the total to 54 hours. The Mean of Figure 5-1 assigns a freshness loss of approximately

\$1.00 to this time interval. Since the method used thus far has represented an ad valorem increase in costs for each stage, the amounts already allocated to freshness losses in the domestic transport subsystem must be subtracted from the \$1.00 amount. The 30 hour cost is approximately 40¢ according to Figure 5-1. Therefore, the ad valorem cost is \$1.00 - \$0.40 = \$0.60. Thus the value for all remaining transmittances is $1\ e^{.6s}$.

<u>Problem Solution</u>. A very handy tool used by the electrical engineer and subsequently used quite frequently in GERT analyses, is presented at this point. This tool is called Mason's Reduction. It is not necessary to understand why Mason's Reduction works. It is only necessary to accept the fact that it does and to understand how it is used.

Basically, Mason's Reduction states that if L_i are the transmittances of the i loops (closed paths) in the system and G_j are the transmittances of the j paths (open paths) in the system which connect the two nodes (i.e. input and output) whose relationship is to be found, then the graph determinant is defined as:

$$\Delta = \left[1 - \sum L_i + \sum L_i L_j - \sum L_i L_j L_k + \ldots\right]$$

Where $\sum L_i$ = sum of all loop transmittances

$\sum L_i L_j$ = sum of products of transmittances of all pairs of NON-TOUCHING loops

$\sum L_i L_j L_k$ = sum of products of all triplets of NON-TOUCHING loops

Further, a path factor Δ_j (cofactor), is defined as the graph determinant in which the transmittance of any loop touching path G_j is made equal to zero. Therefore,

$$\frac{\text{Output}}{\text{Input}} = \frac{G_j\Delta_j}{\Delta} \qquad \frac{\text{path x path factor}}{\text{graph determinant}}$$

Identifying Loops:

$L_1 = W_{D',D'}$

$L_2 = W_{D,D}$

$L_3 = W_{D'',D''}$

Calculating the Graph Determinant:

$\sum L_i = L_1+L_2+L_3 = 0.01e^{0s}+0.04e^{0s}+0.15e^{0s} = 0.2e^{0s}$

$\sum L_iL_j = L_1L_2+L_1L_3+L_2L_3 = (0.01)(0.04)+(0.01)(0.15)+(0.04)(0.15)$

$= 0.0004+0.0015+0.006 = 0.0079e^{0s}$

$\sum L_iL_jL_k = L_1L_2L_3 = (0.01)(0.04)(0.15) = 0.00006e^{0s}$

$\Delta = 1-0.2+0.0079-0.00006$

$\Delta = \boxed{0.80784}$

Categorizing Transmittances:

Transmittance	Path	G_j
$W_{1D'}$	1-2-3-4-8'-D'	$(1e^{1.5s})(0.95)(0.1)(1e^{0s})$
W_{1D}	1-2-3-5-8-D	$(1e^{1.5s})(0.95)(0.75)(1e^{0s})$
$W_{1D''}$	1-2-3-6-8"-D"	$(1e^{1.5s})(0.95)(0.15)(1e^{0s})$
$W_{D'D'}$	D'-D'	$0.01e^{0s}$
$W_{D''D''}$	D"-D"	$0.15e^{0s}$
W_{DD}	D-D	$0.04e^{0s}$
$W_{DD'}$	D-D'	$0.02e^{0s}$
$W_{D''D}$	D"-D	$0.45e^{0s}$
$W_{D'Y'}$	D'-10'-12'-13'-14'-Y'	$(0.97)(1e^{.06s})(0.1e^{.31s})(0.95e^{.01s})$ x$(0.2e^{0s})$

$W_{D'O'}$	D'-10'-12'-13'-14'-0'	$(0.97)(1e^{.06s})(0.1e^{.31s})(0.95e^{.01s}) \times (0.28e^{0s})$
$W_{D'Br'}$	D'-10'-12'-13'-14'-Br'	$(0.97)(1e^{.06s})(0.1e^{.31s})(0.95e^{.01s}) \times (0.16e^{0s})$
W_{DY}	D-10-12-13-14-Y	$(0.90)(1e^{.07s})(0.1e^{.35s})(0.95e^{.01s}) \times (0.2e^{0s})$
W_{DO}	D-10-12-13-14-0	$(0.90)(1e^{.07s})(0.1e^{.35s})(0.95e^{.01s}) \times (0.28e^{0s})$
W_{DBr}	D-10-12-13-14-Br	$(0.90)(1e^{.07s})(0.1e^{.35s})(0.95e^{.01s}) \times (0.16e^{0s})$
$W_{D''Y''}$	D"-10"-12"-13"-14"-Y"	$(0.30)(1e^{.09s})(0.1e^{.44s})(0.95e^{.02s}) \times (0.2e^{0s})$
$W_{D''O''}$	D"-10"-12"-13"-14"-0"	$(0.30)(1e^{.09s})(0.1e^{.44s})(0.95e^{.02s}) \times (0.28e^{0s})$
$W_{D''Br''}$	D"-10"-12"-13"-14"-Br"	$(0.30)(1e^{.09s})(o.1e^{.44s})(0.95e^{.02s}) \times (0.16e^{0s})$
$W_{Y'16'}$	Y'-15'-16'	$(1e^{.53s})(1e^{.01s})$
$W_{O'16'}$	0'-15'-16'	$(1e^{.53s})(1e^{.01s})$
$W_{Br'16'}$	Br'-15'-16'	$(1e^{.53s})(1e^{.01s})$
W_{Y16}	Y-15-16	$(1e^{.53s})(1e^{.01s})$
W_{O16}	0-15-16	$(1e^{.53s})(1e^{.01s})$
W_{Br16}	Br-15-16	$(1e^{.53s})(1e^{.01s})$
$W_{Y''16''}$	Y"-15"-16"	$(1e^{.54s})(1e^{.01s})$
$W_{O''16''}$	0"-15"-16"	$(1e^{.54s})(1e^{.01s})$
$W_{Br''16''}$	Br"-15"-16"	$(1e^{.54s})(1e^{.01s})$
$W_{16'23a'}$	16'-20'-23a'	$(0.9e^{.17s})(0.95e^{.1s})$
$W_{16'23b'}$	16'-20'-23b'	$(0.9e^{.17s})(0.05e^{.65s})$
$W_{16'26a'}$	16'-21'-24'-26a'	$(0.08e^{.01s})(0.65e^{.04s})$
$W_{16'26b'}$	16'-21'-24'-26b'	$(0.08e^{.01s})(0.35e^{.5s})$
$W_{16'28a'}$	16'-22'-25'-27'-28a'	$(0.02e^{0s})(1e^{.06s})(1e^{.03s})(0.75e^{.25s})$
$W_{16'28b'}$	16'-22'-25'-27'-28b'	$(0.02e^{0s})(1e^{.06s})(1e^{.03s})(0.25e^{.65s})$
$W_{16,23a}$	16-20-23a	$(0.9e^{.17s})(0.95e^{.1s})$
$W_{16,23b}$	16-20-23b	$(0.9e^{.17s})(0.05e^{.65s})$
$W_{16,26a}$	16-21-24-26a	$(0.08e^{.02s})(0.65e^{.04s})$
$W_{16,26b}$	16-21-24-26b	$(0.08e^{.02s})(0.35e^{.5s})$
$W_{16,28a}$	16-22-25-27-28a	$(0.02e^{0s})(1e^{.06s})(1e^{.03s})(0.75e^{.25s})$
$W_{16,28b}$	16-22-25-27-28b	$(0.02e^{0s})(1e^{.06s})(1e^{.03s})(0.25e^{.65s})$

$W_{16''23a''}$	16"-20"-23a"	$(0.9e^{.45s})(0.95e^{.1s})$
$W_{16''23b''}$	16"-20"-23b"	$(0.9e^{.45s})(0.05e^{.65s})$
$W_{16''26a''}$	16"-21"-24"-26a"	$(0.08e^{.04s})(0.65e^{.04s})$
$W_{16''26b''}$	16"-21"-24"-26b"	$(0.08e^{.04s})(0.35e^{.5s})$
$W_{16''28a''}$	16"-22"-25"-27"-28a"	$(0.02e^{0s})(1e^{.03s})(0.75e^{.25s})$
$W_{16''28b''}$	16"-22"-25"-27"-28b"	$(0.02e^{0s})(1e^{.03s})(0.25e^{.65s})$
$W_{23a'32'}$	23a'-29-32'	$(1e^{.3s})(0.2e^{1.65s})$
$W_{23b'32'}$	23b'-29-32'	$(1e^{.3s})(0.2e^{1.65s})$
$W_{23a'33'}$	23a'-29-33'	$(1e^{.3s})(0.6e^{1.65s})$
$W_{23b'33'}$	23b'-29-33'	$(1e^{.3s})(0.6e^{1.65s})$
$W_{23a'34'}$	23a'-29-34'	$(1e^{.3s})(0.2e^{1.86s})$
$W_{23b'34'}$	23a'-29-34'	$(1e^{.3s})(0.2e^{1.86s})$
$W_{26a'32'}$	26a'-29-32'	$(1e^{.25s})(0.2e^{1.65s})$
$W_{26b'32'}$	26b'-29-32'	$(1e^{.25s})(0.2e^{1.65s})$
$W_{26a'33'}$	26a'-29-33'	$(1e^{.25s})(0.6e^{1.65s})$
$W_{26b'33'}$	26b'-29-33'	$(1e^{.25s})(0.6e^{1.65s})$
$W_{26a'34'}$	26a'-29-34'	$(1e^{.25s})(0.2e^{1.86s})$
$W_{26b'34'}$	26b'-29-34'	$(1e^{.25s})(0.2e^{1.86s})$
$W_{28a'32'}$	28a'-29-32'	$(1e^{.4s})(0.2e^{1.65s})$
$W_{28b'32'}$	28b'-29-32'	$(1e^{.4s})(0.2e^{1.65s})$
$W_{28a'33'}$	28a'-29-33'	$(1e^{.4s})(0.6e^{1.65s})$
$W_{28b'33'}$	28b'-29-33'	$(1e^{.4s})(0.6e^{1.65s})$
$W_{28a'34'}$	28a'-29-34'	$(1e^{.4s})(0.2e^{1.86s})$
$W_{28b'34'}$	28b'-29-34'	$(1e^{.4s})(0.2e^{1.86s})$
W_{23a32}	23a-30-32	$(1e^{.3s})(0.1e^{1.86s})$
W_{23b32}	23b-30-32	$(1e^{.3s})(0.1e^{1.86s})$

W_{23a33}	23a-30-33	$(1e^{.3s})(0.8e^{1.86s})$
W_{23b33}	23b-30-33	$(1e^{.3s})(0.8e^{1.86s})$
W_{23a34}	23a-30-34	$(1e^{.3s})(0.1e^{2.02s})$
W_{23b34}	23b-30-34	$(1e^{.3s})(0.1e^{2.02s})$
W_{26a32}	26a-30-32	$(1e^{.25s})(0.1e^{1.86s})$
W_{26b32}	26b-30-32	$(1e^{.25s})(0.1e^{1.86s})$
W_{26a33}	26a-30-33	$(1e^{.25s})(0.8e^{1.86s})$
W_{26b33}	26b-30-33	$(1e^{.25s})(0.8e^{1.86s})$
W_{26a34}	26a-30-34	$(1e^{.25s})(0.1e^{2.02s})$
W_{26b34}	26b-30-34	$(1e^{.25s})(0.1e^{2.02s})$
W_{28a32}	28a-30-32	$(1e^{.4s})(0.1e^{1.86s})$
W_{28b32}	28b-30-32	$(1e^{.4s})(0.1e^{1.86s})$
W_{28a33}	28a-30-33	$(1e^{.4s})(0.8e^{1.86s})$
W_{28b33}	28b-30-33	$(1e^{.4s})(0.8e^{1.86s})$
W_{28a34}	28a-30-34	$(1e^{.4s})(0.1e^{2.02s})$
W_{28b34}	28b-30-34	$(1e^{.4s})(0.1e^{2.02s})$
$W_{23a"32"}$	23a"-31-32"	$(1e^{.3s})(0.2e^{2.03s})$
$W_{23b"32"}$	23b"-31-32"	$(1e^{.3s})(0.2e^{2.03s})$
$W_{23a"33"}$	23a"-31-33"	$(1e^{.3s})(0.7e^{2.26s})$
$W_{23b"33"}$	23b"-31-33"	$(1e^{.3s})(0.7e^{2.26s})$
$W_{23a"34"}$	23a"-31-34"	$(1e^{.3s})(0.1e^{2.37s})$
$W_{23b"34"}$	23b"-31-34"	$(1e^{.3s})(0.1e^{2.37s})$
$W_{26a"32"}$	26a"-31-32"	$(1e^{.25s})(0.2e^{2.03s})$
$W_{26b"32"}$	26b"-31-32"	$(1e^{.25s})(0.2e^{2.03s})$
$W_{26a"33"}$	26a"-31-33"	$(1e^{.25s})(0.7e^{2.26s})$
$W_{26b"33"}$	26b"-31-33"	$(1e^{.25s})(0.7e^{2.26s})$
$W_{26a"34"}$	26a"-31-34"	$(1e^{.25s})(0.1e^{2.37s})$
$W_{26b"34"}$	26b"-31-34"	$(1e^{.25s})(0.1e^{2.37s})$

