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San Francisco Port Study

Volume I

Description and Analysis of Maritime Cargo Operations in a U. S. Port

MARITIME CARGO TRANSPORTATION CONFERENCE
Division of Engineering and Industrial Research
NATIONAL ACADEMY OF SCIENCES — NATIONAL RESEARCH COUNCIL

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FOREWORD

The mission of the Maritime Cargo Transportation Conference, National Academy of Sciences—National Research Council, is to provide guidance toward improving transportation of general cargo by sea. As part of this program the San Francisco Port Study was undertaken to:

1. identify factors limiting turn-around time of general cargo ships,

2. find means to reduce ship turn-around time in port, including methods to increase cargo-handling productivity,

3. find ways to reduce the cost of cargo handling, and to reduce the arduousness of the work,

4. develop methods to assess improvements in cargo handling systems and their effects on the port.

The San Francisco Bay Area, including the ports of San Francisco, Oakland, and Alameda, was chosen for this study because its problems in handling general cargo are typical of most United States ports. Willingness of both management and labor to assist in the study was an important factor in the site selection.

While the study was limited to one port, the results also apply to other ports. A major purpose of the project is to stimulate similar programs throughout the industry.

The study was undertaken in 1957 by the staff of the Maritime Cargo Transportation Conference, resident in San Francisco, and operations were completed there in 1962. The staff was guided in its work by the Port Study Committee of the Conference and received advice and assistance from an Industry Advisory Committee and an Academic Advisory Committee, organized locally.

In a study of this nature the cooperation of management, labor, and government are essential to success. This cooperation was generously given by representatives of shipping companies, the Pacific Maritime Association, the International Longshoremen's and Warehousemen's Union, the University of California, the Maritime Administration, and, unstintingly, by the Army and Navy.

E. G. FULLINWIDER
Rear Admiral, USN (Ret.)
Executive Director, Maritime Cargo Transportation Conference
National Academy of Sciences—National Research Council

May, 1964
Washington, D. C.

PREFACE

From late 1957 until the end of 1959, the Pacific Maritime Association and the International Longshoremen's and Warehousemen's Union bargained over the terms of an agreement intended to permit the employers to introduce mechanical cargo-handling methods with liberalized working rules. The men of the registered work force were to be protected from loss of work, and the savings made possible by the mechanization were to be shared with them. The agreement, which became effective in 1960, applied to those longshoremen who were registered members of the work force in 1958 and after.

The descriptions of the port and of the work force in Part I of this volume and the analysis of cargo handling in Part III represent the port as it was just prior to the introduction of the "Mechanization and Modernization" agreement. The information can be used, therefore, as a base from which to measure the effects of changes resulting from the agreement. Part II is the development of a productivity-measurement procedure which distinguishes the results of deliberate changes from those due to uncontrollable causes.

Volume II, an account of modified work methods tested at the Naval Supply Center, Oakland, and the commercial piers in San Francisco, suggests some kinds of change which can improve stevedoring productivity with relatively minor capital outlay. Closely related to the methods tests is a discussion of the way in which stevedoring planning and control affects cargo-handling productivity.

Finally, an analysis of the port system shows how changes in productivity and in labor force size affect the total system cost. It demonstrates the effects of these changes on ship turn-around time and on work force earnings. In this work, mathematical models have been used to evaluate the relationship of ship waiting time to availability of work gangs.

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Part I

DESCRIPTION OF THE PORT OF SAN FRANCISCO

Chapter 1

INTRODUCTION

The important elements of the cargo transfer operation are ships, cargo, manpower, and terminal facilities. Information is presented here concerning these elements, as observed in the San Francisco Bay Area, to quantify the role each plays in the cargo transfer system. Finally, the interaction of these elements on the performance of the port system is analyzed.

While much numerical information is presented in this volume, it is not an up-to-date compendium of port facts. Coverage is limited to the system of transferring mixed dry cargo, excluding bulk commodities. Bulk cargoes have been omitted because they usually require specialized facilities and little manpower from the longshore labor force. The problems to be considered in this study are those of handling breakbulk cargo, or its containers, by longshoremen.

The geographical area of the study is that encompassed by the dispatch of men from the hiring hall for Local 10 of the International Longshoremen's and Warehousemen's Union. This includes all the San Francisco Bay Area, but excludes Stockton and other river ports.

Excluding bulk cargo and limiting the area causes cargo tonnage totals and ship traffic figures in this report to differ from those found in standard references.

Chapter 2

SHIPS

Approximately 3,000 cargo ship visits for longshore service are made to the San Francisco Bay Area each year. Routes, arrival patterns, length of stay, management while in port, and related information concerning the visiting ships are discussed in this section.

SHIP ARRIVALS

A study of general cargo and passenger[1] ship arrivals through the Golden Gate shows the following:

1. The number of ships arriving per day was quite regular throughout the year. About half are U. S. flag ships (Figure 1a).

2. Thursday was a preferred arrival day. Although as many ships arrived on Sunday as on most other days, some did not request gangs until Monday (Figure 1b).

3. Apparently, steaming times were adjusted as much as possible to arrive before 2000 or between 0400 and 0800 (Figure 1c).

4. From two to nineteen ships arrived each day. On over half the days of the year, from six to nine arrivals could be expected (Figure 2).

5. In 1958 there was little seasonal fluctuation, but a considerable variation from day to day.

TRADE ROUTE SYSTEMS

For most of the cargo vessels entering the San Francisco Bay the visit represents a small portion of their journey. San Francisco is the home port for some U. S. ships, but for other U. S. ships and for most foreign ships it is only a stop-over. Approximately 50 per cent of the cargo visits are by foreign flag ships.

To analyze the factors which affect ship arrivals and departures and to evaluate measures for improving ship turn-around, it is important to know the trade route systems of which San Francisco is a part.

Information concerning these trade route systems can be extracted from a simple analysis of publicly announced arrivals, departures, and schedules. Such an analysis is shown in Table 1. The following conclusions are drawn from the table:

1. Eighty per cent of the visits are by ships on regular trade patterns.

2. The Japan-Far East trade route contributed the most ship days in port. Northern European and United Kingdom are next, and Atlantic Straits and Far East trade are nearly tied for third with the Hawaiian trade and the intercoastal trade.

3. Many of the trade route cycles take over three months, and most take two months or more.

4. In a number of trades there are nearly twice as many visits as there are cycles, because many ships make separate discharging and loading stops in the Bay Area while on the West Coast.

SHIP SIZE

Figure 3 shows a distribution of net registered tonnage (from Lloyd's Register) for the 1,041 different general cargo vessels which visited San Francisco in 1958. The net registered tonnage refers to the enclosed volume of a ship in hundreds of cubic feet, excluding essential space such as engine rooms and crew quarters. While the measure system is far from precise in providing cargo carrying capacity, it does give an indication of size. The figure shows that about 45 per cent of the vessels are in the 4 to 5 thousand ton range which is the size category into which most of the U. S. World War II cargo ships fall. Some of these ships of the C1 and C2 classes are listed between 3 and 4 thousand tons because they have nominally opened the deck immediately under the main deck into a so-called "shelter deck," which space is then exempt. This artificial device reduces some port and canal charges when they are based on net registered tons.

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[1] Passenger ships in the Pacific carry a substantial amount of cargo, and require the services of longshoremen, so are included in general cargo ship data in this study.

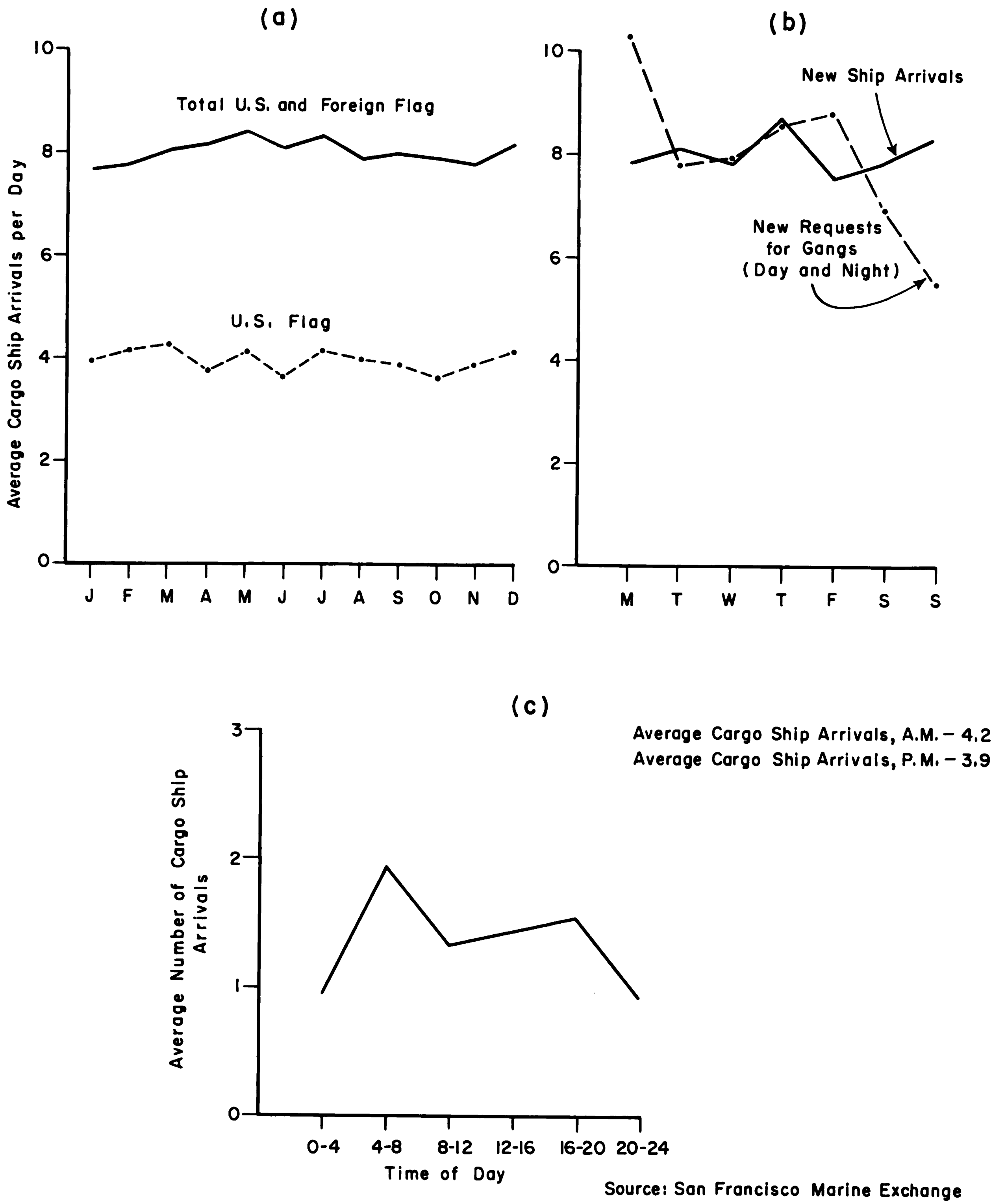


Figure 1. Cargo ship arrivals 1958.

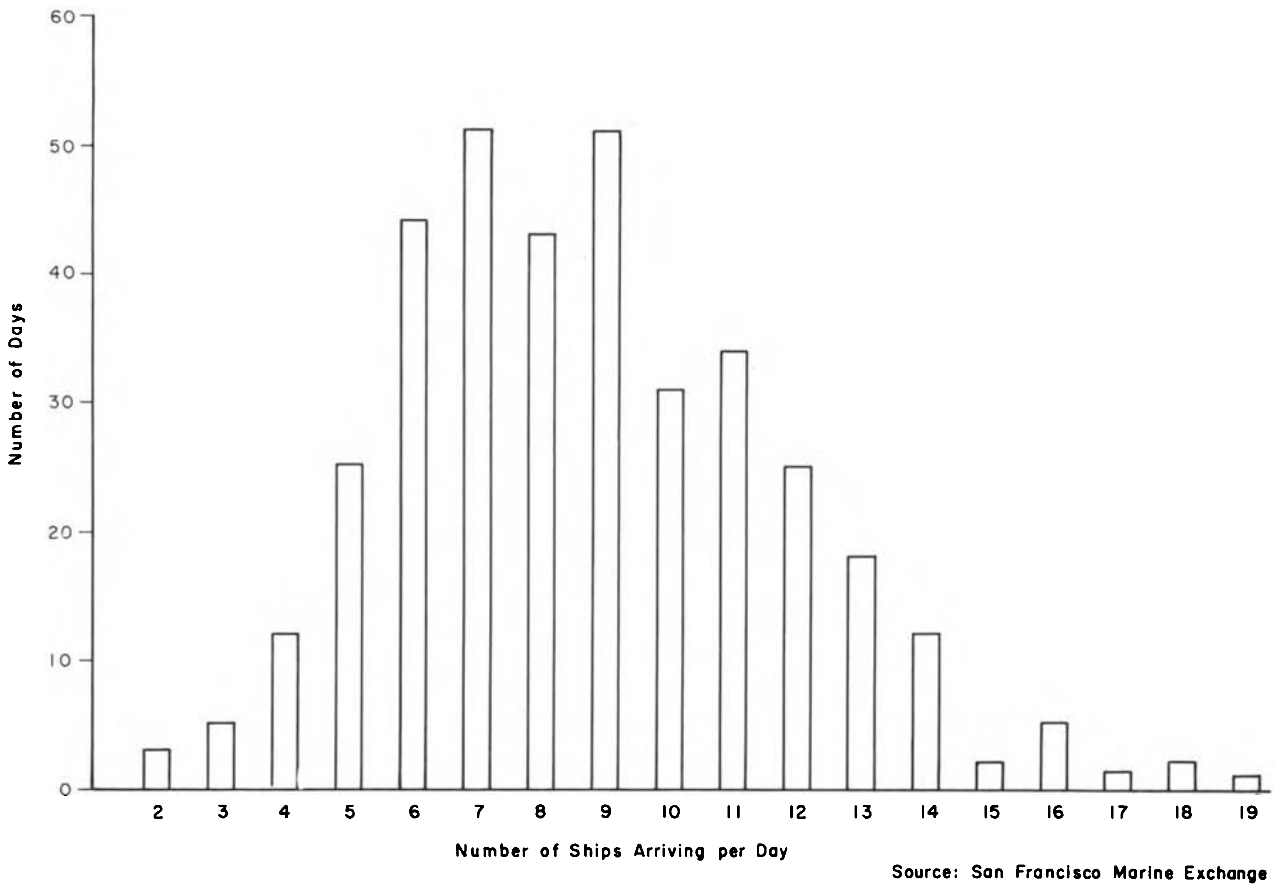


Figure 2. Frequency of ship arrivals 1958.

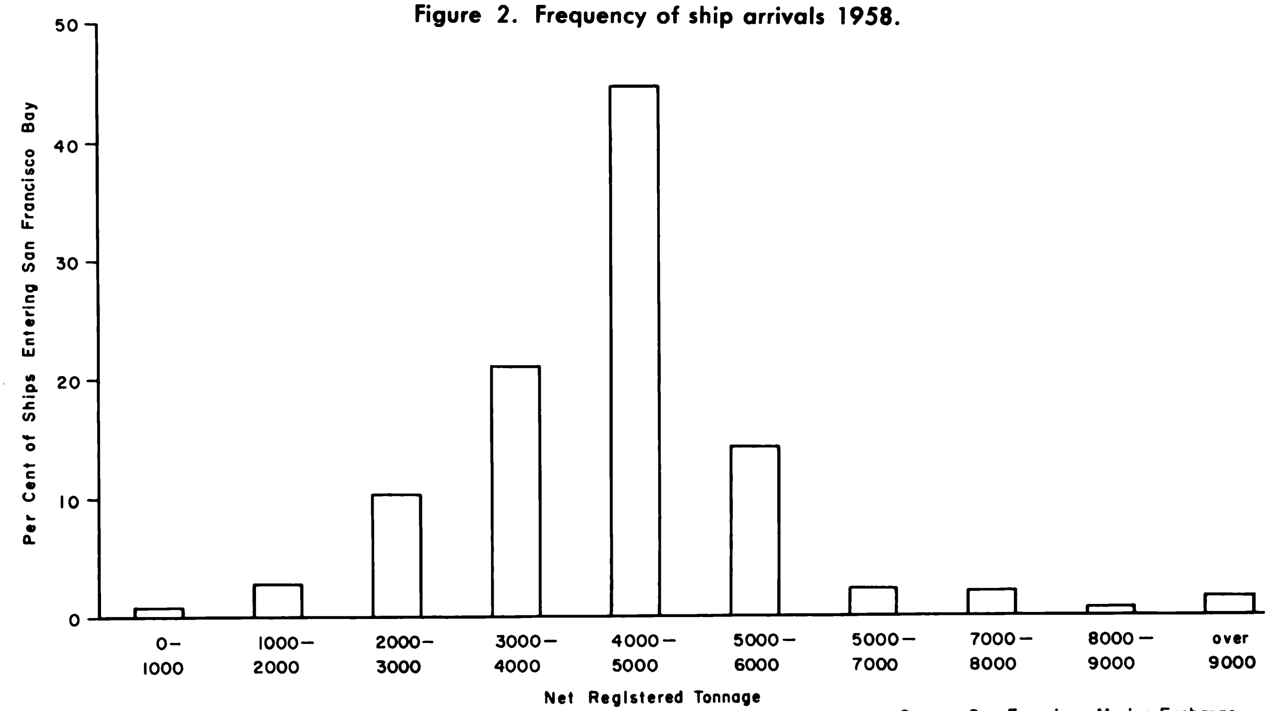


Figure 3. Ship-size distribution of general cargo vessels visiting San Francisco 1958. (net registered tonnage)

TABLE 1

Route Cycle and Ship Visit Information

Route #	Trade Route	No. of S.S. Co's. U. S.	No. of S.S. Co's. For.	No. Ship Visits	No. Ship Days in Port	Av. Days per Visit	No. Ship Cycles	No. Voyage Days	Av. Days per Cycle
				Period: 1 September 1958—31 August 1959					
17	Round-the-World	2	—	47	339	7.2	46	5,772	125
17, 23	Atlantic Straits & F. E.	3	10	307	889	2.9	203	26,358	130
24	So. America East Coast	1	1	54	184	3.4	29	2,977	103
25	So. America West Coast	1	2	155	521	3.4	75	5,568	74
	Latin America (Banana Rt.)	1	—	43	44	1.0	47	2,800	60*
	So. America Circuit	—	1	25	90	2.2	12	1,551	129
26A, B	No. Europe & U. K.	1	11	410	1,226	3.0	233	25,724	110
27	Australasia Freight Rt.	1	5	68	213	3.1	45	4,611	102
	Passenger Rt.	1	1	14	63	4.5	14	654	47
28	Indonesia, India, Suez	2	3	100	386	3.9	61	7,726	127
29	Japan, Far East	6	6	421	1,871	4.4	289	19,467	67
	Freight & Pass. Exp.	1	—	24	111	4.6	24	1,090	45
	So. America, Carrib., & Japan Triangle	—	4	76	188	2.5	69	8,401	122
	Europe & Japan Triangle	—	2	46	99	2.2	37	4,811	130
	Africa	—	2	35	123	3.5	19	3,077	162
	Mediterranean	—	2	46	132	2.9	29	3,239	112
	Canada	—	2	38	107	2.8	36	704	20
	Hawaii Bulk	1	—	22	112	5.1	23	931	40
	Freight	2	—	95	620	6.5	95	2,141	23
	Passenger	2	—	25	103	4.1	25	681	27
	Guam	1	—	61	340	5.6	46	2,777	60
	Intercoastal	5	—	209	757	3.6	143	10,683	75
	Intracoastal—Alaska	1	—	3	8	2.7	3	97	32
	North West	1	—	24	40	1.7	24	415	17
	Los Angeles	1	—	5	4	.8	5	30	6
	Irregulars	—	—	587	2,358	4.0	—	—	—
	TOTALS			2,940	10,928	3.7			

* While arrivals are regular, individual ships have varied itinerary often skipping San Francisco or going via New York giving longer than round-trip cycle average.

MANAGEMENT ORGANIZATION

The ships appear in the port under the auspices of either the ship operator or his agent. In 1958, 50 different operators or agents received longshore gang service through the Pacific Maritime Association, and the ILWU Local 10 Dispatch Hall. One steamship agent often represents many steamship companies.

Figure 4 shows the extent to which each company utilized the facilities of the port in 1958. Port utilization is roughly equivalent to the gangshifts worked in handling cargo. In Figure 4, the gangshifts worked for each company are shown as a proportion of the total gangshifts worked by all companies. (One longshore gang working either one night shift or one day shift constitutes one gangshift.) The five largest company users of the port account for nearly 50 per cent of the gangshifts utilized. However, many of the other 45 companies are large enough users to have a significant impact on port operations.

Twelve stevedoring companies handled cargo for the 50 different steamship companies in 1958. Two were direct subsidiaries of steamship companies. Figure 5 shows the relative use of longshore gangs by the twelve stevedores. The five largest stevedoring companies performed over 50 per cent of the port cargo handling task. However, the number of sizable companies involved suggests strong competition.

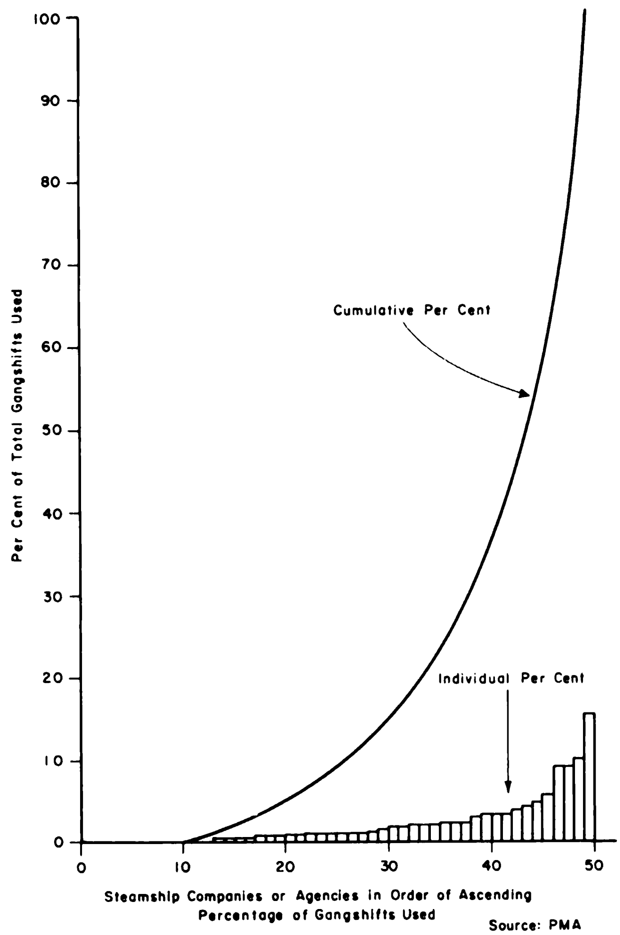


Figure 4. Port utilization among fifty companies 1958.