$W_{28a"32"}$	28a"-31-32"	$(1e^{.4s})(0.2e^{2.03s})$
$W_{28b"32"}$	28a"-31-32"	$(1e^{.4s})(0.2e^{2.03s})$
$W_{28a"33"}$	28a"-31-33"	$(1e^{.4s})(0.7e^{2.26s})$
$W_{28b"33"}$	28b"-31-33"	$(1e^{.4s})(0.7e^{2.26s})$
$W_{28a"34"}$	28a"-31-34"	$(1e^{.4s})(0.1e^{2.37s})$
$W_{28b"34"}$	28b"-31-34"	$(1e^{.4s})(0.1e^{2.37s})$

The preceding categorizations of transmittances are next used as a shorthand method for enumerating all paths for the over-all system transmittance $W_{1,35}$. The enumeration of paths is as follows:

Path #	Path
P1	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'23a'}W_{23a'32'}W_{32'35'}$
P2	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'23a'}W_{23a'33'}W_{33'35}$
P3	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'23a'}W_{23a'34'}W_{34'35}$
P4	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'23b'}W_{23b'32'}W_{32'35}$
P5	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'23b'}W_{23b'33'}W_{33'35}$
P6	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'23b'}W_{23b'34'}W_{34'35}$
P7	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'26a'}W_{26a'32'}W_{32'35}$
P8	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'26a'}W_{26a'33'}W_{33'35}$
P9	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'26a'}W_{26a'34'}W_{34'35}$
P10	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'26b'}W_{26b'32'}W_{32'35}$
P11	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'26b'}W_{26b'33'}W_{33'35}$
P12	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'26b'}W_{26b'34'}W_{34'35}$
P13	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'28a'}W_{28a'32'}W_{32'35}$
P14	$W_{1D'}W_{D'Y'}W_{Y'16'}W_{16'28a'}W_{28a'33'}W_{33'35}$

P15	$W_{1D} \cdot W_{D \cdot Y} \cdot W_{Y \cdot 16} \cdot W_{16 \cdot 28a} \cdot W_{28a \cdot 34} \cdot W_{34 \cdot 35}$
P16	$W_{1D} \cdot W_{D \cdot Y} \cdot W_{Y \cdot 16} \cdot W_{16 \cdot 28b} \cdot W_{28b \cdot 32} \cdot W_{32 \cdot 35}$
P17	$W_{1D} \cdot W_{D \cdot Y} \cdot W_{Y \cdot 16} \cdot W_{16 \cdot 28b} \cdot W_{28b \cdot 33} \cdot W_{33 \cdot 35}$
P18	$W_{1D} \cdot W_{D \cdot Y} \cdot W_{Y \cdot 16} \cdot W_{16 \cdot 28b} \cdot W_{28b \cdot 33} \cdot W_{33 \cdot 35}$
P19	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 23a} \cdot W_{23a \cdot 32} \cdot W_{32 \cdot 35}$
P20	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 23a} \cdot W_{23a \cdot 33} \cdot W_{33 \cdot 35}$
P21	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 23a} \cdot W_{23a \cdot 34} \cdot W_{34 \cdot 35}$
P22	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 23b} \cdot W_{23b \cdot 32} \cdot W_{32 \cdot 35}$
P23	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 23b} \cdot W_{23b \cdot 33} \cdot W_{33 \cdot 35}$
P24	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 23b} \cdot W_{23b \cdot 34} \cdot W_{34 \cdot 35}$
P25	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 26a} \cdot W_{26a \cdot 32} \cdot W_{32 \cdot 35}$
P26	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 26a} \cdot W_{26a \cdot 33} \cdot W_{33 \cdot 35}$
P27	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 26a} \cdot W_{26a \cdot 34} \cdot W_{34 \cdot 35}$
P28	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 26b} \cdot W_{26b \cdot 32} \cdot W_{32 \cdot 35}$
P29	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 26b} \cdot W_{26b \cdot 33} \cdot W_{33 \cdot 35}$
P30	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 26b} \cdot W_{26b \cdot 34} \cdot W_{34 \cdot 35}$
P31	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 28a} \cdot W_{28a \cdot 32} \cdot W_{32 \cdot 35}$
P32	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 28a} \cdot W_{28a \cdot 33} \cdot W_{33 \cdot 35}$
P33	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 28a} \cdot W_{28a \cdot 34} \cdot W_{34 \cdot 35}$
P34	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 28b} \cdot W_{28b \cdot 32} \cdot W_{32 \cdot 35}$
P35	$W_{1D} \cdot W_{D \cdot O} \cdot W_{O \cdot 16} \cdot W_{16 \cdot 28b} \cdot W_{28b \cdot 33} \cdot W_{33 \cdot 35}$
P36	$W_{1D} \cdot {}_{D \cdot O} \cdot {}_{O \cdot 16} \cdot {}_{16 \cdot 28b} \cdot {}_{28b \cdot 34} \cdot {}_{34 \cdot 35}$
P37	$W_{1D} \cdot W_{D \cdot Br} \cdot W_{Br \cdot 16} \cdot W_{16 \cdot 23a} \cdot W_{23a \cdot 32} \cdot W_{32 \cdot 35}$
P38	$W_{1D} \cdot W_{D \cdot Br} \cdot W_{Br \cdot 16} \cdot W_{16 \cdot 23a} \cdot W_{23a \cdot 33} \cdot W_{33 \cdot 35}$
P39	$W_{1D} \cdot W_{D \cdot Br} \cdot W_{Br \cdot 16} \cdot W_{16 \cdot 23a} \cdot W_{23a \cdot 34} \cdot W_{34 \cdot 35}$
P40	$W_{1D} \cdot W_{D \cdot Br} \cdot W_{Br \cdot 16} \cdot W_{16 \cdot 23b} \cdot W_{23b \cdot 32} \cdot W_{32 \cdot 35}$
P41	$W_{1D} \cdot W_{D \cdot Br} \cdot W_{Br \cdot 16} \cdot W_{16 \cdot 23b} \cdot W_{23b \cdot 33} \cdot W_{33 \cdot 35}$
P42	$W_{1D} \cdot W_{D \cdot Br} \cdot W_{Br \cdot 16} \cdot W_{16 \cdot 23b} \cdot W_{23b \cdot 34} \cdot W_{34 \cdot 35}$

P43	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 26a\cdot{}^{W}26a\cdot 32\cdot{}^{W}32\cdot 35$
P44	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 26a\cdot{}^{W}26a\cdot 33\cdot{}^{W}33\cdot 35$
P45	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 26a\cdot{}^{W}26a\cdot 34\cdot{}^{W}34\cdot 35$
P46	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 26b\cdot{}^{W}26b\cdot 32\cdot{}^{W}32\cdot 35$
P47	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 26b\cdot{}^{W}26b\cdot 33\cdot{}^{W}33\cdot 35$
P48	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 26b\cdot{}^{W}26b\cdot 34\cdot{}^{W}34\cdot 35$
P49	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 28a\cdot{}^{W}28a\cdot 32\cdot{}^{W}32\cdot 35$
P50	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 28a\cdot{}^{W}28a\cdot 33\cdot{}^{W}33\cdot 35$
P51	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 28a\cdot{}^{W}28a\cdot 34\cdot{}^{W}34\cdot 35$
P52	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 28b\cdot{}^{W}28b\cdot 32\cdot{}^{W}32\cdot 35$
P53	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 28b\cdot{}^{W}28b\cdot 33\cdot{}^{W}33\cdot 35$
P54	$^{W}1D\cdot{}^{W}D\cdot Br\cdot{}^{W}Br\cdot 16\cdot{}^{W}16\cdot 28b\cdot{}^{W}28b\cdot 34\cdot{}^{W}34\cdot 35$
P55	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 23a\cdot{}^{W}23a\cdot 32\cdot{}^{W}32\cdot 35$
P56	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 23a\cdot{}^{W}23a\cdot 33\cdot{}^{W}33\cdot 35$
P57	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 23a\cdot{}^{W}23a\cdot 34\cdot{}^{W}34\cdot 35$
P58	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 23b\cdot{}^{W}23b\cdot 32\cdot{}^{W}32\cdot 35$
P59	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 23b\cdot{}^{W}23b\cdot 33\cdot{}^{W}33\cdot 35$
P60	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 23b\cdot{}^{W}23b\cdot 34\cdot{}^{W}34\cdot 35$
P61	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 26a\cdot{}^{W}26a\cdot 32\cdot{}^{W}32\cdot 35$
P62	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 26a\cdot{}^{W}26a\cdot 33\cdot{}^{W}33\cdot 35$
P63	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 26a\cdot{}^{W}26a\cdot 34\cdot{}^{W}34\cdot 35$
P64	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 26b\cdot{}^{W}26b\cdot 32\cdot{}^{W}32\cdot 35$
P65	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 26b\cdot{}^{W}26b\cdot 33\cdot{}^{W}33\cdot 35$
P66	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 26b\cdot{}^{W}26b\cdot 34\cdot{}^{W}34\cdot 35$
P67	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 28a\cdot{}^{W}28a\cdot 32\cdot{}^{W}32\cdot 35$
P68	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 28a\cdot{}^{W}28a\cdot 33\cdot{}^{W}33\cdot 35$
P69	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 28a\cdot{}^{W}28a\cdot 34\cdot{}^{W}34\cdot 35$
P70	$^{W}1D{}^{W}DD\cdot{}^{W}D\cdot Y\cdot{}^{W}Y\cdot 16\cdot{}^{W}16\cdot 28b\cdot{}^{W}28b\cdot 32\cdot{}^{W}32\cdot 35$

P71	$W_{1D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'28b'}W_{28b'33'}W_{33'35}$
P72	$W_{1D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'28b'}W_{28b'34'}W_{34'35}$
P73	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'23a'}W_{23a'32'}W_{32'35}$
P74	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'23a'}W_{23a'33'}W_{33'35}$
P75	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'23a'}W_{23a'34'}W_{34'35}$
P76	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'23b'}W_{23b'32'}W_{32'35}$
P77	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'23b'}W_{23b'33'}W_{33'35}$
P78	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'23b'}W_{23b'34'}W_{34'35}$
P79	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'26a'}W_{26a'32'}W_{32'35}$
P80	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'26a'}W_{26a'33'}W_{33'35}$
P81	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'26a'}W_{26a'34'}W_{34'35}$
P82	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'26b'}W_{26b'32'}W_{32'35}$
P83	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'26b'}W_{26b'33'}W_{33'35}$
P84	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'26b'}W_{26b'34'}W_{34'35}$
P85	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'28a'}W_{28a'32'}W_{32'35}$
P86	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'28a'}W_{28a'33'}W_{33'35}$
P87	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'28a'}W_{28a'34'}W_{34'35}$
P88	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'28b'}W_{28b'32'}W_{32'35}$
P89	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'28b'}W_{28b'33'}W_{33'35}$
P90	$W_{1D}W_{DD'}W_{D'O'}W_{O'16'}W_{16'28b'}W_{28b'34'}W_{34'35}$
P91	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'23a'}W_{23a'32'}W_{32'35}$
P92	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'23a'}W_{23a'33'}W_{33'35}$
P93	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'23a'}W_{23a'34'}W_{34'35}$
P94	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'23b'}W_{23b'32'}W_{32'35}$
P95	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'23b'}W_{23b'33'}W_{33'35}$
P96	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'23b'}W_{23b'34'}W_{34'35}$
p97	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'26a'}W_{26a'32'}W_{32'35}$