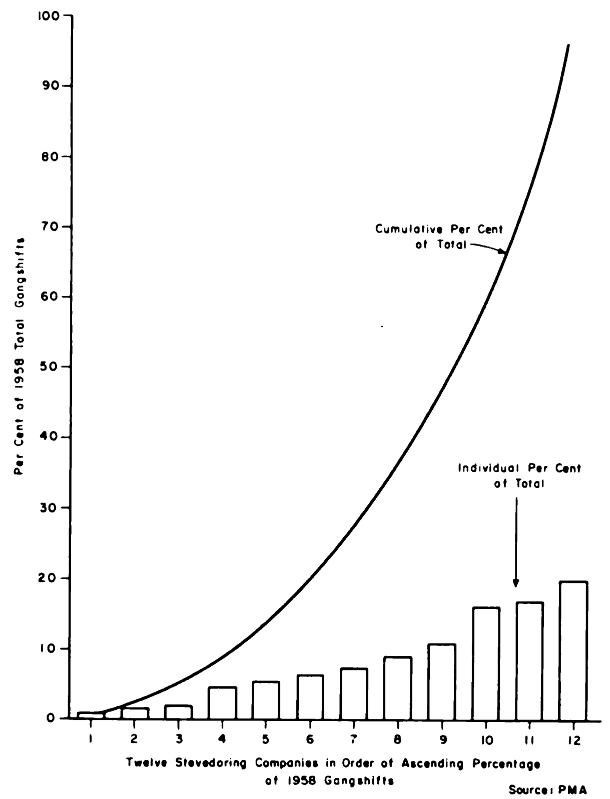


Figure 5. Relative use of gangs by twelve stevedoring companies 1958.

The Pacific Maritime Association (PMA) allocates [2] longshore gangs, handles longshore payrolls and records, and represents management in negotiations with longshore labor unions, and with offshore labor unions. Both steamship companies and stevedoring companies constitute the PMA membership. Not all users of the port are members of this organization, but a steamship company that does not belong is represented by a stevedoring company or an agency which is a member. Organization dues were assessed in 1958 on the basis of tonnage handled and passengers transferred. Voting strength was calculated on a similar basis.

STEVEDORE-STEAMSHIP COMPANY RELATIONSHIP

The business relationship between many of the private stevedoring firms and steamship companies or agents is complex and varies from company to company. A detailed study of the different cases has not been made; however, certain features of this relationship occur often enough to be considered typical.

Commodity rates are used in many stevedoring contracts. On the basis of these rates, the stevedore is paid for the tons of a specific commodity handled. The rates are confidential and are often adjusted at either the stevedore's or the operator's behest, on a basis of observed changes in performance. They do not usually include cost of overtime work, noncommodity work, such as hatch opening and closing, or detention time, where work is delayed for reasons other than stevedoring.

The overtime cost differential is generally repaid to the stevedore on a dollar for dollar basis.

Over-ride is a stevedore charge based on gang hours of work. This is presumed to cover the overhead cost of obtaining the labor and the equipment for the job.

[2] Chooses ships to receive gangs; the hiring hall dispatches gangs to fill specific jobs.

Most stevedoring contracts provide for automatic adjustment in payment to the stevedore in the event of a change in wages.

A contract stevedoring company may well be in a position where it can derive little long-term benefit from capital invested to improve productivity. The great adjustability of the rate structure virtually places him in a "cost plus" position where net profit becomes a percentage of direct cost. In such a situation, capital investment which improves productivity and reduces direct cost may simultaneously reduce profit rather than increase it.

Chapter 3

CARGO TONNAGE TASK

The San Francisco Bay Area, as used in this section, consists of San Francisco and Oakland Harbors, including Alameda.[3] Work opportunity of the longshore labor force is measured primarily in terms of the *general* cargo handled in the area. Though bulk cargo tonnage is often greater than general cargo tonnage it contributes less than 10 per cent to the earnings of longshore labor. As the objective of the Port Study is to develop facts useful to management and longshore labor in the Bay Area, only general cargo tonnage will be analyzed in this report.[4] Richmond, Redwood City, and Suisun Bay, all bulk cargo ports, are not included in the tonnage figures presented here.

Specifically, this report will show and analyze the following data for the years 1954-58:

1. Changes in the Bay Area cargo tonnage task[5] and the significant features of these changes.

2. Effects of a changing commodity mixture upon the man-hours required to handle the cargo tonnage task in the port.

Data regarding the cargo tonnage task of the San Francisco Bay Area have been obtained from *Waterborne Commerce of the United States, Part 4,* 1954-58, Department of Army—Corps of Engineers publication, and the Office of Statistics and Special Studies, Maritime Administration. In this report, the term "ocean-borne domestic" is used in place of "coastwise movements" by the sources to label the non-contiguous, coastal and intercoastal tonnage categories.

[3] The port areas of Oakland and San Francisco Harbor are those defined in *Waterborne Commerce of the United States, Part 4,* 1954-58, Dept. of Army—Corps of Engineers.

[4] The Commodity Classification listing presented in *Waterborne Commerce of the United States, Part 4,* 1954-58, was examined in conjunction with the "S" and "T" Commodity Listings prepared by the Bureau of Census and general cargo commodities selected. All other commodities have been deleted from the cargo tonnage figures analyzed in this report. Selected deletions were made from the following commodity groups: 5—Non-metallic Minerals, 6—Metal Ore and Scrap, 9—Miscellaneous.

[5] The cargo tonnage task is the total general cargo tonnage handled in the port during the years 1954-58.

The cargo tonnage has been broken down into *three* major categories: foreign imports, foreign exports, and ocean-borne domestic. Import and export tonnage is traffic between San Francisco Bay Area and foreign ports, including the Canal Zone. Ocean-borne domestic has been further separated into non-contiguous, intercoastal and coastal traffic. Non-contiguous traffic includes that between Bay Area and Puerto Rico, Hawaii, or Alaska. Intercoastal traffic includes that between the Bay Area and Atlantic or Gulf Coast ports. Coastal traffic is that to other U. S. ports contiguously located on the West Coast.

ANALYSIS

The following patterns characterize the annual cargo tonnage task in the San Francisco Bay Area:

1. The pattern of change of the cargo tonnage task of the San Francisco Bay Area shows a moderate growth rate during 1954-56, followed by a decline in 1957-58.

2. Ocean-borne domestic tonnage is consistently the most important component of the cargo tonnage task of the Bay Area, followed in turn by export tonnage and then import tonnage.

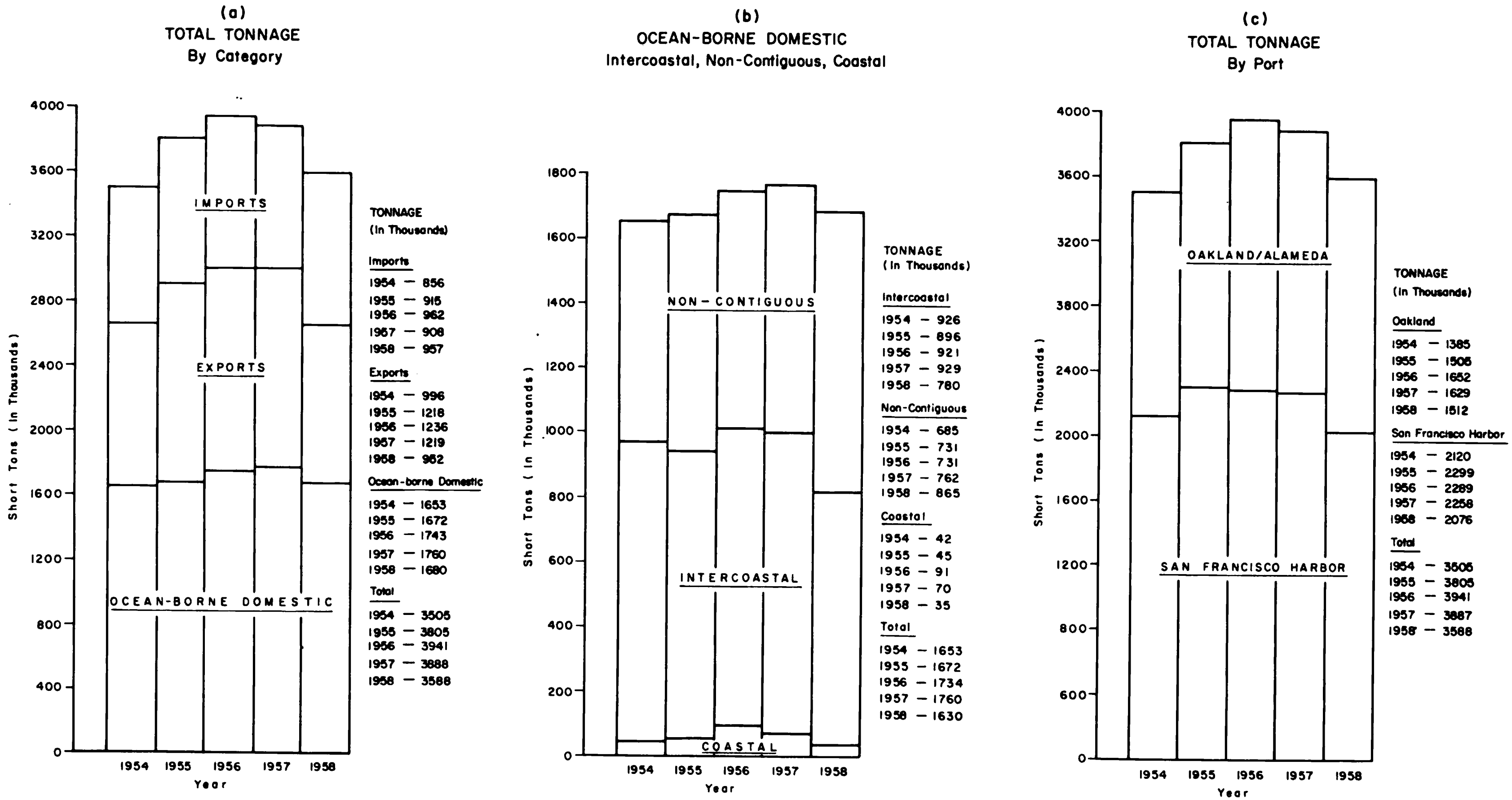
3. There is a declining trend in coastal and intercoastal tonnages in the Bay Area during the five years.

4. The pattern of change of the Oakland cargo tonnage task is similar to the combined task of the Bay Area. That is, Oakland's peak task was attained in 1956, with a subsequent decline in 1958.

5. The pattern of change of the cargo tonnage task of San Francisco Harbor differs from the combined task for the Bay Area. San Francisco's peak task was reached in 1955, followed by declines in each of the three following years.

6. Non-contiguous tonnages in both Oakland and San Francisco Harbor show an over-all growth pattern. Decreases in the coastal and intercoastal tonnages are common to both ports.

These patterns may be seen in Figures 6a, 6b, 6c, and 7a, 7b, 7c, and 7d.



(San Francisco Harbor and Oakland/Alameda Harbor)

Source: Waterborne Commerce of the United States, Part 4, 1954–1958, Department of the Army – Corps of Engineers Publication

Figure 6. General cargo tonnage handled in San Francisco Bay Area 1954-1958. (San Francisco Harbor and Oakland/Alameda Harbor)

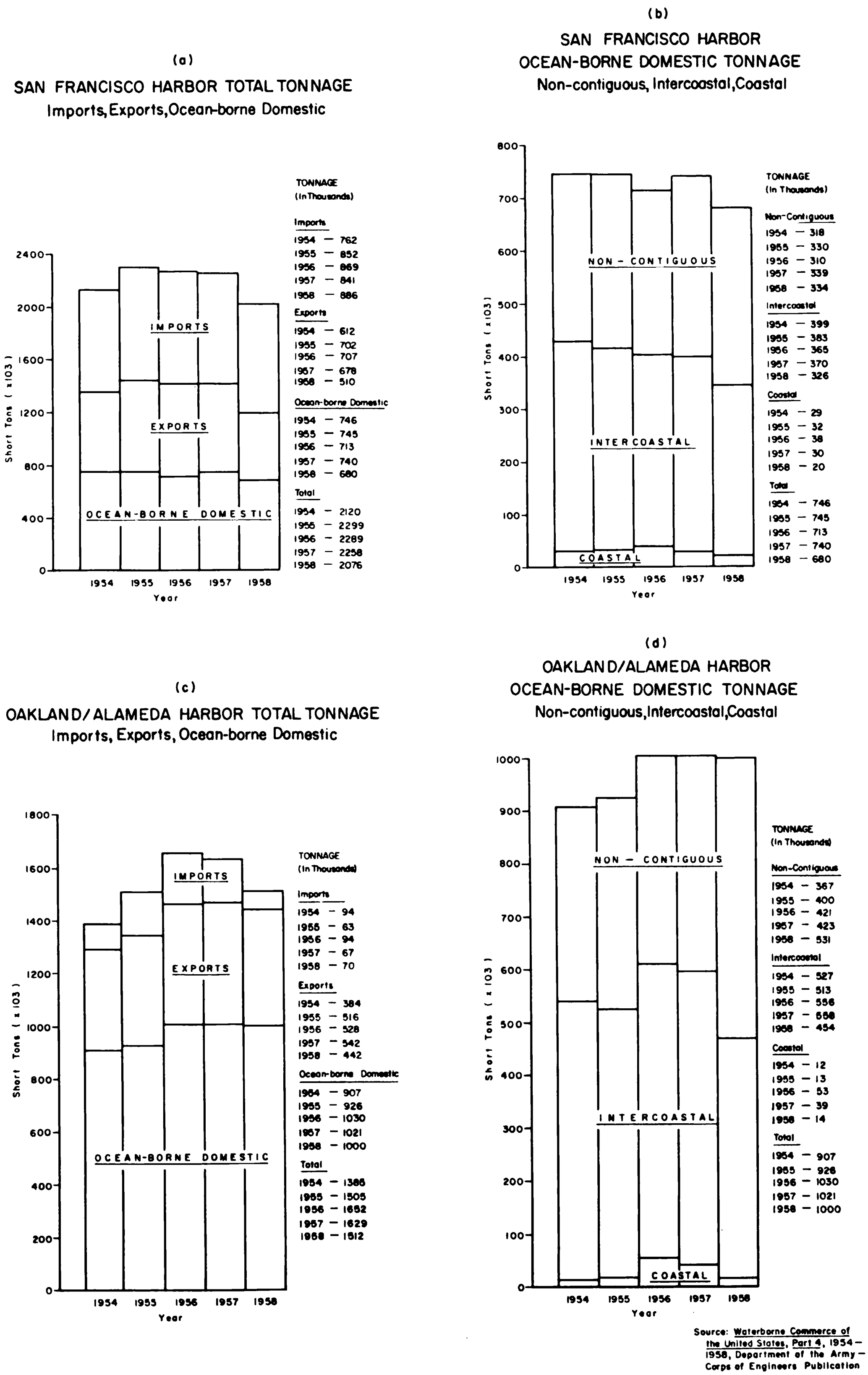


Figure 7. General cargo tonnage comparison, San Francisco and Oakland/Alameda Harbor 1954-1958.

TABLE 2

General Cargo Tonnage by Commodity Group
1954-'58

(Thousands of Tons)

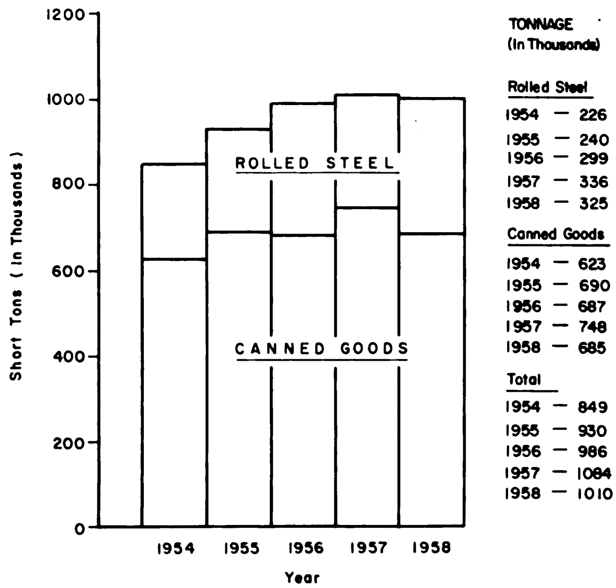
	Year				
	1954	1955	1956	1957	1958
Total Tonnage	3,505	3,805	3,941	3,888	3,588
1. Canned goods	623	690	687	748	685
2. Rolled steel	226	240	299	336	325
3. Standard newsprint paper	146	161	186	147	107
4. Barley and rye	141	145	150	14	103
5. Coffee, raw or green	131	145	157	144	132
6. Rice	112	140	56	80	67
7. Fruits, dried	89	88	100	100	97
8. Cotton, unmfr'd.	80	42	78	138	74
9. Animal products, inedible	72	74	52	71	76
10. Bananas, fresh	64	67	70	63	68
11. Liquors and wines	51	63	64	60	56
12. Nitrogenous fertilizer	29	90	28	36	42
13. Wheat	28	66	86	100	26
14. All other	1,652	1,742	1,852	1,801	1,699

COMMODITY MIXTURE EFFECT

The cargo tonnage task determines the man-hour requirement of a port. The man-hour requirement is a major part of the cost of stevedoring and the yardstick for measuring the earnings of labor. Thus, it is important that the man-hour requirement be accurately determined so that it can be used effectively for evaluation of past and present cargo handling performance and for planning purposes.

Examination of Table 2 shows that the cargo tonnage task of the San Francisco Bay Area consists of many commodities or commodity groups that may vary greatly in tonnage from year to year. Many of these possess characteristics that require different cargo handling methods. As a result, the loading rates (tons per man-hour) of these commodities can differ greatly. To determine the total man-hour requirement of the port, the commodity mixture making up the cargo tonnage task must be considered.

Of the many commodities constituting the cargo tonnage task of the San Francisco Bay Area, two commodities (canned goods and rolled steel) represented approximately 25 per cent of the total during 1954-58. To illustrate the possible effect of commodity mixture upon the man-hour requirement, we assume these two commodity groups to form a cargo tonnage task.



Source: Waterborne Commerce of the United States, Part 4, 1954—1958, Department of the Army—Corps of Engineers Publication

Figure 8. Tonnage of canned goods and rolled steel handled in San Francisco Bay Area 1954-1958.

Figure 8 shows the tonnages of canned goods and rolled steel constituting the assumed task during 1954-58. An evaluation of Figure 8 shows the following:

TABLE 3

Relationship of Canned Goods and Rolled Steel Tonnages to Their Combined Total Tonnage * (1954-'58)

	Rolled Steel Percentage of Total	Canned Goods Percentage of Total
1954	26.6%	73.4%
1955	25.8	74.2
1956	30.3	69.7
1957	30.9	69.1
1958	32.3	67.7

* From Table 2.

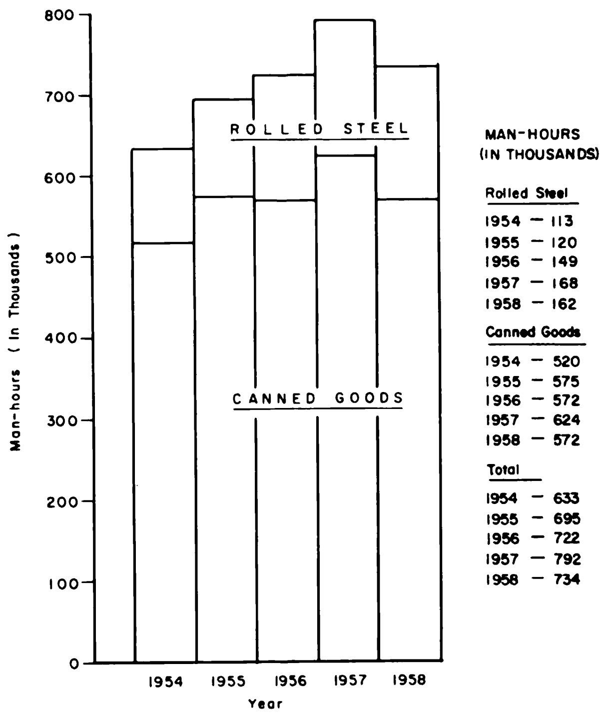
TABLE 4

Percentage Change in Cargo Tonnage Task *

(Base Year 1954)

1954	—
1955	+ 9.5%
1956	+16.1
1957	+27.7
1958	+19.0

* From Table 2.



Man-hours required to handle rolled steel and canned goods have been computed on the basis of loading rates of 18 ST/GH and 30 ST/GH, respectively. These loading rates are assumed to remain constant during 1954 – 1958.

Source: Waterborne Commerce of the United States, Part 4, 1954–1958, Department of the Army—Corps of Engineers Publication

Figure 9. Man-hours required to handle canned goods and rolled steel in San Francisco Bay Area 1954-1958.

The assumed task has the following characteristics:

1. The relationship of canned goods and rolled steel tonnages to their combined tonnage remained approximately constant in 1954-55 and 1956-57, even though their absolute values changed.

2. In 1956 and 1958 the relationship of canned goods and rolled steel tonnages to their combined total tonnage showed a definite shift from those of the preceding year, in addition to a change in absolute values.

3. In each year following 1954, there was a marked change in the level of the combined tonnage of canned goods and rolled steel handled in the San Francisco Bay Area.

These conclusions are based on the figures in Tables 2, 3, and 4.

These data can be used to study the consequences of two basic situations in which the commodity mixture affects the man-hour requirement.

The years 1954-55 and 1956-57 demonstrate the changes in man-hour requirement that occur when the percentage of the commodity tonnages to their combined tonnage remains reasonably constant, although total tonnage changes. Table 5 (based upon the data given in Figure 9) shows the relative change in man-hour requirement as compared to that of the combined tonnage of canned goods and rolled steel for the intervals 1954-55 and 1956-57.