P98	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'26a'}W_{26a'33'}W_{33'35}$
P99	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'26a'}W_{26a'34'}W_{34'35}$
P100	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'26b'}W_{26b'32'}W_{32'35}$
P101	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'26b'}W_{26b'33'}W_{33'35}$
P102	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'26b'}W_{26b'34'}W_{34'35}$
P103	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'28a'}W_{28a'32'}W_{32'35}$
P104	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'28a'}W_{28a'33'}W_{33'35}$
P105	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'28a'}W_{28a'34'}W_{34'35}$
P106	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'28b'}W_{28b'32'}W_{32'35}$
P107	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'28b'}W_{28b'33'}W_{33'35}$
P108	$W_{1D}W_{DD'}W_{D'Br'}W_{Br'16'}W_{16'28b'}W_{28b'34'}W_{34'35}$
P109	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'23a'}W_{23a'32'}W_{32'35}$
P110	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'23a'}W_{23a'33'}W_{33'35}$
P111	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'23a'}W_{23a'34'}W_{34'35}$
P112	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'23b'}W_{23b'32'}W_{32'35}$
P113	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'23b'}W_{23b'33'}W_{33'35}$
P114	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'23b'}W_{23b'34'}W_{34'35}$
P115	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'26a'}W_{26a'32'}W_{32'35}$
P116	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'26a'}W_{26a'33'}W_{33'35}$
P117	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'26a'}W_{26a'34'}W_{34'35}$
P118	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'26b'}W_{26b'32'}W_{32'35}$
P119	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'26b'}W_{26b'33'}W_{33'35}$
P120	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'26b'}W_{26b'34'}W_{34'35}$
P121	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'28a'}W_{28a'32'}W_{32'35}$
P122	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'28a'}W_{28a'33'}W_{33'35}$
P123	$W_{1D''}W_{D''D}W_{DD'}W_{D'Y'}W_{Y'16'}W_{16'28a'}W_{28a'34'}W_{34'35}$
P124	$W_{1D''}\ {}_{D''D}\ {}_{DD'}\ {}_{D'Y'}\ {}_{Y'16'}\ {}_{16'28b'}\ {}_{28b'32'}\ {}_{32'35}$
P125	$W_{1D''}\ {}_{D''D}\ {}_{DD'}\ {}_{D'Y'}\ {}_{Y'16'}\ {}_{16'28b'}\ {}_{28b'33'}\ {}_{33'35}$

P126	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'Y'}\,{}^{W}_{Y'16'}\,{}^{W}_{16'28b'}\,{}^{W}_{28b'34'}\,{}^{W}_{34'35}$
P127	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'23a'}\,{}^{W}_{23a'32'}\,{}^{W}_{32'35}$
P128	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'23a'}\,{}^{W}_{23a'33'}\,{}^{W}_{33'35}$
P129	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'23a'}\,{}^{W}_{23a'34'}\,{}^{W}_{34'35}$
P130	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'23b'}\,{}^{W}_{23b'32'}\,{}^{W}_{32'35}$
P131	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'23b'}\,{}^{W}_{23b'33'}\,{}^{W}_{33'35}$
P132	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'23b'}\,{}^{W}_{23b'34'}\,{}^{W}_{34'35}$
P133	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'26a'}\,{}^{W}_{26a'32'}\,{}^{W}_{32'35}$
P134	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'26a'}\,{}^{W}_{26a'33'}\,{}^{W}_{33'35}$
P135	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'26a'}\,{}^{W}_{26a'34'}\,{}^{W}_{34'35}$
P136	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'26b'}\,{}^{W}_{26b'32'}\,{}^{W}_{32'35}$
P137	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'26b'}\,{}^{W}_{26b'33'}\,{}^{W}_{33'35}$
P138	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'26b'}\,{}^{W}_{26b'34'}\,{}^{W}_{34'35}$
P139	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'28a'}\,{}^{W}_{28a'32'}\,{}^{W}_{32'35}$
P140	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'28a'}\,{}^{W}_{28a'33'}\,{}^{W}_{33'35}$
P141	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'28a'}\,{}^{W}_{28a'34'}\,{}^{W}_{34'35}$
P142	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'28b'}\,{}^{W}_{28b'32'}\,{}^{W}_{32'35}$
P143	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'28b'}\,{}^{W}_{28b'33'}\,{}^{W}_{33'35}$
P144	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'O'}\,{}^{W}_{O'16'}\,{}^{W}_{16'28b'}\,{}^{W}_{28b'34'}\,{}^{W}_{34'35}$
P145	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'Br'}\,{}^{W}_{Br'16'}\,{}^{W}_{16'23a'}\,{}^{W}_{23a'32'}\,{}^{W}_{32'35}$
P146	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'Br'}\,{}^{W}_{Br'16'}\,{}^{W}_{16'23a'}\,{}^{W}_{23a'33'}\,{}^{W}_{33'35}$
P147	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'Br'}\,{}^{W}_{Br'16'}\,{}^{W}_{16'23a'}\,{}^{W}_{23a'34'}\,{}^{W}_{34'35}$
P148	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'Br'}\,{}^{W}_{Br'16'}\,{}^{W}_{16'23b'}\,{}^{W}_{23b'32'}\,{}^{W}_{32'35}$
P149	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'Br'}\,{}^{W}_{Br'16'}\,{}^{W}_{16'23b'}\,{}^{W}_{23b'33'}\,{}^{W}_{33'35}$
P150	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'Br'}\,{}^{W}_{Br'16'}\,{}^{W}_{16'23b'}\,{}^{W}_{23b'34'}\,{}^{W}_{34'35}$
P151	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'Br'}\,{}^{W}_{Br'16'}\,{}^{W}_{16'26a'}\,{}^{W}_{26a'32'}\,{}^{W}_{32'35}$
P152	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'Br'}\,{}^{W}_{Br'16'}\,{}^{W}_{16'26a'}\,{}^{W}_{26a'33'}\,{}^{W}_{33'35}$
P153	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DD'}\,{}^{W}_{D'Br'}\,{}^{W}_{Br'16'}\,{}^{W}_{16'26a'}\,{}^{W}_{26a'34'}\,{}^{W}_{34'35}$

P154	$^{W}1D''\,^{W}D''D\,^{W}DD'\,^{W}D'Br'\,^{W}Br'16'\,^{W}16'26b'\,^{W}26b'32'\,^{W}32'35$
P155	$^{W}1D''\,^{W}D''D\,^{W}DD'\,^{W}D'Br'\,^{W}Br'16'\,^{W}16'26b'\,^{W}26b'33'\,^{W}33'35$
P156	$^{W}1D''\,^{W}D''D\,^{W}DD'\,^{W}D'Br'\,^{W}Br'16'\,^{W}16'26b'\,^{W}26b'34'\,^{W}34'35$
P157	$^{W}1D''\,^{W}D''D\,^{W}DD'\,^{W}D'Br'\,^{W}Br'16'\,^{W}16'28a'\,^{W}28a'32'\,^{W}32'35$
P158	$^{W}1D''\,^{W}D''D\,^{W}DD'\,^{W}D'Br'\,^{W}Br'16'\,^{W}16'28a'\,^{W}28a'33'\,^{W}33'35$
P159	$^{W}1D''\,^{W}D''D\,^{W}DD'\,^{W}D'Br'\,^{W}Br'16'\,^{W}16'28a'\,^{W}28a'34'\,^{W}34'35$
P160	$^{W}1D''\,^{W}D''D\,^{W}DD'\,^{W}D'Br'\,^{W}Br'16'\,^{W}16'28b'\,^{W}28b'32'\,^{W}32'35$
P161	$^{W}1D''\,^{W}D''D\,^{W}DD'\,^{W}D'Br'\,^{W}Br'16'\,^{W}16'28b'\,^{W}28b'33'\,^{W}33'35$
P162	$^{W}1D''\,^{W}D''D\,^{W}DD'\,^{W}D'Br'\,^{W}Br'16'\,^{W}16'28b'\,^{W}28b'34'\,^{W}34'35$
P163	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,23a\,^{W}23a32\,^{W}32,35$
P164	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,23a\,^{W}23a33\,^{W}33,35$
P165	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,23a\,^{W}23a34\,^{W}34,35$
P166	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,23b\,^{W}23b32\,^{W}32,35$
P167	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,23b\,^{W}23b33\,^{W}33,35$
P168	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,23b\,^{W}23b34\,^{W}34,35$
P169	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,26a\,^{W}26a32\,^{W}32,35$
P170	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,26a\,^{W}26a33\,^{W}33,35$
P171	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,26a\,^{W}26a34\,^{W}34,35$
P172	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,26b\,^{W}26b32\,^{W}32,35$
P173	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,26b\,^{W}26b33\,^{W}33,35$
P174	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,26b\,^{W}26b34\,^{W}34,35$
P175	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,28a\,^{W}28a32\,^{W}32,35$
P176	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,28a\,^{W}28a33\,^{W}33,35$
P177	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,28a\,^{W}28a34\,^{W}34,35$
P178	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,28b\,^{W}28b32\,^{W}32,35$
P179	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,28b\,^{W}28b33\,^{W}33,35$
P180	$^{W}1D\,^{W}DY\,^{W}Y16\,^{W}16,28b\,^{W}28b34\,^{W}34,35$

P181	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,23a\,{}^{W}23a32\,{}^{W}32,35$
P182	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,23a\,{}^{W}23a33\,{}^{W}33,35$
P183	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,23a\,{}^{W}23a34\,{}^{W}34,35$
P184	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,23b\,{}^{W}23b32\,{}^{W}32,35$
P185	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,23b\,{}^{W}23b33\,{}^{W}33,35$
P186	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,23b\,{}^{W}23b34\,{}^{W}34,35$
P187	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,26a\,{}^{W}26a32\,{}^{W}32,35$
P188	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,26a\,{}^{W}26a33\,{}^{W}33,35$
P189	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,26a\,{}^{W}26a34\,{}^{W}34,35$
P190	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,26b\,{}^{W}26b32\,{}^{W}32,35$
P191	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,26b\,{}^{W}26b33\,{}^{W}33,35$
P192	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,26b\,{}^{W}26b34\,{}^{W}34,35$
P193	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,28a\,{}^{W}28a32\,{}^{W}32,35$
P194	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,28a\,{}^{W}28a33\,{}^{W}33,35$
P195	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,28a\,{}^{W}28a34\,{}^{W}34,35$
P196	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,28b\,{}^{W}28b32\,{}^{W}32,35$
P197	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,28b\,{}^{W}28b33\,{}^{W}33,35$
P198	${}^{W}1D\,{}^{W}DO\,{}^{W}O16\,{}^{W}16,28b\,{}^{W}28b34\,{}^{W}34,35$
P199	${}^{W}1D\,{}^{W}DBr\,{}^{W}Br16\,{}^{W}16,23a\,{}^{W}23a32\,{}^{W}32,35$
P200	${}^{W}1D\,{}^{W}DBr\,{}^{W}Br16\,{}^{W}16,23a\,{}^{W}23a33\,{}^{W}33,35$
P201	${}^{W}1D\,{}^{W}DBr\,{}^{W}Br16\,{}^{W}16,23a\,{}^{W}23a34\,{}^{W}34,35$
P202	${}^{W}1D\,{}^{W}DBr\,{}^{W}Br16\,{}^{W}16,23b\,{}^{W}23b32\,{}^{W}32,35$
P203	${}^{W}1D\,{}^{W}DBr\,{}^{W}Br16\,{}^{W}16,23b\,{}^{W}23b33\,{}^{W}33,35$
P204	${}^{W}1D\,{}^{W}DBr\,{}^{W}Br16\,{}^{W}16,23b\,{}^{W}23b34\,{}^{W}34,35$
P205	${}^{W}1D\,{}^{W}DBr\,{}^{W}Br16\,{}^{W}16,26a\,{}^{W}26a32\,{}^{W}32,35$
P206	${}^{W}1D\,{}^{W}DBr\,{}^{W}Br16\,{}^{W}16,26a\,{}^{W}26a33\,{}^{W}33,35$
P207	${}^{W}1D\,{}^{W}DBr\,{}^{W}Br16\,{}^{W}16,26a\,{}^{W}26a34\,{}^{W}34,35$

P208	^{W}1D^{W}DBr^{W}Br16^{W}16,26b^{W}26b32^{W}32,35
P209	^{W}1D^{W}Dbr^{W}Br16^{W}16,26b^{W}26b33^{W}33,35
P210	^{W}1D^{W}DBr^{W}Br16^{W}16,26b^{W}26b34^{W}34,35
P211	^{W}1D^{W}DBr^{W}Br16^{W}16,28a^{W}28a32^{W}32,35
P212	^{W}1D^{W}DBr^{W}Br16^{W}16,28a^{W}28a33^{W}33,35
P213	^{W}1D^{W}DBr^{W}Br16^{W}16,28a^{W}28a34^{W}34,35
P214	^{W}1D^{W}DBr^{W}Br16^{W}16,28b^{W}28b32^{W}32,35
P215	^{W}1D^{W}DBr^{W}Br16^{W}16,28b^{W}28b33^{W}33,35
P216	^{W}1D^{W}DBr^{W}Br16^{W}16,28b^{W}28b34^{W}34,35
P217	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,23a^{W}23a32^{W}32,35
P218	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,23a^{W}23a33^{W}33,35
P219	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,23a^{W}23a34^{W}34,35
P220	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,23b^{W}23b32^{W}32,35
P221	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,23b^{W}23b33^{W}33,35
P222	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,23b^{W}23b34^{W}34,35
P223	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,26a^{W}26a32^{W}32,35
P224	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,26a^{W}26a33^{W}33,35
P225	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,26a^{W}26a34^{W}34,35
P226	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,26b^{W}26b32^{W}32,35
P227	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,26b^{W}26b33^{W}33,35
P228	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,26b^{W}26b34^{W}34,35
P229	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,28a^{W}28a32^{W}32,35
P230	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,28a^{W}28a33^{W}33,35
P231	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,28a^{W}28a34^{W}34,35
P232	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,28b^{W}28b32^{W}32,35
P233	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,28b^{W}28b33^{W}33,35
P234	^{W}1D"^{W}D"D^{W}DY^{W}Y16^{W}16,28b^{W}28b34^{W}34,35

P235	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,23a{}^{W}23a32{}^{W}32,35$
P236	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,23a{}^{W}23a33{}^{W}33,35$
P237	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,23a{}^{W}23a34{}^{W}34,35$
P238	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,23b{}^{W}23b32{}^{W}32,35$
P239	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,23b{}^{W}23b33{}^{W}33,35$
P240	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,23b{}^{W}23b34{}^{W}34,35$
P241	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,26a{}^{W}26a32{}^{W}32,35$
P242	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,26a{}^{W}26a33{}^{W}33,35$
P243	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,26a{}^{W}26a34{}^{W}34,35$
P244	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,26b{}^{W}26b32{}^{W}32,35$
P245	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,26b{}^{W}26b33{}^{W}33,35$
P246	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,26b{}^{W}26b34{}^{W}34,35$
P247	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,28a{}^{W}28a32{}^{W}32,35$
P248	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,28a{}^{W}28a33{}^{W}33,35$
P249	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,28a{}^{W}28a34{}^{W}34,35$
P250	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,28b{}^{W}28b32{}^{W}32,35$
P251	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,28b{}^{W}28b33{}^{W}33,35$
P252	${}^{W}1D''{}^{W}D''D{}^{W}DO{}^{W}O16{}^{W}16,28b{}^{W}28b34{}^{W}34,35$
P253	${}^{W}1D''{}^{W}D''D{}^{W}DBr{}^{W}Br16{}^{W}16,23a{}^{W}23a32{}^{W}32,35$
P254	${}^{W}1D''{}^{W}D''D{}^{W}DBr{}^{W}Br16{}^{W}16,23a{}^{W}23a33{}^{W}33,35$
P255	${}^{W}1D''{}^{W}D''D{}^{W}DBr{}^{W}Br16{}^{W}16,23a{}^{W}23a34{}^{W}34,35$
P256	${}^{W}1D''{}^{W}D''D{}^{W}DBr{}^{W}Br16{}^{W}16,23b{}^{W}23b32{}^{W}32,35$
P257	${}^{W}1D''{}^{W}D''D{}^{W}DBr{}^{W}Br16{}^{W}16,23b{}^{W}23b33{}^{W}33,35$
P258	${}^{W}1D''{}^{W}D''D{}^{W}DBr{}^{W}Br16{}^{W}16,23b{}^{W}23b34{}^{W}34,35$
P259	${}^{W}1D''{}^{W}D''D{}^{W}DBr{}^{W}Br16{}^{W}16,26a{}^{W}26a32{}^{W}32,35$
P260	${}^{W}1D''{}^{W}D''D{}^{W}DBr{}^{W}Br16{}^{W}16,26a{}^{W}26a33{}^{W}33,35$
P261	${}^{W}1D''{}^{W}D''D{}^{W}DBr{}^{W}Br16{}^{W}16,26a{}^{W}26a34{}^{W}34,35$

P262	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DBr}\,{}^{W}_{Br16}\,{}^{W}_{16,26b}\,{}^{W}_{26b32}\,{}^{W}_{32,35}$
P263	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DBr}\,{}^{W}_{Br16}\,{}^{W}_{16,26b}\,{}^{W}_{26b33}\,{}^{W}_{33,35}$
P264	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DBr}\,{}^{W}_{Br16}\,{}^{W}_{16,26b}\,{}^{W}_{26b34}\,{}^{W}_{34,35}$
P265	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DBr}\,{}^{W}_{Br16}\,{}^{W}_{16,28a}\,{}^{W}_{28a32}\,{}^{W}_{32,35}$
P266	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DBr}\,{}^{W}_{Br16}\,{}^{W}_{16,28a}\,{}^{W}_{28a33}\,{}^{W}_{33,35}$
P267	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DBr}\,{}^{W}_{Br16}\,{}^{W}_{16,28a}\,{}^{W}_{28a34}\,{}^{W}_{34,35}$
P268	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DBr}\,{}^{W}_{Br16}\,{}^{W}_{16,28b}\,{}^{W}_{28b32}\,{}^{W}_{32,35}$
P269	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DBr}\,{}^{W}_{Br16}\,{}^{W}_{16,28b}\,{}^{W}_{28b33}\,{}^{W}_{33,35}$
P270	${}^{W}_{1D''}\,{}^{W}_{D''D}\,{}^{W}_{DBr}\,{}^{W}_{Br16}\,{}^{W}_{16,28b}\,{}^{W}_{28b34}\,{}^{W}_{34,35}$
P271	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''23a''}\,{}^{W}_{23a''32''}\,{}^{W}_{32''35}$
P272	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''23a''}\,{}^{W}_{23a''33''}\,{}^{W}_{33''35}$
P273	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''23a''}\,{}^{W}_{23a''34''}\,{}^{W}_{34''35}$
P274	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''23b''}\,{}^{W}_{23b''32''}\,{}^{W}_{32''35}$
P275	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''23b''}\,{}^{W}_{23b''33''}\,{}^{W}_{33''35}$
P276	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''23b''}\,{}^{W}_{23b''34''}\,{}^{W}_{34''35}$
P277	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''26a''}\,{}^{W}_{26a''32''}\,{}^{W}_{32''35}$
P278	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''26a''}\,{}^{W}_{26a''33''}\,{}^{W}_{33''35}$
P279	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''26a''}\,{}^{W}_{26a''34''}\,{}^{W}_{34''35}$
P280	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''26b''}\,{}^{W}_{26b''32''}\,{}^{W}_{32''35}$
P281	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''26b''}\,{}^{W}_{26b''33''}\,{}^{W}_{33''35}$
P282	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''26b''}\,{}^{W}_{26b''34''}\,{}^{W}_{34''35}$
P283	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''28a''}\,{}^{W}_{28a''32''}\,{}^{W}_{32''35}$
P284	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''28a''}\,{}^{W}_{28a''33''}\,{}^{W}_{33''35}$
P285	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''28a''}\,{}^{W}_{28a''34''}\,{}^{W}_{34''35}$
P286	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''28b''}\,{}^{W}_{28b''32''}\,{}^{W}_{32''35}$
P287	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''28b''}\,{}^{W}_{28b''33''}\,{}^{W}_{33''35}$
P288	${}^{W}_{1D''}\,{}^{W}_{D''Y''}\,{}^{W}_{Y''16''}\,{}^{W}_{16''28b''}\,{}^{W}_{28b''34''}\,{}^{W}_{34''35}$

P289	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"23a"^{W}23a"32"^{W}32"35
P290	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"23a"^{W}23a"33"^{W}33"35
P291	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"23a"^{W}23a"34"^{W}34"35
P292	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"23b"^{W}23b"32"^{W}32"35
P293	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"23b"^{W}23b"33"^{W}33"35
P294	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"23b"^{W}23b"34"^{W}34"35
P295	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"26a"^{W}26a"32"^{W}32"35
P296	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"26a"^{W}26a"33"^{W}33"35
P297	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"26a"^{W}26a"34"^{W}34"35
P298	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"26b"^{W}26b"32"^{W}32"35
P299	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"26b"^{W}26b"33"^{W}33"35
P300	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"26b"^{W}26b"34"^{W}34"35
P301	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"28a"^{W}28a"32"^{W}32"35
P302	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"28a"^{W}28a"33"^{W}33"35
P303	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"28a"^{W}28a"34"^{W}34"35
P304	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"28b"^{W}28b"32"^{W}32"35
P305	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"28b"^{W}28b"33"^{W}33"35
P306	^{W}1D"^{W}D"O"^{W}O"16"^{W}16"28b"^{W}28b"34"^{W}34"35
P307	^{W}1D"^{W}D"Br"^{W}Br"16"^{W}16"23a"^{W}23a"32"^{W}32"35
P308	^{W}1D"^{W}D"Br"^{W}Br"16"^{W}16"23a"^{W}23a"33"^{W}33"35
P309	^{W}1D"^{W}D"Br"^{W}Br"16"^{W}16"23a"^{W}23a"34"^{W}34"35
P310	^{W}1D"^{W}D"Br"^{W}Br"16"^{W}16"23b"^{W}23b"32"^{W}32"35
P311	^{W}1D"^{W}D"Br"^{W}Br"16"^{W}16"23b"^{W}23b"33"^{W}33"35
P312	^{W}1D"^{W}D"Br"^{W}Br"16"^{W}16"23b"^{W}23b"34"^{W}34"35
P313	^{W}1D"^{W}D"Br"^{W}Br"16"^{W}16"26a"^{W}26a"32"^{W}32"35
P314	^{W}1D"^{W}D"Br"^{W}Br"16"^{W}16"26a"^{W}26a"33"^{W}33"35
P315	^{W}1D"^{W}D"Br"^{W}Br"16"^{W}16"26a"^{W}26a"34"^{W}34"35

P316	$W_{1D''}W_{D''Br''}W_{Br''16''}W_{16''26b''}W_{26b''32''}W_{32''35}$
P317	$W_{1D''}W_{D''Br''}W_{Br''16''}W_{16''26b''}W_{26b''33''}W_{33''35}$
P318	$W_{1D''}W_{D''Br''}W_{Br''16''}W_{16''26b''}W_{26b''34''}W_{34''35}$
P319	$W_{1D''}W_{D''Br''}W_{Br''16''}W_{16''28a''}W_{28a''32''}W_{32''35}$
P320	$W_{1D''}W_{D''Br''}W_{Br''16''}W_{16''28a''}W_{28a''33''}W_{33''35}$
P321	$W_{1D''}W_{D''Br''}W_{Br''16''}W_{16''28a''}W_{28a''34''}W_{34''35}$
P322	$W_{1D''}W_{D''Br''}W_{Br''16''}W_{16''28b''}W_{28b''32''}W_{32''35}$
P323	$W_{1D''}W_{D''Br''}W_{Br''16''}W_{16''28b''}W_{28b''33''}W_{33''35}$
P324	$W_{1D''}W_{D''Br''}W_{Br''16''}W_{16''28b''}W_{28b''34''}W_{34''35}$

Because the paths for the remaining system transmittances are relatively few, they are enumerated in their entirety as follows:

For system transmittance $W_{1,18}$:

P325	1-2-3-4-8'-D'-10'-12'-13'-14'-B'-17'-18'-18
P326	1-2-3-4-8'-D'-10'-12'-13'-14'-Br'-17'-18'-18
P327	1-2-3-5-8-D-D'-10'-12'-13'-14'-B'-17'-18'-18
P328	1-2-3-5-8-D-D'-10'-12'-13'-14'-Br'-17'-18'-18
P329	1-2-3-6-8"-D"-D-D'-10'-12'-13'-14'-B'-17'-18'-18
P330	1-2-3-6-8"-D"-D-D'-10'-12'-13'-14'-Br'-17'-18'-18
P331	1-2-3-5-8-D-10-12-13-14-B-17-18
P332	1-2-3-5-8-D-10-12-13-14-Br-17-18
P333	1-2-3-6-8"-D"-D-10-12-13-14-B-17-18
P334	1-2-3-6-8"-D"-D-10-12-13-14-Br-17-18
P335	1-2-3-6-8"-D"-10"-12"-13"-14"-B"-17"-18"-18
P336	1-2-3-6-8"-D"-10"-12"-13"-14"-Br"-17"-18"-18

For system transmittance $W_{1,19}$:

P337	1-2-3-4-8'-D'-10'-12'-13'-14'-Br'-Sc'-19
P338	1-2-3-4-8'-D'-10'-12'-13'-14'-Sc'-19
P339	1-2-3-4-8'-D'-10'-12'-13'-Sc'-19
P340	1-2-3-4-8'-D'-10'-12'-Sc'-19
P341	1-2-3-5-8-D-D'-10'-12'-13'-14'-Br'-Sc'-19
P342	1-2-3-5-8-D-D'-10'-12'-13'-14'-Sc'-19
P343	1-2-3-5-8-D-D'-10'-12'-13'-Sc'-19
P344	1-2-3-5-8-D-D'-10'-12'-Sc'-19
P345	1-2-3-6-8"-D"-D-D'-10'-12'-13'-14'-Br'-Sc'-19
P346	1-2-3-6-8"-D"-D-D'-10'-12'-13'-14'-Sc'-19
P347	1-2-3-6-8"-D"-D-D'-10'-12'-13'-Sc'-19
P348	1-2-3-6-8"-D"-D-D'-10'-12'-Sc'-19
P349	1-2-3-5-8-D-10-12-13-14-Br-Sc-19
P350	1-2-3-5-8-D-10-12-13-14-Sc-19
P351	1-2-3-5-8-D-10-12-13-Sc-19
P352	1-2-3-4-8-D-10-12-Sc-19
P353	1-2-3-6-8"-D"-D-10-12-13-14-Br-Sc-19
P354	1-2-3-6-8"-D"-D-10-12-13-14-Sc-19
P355	1-2-3-6-8"-D"-D-10-12-13-Sc-19
P356	1-2-3-6-8"-D"-D-10-12-Sc-19
P357	1-2-3-6-8"-D"-10"-12"-13"-14"-Br"-Sc"-19
P358	1-2-3-6-8"-D"-10"-12"-13"-14"-Sc"-19
P359	1-2-3-6-8"-D"-10"-12"-13"-Sc"-19
P360	1-2-3-6-8"-D"-10"-12"-Sc"-19

For system transmittance W_{1p}:

P361	1-2-3-4-8'-D'-9'-P
P362	1-2-3-5-8-D-D'-9'-P
P363	1-2-3-6-8"-D"-D-D'-9'-P
P364	1-2-3-5-8-D-9-P
P365	1-2-3-6-8"-D"-D-9-P
P366	1-2-3-6-8"-D"-9"-P

For system transmittance $W_{1,11}$:

P367	1-2-3-4-8'-D'-11
P368	1-2-3-5-8-D-D'-11
P369	1-2-3-6-8"-D"-D-D'-11
P370	1-2-3-5-8-D-11
P371	1-2-3-6-8"-D"-D-11
P372	1-2-3-6-8"-D"-11

For system transmittance $W_{1,7}$:

P373	1-2-7

Transmittance $W_{1,35}$

PATH	G_j	Δ_j
P1	$.00029939e^{5.15s}$	1-0.19
P2	$.00089817e^{5.15s}$	1-0.19
P3	$.00029939e^{5.36s}$	1-0.19
P4	$.00001575e^{5.79s}$	1-0.19
P5	$.00004725e^{5.79s}$	1-0.19
P6	$.00001575e^{6.00s}$	1-0.19
P7	$.00001820e^{4.97s}$	1-0.19
P8	$.00005460e^{4.97s}$	1-0.19

PATH	G_j	Δ_j
P9	$0.0000182e^{5.18s}$	1-0.19
P10	$0.0000098e^{5.43s}$	1-0.19
P11	$0.0000294e^{5.43s}$	1-0.19
P12	$0.0000098e^{5.64s}$	1-0.19
P13	$0.0000053e^{5.41s}$	1-0.19
P14	$0.0000158e^{5.41s}$	1-0.19
P15	$0.0000053e^{5.62s}$	1-0.19
P16	$0.0000018e^{5.8\ s}$	1-0.19

PATH	G_j	Δ_j
P17	$0.0000053e^{5.81s}$	1-0.19
P18	$0.0000018e^{6.02s}$	1-0.19
P19	$0.0004192e^{5.15s}$	1-0.19
P20	$0.0012575e^{5.15s}$	1-0.19
P21	$0.0004192e^{5.36s}$	1-0.19
P22	$0.0000221e^{5.79s}$	1-0.19
P23	$0.0000662e^{5.79s}$	1-0.19
P24	$0.0000221e^{6.00s}$	1-0.19
P25	$0.0000255e^{4.97s}$	1-0.19
P26	$0.0000765e^{4.97s}$	1-0.19
P27	$0.0000255e^{5.18s}$	1-0.19
P28	$0.0000137e^{5.43s}$	1-0.19
P29	$0.0000412e^{5.43s}$	1-0.19
P30	$0.0000137e^{5.64s}$	1-0.19
P31	$0.0000074e^{5.41s}$	1-0.19
P32	$0.0000221e^{5.41s}$	1-0.19
P33	$0.0000074e^{5.62s}$	1-0.19
P34	$0.0000025e^{5.81s}$	1-0.19
P35	$0.0000074e^{5.81s}$	1-0.19
P36	$0.0000025e^{6.02s}$	1-0.19
P37	$0.0000239e^{5.15s}$	1-0.19
P38	$0.0007182e^{5.15s}$	1-0.19
P39	$0.0000239e^{5.36s}$	1-0.19
P40	$0.0000378e^{5.79s}$	1-0.19
P41	$0.0001134e^{5.79s}$	1-0.19
P42	$0.0000378e^{6.00s}$	1-0.19

PATH	G_j	Δ_j
P43	$0.0000145e^{4.97s}$	1-0.19
P44	$0.0000435e^{4.97s}$	1-0.19
P45	$0.0000145e^{5.18s}$	1-0.19
P46	$0.0000234e^{5.43s}$	1-0.19
P47	$0.0000702e^{5.43s}$	1-0.19
P48	$0.0000234e^{5.64s}$	1-0.19
P49	$0.0000042e^{5.41s}$	1-0.19
P50	$0.0000126e^{5.41s}$	1-0.19
P51	$0.0000042e^{5.62s}$	1-0.19
P52	$0.0000014e^{5.81s}$	1-0.19
P53	$0.0000042e^{5.81s}$	1-0.19
P54	$0.0000014e^{6.02s}$	1-0.19
P55	$0.0000448e^{5.15s}$	1-0.15
P56	$0.0001344e^{5.15s}$	1-0.15
P57	$0.0000448e^{5.36s}$	1-0.15
P58	$0.0000023e^{5.79s}$	1-0.15
P59	$0.0000069e^{5.79s}$	1-0.15
P60	$0.0000023e^{6.00s}$	1-0.15
P61	$0.0000027e^{4.97s}$	1-0.15
P62	$0.0000081e^{4.97s}$	1-0.15
P63	$0.0000027e^{5.18s}$	1-0.15
P64	$0.0000043e^{5.43s}$	1-0.15
P65	$0.0000129e^{5.43s}$	1-0.15
P66	$0.0000043e^{5.64s}$	1-0.15
P67	$0.0000007e^{5.41s}$	1-0.15
P68	$0.0000021e^{5.41s}$	1-0.15

PATH	G_j	Δ_j
P69	$0.0000007e^{5.62s}$	1-0.15
P70	$0.0000002e^{5.81s}$	1-0.15
P71	$0.0000006e^{5.81s}$	1-0.15
P72	$0.0000002e^{6.02s}$	1-0.15
P73	$0.0000628e^{5.15s}$	1-0.15
P74	$0.0001881e^{5.15s}$	1-0.15
P75	$0.0000628e^{5.36s}$	1-0.15
P76	$0.0000032e^{5.79s}$	1-0.15
P77	$0.0000096e^{5.79s}$	1-0.15
P78	$0.0000032e^{6.00s}$	1-0.15
P79	$0.0000037e^{4.97s}$	1-0.15
P80	$0.0000113e^{4.97s}$	1-0.15
P81	$0.0000037e^{5.18s}$	1-0.15
P82	$0.0000060e^{5.43s}$	1-0.15
P83	$0.0000180e^{5.43s}$	1-0.15
P84	$0.0000060e^{5.64s}$	1-0.15
P85	$0.0000009e^{5.41s}$	1-0.15
P86	$0.0000027e^{5.41s}$	1-0.15
P87	$0.0000009e^{5.62s}$	1-0.15
P88	$0.0000003e^{5.81s}$	1-0.15
P89	$0.0000009e^{5.81s}$	1-0.15
P90	$0.0000003e^{6.02s}$	1-0.15
P91	$0.0000359e^{5.15s}$	1-0.15
P92	$0.0001075e^{5.15s}$	1-0.15
P93	$0.0000359e^{5.36s}$	1-0.15
P94	$0.0000018e^{5.79s}$	1-0.15

PATH	G_j	Δ_j
P95	$0.0000054e^{5.79s}$	1-0.15
P96	$0.0000018e^{6.00s}$	1-0.15
P97	$0.0000021e^{4.97s}$	1-0.15
P98	$0.0000064e^{4.97s}$	1-0.15
P99	$0.0000021e^{5.18s}$	1-0.15
P100	$0.0000034e^{5.43s}$	1-0.15
P101	$0.0000103e^{5.43s}$	1-0.15
P102	$0.0000034e^{5.64s}$	1-0.15
P103	$0.0000006e^{5.41s}$	1-0.15
P104	$0.0000018e^{5.41s}$	1-0.15
P105	$0.0000006e^{5.62s}$	1-0.15
P106	$0.0000002e^{5.81s}$	1-0.15
P107	$0.0000006e^{5.81s}$	1-0.15
P108	$0.0000002e^{6.02s}$	1-0.15
P109	$0.0000040e^{5.15s}$	1
P110	$0.0000120e^{5.15s}$	1
P111	$0.0000040e^{5.36s}$	1
P112	$0.0000002e^{5.79s}$	1
P113	$0.0000006e^{5.79s}$	1
P114	$0.0000002e^{6.00s}$	1
P115	$0.0000001e^{4.97s}$	1
P116	$0.0000003e^{4.97s}$	1
P117	$0.0000001e^{5.18s}$	1
P118	0.0000000	1
P119	0.0000000	1
P120	0.0000000	1

PATH	G_j	Δj
P121	$0.0000035e^{5.41s}$	1
P122	$0.0000105e^{5.41s}$	1
P123	$0.0000035e^{5.62s}$	1
P124	$0.0000011e^{5.81s}$	1
P125	$0.0000035e^{5.81s}$	1
P126	$0.0000011e^{6.02s}$	1
P127	$0.0000056e^{5.15s}$	1
P128	$0.0000168e^{5.15s}$	1
P129	$0.0000056e^{5.36s}$	1
P130	$0.0000002e^{5.79s}$	1
P131	$0.0000006e^{5.79s}$	1
P132	$0.0000002e^{6.00s}$	1
P133	$0.0000001e^{4.97s}$	1
P134	$0.0000003e^{4.97s}$	1
P135	$0.0000001e^{5.18s}$	1
P136	0.0000000	1
P137	0.0000000	1
P138	0.0000000	1
P139	$0.0000049e^{5.41s}$	1
P140	$0.0000148e^{5.41s}$	1
P141	$0.0000049e^{5.62s}$	1
P142	$0.0000015e^{5.81s}$	1
P143	$0.0000045e^{5.81s}$	1
P144	$0.0000015e^{6.02s}$	1
P145	$0.0000032e^{5.15s}$	1
P146	$0.0000096e^{5.15s}$	1
P147	$0.0000032e^{5.36s}$	1
P148	$0.0000001e^{5.79s}$	1
P149	$0.0000003e^{5.79s}$	1
P150	$0.0000001e^{6.00s}$	1
P151	0.0000000	1
P152	0.0000000	1
P153	0.0000000	1
P154	0.0000000	1
P155	0.0000000	1
P156	0.0000000	1
P157	$0.0000028e^{5.41s}$	1
P158	$0.0000084e^{5.41s}$	1
P159	$0.0000028e^{5.62s}$	1
P160	$0.0000009e^{5.81s}$	1
P161	$0.0000028e^{5.81s}$	1
P162	$0.0000009e^{6.02s}$	1
P163	$0.0010417e^{5.41s}$	1-0.16
P164	$0.0083336e^{5.41s}$	1-0.16
P165	$0.0010417e^{5.62s}$	1-0.16
P166	$0.0000548e^{6.05s}$	1-0.16
P167	$0.0004384e^{6.05s}$	1-0.16
P168	$0.0000548e^{6.21s}$	1-0.16
P169	$0.0000633e^{5.24s}$	1-0.16
P170	$0.0005064e^{5.24s}$	1-0.16
P171	$0.0000633e^{5.49s}$	1-0.16
P172	$0.0000341e^{5.70s}$	1-0.16