From Table 5 it can be seen that the relative change in man-hour requirement is equal to the relative change in the cargo tonnage task.

TABLE 5

Percentage Change in Man-Hour Requirement and Combined Total Tonnage, Canned Goods and Rolled Steel (1954-55 & 1956-57)

(No significant change in commodity mix)

	Man-Hour Requirement	Combined Tonnage
1954	—	—
1955	+ 9.5%	+ 9.7%
1956	—	—
1957	+11.0	+11.0

The years 1956 and 1958 when compared to the preceding years, demonstrate the change in man-hour requirement that occurs when the percentage of the commodity tonnages changes.

As shown in Table 6, when the commodity mix changes the percentage change in man-hours does not necessarily equal the percentage change in tonnage. This example deals with only two commodities assumed to compose the cargo tonnage task and is relatively simple. When many commodities make up the cargo tonnage task, their handling rates and their mix must be determined to insure an accurate measure of total man-hour requirement.

TABLE 6

Percentage Change in Man-Hour Requirement and Combined Total Tonnage, Canned Goods and Rolled Steel (1955-56 & 1957-58)

(Significant change in commodity mix)

	Man-Hour Requirement	Combined Tonnage
1955	—	—
1956	+3.9%	+6.0%
1957	—	—
1958	−7.3	−6.7

Chapter 4

LABOR FORCE

A complete description of a port must include its manpower. The longshoreman is a major factor in the cargo handling process.

The stevedoring industry must have a labor supply large enough to meet most of the peaks in demand, yet not so large that individual income of the workers is depressed, or payment made for idle workers. The longshore work force must include clerks, supervisors, equipment operators, and cargo handlers. Mechanization of the stevedoring functions will affect the longshoreman, the nature of his work, the organization of his gang, and the organization of his union.

This study is based on San Francisco longshore labor force data for the year 1958, collected from two sources: the Pacific Maritime Association (PMA) and the International Longshoremen's and Warehousemen's Union (ILWU).

The purpose of this chapter is to describe the "men on the job" who make up the San Francisco longshore labor force, to analyze their organization, and to explain the method of allocating work opportunity within this labor force. Three major divisions of the labor force are considered: (1) the *longshoremen*, who perform the cargo handling tasks; (2) the *walking bosses*, who supervise the longshoremen; and (3) the *clerks*, who perform the clerical functions directly associated with cargo operations between ship and dock.

LONGSHOREMEN

Longshoremen are employed to perform the physical tasks required in loading and unloading ships' cargoes. The Pacific Coast Longshore Labor Agreement defines the work as ". . . all handling of cargo in its transfer from vessel to first place of rest, and vice-versa, including sorting and piling of cargo on the dock, and the direct transfer of cargo from vessel to railroad car or barge, or vice-versa." These definitions include the jobs of the winch operator, jitney and forklift driver, and dockman. With few exceptions the work is predominantly manual.

Registered and Non-Registered Men

In the San Francisco Bay Area there are two groups of longshoremen, those who are registered with the Joint Port Committee [6] and those who are not. Nearly all registered longshoremen are members of Local 10 of the ILWU,[7] pay dues to the union, vote on union problems, and receive the benefits associated with union work. They are the primary source of longshore labor. In 1958 this group was composed of 3,273 men. The non-registered longshoremen are referred to as "casuals." These casuals are not members of Local 10, but are obtained from other closely related unions, and from the California State Department of Employment, to augment the registered work force during peak periods of demand. During the year 1958, 4,607 casual workers were employed.

The casuals are unorganized workers, generally unskilled in all but the most basic of the longshoring functions. Many of the men constituting this group also work elsewhere. They are needed and used in longshore vacancies only for short periods. In 1958, less than 10 per cent of the total longshore manhours were worked by casuals. These characteristics, coupled with the dearth of records kept on this group, make it difficult to develop information about these men. Consequently, this report concentrates primarily on the registered longshoremen.

Worker Classification

The men in the registered work force are classified into several categories to identify work priority, job category, pay rate, and work shift.

In the San Francisco Bay Area, the registered work force is organized into regular gangs, each of which functions as a work team to fulfill the requirements of loading or discharging cargo. Within each gang there is a nucleus of permanent members,

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[6] See Joint Port Committees, page 19.

[7] Union membership is not a condition of registration, but nearly all registered men are members of the ILWU. For the purposes of this study, the terms "registered" and "Local 10" will be synonymous.

identified as "gang" men. By obligating themselves to a particular gang, these men are assured of employment when the gang is working.[8] The remaining positions in every gang are filled by "plug" [9] men. These plug men are available for work in any incomplete gang. They retain the option of whether to work or not, according to their own wishes. A well-defined system of worker priority regulates the distribution of work opportunity. This priority system rewards plug men who show a willingness to make themselves available for work. Whenever the supply of available plug men is exhausted, non-registered casuals are employed.[10]

In 1958, there were 206 gangs on the San Francisco waterfront, with 1,797 registered men listed as regular members. The regular membership of the day gangs averaged 7.5 men; night gangs, 11.0 men. Generally, there were not enough regulars to make up the entire gang for dispatch. Figure 10 presents a comparison of the distribution of regular members of day and night gangs.

The size of the gang dispatched from the hiring hall usually depends upon the specific task to be performed. In loading operations a 14-man gang is

[8] Since gangs are hired on a rotational basis, each gang can expect its share of the work opportunity. Gang men can normally expect to be steadily employed.

[9] Originally these men indicated their desire for work by inserting pegs with their names on them into a plug board kept at the dispatch hall; hence the term "plug" man.

[10] Subsequent to this analysis a Class "B" membership in Local 10 was established. Class "B" men are in effect "preferred casuals."

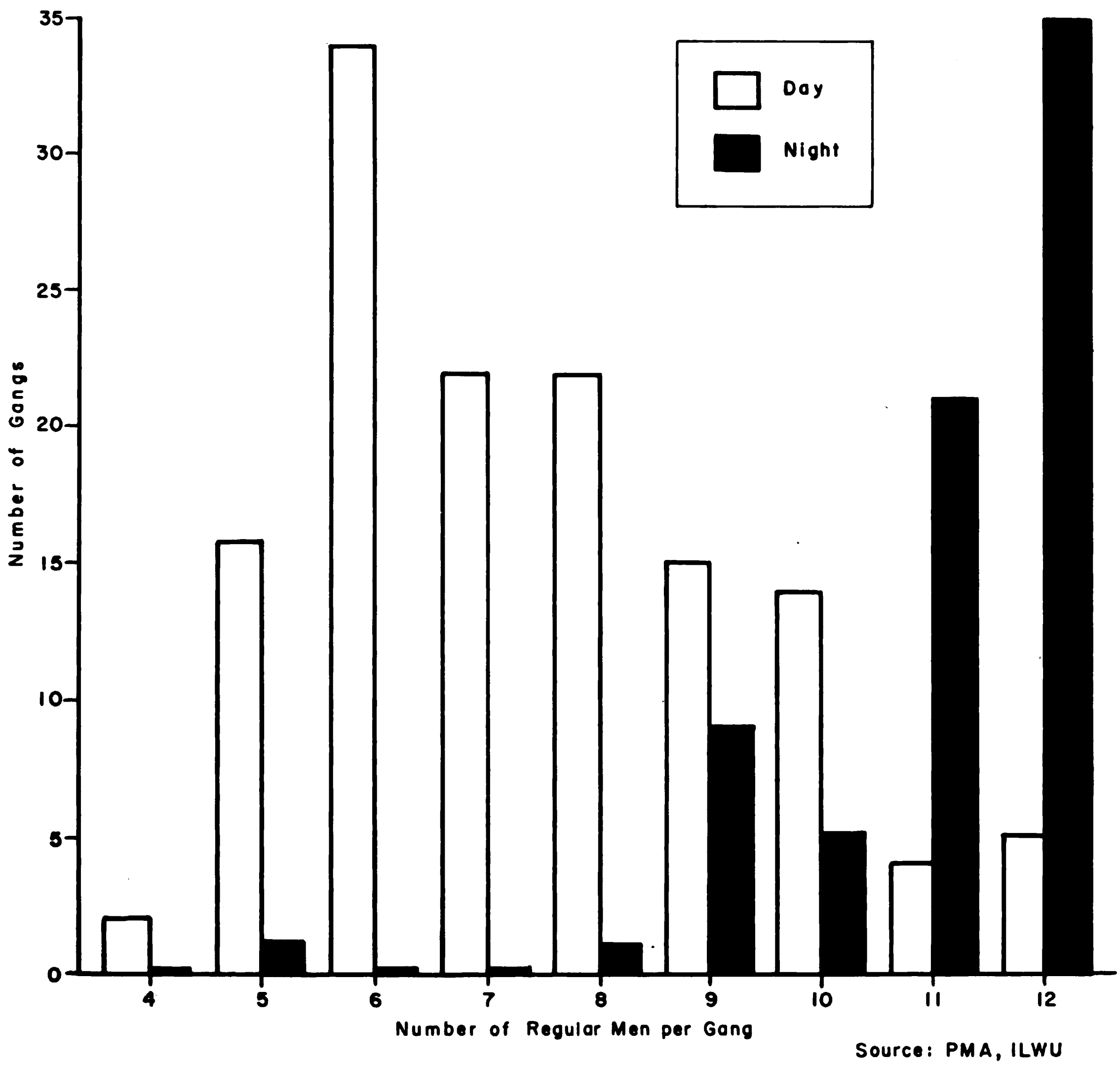


Figure 10. Number of men registered in day gangs and night gangs 1958.

generally used; for discharging, 12 men are employed.[11] Gangs of these sizes are used for the majority of work in the port.[12] However, specialty gangs of various sizes are employed for banana, copra, and bulk cargoes. Their size depends upon the type of cargo being handled.

Table 7 shows that the basic gang structure is built around a regular group containing a foreman, 2 winch drivers and a jitney driver. This group is then increased with dockmen and holdmen to round out the gang.

TABLE 7
Typical Manning Structure of Organized Gangs

Job Positions	Number of Men in Gang								
	4	5	6	7	8	9	10	11	12
Foreman	1	1	1	1	1	1	1	1	1
Winch driver	2	2	2	2	2	2	2	2	2
Jitney driver	1	1	1	1	1	1	1	1	1
Dockman	0	1	2	2	2	2	2	2	2
Holdman	0	0	0	1	2	3	4	5	6

The job categories in Table 7 are described as follows:

1. A *foreman,* or *gang boss,* is the leader of the gang. He is the direct supervisor of the longshoremen. The foreman is responsible for the work of his gang to the walking boss representing the stevedore, and the supercargo representing the steamship company. He directs the movement of the cargo between the ship and the dock or barge. He also informs his gang members when and where to report to work. *Foreman* is the highest skill rating in the gang.

2. The *winch operators,* who control the ships' cargo gear, work in pairs. While one of the operators is at the winch controls, the other acts a signalman or hatch tender, directing the winch driver in movement of the cargo during the winch cycle. Occasionally, as signalman, he will help in the manual positioning of the cargo. The *winch operator* is the second highest skilled position in the gang.

3. The *jitney,* or *forklift, driver* operates the mechanical cargo handling equipment that is used on the dock and within the ships' holds.

4. Two *dockmen* are stationed on the pier apron to engage and disengage the cargo loads from the hook.

5. The *holdmen* are the largest group within the gang. They perform the various manual operations required for loading or discharging cargoes in the holds of ships. When gang size is changed, the change is usually in the number of holdmen assigned. Neither dockmen nor holdmen are considered to be skilled categories.

In addition to his occupation, a man is designated as a day-man or a night-man, depending upon the shift he works. There is a pay differential for night work.

Table 8, which is based on 1958 records of the PMA indicates the distribution of registered men by work shift (day-night), work category (gang-plug), and job, or skill, classification (foreman, winch operator, etc.). Men whose work categories or skill positions were changed during the year were classed according to the positions held the greatest length of time during the year.

The distribution shown in Table 8 is created by the following conditions:

1. The greatest demand for gangs occurs during the day shift.

a. Many plug men are used in day gangs, especially holdmen, jitney drivers, and dockmen.

b. A foreman and two winch operators form the nucleus of an organized gang, so plug men are not often used in these positions. A vacancy in these jobs is usually caused by vacation or sickness.

2. Although fewer gangs are employed in the night shift, they are more permanently and fully organized.

a. Because of the favorable pay differential

[11] These do not include the gang clerk.
[12] In addition to the regular gang, a sufficient number of spare men must be provided to give each hook-on man 15 minutes relief every two hours.

TABLE 8
Distribution of Registered Men by Classification
1958

Job Classification	Day		Night		Total
	Gang	Plug	Gang	Plug	
Foreman	137	7	70	11	225
Winch operator	240	97	141	54	532
Jitney driver	116	138	68	51	373
Dockman	260	199	136	124	719
Holdman	250	539	379	256	1,424
TOTAL	1,003	980 [13]	794	496 [14]	3,273

associated with night work, night gangs have more permanent members than day gangs. Thus, fewer plug men are used at night.

Joint Port Committees

If the registered workers were allowed to change categories or work shifts at will, the supply of men might vary considerably from day to day. To avoid this, two committees within the port regulate the movement of men from one job classification to another.

The *Joint Labor Relations Committee,* which is composed of both labor and management representatives, determines the need for shifting men to different job categories. They analyze the needs of the port on each work shift and in each job category and then determine how many men are required for the task.

When the manpower requirements have been established, the second joint committee, the *Promotion Board,* notifies the registered men of available openings. Applications for positions are submitted by the longshoremen; the Promotion Board makes selections and assignments.[15] If two men with similar qualifications apply for the same position, the man with the greatest amount of seniority, in terms of length of service, will be chosen. If there is doubt concerning the qualifications of applicants for a particular position, the committee may test their skills in a "dry run" of the job requirements. This procedure is not often used, since there are usually adequately trained men applying for skilled positions.

At the present time there is no formal training program for skilled workmen. Demands of the port are met by men who have received on-the-job training.

Dispatching Methods

In San Francisco, the ILWU and the PMA jointly maintain and operate a hall through which the port's demands for workers and the workers' need for jobs are met. The dispatch hall, operating in conjunction with the Allocations Office of the PMA, orders and dispatches workers to jobs available within the port. The Allocations Office receives the orders for gangs from individual stevedoring companies. A list of the orders is tallied and relayed to the Chief Dispatcher at the dispatch hall. The dispatcher fills the orders for each shift by coordinating them with the gangs which have indicated their availability to work. He notifies the gang foreman of the location of the job, the number of longshoremen needed, and the expected duration of the work. The dispatcher also assigns the plug men and the nonregistered casuals needed to fill incomplete gangs. A record of all time worked is maintained in the hall for each permanently organized gang and for each individual longshoreman who is not a member of a regular gang. Assignments are made on the basis of these records to equalize the amount of time worked by all the registered longshoremen.

At times, there is a shortage of available workers at the dispatch hall. When this occurs, "priority numbers" are assigned by the PMA Allocations Office to the ships on a first-come first-served basis. However, ships carrying highly perishable cargoes or

[13] This total does not include 332 day plug men with related tasks such as "car men" or "storemen."

[14] This total does not include 55 night plug men with related tasks such as "car men" or "storemen."

[15] It should be noted that this procedure is also used for the gang boss assignment after he has been selected by the gang.

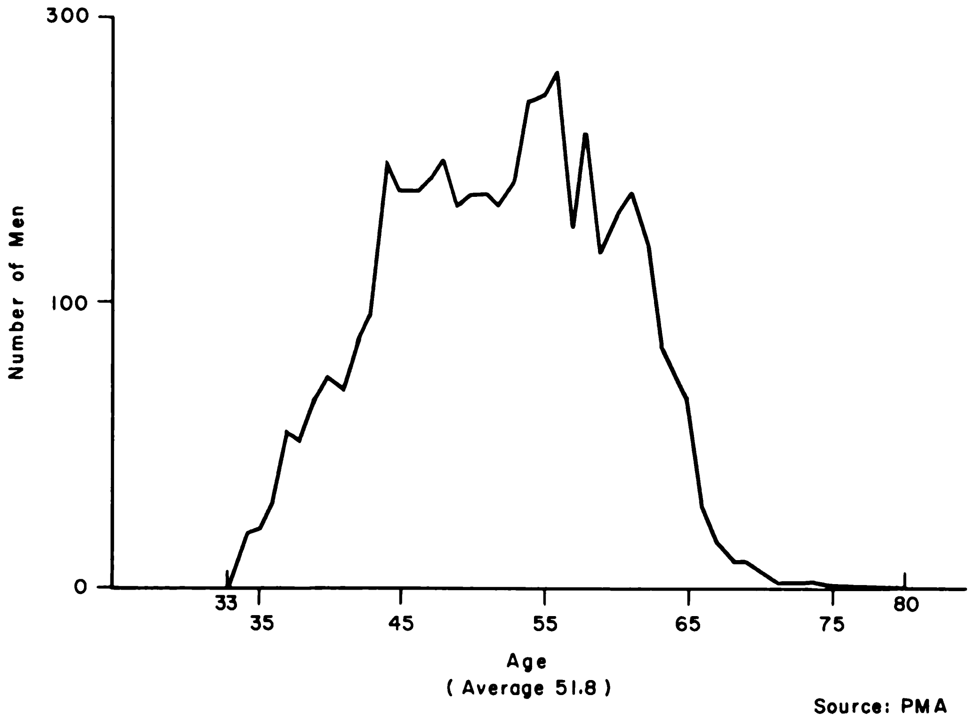


Figure 11. Age distribution of registered men 1958.

passenger baggage are serviced as soon as possible, taking precedence over the ships carrying normal cargoes which arrived in port earlier.

Age of Longshoremen

One of the marked characteristics of the San Francisco labor force is the advanced age of the workers. Few other industries employ a work force in which 75 per cent of the men fall between the ages of 44 and 62 years. The average age of the longshoreman in 1958 was 52 years, and the ages of the total labor force ranged between 29 and 82 years.

Figure 11 presents a distribution of ages of the registered work force (based upon data obtained from the Records Office of the PMA). The high average age of the registered longshoremen is attributed to two possible causes: (1) Registrations were closed after 1948 and only a few men were admitted to the rolls after that time. (2) A number of men, over-age for military service, entered the work force during the war years (1941-45). To qualify for full retirement benefits they have continued to work beyond age 65.

Table 9 is an age comparison between the gang and

TABLE 9

Ages of Longshoremen by Work Classification

Job Category	Gang Men Day	Gang Men Night	Plug Men Day	Plug Men Night	Average
Foreman	55	52	56	55	54
Winch operator	53	51	53	52	52
Jitney driver	56	52	55	52	54
Dockman	55	53	56	54	55
Holdman	51	47	50	49	49
Average	53.5	49.8	52.1	50.8	51.8

Gang Average = 51.8 Plug Average = 51.8

plug groups, day and night, and the several job occupations for 1958.

There was no difference between the average age for the gang men and for the plug men. However, it is interesting to note that the day men were older than the night men. As might be expected, the younger men are concentrated in the holdman category where greatest physical exertion is required.

The influence of age upon workers' availability is indicated by Figure 12, which correlates ages of the registered longshoremen with the average hours of work performed during the year 1958. The figure shows a definite tendency for hours worked to decline as the age of the longshoreman increases. This tendency is significant when combined with the previous observation that the age of the registered work force averaged 52 years in 1958. With few, if any, additions of young men to the work force since that time, the average age of the work force has been steadily increasing each year, and it may be assumed that this age increase will be accompanied by a decline in number of hours worked by this group. This decline is extremely important to the future of the port, as it represents an important factor in estimating manpower requirements.

Length of Service

Length of service, rather than being measured from the time a man first registered in the industry, is measured in terms of the "qualifying" years of work he has put in. A man is required to work at least 800 hours for each of these qualifying years. Thus, length of service and years in the industry are not identical.

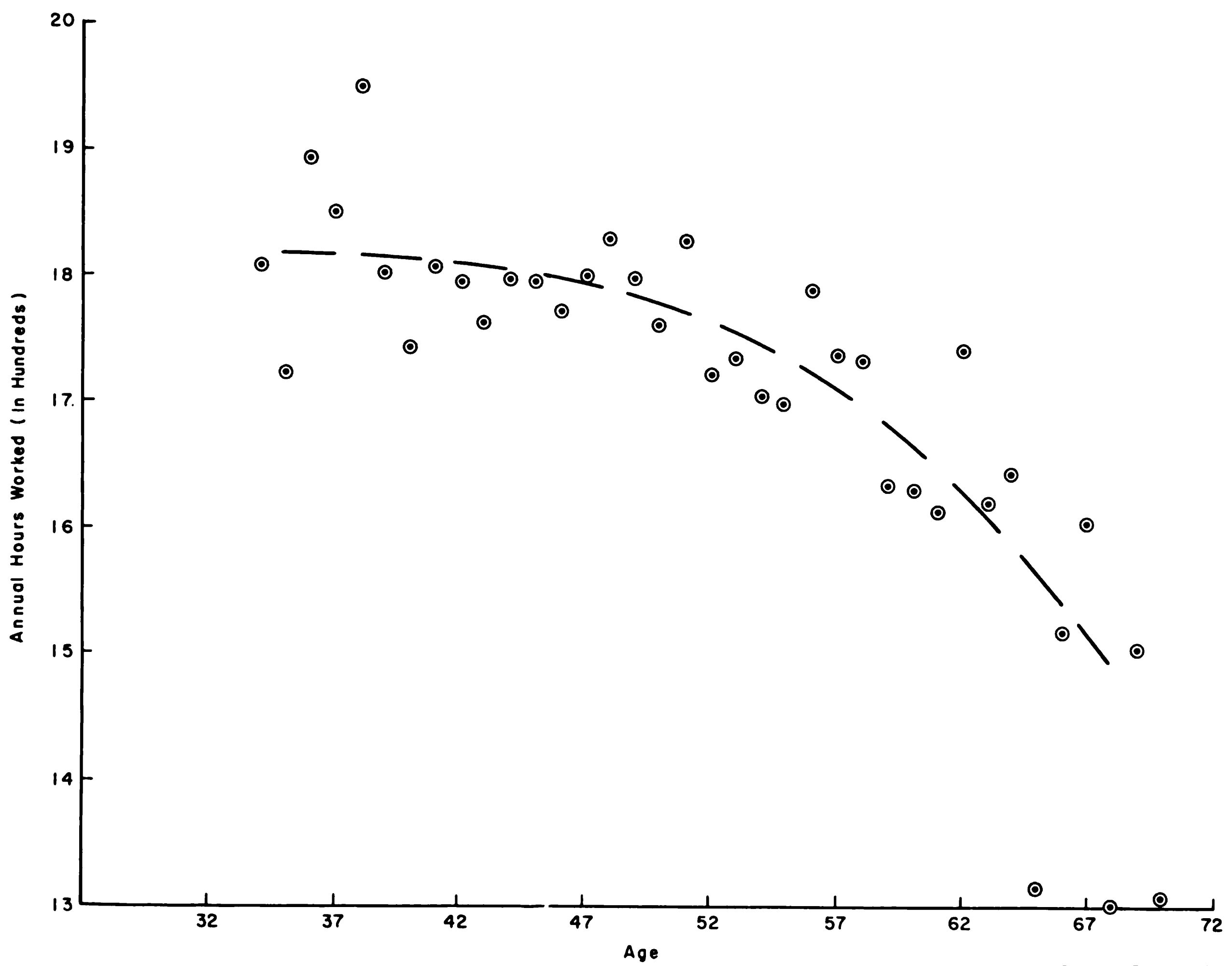


Figure 12. Comparison of age and hours worked 1958.

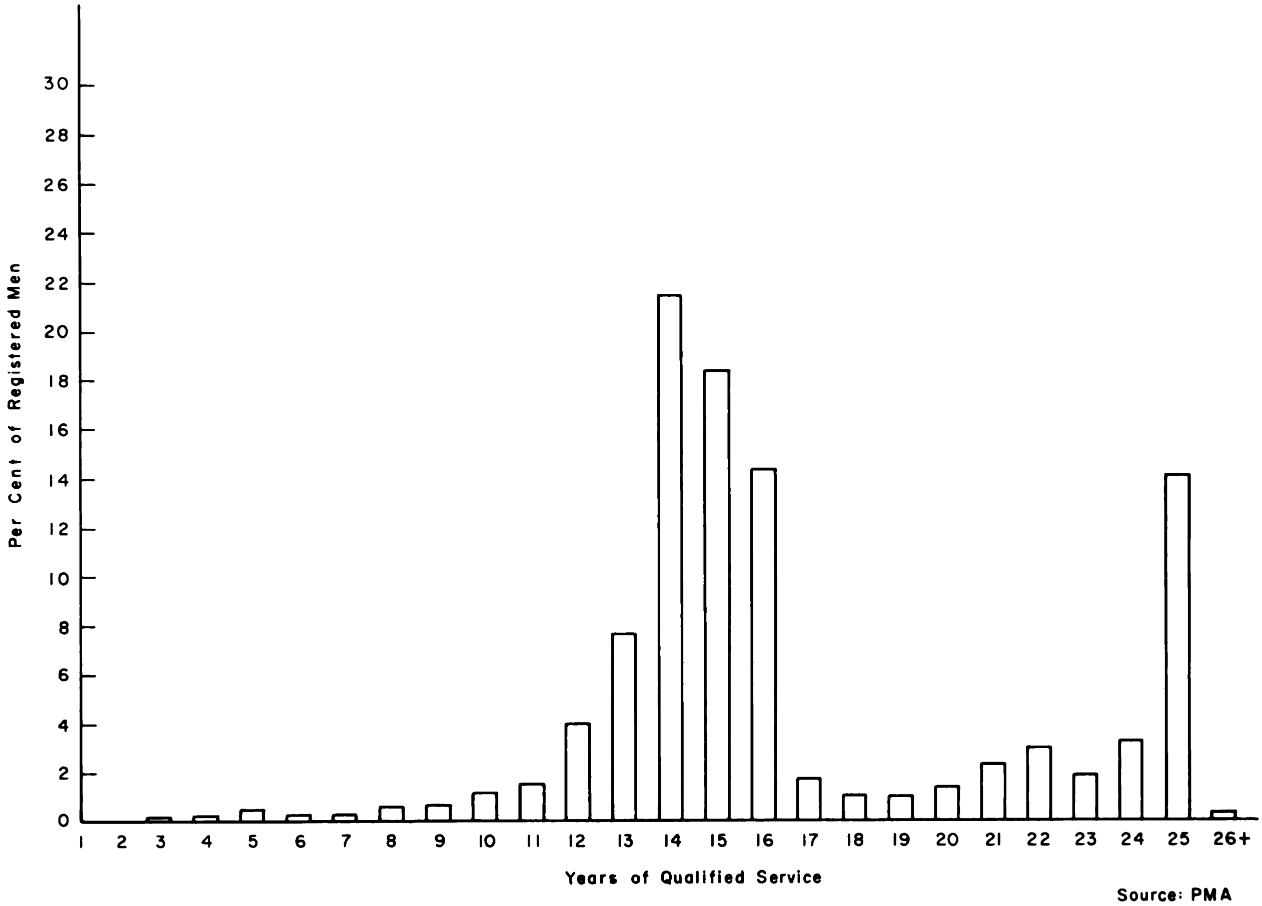


Figure 13. Length of service—registered work force 1958.

Length of service of the registered longshoremen is shown in Figure 13. The outstanding characteristic of this distribution is the two peaks. This illustrates the registration policy of the Joint Port Committee since 1934, when the union was recognized as the bargaining agent. The initial registration period accounts for the large peak at 25 years of service. The war years, 1940-43, accounted for another prominent rise in the curve at 13-16 years of service. The men whose service falls between these peaks were those registered and those who stopped working for a few years since their 1934 registration. After 1948, the registrations were all but closed to entrants. Therefore, those who have less than 10 years of service are principally men who have not made themselves available to work.

Table 10 shows that skill classification increases with length of service. The foremen have the greatest seniority, winch operators rank next, and so on. The length of service records indicate that the promotion policies of the port place some emphasis on the length of time in the industry. This, combined with the age of the work force, supports a conclusion that the essential skills of the port, i.e., foreman, winch and jitney operator, will be most affected by depletion through retirements. Even though registrations are reopened a rapid turnover in the high skill classifications can be expected. On-the-job training may no longer be adequate to supply the skills.

An attempt was made to correlate hours worked with length of service records of the longshore population. No relationship was found between these two variables.

Attrition

In order for a longshoreman to qualify for full benefits under the retirement program of the PMA-ILWU, he must have attained the age of 65 years, accumulated at least 25 qualifying years of service, and be registered with the Joint Port Committee.

TABLE 10
Length of Service Records by Work Categories

Job Category	Gang Day	Gang Night	Plug Day	Plug Night	Avg. Yrs.
Foreman	22	20	22	20	21.5
Winch driver	21	19	19	18	19.6
Jitney driver	21	18	20	16	19.2
Dockman	17	16	17	15	16.4
Holdman	15	14	15	14	14.6
Average yrs.	18.7	16.1	16.4	14.9	16.8

Data on age of the work force and length of service were combined to estimate the possible effects of retirements upon the work force. In 1958 approximately 1 per cent of the work force was eligible to retire. Until 1966 the retirement rate is relatively constant, when it increases sharply to a peak in 1969. By 1969 over 40 per cent of the 1958 work force will have achieved retirement eligibility.

In all industries, workmen leave their employment, either permanently or temporarily, for a number of reasons, e.g., illness, death, or better job opportunities. An analysis of the withdrawal rate of the San Francisco longshore labor force, other than through retirement, has indicated that about 3 per cent of that work force leaves the industry every year. This rate, assumed to remain unchanged over future years,[16] has been combined with the retirement projection and presented in Figure 14. By 1969, according to this projection, the 1958 work force will be reduced to less than half its original size.

Although man-hours cannot exactly be equated with men in relation to attrition, this yearly reduction in workers indicates the reduction in man-hours due to productivity improvement which the port system can absorb without reduction in work opportunity.

Work Opportunity, Registered versus Non-Registered

Table 11 compares the hours which the registered and the non-registered groups worked in the port during the year 1958, in total hours and average hours per man.

Registered men accounted for about 92 per cent of the hours worked and the non-registered men accumulated the remaining 8 per cent. The registered men worked an average of 1,950 hours per man, whereas the casuals worked an average of 122 hours per man during the year.

Figure 15 shows the distribution of hours worked by the registered and non-registered workers during the year. The distribution shows that about 87 per cent of the casuals worked between 1 and 300 hours. Only 3 per cent of the registered men worked between 1 and 300 hours. Relatively few casuals worked in excess of 300 hours.

Use of Casuals

Figure 16 illustrates the number of non-registered men employed in the day and night shifts. The data were obtained from the Records Office of the PMA which recorded the day-by-day dispatch of casuals in the port.

Figure 16 also shows the marked difference between the dispatch rates of day and night casuals. The range of the day shift was 0-600 men per shift and the night shift was 0-120 per shift. Night gangs, it will be remembered, have more assigned gang men than the day shift gangs. Thus, there are fewer openings for casuals at night.

Figures 17a and 17b relate the dispatch of casuals to the dispatch of gangs for the day and night work shifts during the summer and winter periods. For a

TABLE 11
Man-Hours Worked—1958

	Total Hours	Number of Men	Average per Man
Registered	6,373,000	3,273	1,950
Non-registered	560,000	4,607	122
TOTAL	6,933,000	7,890	

[16] Attrition by illness and death increases as age increases so that the assumption of a constant figure is conservative.

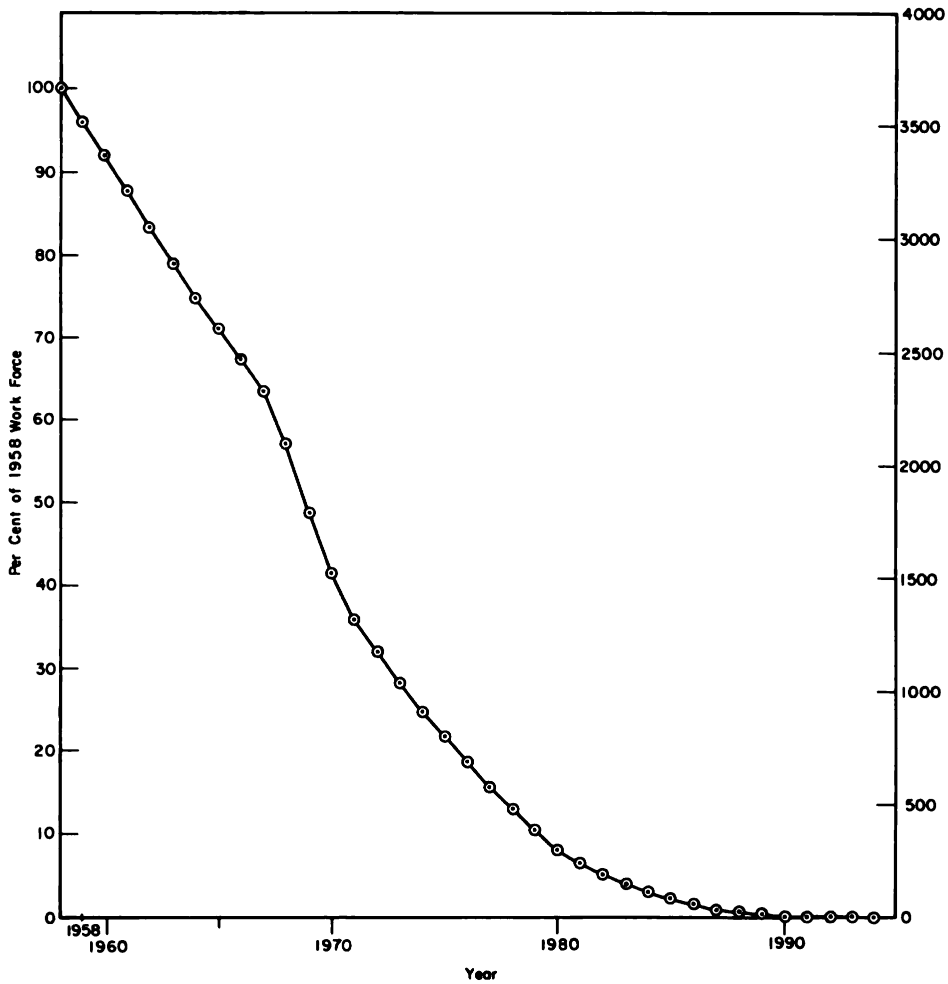


Figure 14. Attrition of 1958 longshoremen through retirement and withdrawal 1958-1994.

given number of day gangs, more casuals are needed to fill vacancies in the summertime than in the wintertime. In both summer and winter periods as the number of day gangs working approaches the maximum number available, up to 10 casuals are needed to fill the gang. The use of casuals is much lower on the night shift than on the day shift. In 1958 an average of only about 0.3 casuals were used per night gang employed while an average of slightly more than two casuals were used per day gang employed. These averages would both be considerably lower if there were not so much fluctuation in the demand for gangs.

It was noted earlier that incomplete gangs were usually short of holdmen. This is the longshore job in which most of the casuals work. Vacancies in the more skilled categories were usually filled by the registered men.

Gang-Plug Distributions of Registered Workers

Of the 6,373,000 registered work hours accumulated during 1958, gang men worked a total of 3,249,000, and plug men worked 3,124,000 hours. The average hours worked by gang men was 1,808, whereas plug men averaged 1,677 hours for the year. Some of the plug hours were worked by gang members when they were not working with the gang.

The average day gang was dispatched to work 1,875 hours during the year, and the average night gang was dispatched to work 1,878 hours during the year. Gangs were dispatched so that all gangs got

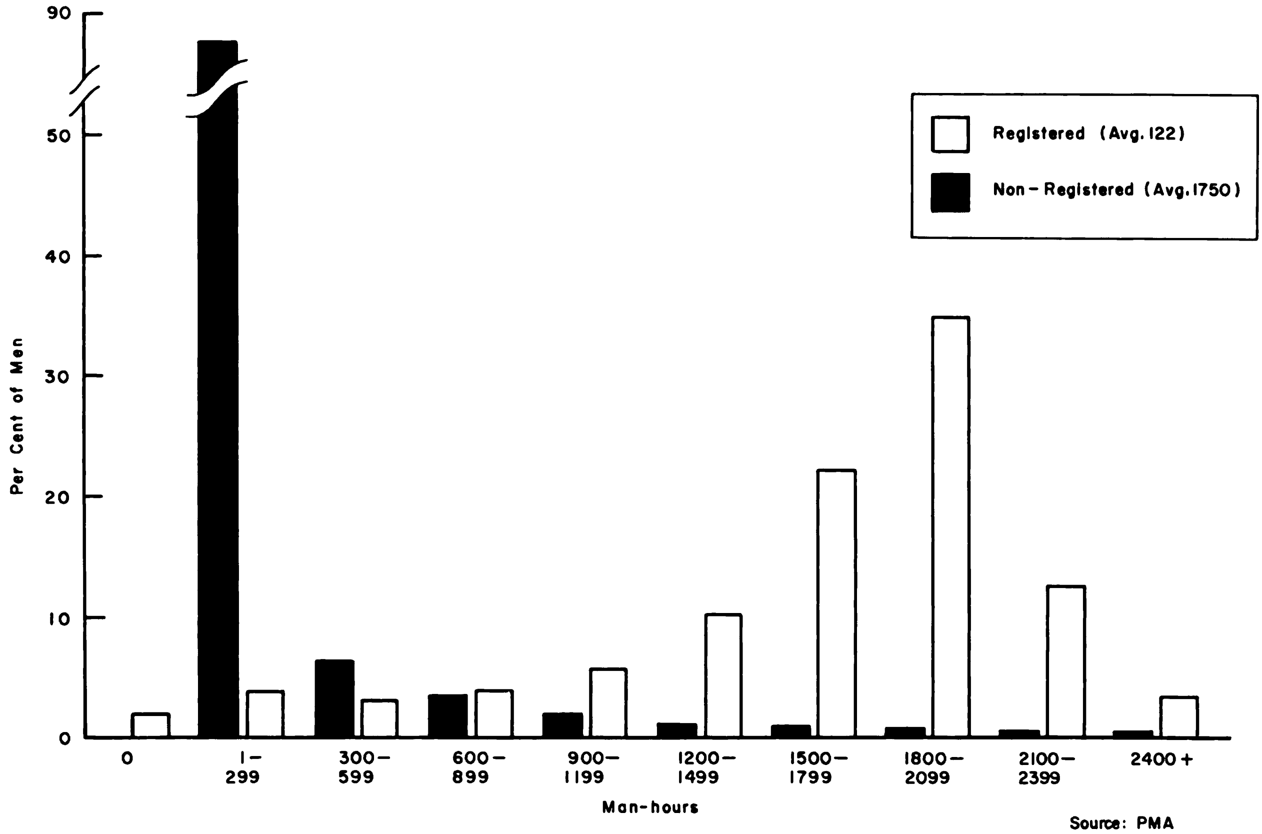


Figure 15. Distribution of hours worked by registered and non-registered men 1958.

within 50 hours of the annual average work opportunity. The Joint Labor Relations Committee switched gangs between day and night, balancing the amount of work opportunity between day gangs and night gangs.

Figures 18a and 18b show the day shift and night shift man-hours worked by gang members and plug men during 1958. In both day and night shifts, over 40 per cent of the men attached to gangs worked approximately as many hours as the gangs themselves. Some gang men managed to get more work than the gang by going to the plug board on days when their gang was not working. Of course, there are always some who work less than their gang for a number of personal reasons. On the day shift the plug men averaged almost as many hours as the gang men, and a somewhat larger percentage of plug men than gang members worked over 2,000 hours. The plug men in the night shift averaged 300 hours less work than the gang members.

A plug man is dispatched according to the number of hours he has worked over the previous three-month period. Thus, each night plug man shares the available work opportunity. However, with lower work opportunity at night, a number of men could have been shifted to day work if they had wanted it. Because of the pay differential for night work, the night plug men had greater average earnings than the day plug men, even though they worked fewer hours.

Vacations and Days Off

The supply of registered longshoremen is seasonally decreased by vacations. Vacation scheduling is arranged by the Joint Labor Relations Committee of the port and provides for a fairly even distribution of vacations from May through October. During each week of this six-month period, eight gangs and about 60 plug men were scheduled to begin vacation. The average vacation length was three weeks, so that during any week in the May-October period, about 24 gangs were not available.

Registered longshoremen are entitled to at least one day off during the work week. To insure that

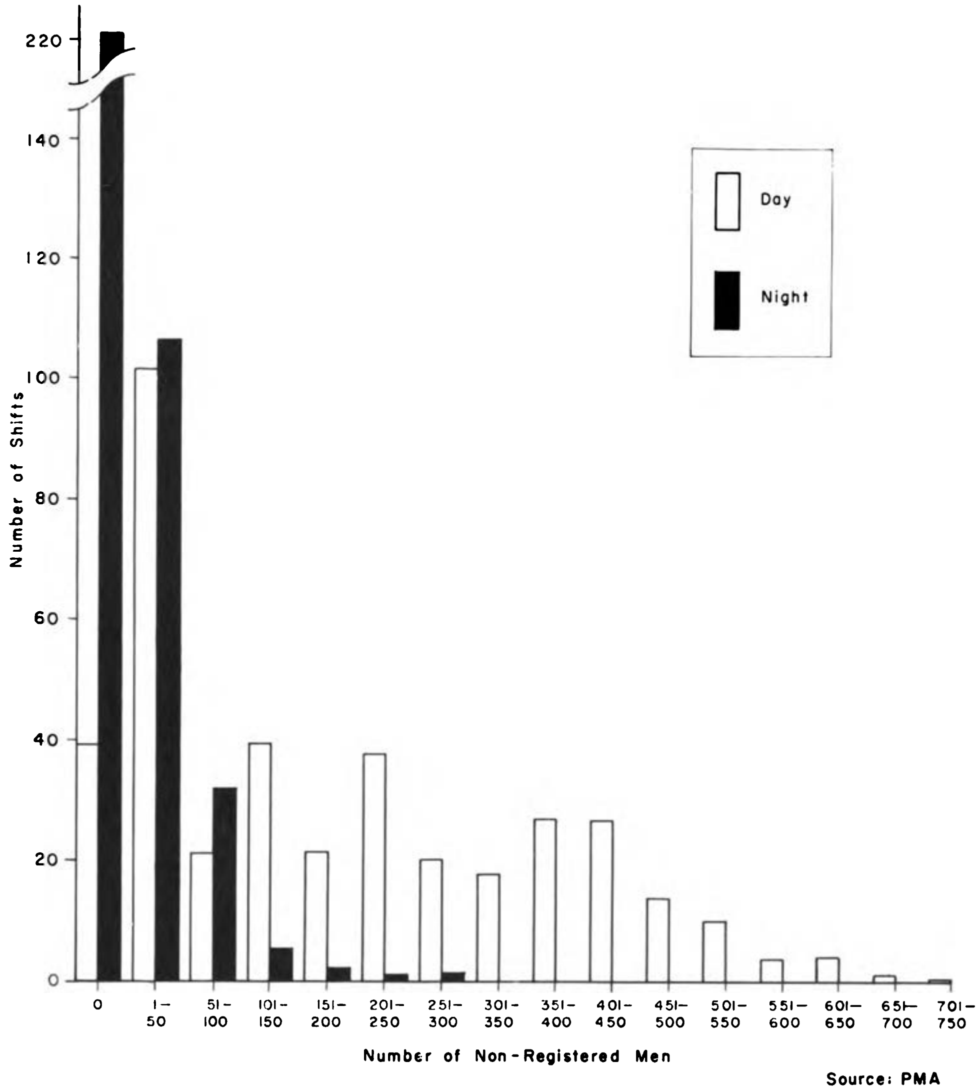


Figure 16. Employment of non-registered men by day and night work shifts 1958.

men will have the opportunity to take that day off, the labor contract provides for the scheduling of days off by the Joint Labor Relations Committee. The contract states that Sunday is the day on which most men should be off. Men are scheduled to have consecutive Sundays off for a period of two months, and a week-day off the third month. Thus, on Sunday, about one-third of the registered work force is available for dispatch.

Union Meetings

In 1958, Local 10 held its general membership meetings on the first and third Monday nights of each month. Members were required, under penalty of fine, to attend at least one meeting a month. Because of the shortage of labor on Sunday, Monday was often a day of peak demand for service. The choice of Monday as a meeting night was unfortunate for the registered workers and for the companies. The meeting reduced the number of gangs available for dispatch, and increased the number of casuals performing work that could have been done by registered longshoremen.

CLERKS

Under the terms of the Master Agreement for Clerks on the Pacific Coast, clerks perform clerical functions related to handling cargo, including keeping records for individual employers.