PATH	G_j	Δj
P173	$0.0002723e^{5.70s}$	1-0.16
P174	$0.0000341e^{5.86s}$	1-0.16
P175	$0.0000182e^{5.67s}$	1-0.16
P176	$0.0001456e^{5.67s}$	1-0.16
P177	$0.0000182e^{5.83s}$	1-0.16
P178	$0.0000060e^{6.07s}$	1-0.16
P179	$0.0000487e^{6.07s}$	1-0.16
P180	$0.0000060e^{6.23s}$	1-0.16
P181	$0.0014583e^{5.41s}$	1-0.16
P182	$0.0116670e^{5.41s}$	1-0.16
P183	$0.0014583e^{5.62s}$	1-0.16
P184	$0.0000767e^{6.05s}$	1-0.16
P185	$0.0006137e^{6.05s}$	1-0.16
P186	$0.0000767e^{6.21s}$	1-0.16
P187	$0.0000886e^{5.24s}$	1-0.16
P188	$0.0007089e^{5.24s}$	1-0.16
P189	$0.0000886e^{5.49s}$	1-0.16
P190	$0.0000477e^{5.70s}$	1-0.16
P191	$0.0003812e^{5.70s}$	1-0.16
P192	$0.0000477e^{5.86s}$	1-0.16
P193	$0.0000254e^{5.67s}$	1-0.16
P194	$0.0002038e^{5.67s}$	1-0.16
P195	$0.0000254e^{5.83s}$	1-0.16
P196	$0.0000084e^{6.07s}$	1-0.16
P197	$0.0000681e^{6.07s}$	1-0.16
P198	$0.0000084e^{6.23s}$	1-0.16

PATH	G_j	Δj
P199	$0.0008333e^{5.41s}$	1-0.16
P200	$0.0066668e^{5.41s}$	1-0.16
P201	$0.0008333e^{5.62s}$	1-0.16
P202	$0.0000438e^{6.05s}$	1-0.16
P203	$0.0003504e^{6.05s}$	1-0.16
P204	$0.0000438e^{6.21s}$	1-0.16
P205	$0.0000506e^{5.24s}$	1-0.16
P206	$0.0004051e^{5.24s}$	1-0.16
P207	$0.0000506e^{5.49s}$	1-0.16
P208	$0.0000272e^{5.70s}$	1-0.16
P209	$0.0002178e^{5.70s}$	1-0.16
P210	$0.0000272e^{5.86s}$	1-0.16
P211	$0.0000145e^{5.67s}$	1-0.16
P212	$0.0001164e^{5.67s}$	1-0.16
P213	$0.0000145e^{5.83s}$	1-0.16
P214	$0.0000048e^{6.07s}$	1-0.16
P215	$0.0000389e^{6.07s}$	1-0.16
P216	$0.0000048e^{6.23s}$	1-0.16
P217	$0.0009370e^{5.41s}$	1-0.01
P218	$0.0007500e^{5.41s}$	1-0.01
P219	$0.0009370e^{5.62s}$	1-0.01
P220	$0.0000049e^{6.05s}$	1-0.01
P221	$0.0000394e^{6.05s}$	1-0.01
P222	$0.0000049e^{6.21s}$	1-0.01
P223	$0.0000056e^{5.24s}$	1-0.01
P224	$0.0000455e^{5.24s}$	1-0.01

PATH	G_j	Δ_j
P225	$0.0000056e^{5.49s}$	1-0.01
P226	$0.0000030e^{5.70s}$	1-0.01
P227	$0.0000240e^{5.70s}$	1-0.01
P228	$0.0000030e^{5.86s}$	1-0.01
P229	$0.0000016e^{5.67s}$	1-0.01
P230	$0.0000131e^{5.67s}$	1-0.01
P231	$0.0000016e^{5.83s}$	1-0.01
P232	$0.0000005e^{6.07s}$	1-0.01
P233	$0.0000043e^{6.07s}$	1-0.01
P234	$0.0000005e^{6.23s}$	1-0.01
P235	$0.0001312e^{5.41s}$	1-0.01
P236	$0.0010500e^{5.41s}$	1-0.01
P237	$0.0001312e^{5.62s}$	1-0.01
P238	$0.0000069e^{6.05s}$	1-0.01
P239	$0.0000552e^{6.05s}$	1-0.01
P240	$0.0000069e^{6.21s}$	1-0.01
P241	$0.0000079e^{5.24s}$	1-0.01
P242	$0.0000638e^{5.24s}$	1-0.01
P243	$0.0000079e^{5.49s}$	1-0.01
P244	$0.0000042e^{5.70s}$	1-0.01
P245	$0.0000343e^{5.70s}$	1-0.01
P246	$0.0000042e^{5.86s}$	1-0.01
P247	$0.0000022e^{5.67s}$	1-0.01
P248	$0.0000183e^{5.67s}$	1-0.01
P249	$0.0000022e^{5.83s}$	1-0.01
P250	$0.0000007e^{6.07s}$	1-0.01

PATH	G_j	Δ_j
P251	$0.0000061e^{6.07s}$	1-0.01
P252	$0.0000007e^{6.23s}$	1-0.01
P253	$0.0000749e^{5.41s}$	1-0.01
P254	$0.0006000e^{5.41s}$	1-0.01
P255	$0.0000749e^{5.62s}$	1-0.01
P256	$0.0000039e^{6.05s}$	1-0.01
P257	$0.0000315e^{6.05s}$	1-0.01
P258	$0.0000039e^{6.21s}$	1-0.01
P259	$0.0000045e^{5.24s}$	1-0.01
P260	$0.0000364e^{5.24s}$	1-0.01
P261	$0.0000045e^{5.49s}$	1-0.01
P262	$0.0000024e^{5.70s}$	1-0.01
P263	$0.0000196e^{5.70s}$	1-0.01
P264	$0.0000024e^{5.86s}$	1-0.01
P265	$0.0000013e^{5.67s}$	1-0.01
P266	$0.0000104e^{5.67s}$	1-0.01
P267	$0.0000013e^{5.83s}$	1-0.01
P268	$0.0000004e^{6.07s}$	1-0.01
P269	$0.0000035e^{6.07s}$	1-0.01
P270	$0.0000004e^{6.23s}$	1-0.01
P271	$0.0001388e^{5.99s}$	1-0.05
P272	$0.0004860e^{6.22s}$	1-0.05
P273	$0.0000694e^{6.33s}$	1-0.05
P274	$0.0000073e^{6.63s}$	1-0.05
P275	$0.0000255e^{6.86s}$	1-0.05
P276	$0.0000036e^{6.97s}$	1-0.05

PATH	G_j	Δ_j
P277	$0.0000083e^{5.56s}$	1-0.05
P278	$0.0000294e^{5.79s}$	1-0.05
P279	$0.0000042e^{5.90s}$	1-0.05
P280	$0.0000045e^{6.02s}$	1-0.05
P281	$0.0000158e^{6.25s}$	1-0.05
P282	$0.0000022e^{6.36s}$	1-0.05
P283	$0.0000024e^{5.91s}$	1-0.05
P284	$0.0000084e^{6.14s}$	1-0.05
P285	$0.0000012e^{6.25s}$	1-0.05
P286	$0.0000008e^{6.31s}$	1-0.05
P287	$0.0000028e^{6.54s}$	1-0.05
P288	$0.0000004e^{6.65s}$	1-0.05
P289	$0.0001943e^{5.99s}$	1-0.05
P290	$0.0006804e^{6.22s}$	1-0.05
P291	$0.0000971e^{6.33s}$	1-0.05
P292	$0.0000102e^{6.63s}$	1-0.05
P293	$0.0000357e^{6.86s}$	1-0.05
P294	$0.0000050e^{6.97s}$	1-0.05
P295	$0.0000116e^{5.56s}$	1-0.05
P296	$0.0000411e^{5.79s}$	1-0.05
P297	$0.0000058e^{5.90s}$	1-0.05
P298	$0.0000063e^{6.02s}$	1-0.05
P299	$0.0000221e^{6.25s}$	1-0.05
P300	$0.0000030e^{6.36s}$	1-0.05
P301	$0.0000033e^{5.91s}$	1-0.05
P302	$0.0000117e^{6.14s}$	1-0.05

PATH	G_j	Δ_j
P303	$0.0000016e^{6.25s}$	1-0.05
P304	$0.0000011e^{6.31s}$	1-0.05
P305	$0.0000039e^{6.54s}$	1-0.05
P306	$0.0000005e^{6.65s}$	1-0.05
P307	$0.0001111e^{5.99s}$	1-0.05
P308	$0.0003888e^{6.22s}$	1-0.05
P309	$0.0000555e^{6.33s}$	1-0.05
P310	$0.0000058e^{6.63s}$	1-0.05
P311	$0.0000204e^{6.86s}$	1-0.05
P312	$0.0000028e^{6.97s}$	1-0.05
P313	$0.0000066e^{5.56s}$	1-0.05
P314	$0.0000235e^{5.79s}$	1-0.05
P315	$0.0000033e^{5.90s}$	1-0.05
P316	$0.0000036e^{6.02s}$	1-0.05
P317	$0.0000126e^{6.25s}$	1-0.05
P318	$0.0000017e^{6.36s}$	1-0.05
P319	$0.0000019e^{5.91s}$	1-0.05
P320	$0.0000067e^{6.14s}$	1-0.05
P321	$0.0000009e^{6.25s}$	1-0.05
P322	$0.0000006e^{6.31s}$	1-0.05
P323	$0.0000050e^{6.54s}$	1-0.05
P324	$0.0000003e^{6.65s}$	1-0.05

Transmittance $W_{1,18}$

PATH	G_j	Δ_j
P325	$0.0014006e^{1.91s}$	1-0.2
P326	$0.0061279e^{1.91s}$	1-0.2
P327	$0.0002100e^{1.91s}$	1-0.2
P328	$0.0009187e^{1.91s}$	1-0.2
P329	$0.0000188e^{1.91s}$	1-0.2
P330	$0.0000822e^{1.91s}$	1-0.2
P331	$0.0097469e^{1.91s}$	1-0.2
P332	$0.0426426e^{1.91s}$	1-0.2
P333	$0.0008772e^{1.91s}$	1-0.2
P334	$0.0038377e^{1.91s}$	1-0.2
P335	$0.0006497e^{1.92s}$	1-0.2
P336	$0.0028424e^{1.92s}$	1-0.2
P337	$0.0000140e^{1.88s}$	1-0.2
P338	$0.0012635e^{1.88s}$	1-0.2
P339	$0.0000921e^{1.87s}$	1-0.2
P340	$0.0829350e^{1.56s}$	1-0.2
P341	$0.0000021e^{1.88s}$	1-0.2
P342	$0.0002626e^{1.88s}$	1-0.2
P343	$0.0000691e^{1.87s}$	1-0.2
P344	$0.0124402e^{1.56s}$	1-0.2
P345	$0.0000001e^{1.88s}$	1-0.2
P346	$0.0000236e^{1.88s}$	1-0.2
P347	$0.0000062e^{1.87s}$	1-0.2
P348	$0.0011196e^{1.56s}$	1-0.2

PATH	G_j	Δ_j
P349	$0.0000974e^{1.93s}$	1-0.2
P350	$0.0121837e^{1.93s}$	1-0.2
P351	$0.0032062e^{1.92s}$	1-0.2
P352	$0.5771250e^{1.57s}$	1-0.2
P353	$0.0000087e^{1.93s}$	1-0.2
P354	$0.0010965e^{1.93s}$	1-0.2
P355	$0.0002885e^{1.92s}$	1-0.2
P356	$0.0519412e^{1.57s}$	1-0.2
P357	$0.0000064e^{2.05s}$	1-0.2
P358	$0.0008122e^{2.05s}$	1-0.2
P359	$0.0002137e^{2.03s}$	1-0.2
P360	$0.0384750e^{1.59s}$	1-0.2
P361	$0.0009500e^{1.61s}$	1-0.2
P362	$0.0001425e^{1.61s}$	1-0.2
P363	$0.0000128e^{1.61s}$	1-0.2
P364	$0.0213750e^{1.61s}$	1-0.2
P365	$0.0019237e^{1.61s}$	1-0.2
P366	$0.0213750e^{1.61s}$	1-0.2

Transmittance $W_{1,11}$

P367	$0.0009500e^{1.50s}$	1-0.2
P368	$0.0001425e^{1.50s}$	1-0.2
P369	$0.0012825e^{1.50s}$	1-0.2
P370	$0.0071250e^{1.5s}$	1-0.2
P371	$0.0006412e^{1.5s}$	1-0.2

PATH	G_j	Δ_j
P372	$0.007125e^{1.50s}$	1-0.2

Transmittance $W_{1,7}$

P373	$0.05e^{1.50s}$	1-0.2

The mean cost is defined as $E_{(cost)} = \frac{d}{ds} \left. \frac{W_E(S)}{W_E(0)} \right|_{S=0}$

where $W_E(S) = \sum G_j\Delta_j/\Delta$, and $W_E(0)$ is $W_E(S)$ evaluated at S = zero.

Calculating $W_E(S)_{1,35}$,

$$\sum G_j\Delta_j = (0.0036164e^{5.15s}+0.0007425e^{5.36s}+0.0003026e^{5.79s}$$
$$+0.0000757e^{6.00s}+0.0002328e^{4.97s}+0.0000582e^{5.18s}$$
$$+0.0001877e^{5.43s}+0.0000469e^{5.64s}+0.0000674e^{5.41s}$$
$$+0.0000169e^{5.62s}+0.0000226e^{5.81s}+0.0000057e^{6.02s})(0.81)$$
$$+(0.0005735e^{5.15s}+0.0001435e^{5.36s}+0.0000292e^{5.79s}$$
$$+0.0000073e^{6.00s}+0.0000305e^{4.97s}+0.0000085e^{5.18s}$$
$$+0.0000549e^{5.43s}+0.0000137e^{5.64s}+0.0000088e^{5.41s}$$
$$+0.0000022e^{5.62s}+0.0000028e^{5.81s}+0.0000007e^{6.02s})(0.85)$$
$$+(0.0000512e^{5.15s}+0.0000128e^{5.36s}+0.0000020e^{5.79s}$$
$$+0.0000005e^{6.00s}+0.0000008e^{4.97s}+0.0000002e^{5.18s}$$
$$+0.0000449e^{5.41s}+0.0000112e^{5.62s}+0.0000143e^{5.81s}$$
$$+0.0000035e^{6.02s})(1) +(0.03000007e^{5.41s}+0.0108330e^{5.62s}$$
$$+0.0015778e^{6.05s}+0.0001753e^{6.21s}+0.0018229e^{5.24s}$$
$$+0.0002005e^{5.49s}+0.0009803e^{5.70s}+0.0001090e^{5.86s}$$
$$+0.0005239e^{5.67s}+0.0000581e^{5.83s}+0.0001749e^{6.07s}$$
$$+0.0000192e^{6.23s})(0.84) +(0.0035431e^{5.41s}+0.0002110e^{5.62s}$$
$$+0.0001418e^{6.05s}+0.0000157e^{6.21s}+0.0001637e^{5.24s}$$

$$+0.0000180e^{5.49s}+0.0000875e^{5.70s}+0.0000096e^{5.86s}$$
$$+0.0000469e^{5.67s}+0.0000051e^{5.83s}+0.0000155e^{6.07s}$$
$$+0.0000016e^{6.23s})(0.99)+(0.0004442e^{5.99s}+0.0015552e^{6.22s}$$
$$+0.0002220e^{6.33s}+0.0000233e^{6.63s}+0.0000816e^{6.86s}$$
$$+0.0000114e^{6.97s}+0.0000265e^{5.56s}+0.0000940e^{5.79s}$$
$$+0.0000133e^{5.90s}+0.0000144e^{6.02s}+0.0000542e^{6.25s}$$
$$+0.0000069e^{6.36s}+0.0000076e^{5.91s}+0.0000268e^{6.14s}$$
$$+0.0000025e^{6.31s}+0.0000117e^{6.54s}+0.0000012e^{6.65s})(0.95)$$

$$\sum G_j\Delta_j = 0.0034678e^{5.15s}+0.0007361e^{5.36s}+0.0003612e^{5.79s}$$
$$+0.0000680e^{6.00s}+0.0002152e^{4.97s}+0.0000545e^{5.18s}$$
$$+0.0001986e^{5.43s}+0.0000495e^{5.64s}+0.0001068e^{5.41s}$$
$$+0.0093351e^{5.62s}+0.0000349e^{5.81s}+0.0000222e^{6.02s}$$
$$+0.0287081e^{5.41s}+0.0014656e^{6.05s}+0.0001627e^{6.21s}$$
$$+0.0016932e^{5.24s}+0.0001862e^{5.49s}+0.0009100e^{5.70s}$$
$$+0.0001010e^{5.86s}+0.0004864e^{5.67s}+0.0000538e^{5.83s}$$
$$+0.0002122e^{6.07s}+0.0000176e^{6.23s}+0.0004219e^{5.99s}$$
$$+0.0014774e^{6.22s}+0.0002109e^{6.33s}+0.0000221e^{6.63s}$$
$$+0.0000775e^{6.86s}+0.0000108e^{6.97s}+0.0000251e^{5.56s}$$
$$+0.0000126e^{5.90s}+0.0000514e^{6.25s}+0.0000065e^{6.36s}$$
$$+0.0000072e^{5.91s}+0.0000254e^{6.14s}+0.0000023e^{6.31s}$$
$$+0.0000111e^{6.54s}+0.0000011e^{6.65s}$$

Setting $S = 0$, $\sum G_j\Delta_j = 0.05101$ The value of Δ was calculated earlier to be 0.80784 Therefore, $W_E(0)_{1,35}$ is determined to be:

$$0.05101/0.80784 = 0.0631436$$

$$W_E(0)_{1,35} = \boxed{0.0631436}$$

$$\frac{d}{ds}\left(\frac{W_E(S)_{1,35}}{W_E(0)_{1,35}}\right)\Bigg|_{S=0} = (0.0178591+0.0039454+0.0020913+0.0004080$$
$$+0.0010695+0.0002823+0.0010783+0.0002791$$
$$+0.0005777+0.0524632+0.0002027+0.0001336$$
$$+0.1553108+0.0088668+0.0010103+0.0088723$$
$$+0.0010222+0.0051870+0.0005918+0.0027578$$
$$+0.0003136+0.0012880+0.0001096+0.0025271$$
$$+0.0091894+0.0013349+0.0001465+0.0005316$$
$$+0.0000752+0.0001395+0.0000743+0.0003212$$
$$+0.0000413+0.0000425+0.0001559+0.0000145$$
$$+0.0000725+0.0000073)(0.80784 \times 0.0631436)^{-1}$$

$$= (0.3470911)(0.80784 \times 0.0631436)^{-1}$$

$$= \boxed{\$5.4968532}$$

Therefore, the cost of harvesting sea urchins and of processing and transporting fresh sea urchin roe to Japan is \$5.50 per pound. It is noted at this point that harvesting and packaging the bulk urchin for shipment to New York at a total of \$1.50+0.11+0.25= \$1.86 per pound of roe, and harvesting, processing, and packaging sea urchin roe for shipment domestically at a total of \$1.50+0.38+0.54+0.25= \$2.67 per pound of roe, and finally the cost of scrap that is sold for fertilizer, etc. all add to the total cost of the operation. However, to simplify the analysis, it is assumed that all amounts shipped by either of these routes will be sold at cost and not affect the cost incurred at the Tokyo market.

Because the \$5.50 per pound value represents the mean of a cost distribution, it becomes desirable to know what the distribution looks like. Calculation of the distribution's variance provides this information. The distribution's variance, defined by σ^2, is expressed as:

$$\sigma^2 = \frac{d^2}{ds^2} \frac{W_E(S)_{1,35}}{W_E(0)_{1,35}}\Bigg|_{S=0} - \left(\frac{d}{ds} \frac{W_E(S)_{1,35}}{W_E(0)_{1,35}}\Bigg|_{S=0}\right)^2$$

$$\frac{d^2}{ds^2} \frac{W_E(S)_{1,35}}{W_E(0)_{1,35}}\Bigg|_{S=0} = (0.0919743+0.0211473+0.0121086+0.0024480$$
$$+0.0053154+0.0014623+0.0058551+0.0015741$$
$$+0.0031253+0.2948431+0.0011776+0.0008042$$
$$+0.8402314+0.0536441+0.0062739+0.0464908$$
$$+0.0056118+0.0295659+0.0034679+0.0156361$$
$$+0.0018282+0.0078181+0.0006828+0.0151373$$
$$+0.0571580+0.0084499+0.0009712+0.0036467$$
$$+0.0005241+0.0007756+0.0004383+0.0020075$$
$$+0.0002626+0.0002511+0.0009572+0.0000914$$
$$+0.0004741+0.0000485)(0.80784 \times 0.0631436)^{-1}$$

$$= (1.5442798)(0.80784 \times 0.0631436)^{-1}$$

$$= \boxed{30.274103}$$

$$\sigma^2 = 30.274103 - (5.4968532)^2$$
$$= 30.274103 - 30.215395$$
$$= \boxed{0.058708}$$

Which signifies that the distribution is very tight. This further indicates that the costs will not vary significantly from the \$5.50 per pound ad valorem amount. This tight variation could have been much greater if more factors had been varied.

CHAPTER VI

CONCLUSION

General

The original hypothesis to be tested was:

The harvesting and processing of sea urchin roe for export is an economically feasible venture for certain fisheries industries in New England.

The specific case of processing sea urchin roe in the state of Maine for export to Japan was used to test the validity of this hypothesis. A new managerial decision tool called SMART was developed for the purpose of conducting this test. The SMART method used the systems approach and GERT (Graphical Evaluation and Review Technique) to model the total system and to derive a projected distribution of costs. In Chapter V, an average cost of $5.50 per pound of fresh processed sea urchin roe was calculated. This figure included a correction factor which enabled the costs derived from the SMART model to be compared directly to the price being offered in the Tokyo market. In other words, the actual cost seen by the Maine processor would be $4.80 per pound but this figure cannot be compared directly to the prices offered on the Tokyo exchange because of an approximate 36 hour difference in freshness between the Maine product and its Japanese competitor.

Therefore a correction factor was derived as depicted in Figure 5-1 to compensate for the difference in freshness, and was then added to the costs seen by the processor so that direct comparisons could be made.

Comparing the $5.50 per pound amount with the January 1973 price range for sea urchin roe in the Tokyo market, which ranged between $5.32 and $6.64 per pound, it can be concluded that the venture is feasible but not particularly profitable. This is based on the assumption that the quoted price range represents that which could be expected for the "seasonal high" in the same month of succeeding years. It is anticipated that the price range would be somewhat lower in the month of December and February, even lower in November and October, and significantly lower in March. Therefore, at $5.50 per pound the venture would be marginal at best. There are many other influencing factors that should be considered, however, before passing final judgement on the economic feasibility of the venture.

The revaluation of the Yen should serve to raise the U.S. dollar price offered for processed sea urchin roe in the Japanese market. Further dollar devaluations which could be anticipated over a five year planning horizon would shift the offered price further upward making the venture even more attractive. In short, the evaluation of this venture's economic feasibility must be considered against expected future market conditions as well as against current conditions.