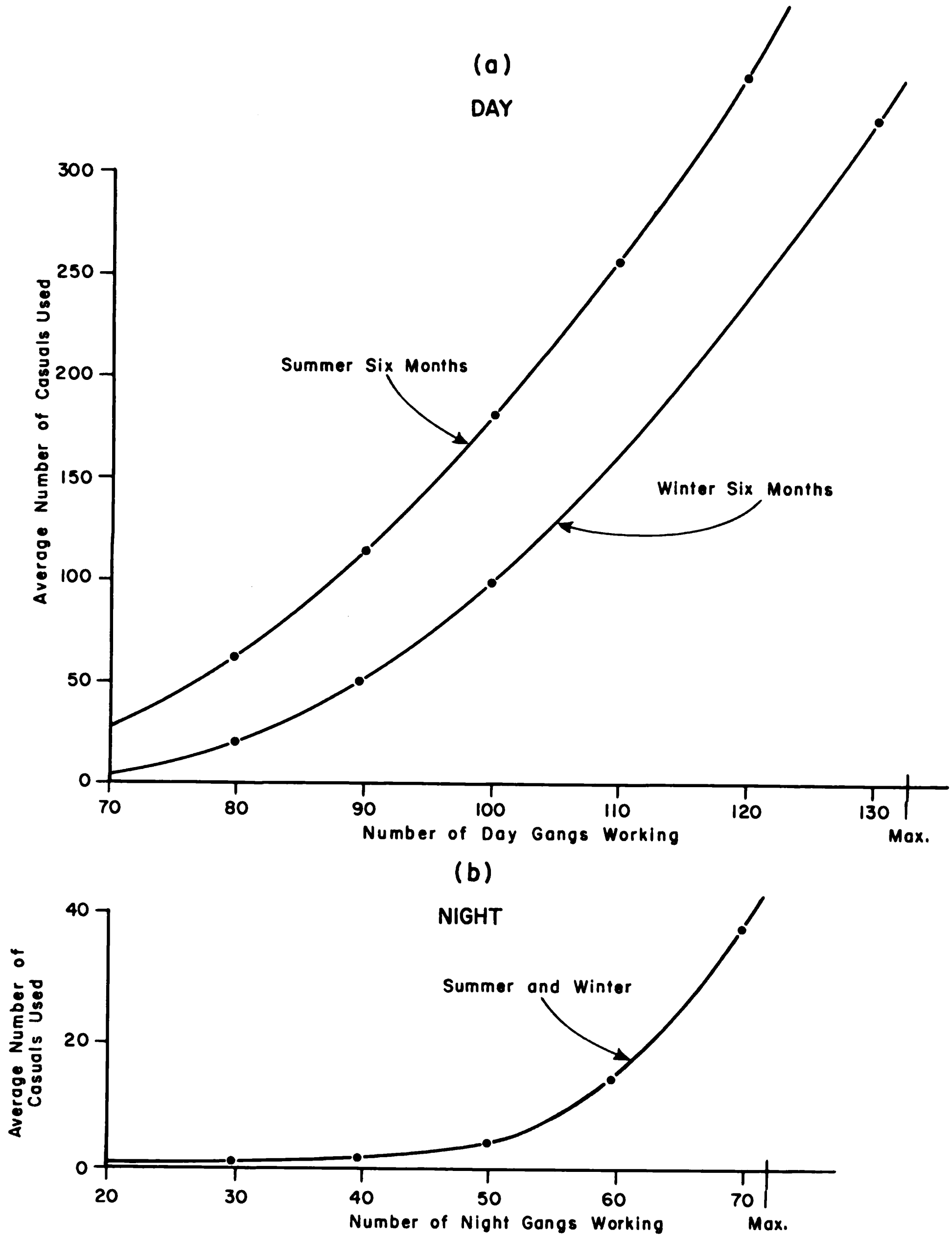


Figure 17. Use of casuals against number of gangs working 1958.

Registered, Limited-Registered and Non-Registered Men

In 1958 there were two classes of clerks registered with the Joint Port Committee. Casual clerks employed occasionally had no standing with the Joint Port Committee. The two groups registered with the Joint Port Committee were designated "fully registered" and "limited-registered" clerks. Fully registered clerks were members of Local 34 of the International Longshoremen's and Warehousemen's Union. Limited registered clerks were not entitled to all of the rights and benefits extended to fully registered men, but were allowed to use the grievance machinery and the dispatch hall. They received contract scale pay and earned qualification toward retirement pay. For such rights, these men were required to pay to the union a sum equivalent to dues. Limited-registered clerks were not entitled to the benefits of work equalization given union members; they were given work ahead of casuals. When

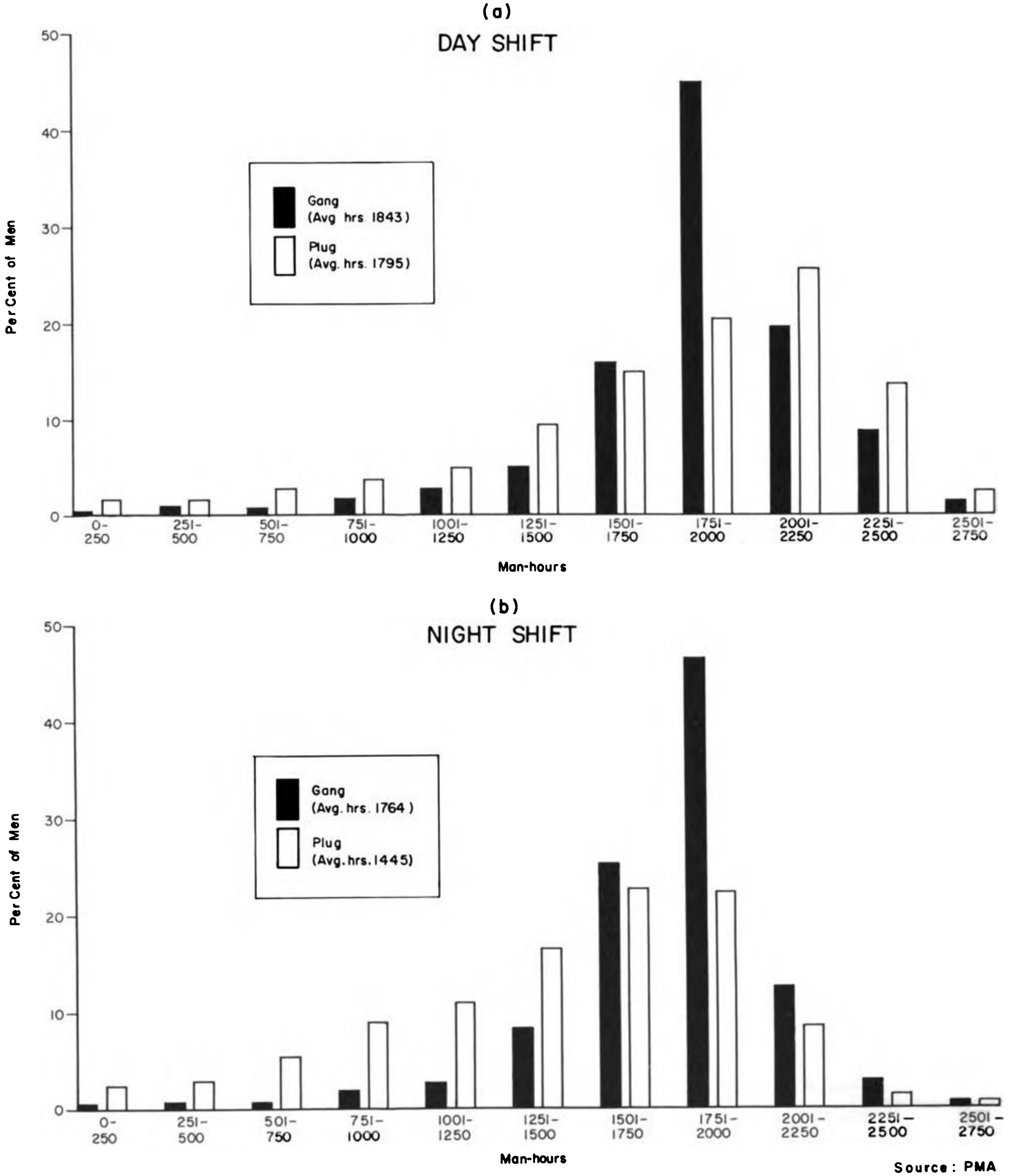


Figure 18. Distribution of gang member and plug man-hours 1958.

the rolls of the fully registered group were opened for new members, they were selected from the limited-registered group.

Casual clerks worked intermittently and the group changed rapidly in composition. Little data was available on this group; hence, this section applies only to the fully registered and limited-registered groups.

Worker Classification

There are four classifications of men performing clerical function: clerks, supervisors, chief supervisors, and supercargoes. Following is a brief description of these classifications.

1. *Clerks* perform the clerical functions related to receiving, delivering, checking, tallying, sorting, and spotting cargo, including the recording of necessary notations and the keeping of such records as may be required by the individual employer.

2. *Supervisors* direct or supervise the work of clerks, but may be assigned to other work incidental to their regular duties.

3. *Chief Supervisors* direct the work of the supervisors.

4. *Supercargoes* supervise the loading and/or discharging operations of a vessel and, as direct representatives of the ship operator, in conjunction with other representatives of the employer, are responsible for the safe, efficient and proper handling of cargo. They have the authority to hire, supervise, place and/or discharge men and perform these duties in accordance with the orders and requirements of the employer. Supercargoes do not do the work of clerks or supervisors except as incidental to their other duties.

Dispatch Procedures

The ILWU and the PMA jointly maintain a dispatching hall in the port of San Francisco through which clerks are assigned to available jobs. In 1958 there was generally one clerk assigned for each longshore gang, but assignment procedure varied somewhat from company to company. All clerks were dispatched through the dispatch hall on a daily basis, except for 44 "monthly men." Each of these "monthly men" worked for a single company which guaranteed him a minimum of 173 hours per month. Some clerks were dispatched to particular companies on a preferred basis, but worked elsewhere when not needed by that company.

All fully registered clerks were given hiring preference, followed in turn by the limited-registered men and then the non-registered clerks. A record was kept of the hours worked by fully registered clerks. This record was used to assure equalization of work opportunity among these men. There was no minimum guarantee of 173 hours work per month for these clerks. However, it was possible for them to work more than this total during any given month. Should 173 hours be exceeded, the right to share equally in the "excess" work hours was extended to the clerks who were working full time for a single company.

Age of Clerks

Figure 19 presents a distribution of the ages of the fully registered and limited-registered clerks whose records are maintained by the PMA. The ages range from 23 to over 69, with the average age being approximately 53 years. A total of 41 clerks are 69 years of age or more. As in the case of longshoremen the older men probably entered the union during the war years and have continued to work past the age of 65 in order to qualify for full retirement benefits (25 years of service).

Length of Service

Length of service for clerks is calculated in the same manner as for longshoremen. Length of service for 690 of the fully registered and limited-registered clerks is presented in Figure 20. The peaks of the curve show that 98 men of this group had 25 years or more of service as of 1958. These men were original members of the ILWU. A second peak occurs at 15 years of service. These were the World War II entries. The third peak, at eight years service, apparently relates only to the limited-registered men.

Attrition

In 1958 approximately one per cent of the clerks were eligible to retire. Until 1965, the rate at which men become eligible to retire is fairly constant. At that time the rate of retirement will increase sharply. By 1971, approximately half the clerks working in 1958 will have become eligible to retire. By 1983, 88 per cent of the 1958 work force will have earned their retirement. Adding the three per cent attrition rate for causes other than retirement, used for the longshoremen, gives the prediction in Figure 21. This projection of the 1958 clerks attrition affords a

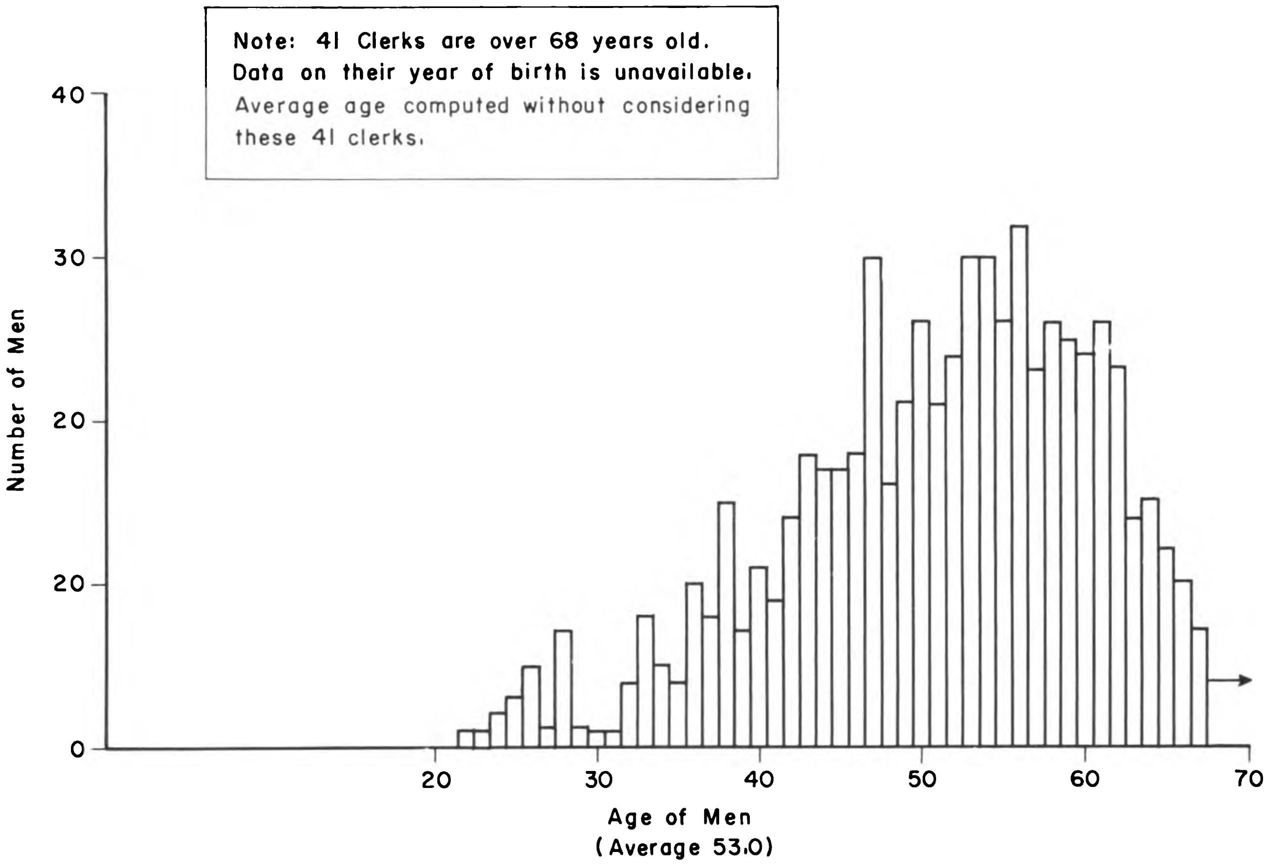


Figure 19. Age distribution of clerks 1958.
(690 clerks for whom information was available)

picture of the replacement needs of the industry if it is to meet the rapid retirement rate of the late 1960's.

Work Opportunity

Figure 22 shows the distribution of hours worked by the registered clerks during 1958. The average employment was high. More than 80 per cent of the men received over 1,500 hours of employment for the year and over 60 per cent received more than 2,000 hours. Undoubtedly some of the low hours reported were "monthly men" whose major employment with a company is not included here, but extra jobs they took from the hall during peak periods are shown.

WALKING BOSSES

Walking bosses represent stevedoring companies during cargo loading and discharging operations. They are responsible for the stevedore gangs and the performance of work. They are also responsible for proper handling of equipment and gear during the cargo handling operations.

Company-Preferred and Plug Walking Bosses

Walking bosses fall into two categories, "company-preferred" and "plug." A company-preferred walking boss works full time for a stevedoring company. A plug walking boss works as the opportunity arises and is not associated with a specific company.

There is no difference in skill classification between the company-preferred and plug walking bosses. The individuals constituting both these groups are members of the ILWU. All permanent walking bosses belong to Local 91. However, on occasions when the membership of Local 91 is unable to meet the demands of the port, temporary walking bosses are obtained from ILWU Local 10, Longshoremen. At no time are non-ILWU members permitted to work as walking bosses.

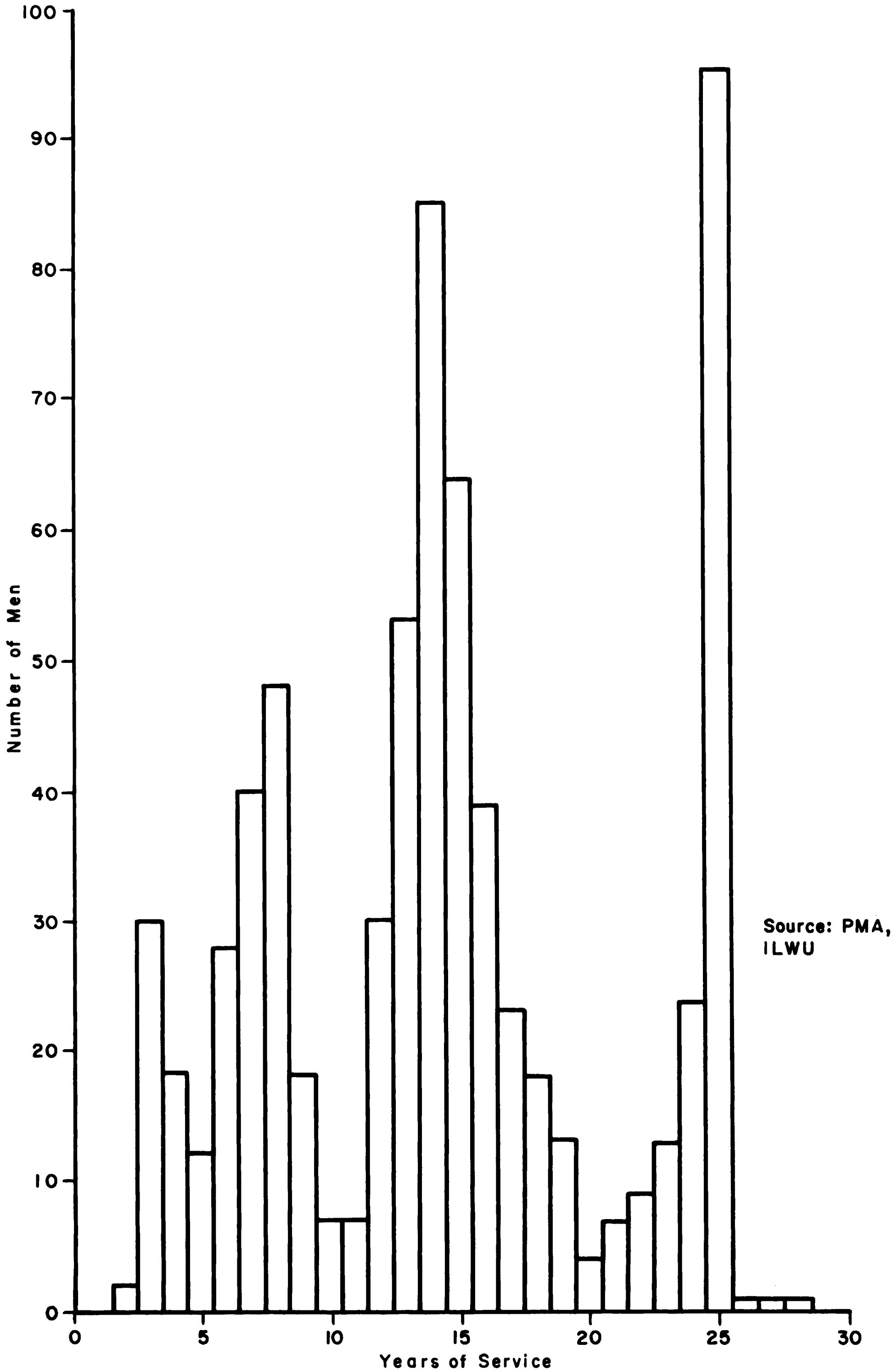


Figure 20. Length of service of clerks 1958.
(690 clerks for whom data on length of service were available)

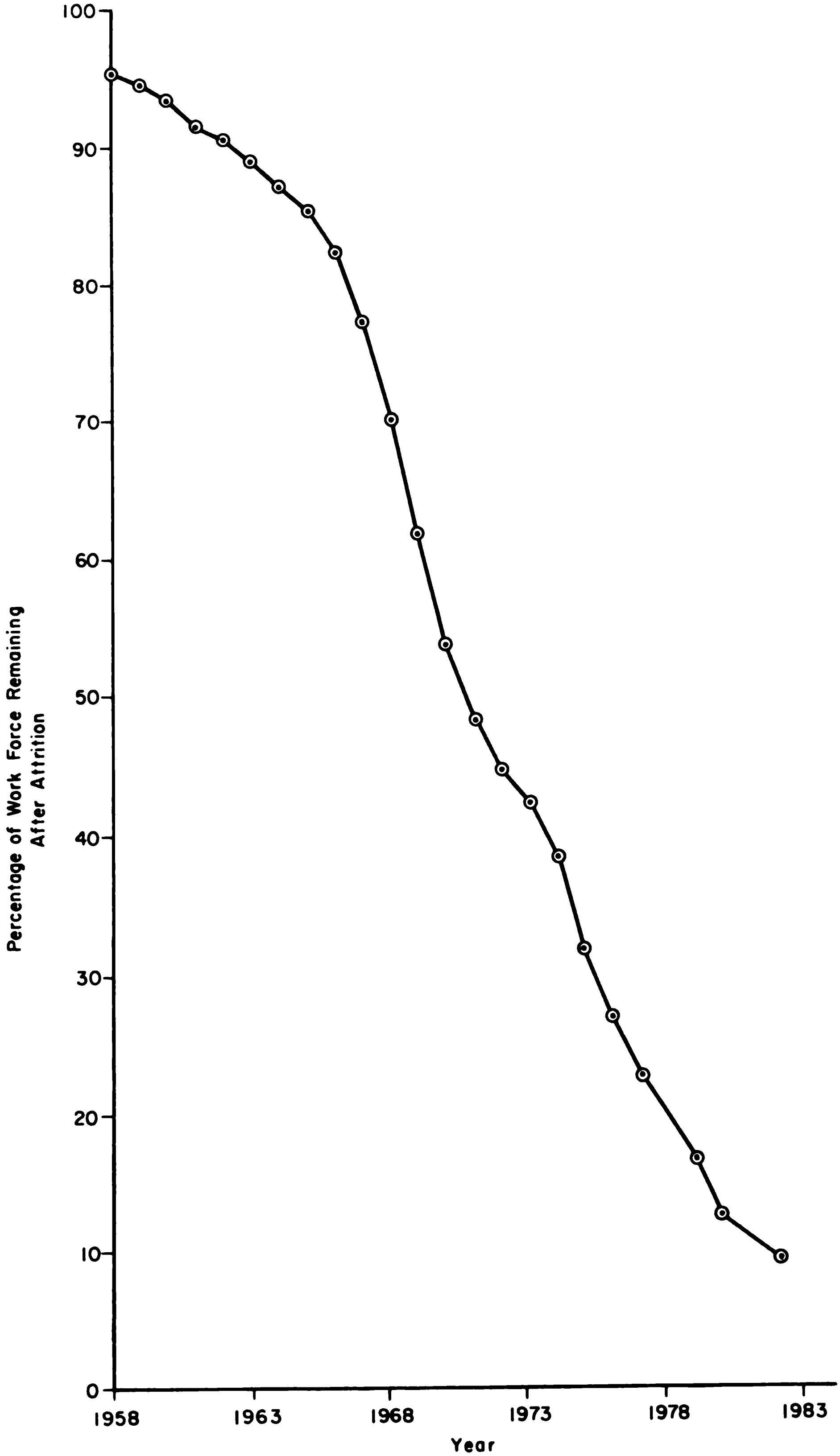


Figure 21. Attrition of 1958 clerks through retirement and withdrawal 1958-1983.

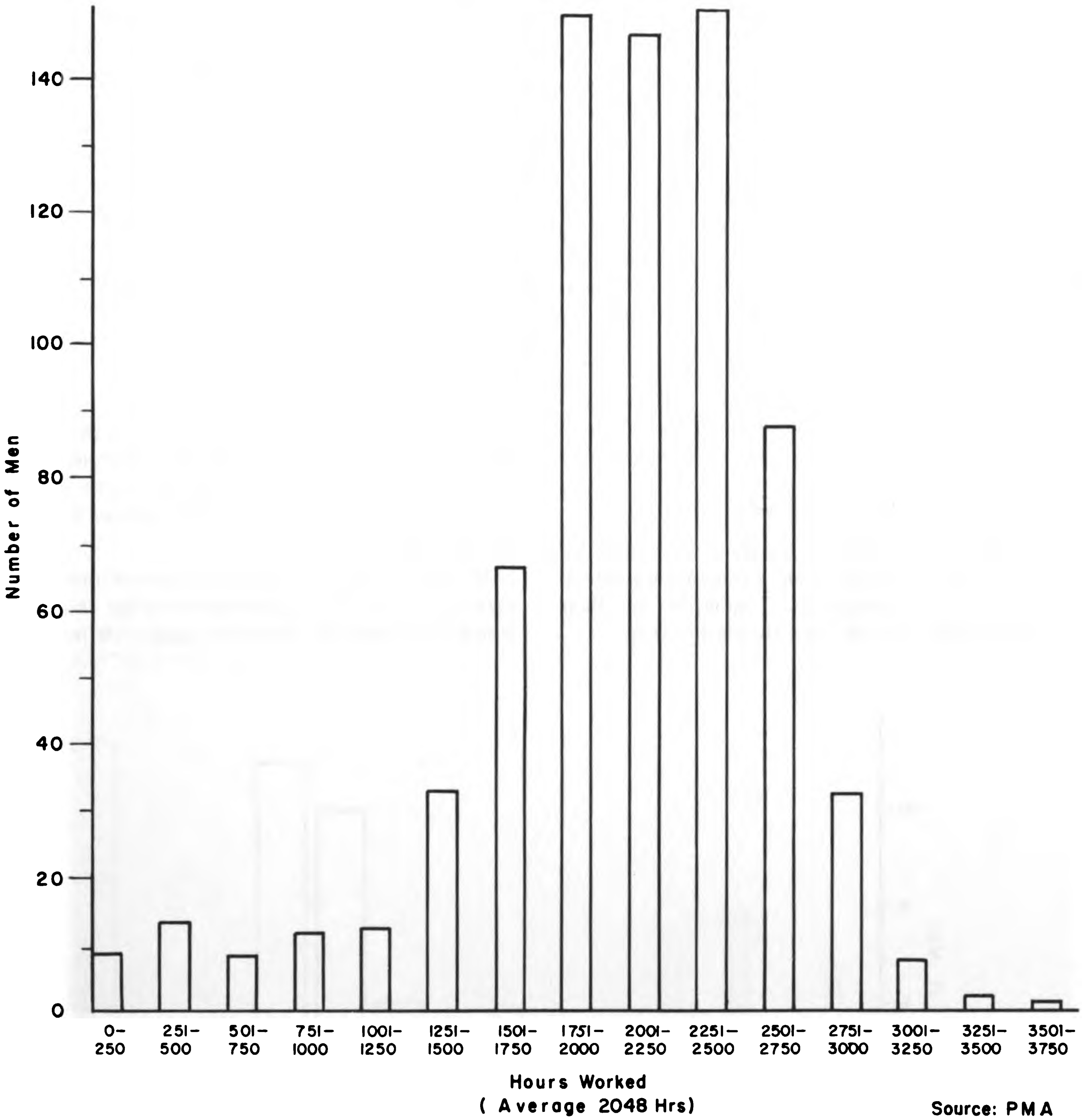


Figure 22. Distribution of total hours worked by clerks 1958.
(725 clerks for whom data were available)

Walking Boss Selection

A man is selected to become a walking boss by a company in need of his services. Local 91 is then requested to admit the man as a member. The company must guarantee the man one year's work as a walking boss.

Walking bosses are selected from the membership of ILWU, Local 10. Thus, men selected as walking bosses are usually experienced in cargo handling, and are known to the stevedoring companies. All walking bosses are selected in the same way. A man may voluntarily transfer to the "plug" after he has worked as a company employee. A man may be selected as walking boss at any age or after any length of service. In practice, he will have worked on the waterfront a number of years before he is known to the companies.

Hiring Methods

Company walking bosses are given their work assignments by the stevedoring company for whom they work. The company is responsible for their men obtaining sufficient work during the year.

Plug walking bosses are dispatched by Local 91. There is no joint dispatch hall such as that of the longshoremen. Every effort is made by Local 91 to insure that plug walking bosses share the available work throughout the year. Plug walking bosses averaged 1,889 work hours per year. Eighty-nine per cent of the plug men worked more than 1,500 hours. Figure 23 shows the distribution of hours worked by plug walking bosses.

If a company walking boss does not get enough work from his company, he may become a plug man upon request to the union.

Assignment of Walking Bosses

Walking bosses are assigned to ships on the following basis: one walking boss for one stevedore gang, two walking bosses for three gangs, three walking bosses for six gangs, four walking bosses for nine or more gangs.

Walking bosses are stationed anywhere on a vessel, depending upon the requirements of the ship upon which they and the stevedore gangs are working.

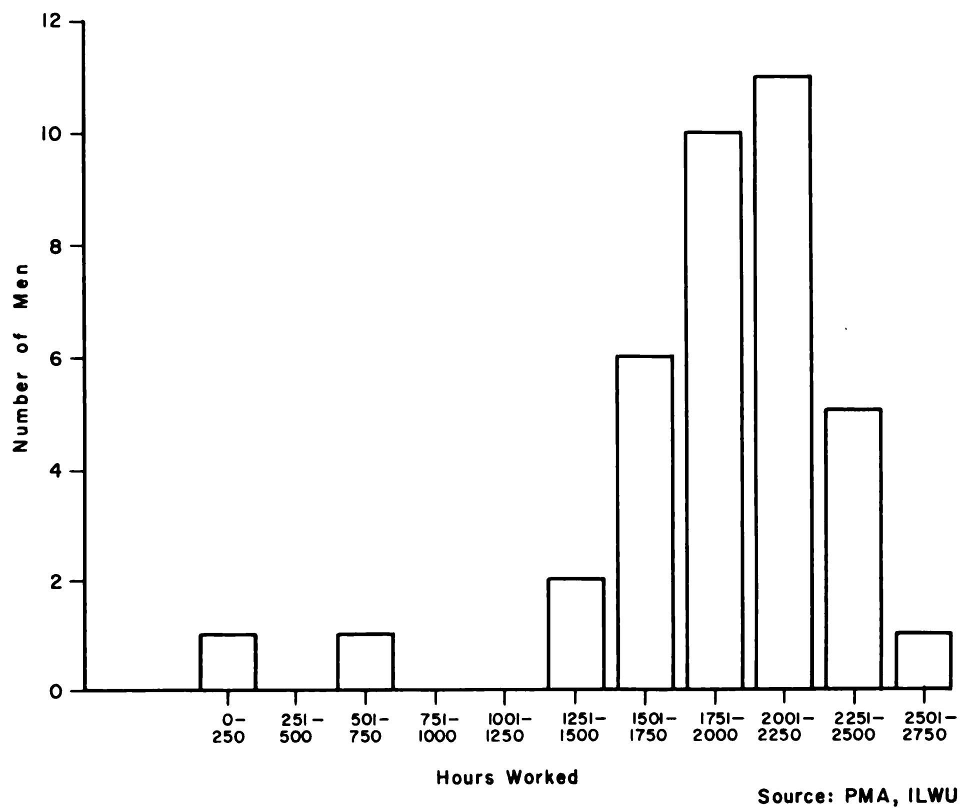


Figure 23. Distribution of hours worked for plug walking bosses 1958.

When more than one walking boss is assigned to a ship, one of them is designated senior and the others are responsible to him.

Membership in Local 91

Of the 171 walking bosses active in 1958, 134 were company employees and the other 37 were plug men.

Approximately 80 per cent of the company men (107) worked on the day shift. About 60 per cent of the plug men (22) worked on the day shift.

Age

Walking bosses ranged from 36 to 67 years of age. The average age was 52.8 years. The age distribution of this group, shown in Figure 24, is strikingly similar to that of longshoremen.

It might be expected that the age characteristics of walking bosses would differ from those of longshoremen. However, since there was no seniority requirement in the selection of new walking bosses from Local 10 it was to the advantage of the stevedore companies to select men to be walking bosses whose age was such that they would be available for a number of years.

Length of Service

One hundred ten walking bosses had accumulated 25 or more years of service before or during 1958. These men represent almost two-thirds of the 1958 work force. Figure 25 shows the length of service of this group.

Retirement

Retirement is based on age and length of service. Length of service commenced at the time a longshoreman entered the industry. Registration as a longshoreman is the usual evidence of entry.

Data on the ages of the 1958 walking bosses and their length of service were combined to estimate the possible effect of retirement upon the future work force. Figure 26 is a projection of the attrition caused by retirement of this group. The retirement rate for the group is relatively constant for the period

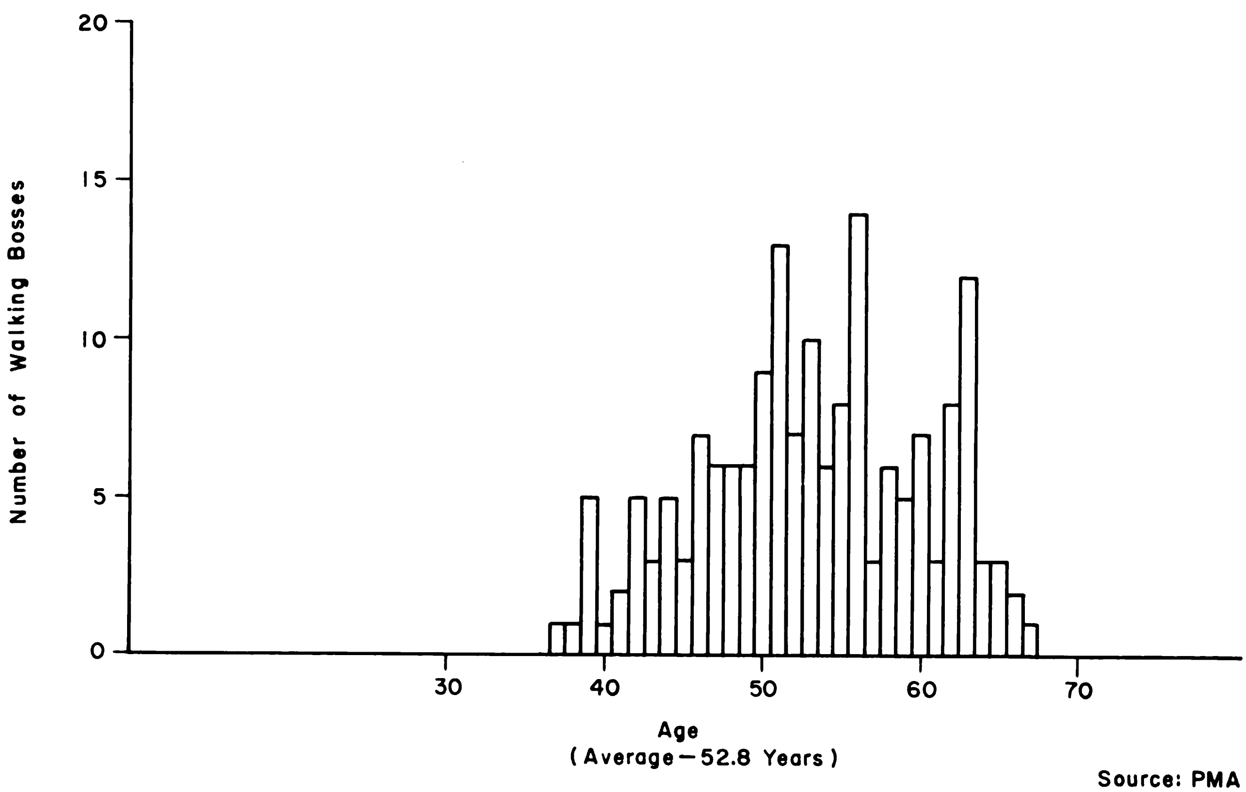


Figure 24. Age distribution of walking bosses—plug and company-preferred 1958.

indicated, 1958-80, inclusive. The peak retirement years are 1967 and 1972 when 16 and 15 men, respectively, will be eligible for retirement.

Walking bosses are replaced as they retire. With a relatively even rate of retirement over the years, the skill level and competence of the walking boss work force is maintained while replacements are occurring.

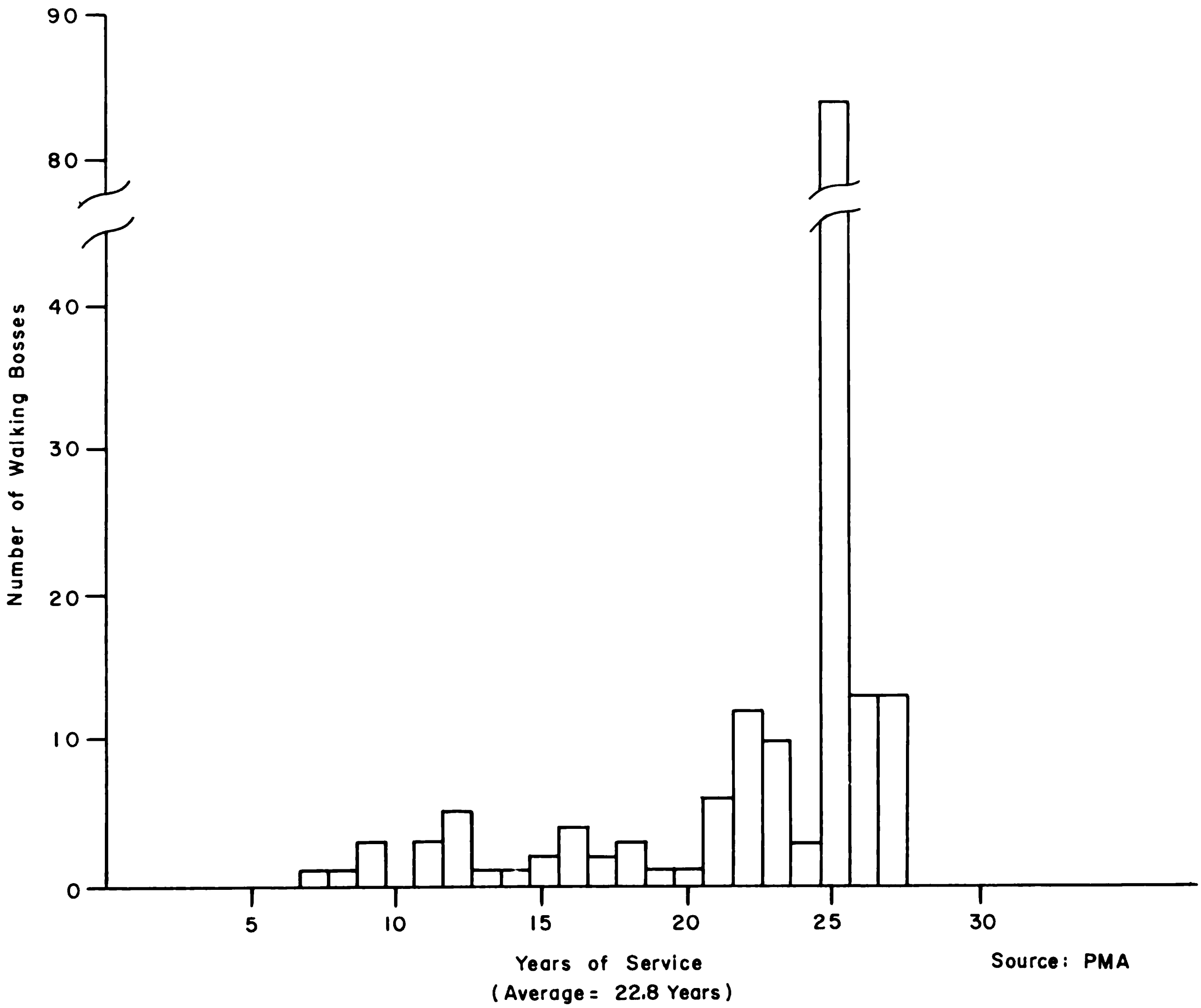


Figure 25. Length of service of walking bosses 1958.

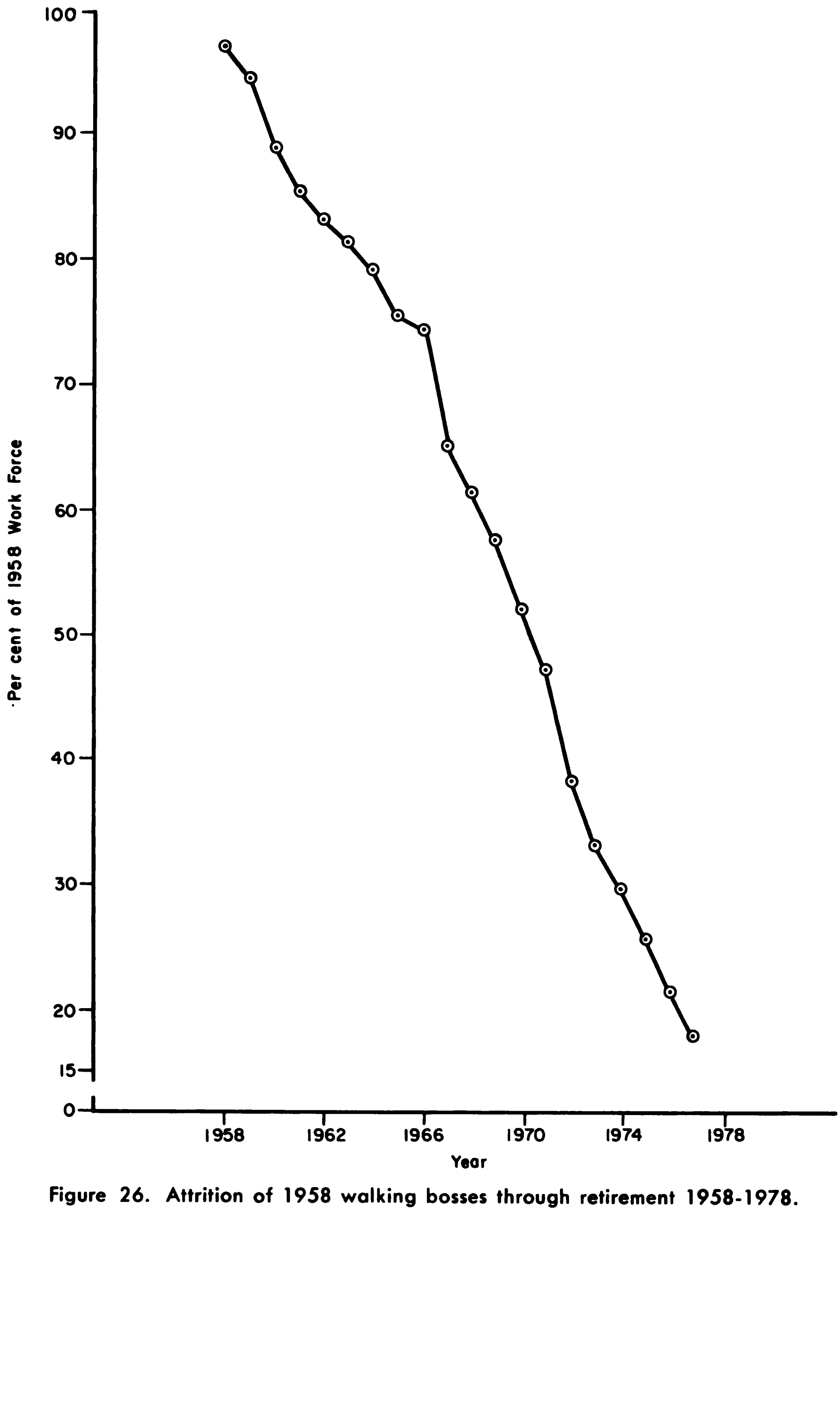


Figure 26. Attrition of 1958 walking bosses through retirement 1958-1978.

Chapter 5

TERMINAL FACILITIES

This chapter describes the general cargo terminal facilities in the San Francisco Bay Area and discusses the relationship of existing terminals to the performance of the port.

Table 12 lists the principal general cargo facilities in the San Francisco Bay Area. The terminals are classified as public, private, or military.