Another very important consideration is the definition of purpose for evaluating the venture in the first place. If it is the processor's desire to maintain employment for his work force through the winter months and to utilize facilities which would otherwise stand idle, then the overall profitability consideration might not be as important as the economic feasibility consideration. If the processor is concerned about profit potential the venture may not seem feasible. But from the standpoint of providing year round employment and utilizing idle plant capacity at little or no loss, the venture becomes economically feasible.

In actuality, the only way to truly test the economic feasibility of the venture is to conduct one or more "test runs." Had the predicted costs of the SMART analysis been higher, there would have been little justification for conducting a test run. But the $5.50 per pound cost places the venture in the "maybe" category which certainly warrants further investigation and justifies a test run through the entire system.

During the course of any "test run," careful attention should be paid to the following parameters: (1) Number of sea urchins harvested per hour; (2) Survival rate of the captured sea urchins when kept in holding tanks for 12, 24, 36, 48, 60, and 72 hours; (3) Number of pounds of roe processed per person per day. A minimum of 100 pounds of roe should be processed by a team of 9 workers during the initial test run. A second test run, if conducted, should yield a minimum of 175 pounds per team per day; (4) Percentage breakdown actually encountered in the test sample of sea urchin roe by grade: high quality yellow, intermediate quality orange, low quality brown, and percentage lost or broken during the processing operation; (5) Quality loss of the processed roe over periods of 12, 24, 36, 48, 60, and 72 hours under refrigerated conditions; (6) Actual costs of obtaining dry cedar wood trays. Price of each tray should not exceed 20 cents; (7) Percentage of roe damaged during domestic transit via privately owned vehicle and, if possible, as compared to percentage damaged during domestic transit via a common carrier trucking firm, and/or via Delta Airlines from Portland, Maine to Kennedy International Airport in New York; (8) Percentage of roe damaged during international transit; (9) Actual price obtained in the Tokyo market as compared to that which was expected.

Such a test as the one just described is absolutely essential before any final judgement can be made as to the economic feasibility of the venture. The data derived from the test should then be used to validate the assumptions used during the SMART approach. Since the SMART approach attempted to envision the most pessimistic outcome for the venture, the actual data should improve the cost figures by some amount. The revised figures can only be obtained, however, through an actual test run.

Recommendations

It has been shown that processing sea urchin roe in New England for export is economically feasible if the venture is undertaken as a means for utilizing idle resources and for providing employment. It has also been shown that profit potential in the current market is near zero. Yet the profit potential always has been, is, and always will be a primary consideration for assessing economic feasibility regardless of an entrepreneur's motivation for undertaking a particular venture. Therefore, the task remains to look at the aggregate system and to determine what changes, if any, can be made to improve the profitability picture of the "sea urchin roe for export" venture.

In keeping with the theme just described, the following recommendations are offered:

(1) A test run must be conducted, actually harvesting, processing, and transporting sea urchin roe to Japan. The data and information listed in the preceding section should be collected and recorded.

(2) The SMART model can be used to demonstrate the sensitivity of the cost of the final delivered product to the cost of transportation. It should be obvious that domestic and international transport costs account for a substantial portion of the overall cost. It logically follows that larger bulk shipments could result in economies of scale and a significant reduction in transportation costs. However, the processing operation is extremely labor intensive, a factor which has a profound impact on available alternatives for reducing costs in the transportation segment of the aggregate system.

It has been estimated that a medium to large processing plant can produce from 400 to 700 pounds of roe per day on a regular basis. Yet approximately 800 pounds of roe per day must be produced at a minimum before any significant savings in transportation costs are to be realized. In terms of the network modeled in this report, a regular output of 800 pounds of processed roe reduces the cost seen by the processor from the corrected $5.50 to a corrected $4.96 per pound. An output of 1200 pounds per day reduces the amount to a corrected $4.80 per pound. The last significant break occurs at the minimum sustained output of 1700 pounds per day. At this rate, the cost seen by the processor is reduced to a corrected $4.68 per pound. At this point the processor is realizing a profit of $0.70 to $0.90 per pound during the seasonal high in January.

One final break point in the cost structure could be manufactured at a steady output of processed roe in excess of 2500 pounds per day. At this point a commodity rate can be negotiated with domestic and international common carriers. At 2500 pounds, the total gross weight per shipment would be in excess of 6000 pounds per day.

Since one processing plant is not capable of producing a regular minimum output of 800 pounds per day, due primarily to the labor intensive characteristics of the process, the venture would seldom, if ever, be profitable. However, if two or three processors were to ship together, the less costly shipping rates could be attained and higher profits could be realized. The recommendation, therefore, is that interested processors seriously consider some type of processor's cooperative, or at least some form of mutual shipping pool.

(3) Before any substantial harvesting and processing operation is undertaken, research should be conducted to

determine the current size of the sea urchin population, and to further determine the maximum sustainable yield.

REFERENCES

1. Ackoff, R. L., A Concept of Corporate Planning, New York, Wiley-Interscience, division of John Wiley & Sons, Inc., 1970.

2. Barringer, Richard, A Maine Manifest. Portland, Maine, Tower Publishing Company, 1972

3. Beer, Stafford, Cybernetics and Management. New York, John Wiley and Sons, Inc., 1964

4. Bennis, Warren G., Kenneth D. Benne, and Robert Chin, The Planning of Change, 2nd ed. New York, Holt, Rinehart, and Winston, 1969.

5. Bouchard, Reggie, Potential Markets for Maine Seafoods in Japan. Maine Department of Sea & Shore Fisheries, 1973.

6. Bradley, Earl H. Jr., and John M. Armstrong, A Description and Analysis of Coastal Zone and Shoreland Management Programs in the United States. University of Michigan, Sea Grant Program, Technical Report 20, 1972.

7. Chambers, John C., Satinder K. Mullick, and Donald D. Smith, "How to Choose the Right Forecasting Technique," Harvard Business Review, July-August, 1971.

8. Churchman, C. West, A Challenge to Reason. New York, McGraw-Hill Book Company, Inc., 1968

9. Churchman, C. W., The Systems Approach. New York, Dell Publishing Company, 1968.

10. Cyert, Richard M. and James G. March, A Behavioral Theory of the Firm. Englewood Cliffs, New Jersey, Prentice-Hall, 1963.

11. Cyert, R. M., H. A. Simon, and D. B. Trow, "Observation of Business Decision," The Journal of Business, Vol. 29, 1956.

12. Daniels, Alan and Donald Yeates, Systems Analysis. Science Research Associates, Inc., Palo Alto, California, 1971.

13. Dimock, Marshall E., The Executive in Action. New York, Harper and Row Publishers, Inc., 1945.

14. Dow, Robert L., Renewable Marine Resource Industry Potential in Maine. Maine Department of Sea & Shore Fisheries, Augusta, Maine, November 1970.

15. Drucker, Peter F., The Practice of Management. New York, Harper and Row, Publishers, Inc., 1954

16. Dublin, Robert A., Human Relations in Administration. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1951.

17. Elmaghraby, S. E., "An Algebra for the Analysis of Generalized Activity Networks," Management Science, Volume 10, No. 3, 1964, pp. 494-514.

18. Forrester, Jay W., "Industrial Dynamics - After the First Decade," Management Science, Volume 14, No. 7, March 1968.

19. Forrester, Jay W., "Industrial Dynamics - A Response to Ansoff and Slevin," Management Science, Volume 14, No. 9, May 1968.

20. Frankel, Professor E. G., Lecture Notes, Massachusetts Institute of Technology, Department of Ocean Engineering, 1973.

21. Gilbert, Jerome, Transportation Economics. New York, New York University, 1971.

22. Grad, Frank P., Environmental Law, Sources and Problems. New York, Mathew Bender & Company, Inc., 1971.

23. Herman, Stanley H., The People Specialists. New York, Alfred A. Knopf, 1968.

24. Herzberg, Frederick, Work and the Nature of Man. Cleveland, Ohio, World Publishers, Inc., 1966.

25. Hyman, Libbie H., The Invertebrades: Echinodermata, The Coelomate Bilateria, Volume IV. New York, The McGraw-Hill Book Company, 1955.

26. Hynes, Richard Olding, Regulation of Gene Expression During Early Cleavage in the Sea Urchin Embryo. PhD. Thesis, Department of Philosophy, Massachusetts Institute of Technology, August, 1969.

27. Kanter, Jerome, Management Guide to Computer System Selection and Use. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1970.

28. Ketchum, Bostwick H., The Water's Edge, Critical Problems of the Coastal Zone. Cambridge, Massachusetts, The MIT Press, 1972.

29. Lewin, Kurt, Resolving Social Conflicts. New York, Harper & Row Publishers, Inc., 1948.

30. Likert, Rensis, The Human Organization. New York, McGraw-Hill Book Co., Inc., 1967.

31. Love, Professor D. A., Lecture Notes, Graduate School of Business Administration, New York University, 1971.

32. Maine Coastal Resources Renewal. Augusta, Maine, State Planning Office Executive Department, 1971.

33. Marks, Professor David H., Lecture Notes, Massachusetts Institute of Technology, Department of Civil Engineering, 1972.

34. Martin, Professor Norman, Lecture Notes, Graduate School of Business Adminstration, New York University, 1972.

35. Maslow, Abraham H., Motivation and Personality. New York, Harper & Row, Publishers, Inc., 1954.

36. McFarland, Dalton E., Management Principles and Practices, 3rd ed. New York, The Macmillan Company, 1971.

37. McGregor, Douglas, The Human Side of Enterprise. New York, McGraw-Hill Book Co., Inc.

38. Merton, Robert K., Social Theory and Social Structure, rev. ed. New York, Glencoe Publishing, 1957.

39. Mortensen, T., Monograph of the Echinoidea, (15 volumes) published from 1928 to 1951.

40. Nisiyama, S., The Echinoid Fauna From Japan and Adjacent Regions. Part I. Special Paper on Palaeontology, Japan 11, 1966.

41. Optner, Stanford L., Systems Analysis for Business and Industrial Problem Solving. Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1965.

42. Portland Press Herald, Financial and Industrial Edition, January 31, 1970.

43. Pritsker, A.A.B., GERT: Graphical Evaluation and Review Technique. National Aeronautics and Space Administration, Rand Corporation, Santa Monica, California, 1966.

44. Pritsker, A.A.B. and Happ, W. William, "GERT: Graphical Evaluation and Review Technique, Part I, Fundamentals," The Journal of Industrial Engineering, Vol. XVII, No. 5. May 1966.

45. Regional and National Demands on the Maine Coastal Zone. Boston, Massachusetts, New England River Basins Commission, 1971.

46. Regulation of the Coast: Land and Water Uses. Maine Law Affecting Marine Resources, Volume Three, University of Maine Law School, 1970.

47. Resources from the Sea and Federal Limitations on State Control. Maine Law Affecting Marine Resources, Volume Four, University of Maine Law School, 1970.

48. Roman, Daniel D., "The PERT System: An Appraisal of Program Evaluation Review Technique," Journal of the Academy of Management. April 1962.

49. Seiler, John, Systems Analysis in Organizational Behavior. Homewood, Illinois, Irwin-Dorsey, 1967.

50. Simon, Herbert A., Administrative Behavior, 2nd ed. New York, The Macmillan Publishing Company, Inc., 1957.

51. Simon, Herbert A., "A Behavioral Model of Rational Choice," Quarterly Journal of Economics, 69, 1955, pp. 99-118

52. Simon, Herbert A., The New Science of Management Decision. New York, Harper and Row, Publishers, Inc., 1960.

53. State Government Organization: Agencies Dealing With Marine Resources. Maine Law Affecting Marine Resources, Volume One, University of Maine Law School, 1970.

54. State, Public and Private Rights, Privileges and Powers. Maine Law Affecting Marine Resources, Volume Two, University of Maine Law School, 1970.

55. Storer, T. I. and Usinger, R. L., General Zoology. New York, McGraw-Hill Book Co., Inc., 1947.

56. Taylor, Frederick, Scientific Management. New York, Harper

57. Tools for Coastal Zone Management, Proceeding of the Conference. Washington, D. C., Marine Technology Society, 1972.

58. Von Daniken, Eric, Chariots of the Gods? New York, G. P. Putnam & Sons, New York, 1970.

59. Wagner, Harvey M., Principles of Operations Research. Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1969.

60. Zand, Professor D. E., Lecture Notes, Graduate School of Business Administration, New York University, 1971.