SAN FRANCISCO PORT AUTHORITY PUBLIC FACILITIES

The piers in the Port of San Francisco represent the most extensive public facilities for general cargo operations in the Bay Area. They are owned by the State of California and managed by the San Francisco Port Authority. All of the facilities for the 63 berths listed in Table 12 were leased in 1958 to private steamship companies, or terminal operators, on a so-called "preferential rent" basis. Under this plan, an operator pays rent for the privilege of using the pier for his own operations. If the pier is not being used, the Port Authority is still at liberty to assign other ships to the facility. All operators pay dockage fees while ships are in berth, and wharfage fees for cargo handled on the pier.

Most of the piers are finger piers with sheds. Piers 30 and 32 and Piers 15 and 17 are listed as pairs because the docks between them have been filled to make double piers. Pier 50 is a large fill area providing six berths of a quay type. All of the San Francisco piers have at least 30,000 square feet of cargo shed area per berth with the average over 50,000 square feet. All piers have aprons (working area between shed and ship) 15 feet, or more, wide. While many piers were built after the 1906 earthquake, they are in reasonably good condition. They are adequate for the rates of handling break-bulk cargo observed in 1958. Rail connections with the state operated Belt Line are provided for all piers, although as of 1950

TABLE 12

General Cargo Berths in San Francisco Bay Area in 1958 *

San Francisco Public Piers (Leased)				Oakland-Alameda Piers					
				Public		Private		Military	
Pier No.	No. Berths	Pier No.	No. Berths	Pier No.	No. Berths	Pier No.	No. Berths	Pier No.	No. Berths
45	4	9	2	Market St.	2	Howard	4	OART	8
41	4	22	2	Grove St.	3	Encinal	6	NSC	8
39	3	24	2	9th Ave.	4				
37	3	26	2	14th St. & 7th	6				
35	3	28	2						
33	2	30-32	3						
31	2	34	2						
29	2	38	2						
23	2	42	2						
19	2	44	2						
17-15	3	46 A & B	3						
		48	3						
		50	6						
TOTAL			63		15		10		16

* The few piers of the San Francisco Port Authority not listed in Table 12 are either bulk-handling terminals or unleased general cargo piers of lower quality and/or in a poor state of repair.

only 18 per cent of the general cargo was transferred to or from rail cars. The proportion of rail cargo has declined significantly since 1950. Except for a small amount of cargo carried by barge, the rest of the ocean-borne cargo comes or goes by truck. Trucks can drive on all of the piers. Severe congestion occurs at most piers during busy periods. The inability of most of the facilities to accommodate the normal accumulation of "last minute" truck arrivals represents the greatest inadequacy of the facilities. This, of course, is a problem common to finger pier facilities in many other ports, as well.

OAKLAND, PUBLIC, PRIVATE, AND MILITARY FACILITIES

The public, private, and military facilities in Oakland are as good as the San Francisco Port Authority piers. Oakland Army Terminal is a basin surrounded by quay-type berths. Most of the berths have ample adjacent shed space. Naval Supply Center piers are well constructed, generously proportioned finger piers. The private Encinal and Howard Terminals operate from some of the Oakland piers, and also from comparable facilities of their own.

The private terminals operate in a different fashion from the public terminals. Basically, the private terminal operators are agents for cargo shippers for whom they perform various special services such as storage, cargo marking, shipment consolidation, etc. Ships calling for cargo at the private terminals bring in their own stevedoring companies and, thus, are responsible for loading and discharging their own cargo. No preferential rent system is used, so many different steamship companies use the same berths, resulting in higher berth occupancy than the public piers.

Ships of many commercial companies call at the Army and Navy terminals upon request of the Military Sea Transport Service, which books all cargo for both services. The military services, not the steamship companies, are responsible for handling cargo on commercial ships at the military terminals. In 1958 all the Army stevedoring work was performed by a commercial contract stevedoring company. Another contractor performed the clerical and terminal work. The Navy used civil service employees under Naval supervision for longshore and terminal work. A commerical stevedore using union longshoremen was hired for peak load periods.

EFFECT OF FACILITY QUALITY ON PERFORMANCE

Most of the piers in the San Francisco Bay Area have adequate apron width and shed space for conventional cargo handling operations as performed in 1958 and 1959. The analysis in Chapter 3 of Part III indicates that operations on the apron caused no more than six per cent delay time in San Francisco ship loading and discharging operations. The same analysis suggests that the cargo handling system was not functioning at a productivity rate which greatly taxed the delivery capacity of terminal facilities. An increase in shipments of unitized cargo and improvements in break-bulk handling productivity could easily change this situation so that space, floor loading, pillar location, doorway dimensions, etc., of the present piers could become critical factors.

In January 1958, the Job Level Safety Committee of the ILWU made a survey of safety conditions on Bay Area piers. Testifying before the State Legislature, the committee stated that many piers throughout the area did not meet the minimum safety standards of the General Industry Safety Orders, California Administrative Code. Twenty-four piers in San Francisco and the East Bay were without curbs or rails. Only one pier on each side of the bay was equipped with a permanent safety ladder, and only a few had portable ladders that could be used in an emergency. Half the piers in the area had less than the required number of life rings. Lighting was poor on most piers, but was in the process of being corrected, at least in San Francisco.

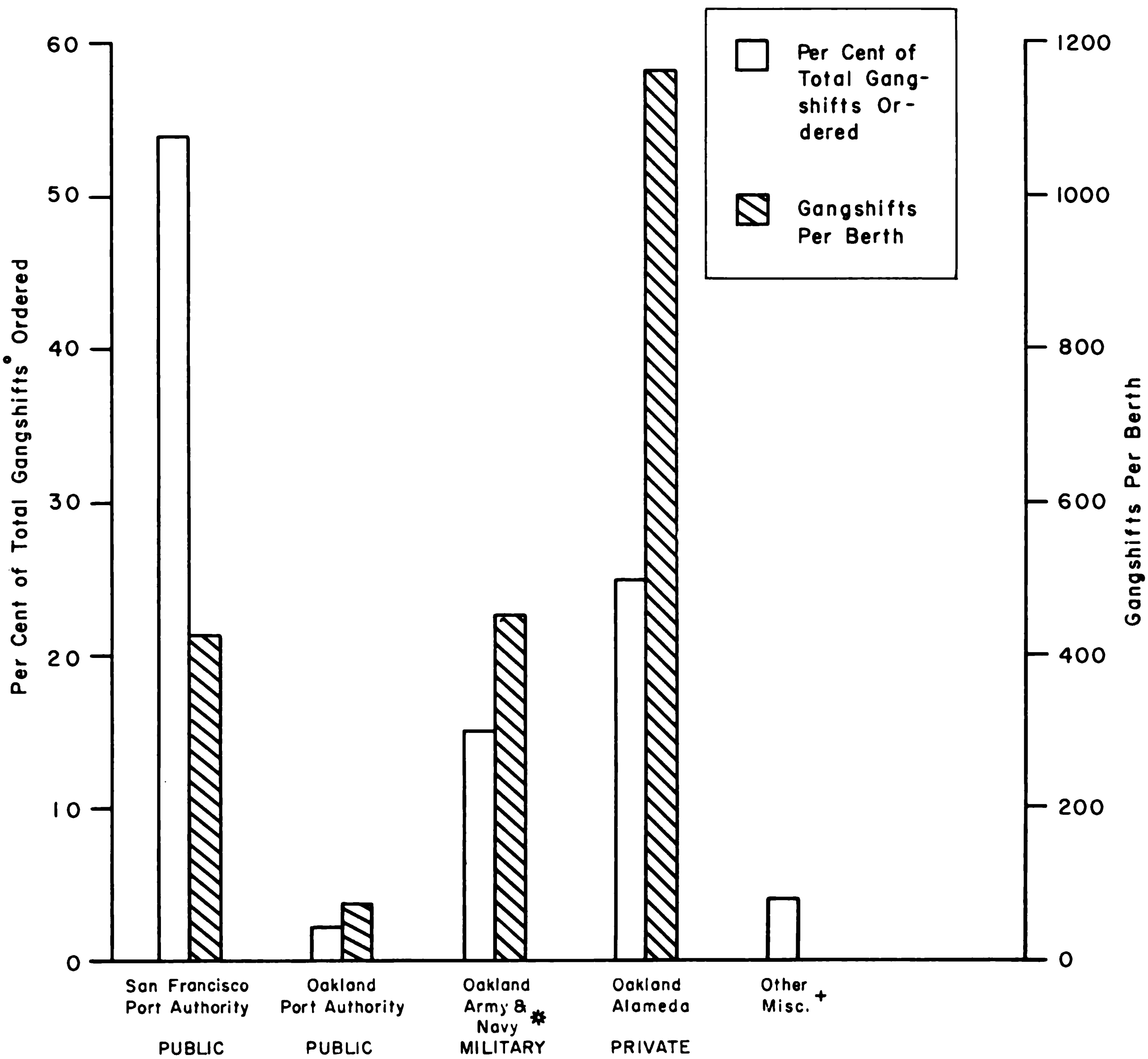
The effect of these deficiencies on productivity was not measurable in the study. Obviously, accidents disrupt operations and reduce performance.

An aspect of the terminals which can affect morale and, indirectly, cargo handling productivity is the number, location, and cleanliness of lavoratory facilities. Longshoremen are seldom allowed to utilize shipboard toilets, but must use the facilities on the dock. If these are crowded or located a long distance from shipside, delays in getting back and forth can keep men away from the job for long periods of time. The California General Industry Safety Code calls for a combination of water closets and urinals providing about one unit for every 15 men involved. It also calls for "adequate washing facilities." Under this rule, toilets for 75 to 100 men were provided on nine piers observed, including public and privately owned terminals. The level of cleanliness varied considerably from pier to pier, but in most cases was acceptable. Generally, the washing facilities amounted to only one or two wash basins.

Lunch room facilities can similarly affect morale. There is no state requirement concerning snack facilities or lunch rooms. Four of the nine piers observed had no lunch room facilities. All piers had some candy, coke, and cigarette machines. Lunch room facilities on the piers are important as they usually provide the only location where longshoremen are permitted to smoke.

TERMINAL UTILIZATION

In 1958, the two private terminals in the Bay Area, with less than 10 per cent of the available cargo berths, used 25 per cent of all longshore gangs ordered. The right-hand scale on Figure 27 indicates



* Excludes Civil Service gangs at Navy Supply Center

\+ Includes Crockett, Richmond, and Various anchorages

° One gang ordered for one day or night shift constitutes a "gangshift"

Figure 27. Relative use of piers by category for cargo operations with union longshoremen 1958.

the average number of gangshifts ordered per berth at private, public, and military piers in 1958. The cross-hatched bars represent gangshifts worked per berth. The comparison shows that private facilities worked three times as many gangshifts per berth as the San Francisco public piers. This is a relative measure of terminal utilization, since the cargo handling rates were similar between public and private terminals.

A similar relationship between terminal utilization at public and private facilities is evident when per cent of berth occupancy, rather than gangshifts ordered, is used as a measure. The per cent of time San Francisco Port Authority berths are occupied by ships is shown in Figure 28. Over half the berths in San Francisco were occupied less than 15 per cent of the time. The berths of the two private operators had ships in them from 30 to 35 per cent of the time.

During the year 1958, there were never more than 22 ships handling cargo on San Francisco piers at any one time. The average number of ships working was 13. The 63 berths were more than enough to take care of the demand. In the Bay Area there was an average of 21 ships handling cargo. At no time were more than 38 ships handling general cargo, although there were 105 berths available for cargo ships. It is evident that the Bay Area had sufficient piers to handle any probable demand.

PUBLIC TERMINAL COST

Figure 29 shows the revenue collected per square foot of cargo space against the tons handled per square foot during 1958 for each San Francisco Port Authority pier rented. This revenue includes pier rental, cargo wharfage, demurrage, and vessel dockage. All of the fees are charged by the Port Authority under uniform principles set up by the California Association of Port Authorities. In 1958 about 28 per cent of the Port Authority's [17] income from cargo

[17] *Port of San Francisco, Facilities Improvement Survey;* Ebasco Services, Inc. (In two volumes) San Francisco, July 1959.

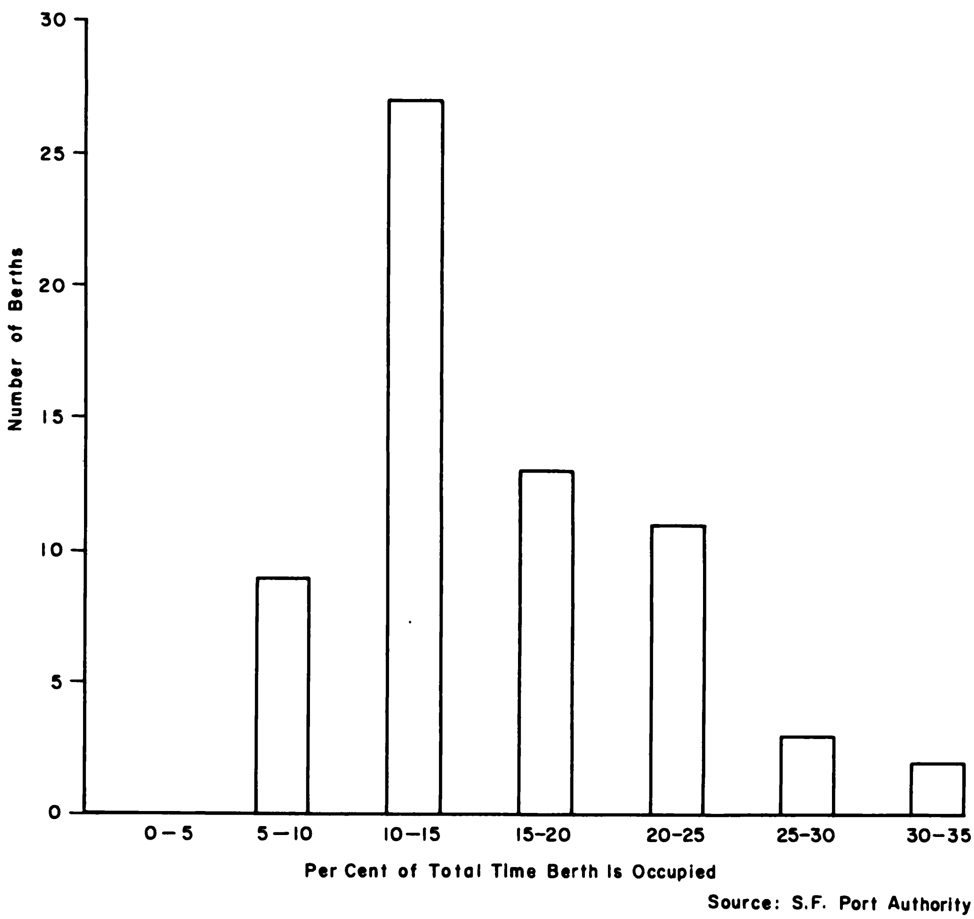
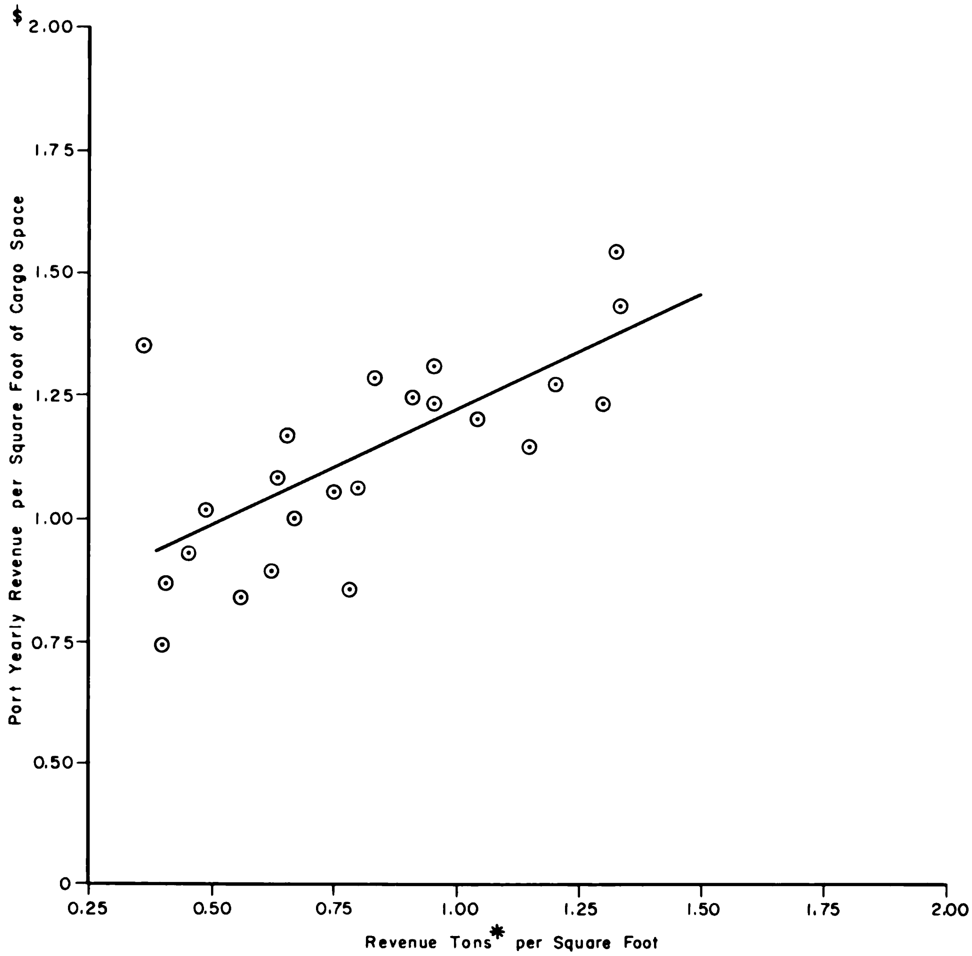


Figure 28. Per cent of berth occupancy for San Francisco Port Authority piers 1958.



* 2240 pounds per weight ton or 40 cubic feet per measurement ton, whichever is greater

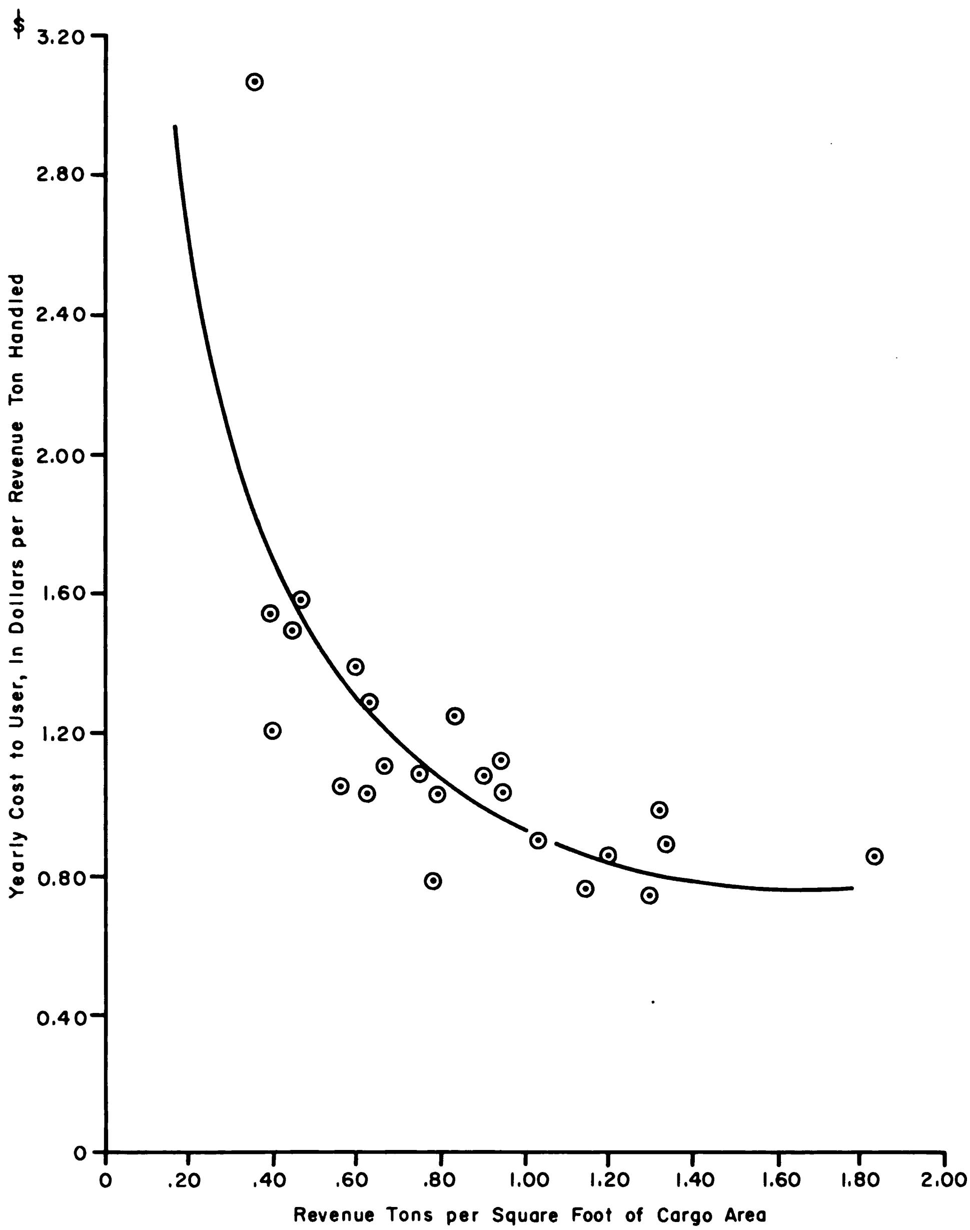
Derived from S.F. Port Authority Records

Figure 29. Revenue per square foot of rented cargo area vs. cargo transferred per square foot—San Francisco Port Authority 1958.

piers came from rental fees under the preferential rent system which averaged about $0.27 per year per square foot of cargo area. About 62 per cent of the cargo pier income came from wharfage fees charged on cargo crossing the pier, together with demurrage fees charged on cargo stored on the pier beyond a specified number of days. The remaining 10 per cent of the cargo pier income in 1958 came from dockage fees charged for each day a ship occupies a berth. The income from all of these fees barely covered the port's operating expenses. Because wharfage and demurrage fees are such a large part of port income, port revenue per square foot of cargo space increases as more cargo is handled per square foot of space (Figure 29).

Figure 30 shows that the greatest utilization rates are associated with the lowest cost per ton of cargo handled. Figures 29 and 30 together indicate that both the Port Authority and the terminal operator have something to gain from a high utilization of facilities. The shape of the curve on Figure 30 indicates that an operator with low utilization of facilities has much more to gain from increasing his utilization than an operator already achieving a utilization of 1.25 tons per square foot. The latter will not see much reduction in cost per ton if he increases his utilization to 1.75 tons per square foot or more. On the other hand, Figure 29 suggests that measures taken by the port to consolidate and improve facilities for better utilization will increase the revenue received per square foot. The problem of consolidation is complicated by the preferential rent system.

The abundant facilities in San Francisco may make the "preferential rent" of the piers desirable for the present as a convenience to the operators; however, when modern facilities are constructed, amortizing their higher cost per square foot may require higher utilization. Unless there is a sudden trade growth pattern not indicated by past trends, older San Francisco facilities must be retired or converted to other uses as newer ones are built so that the burden of port maintenance costs is reduced. To utilize new facilities economically, smaller operators will have to share them to a greater extent than they have shared the older piers under the preferential rent system.



Derived from S.F. Port Authority Records

Figure 30. Terminal costs to users of general cargo piers—San Francisco Port Authority 1958. (includes rental, wharfage, and dockage)

Chapter 6

SYSTEM PERFORMANCE OF THE PORT

The varied interests in a port are difficult to deal with as a single system. *Labor* wants high pay and steady employment under good working conditions. The *steamship operator* wants low costs, rapid ship turn-around, and good port facilities. The *terminal owner* wants the best possible profit from his investment in equipment and expenditure for labor.

In this welter of interests, there is one over-riding interest that Port Authority, management, and labor must heed if the port is to prosper—that is, the interest of the shipper. All costs in port operations are eventually passed on to the shipper. He wants safe, reliable, and fast cargo transportation at lowest cost. A shipper's desire to use a port will depend on the total cost of shipping through the port. This is not just a factor affecting competition between one port and another, but a factor affecting the entire level of trade. United States products will not be shipped overseas if transportation cost barriers make them unable to compete with foreign products overseas. Experience has shown that if we cannot export our products, we cannot import foreign products. Cargo trade is the life blood of a port, affecting all port personnel.

It is logical, therefore, to measure port system performance in terms of the total system cost which is passed on to the shipper. Figure 31 shows a rough breakdown of the total daily cost of turning cargo ships around in the San Francisco Bay Area. The total runs to about $150,000 per day or about $9.50 per short ton of cargo handled. The breakdown shows the part each element plays in the over-all cost pattern. Figure 31 is based on cost information collected from a number of sources.

The 11 per cent terminal use cost covers wharfage, demurrage, dockage, and rental fees. It is arbitrarily obtained by applying San Francisco Port Authority average rates per ton of cargo to cargo handled at all facilities in the Bay Area: military, private, and public. Military terminals do not levy such charges on cargo for commercial ships, but it is reasonable to assume that they incur nearly equivalent expenses. Private terminals apply similar wharfage and dockage fees, but do not have anything comparable to rental fees on their own docks. They assess service charges which reimburse the terminal operator for clerical services involved in receiving and delivering cargo, and defray a portion of his facility costs. If the carrier performs the cargo receiving and delivery function a facility charge in lieu of the service charge is assessed by the terminal.

The 4 per cent cost for *materials handling equipment* applies largely to fork lifts operated on the docks. It is an estimate based on amortization and

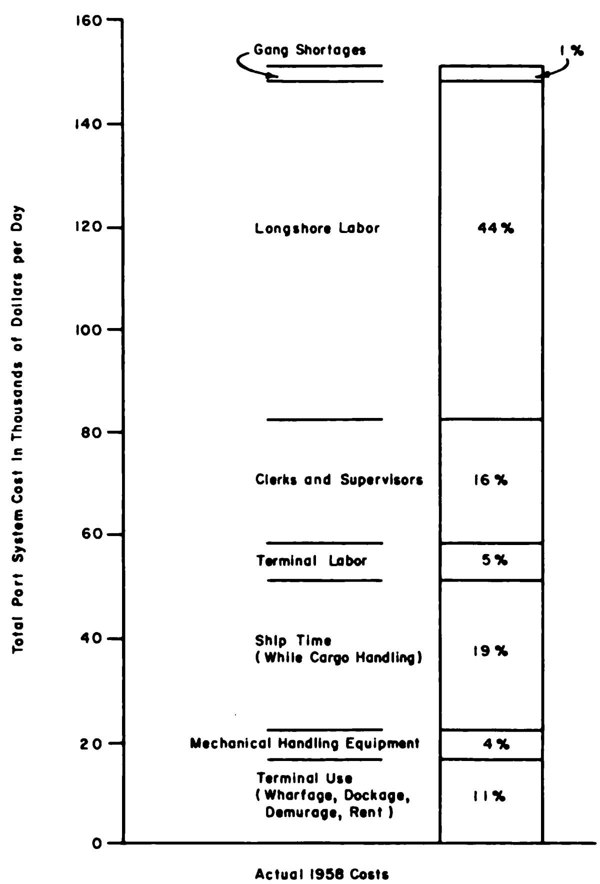


Figure 31. San Francisco Port System costs.

machine operation costs of $4 per fork lift operating hour, not including the wages of the operator. While the cost allowance per equipment operating hour is generous, the amount of equipment used is now a minimum. Costs will increase to some extent as more equipment is obtained and utilized to improve productivity.

Terminal labor costs were only 5 per cent of the total port cost in 1958, even though there was much unnecessary double handling of cargo on the docks. Much double handling has been eliminated by negotiation among PMA, the longshoremen, and the teamsters subsequent to the study.

The 19 per cent cost of ship time in port was evaluated conservatively at $1,000 per eight-hour work shift. The 1 per cent ship time lost because of gang shortage was evaluated on the same basis. Ship time spent solely on maintenance or sitting idle waiting out a schedule was assumed to be no part of turn-around time for the purpose of this calculation.

The 16 per cent for clerks and supervisors includes both dock and shipboard work. It covers all wage costs, including straight time, overtime, fringes, insurance, taxes, etc. The 44 per cent, or about $65,000 per day spent for longshore work, also covers all wage costs.

The longshore, clerk, and supervisory labor costs, together with the cost of ship time, amounts to 80 per cent of the total cost. All of these costs can be reduced as longshore productivity is improved. It is for this reason that the major emphasis of this study has been placed on cargo handling improvement.

Other aspects of port operation affect system performance although they are not of such importance in San Francisco that they require attention in this report. However, they may be relatively more significant in other ports. The Bay Area has more than enough berths to take care of the largest observed number of ships in port (see Chapter 5, Terminal Facilities). The normal delays incurred by a ship entering San Francisco Bay in picking up harbor and dock pilots, receiving tugs, and obtaining quarantine clearance are generally insignificant compared to the time required for getting longshore gangs and fulfilling the ship's cargo handling task.

The availability of cargo on the dock also affects ship turn-around time and cost. However, this factor is largely beyond the control of port or waterfront personnel except in so far as port facilities are designed and maintained for rapid processing of incoming truck and rail vehicles. This subject has already been briefly discussed in Chapter 5, Terminal Facilities.

LABOR SUPPLY AND DEMAND

Among the restraints on system performance are longshore gang shortages. The cost of gang shortages, expressed as lost ship time, is shown in Figure 31 to be only one per cent of the total system cost. When averaged over the year this is a small part of the cost. However, the yearly average hides the fact that during some months the shortages represent seven per cent of the cost. Large gang shortages in one port may divert traffic to another port. Business once lost may be very difficult to regain. On the other hand, too large a supply of gangs, under a wage protection plan may mean that many men would be paid for being idle. Determination of the proper balance between gang shortages and idle gangs is discussed in Part V of this study.

Gang shortages result from increased demand for service or decreased supply of gangs. In San Francisco, sufficient gangs were available to take care of the average demand for gangs. In spite of this, shortages occurred rather frequently.

Gang shortages caused by uneven demand for gangs are shown in Figure 32. The example covers the months of May through October, 1958, during which time vacations reduced gang availability by about ten per cent below the number available during the winter months. Days on which shortages occur are indicated on the figure by the shaded area in the request distribution. The average daily request (excluding Sundays and holidays) was for 98 gangs while the average number of gangs available was about 109. If there had been no variations in labor supply or demand, there would have been no gang shortages. As it was, the deviations caused an average shortage of about seven gangs per day shift. The uneven demand and supply also caused an irregular work schedule for the workers.

Figure 33 shows day-by-day variations of all gang requests for day and night shifts during August, September, and October, 1958. The period chosen is a peak period of port activity during 1958. Figure 33 demonstrates a number of characteristics of the development and fulfillment of requests.

1. Requests for night work were far fewer than requests for day work even though the two patterns

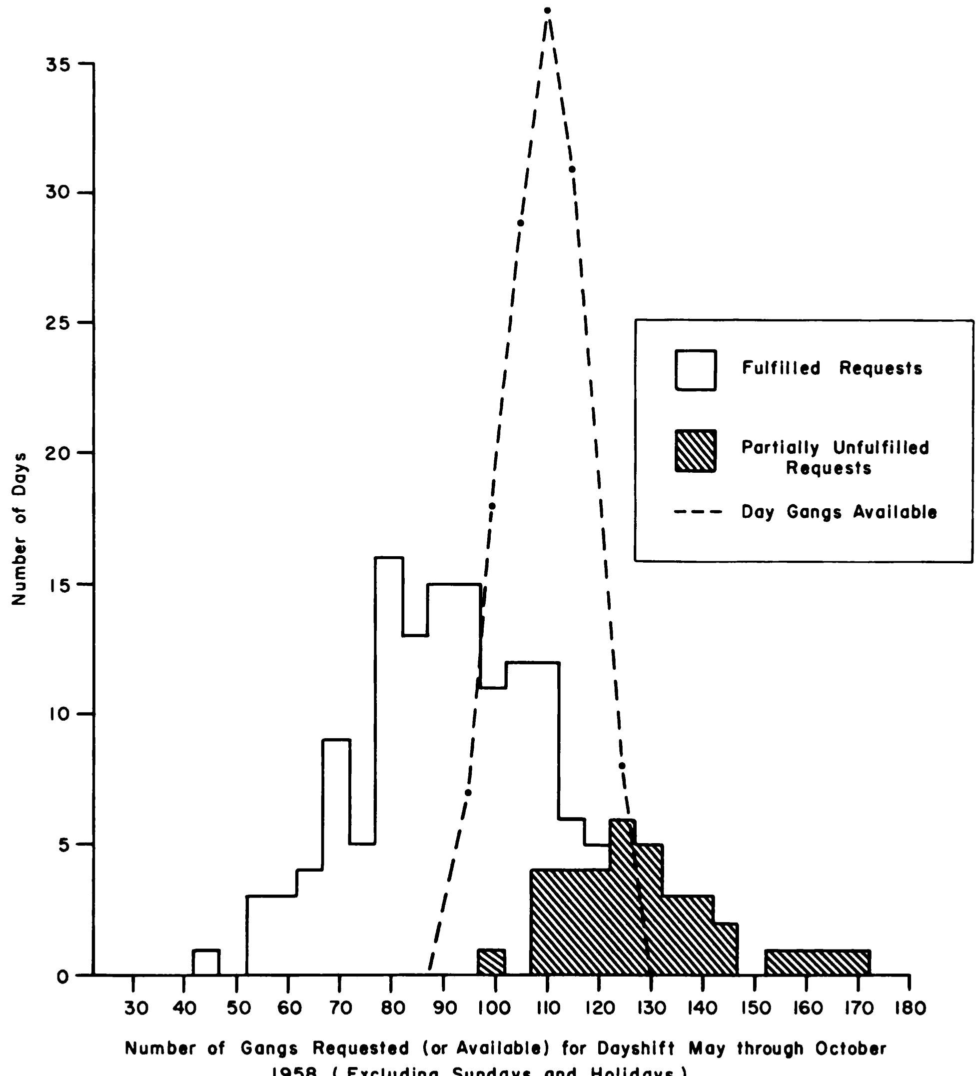


Figure 32. Fluctuations in requests and number of day gangs available. (May through October 1958)

of daily variations are almost mirror images of each other. In 1958, only 35 per cent of the total work was night work. There were also fewer new requests at night.

2. Shortages frequently occurred on Sundays or meeting nights when labor availability was low for contract reasons.

3. Following a holiday or period of low labor availability, there was often a large demand and, hence, a high probability for shortages.

Characteristic examples of such shortages are those following Labor Day, September 1, and following the stopwork meetings on August 12 and October 2. Ships had been arriving on both Sunday and Labor Day, so that, on Tuesday morning, September 2, there were 18 new requests for gangs added to the 13 already in port. This increased the number of requests well above the 22 or 23 which could be accommodated during the summer period. The surplus demand spilled over into the night shift as well, causing a shortage there, even though there were no new night arrivals. To a lesser extent the same happened every Sunday when only one third of the labor force was available.

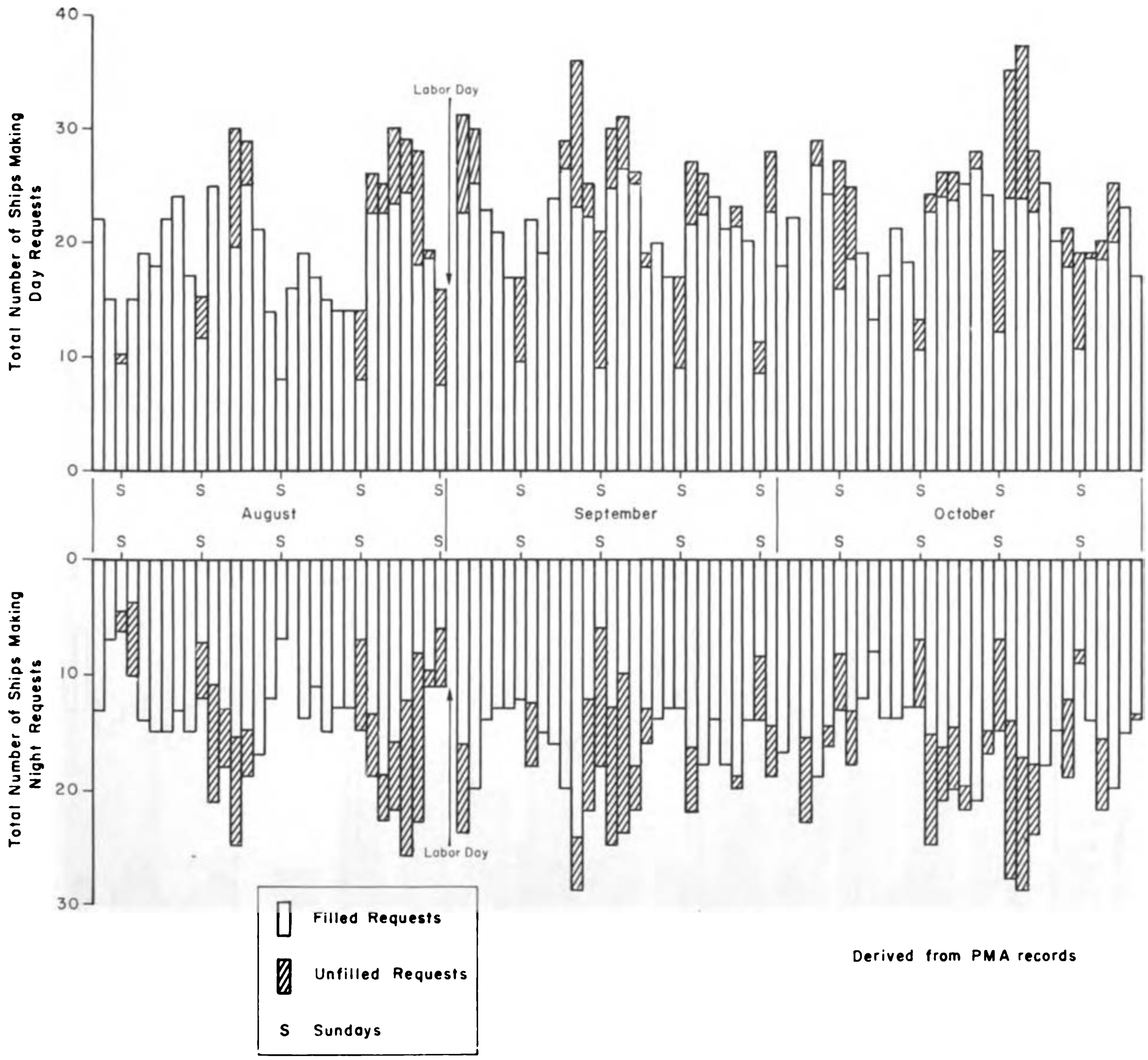


Figure 33. Filled and unfilled daily requests. (August through October 1958)

Average Request Size

Figure 34, also covering August through October, 1958, shows the average request size fluctuations and gang shortages. The average night request was lower than the average day request, because night work cost almost half again as much as day work. A number of ships made no request for night work, and fewer gangs were ordered by those working. No relationship is evident between gang shortages and average request size.

SEASONAL AND LARGER TERM FLUCTUATIONS

The previous discussion concerns day-by-day effects of changes in labor supply and in daily demand for service. Superimposed upon these are seasonal changes in labor force supply caused by the summer vacation program, business fluctuations, and productivity changes affecting the demand for longshore service.

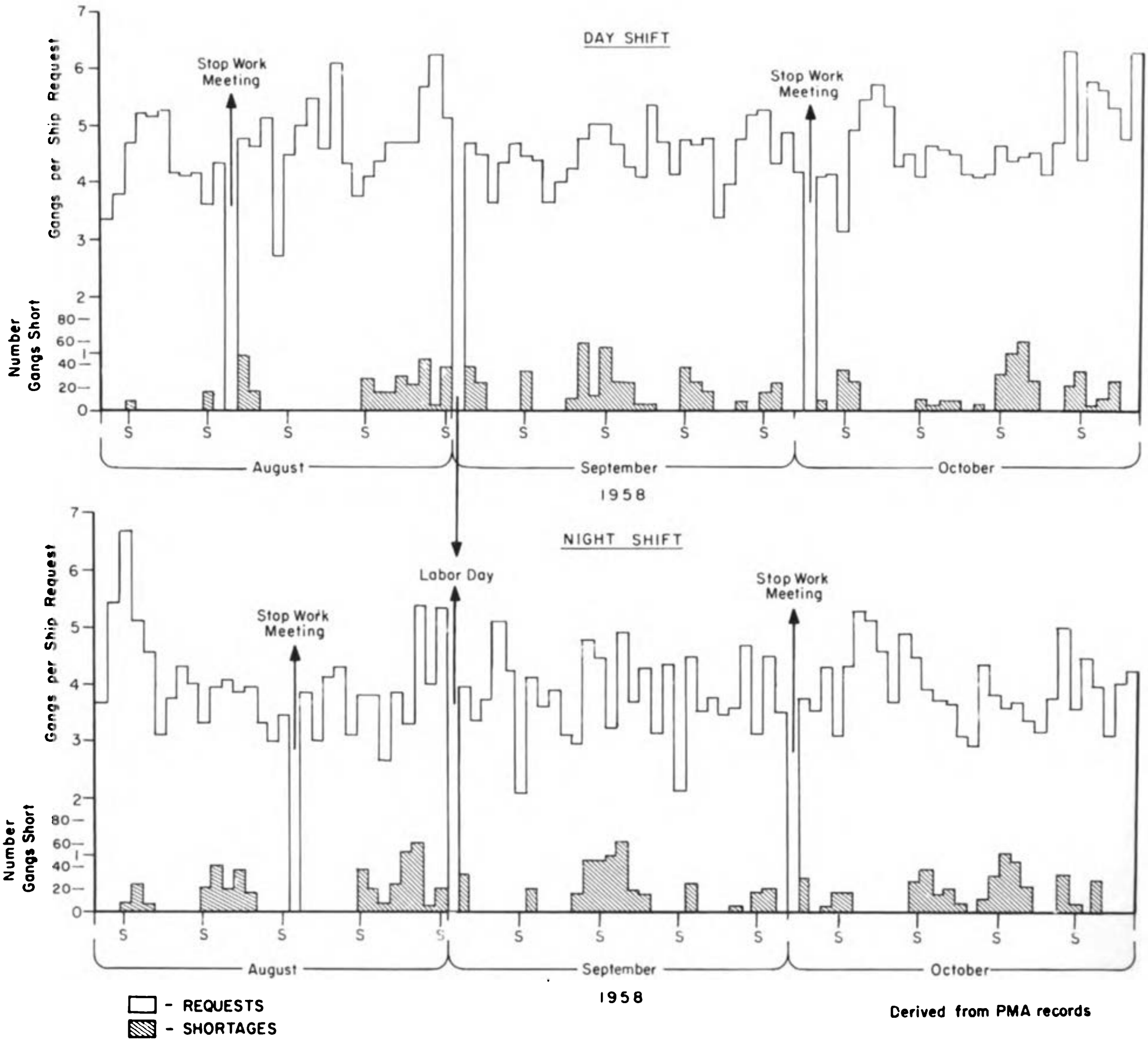


Figure 34. Average daily requests per ship vs. shortages. (for August, September and October 1958)

LABOR AVAILABILITY TRENDS

In San Francisco, the number of gangs available for day or night shift has been limited by the number of regular gangs enrolled rather than by the number of men on the registered list. When vacancies in dispatched regular gangs could not be filled with registered plug men they were usually filled with non-registered casuals.

From June 1956 through December 1960, the pattern of labor availability has been reasonably consistent. Under the control of a joint labor management committee, there has been a gradual decline from 208 to 200 (about 4 per cent) in the maximum number of day and night regular gangs enrolled. During the winter months, from November through April, the Dispatch Hall provided an average number of gangs equal to about 90 per cent of the maximum enrollment. Of the other 10 per cent, almost half were unavailable because of contract requirements. During the summer six months the number of gangs dispatched dropped to about 80 per cent of the maximum enrollment because an additional 10 per cent of the gangs were on vacation. This resulted in more severe gang shortages in summer than in winter.

Trend in Gangs Used

The level of cargo handling activity in the port can be estimated roughly from the average number of gangs used per shift. Sundays and holidays must be included in the average since the work must ultimately be performed regardless of holidays or shortages. Figure 35 shows seasonal fluctuations in monthly average day gangs used over a five year period. The most significant fluctuation is the peak use of gangs in October during the vacation period.

AVERAGE GANG SHORTAGES

In Figure 36 the average day gang shortages are compared to the average number of day gangs used per shift for the winter months (November-April). The same information for the summer months (May-

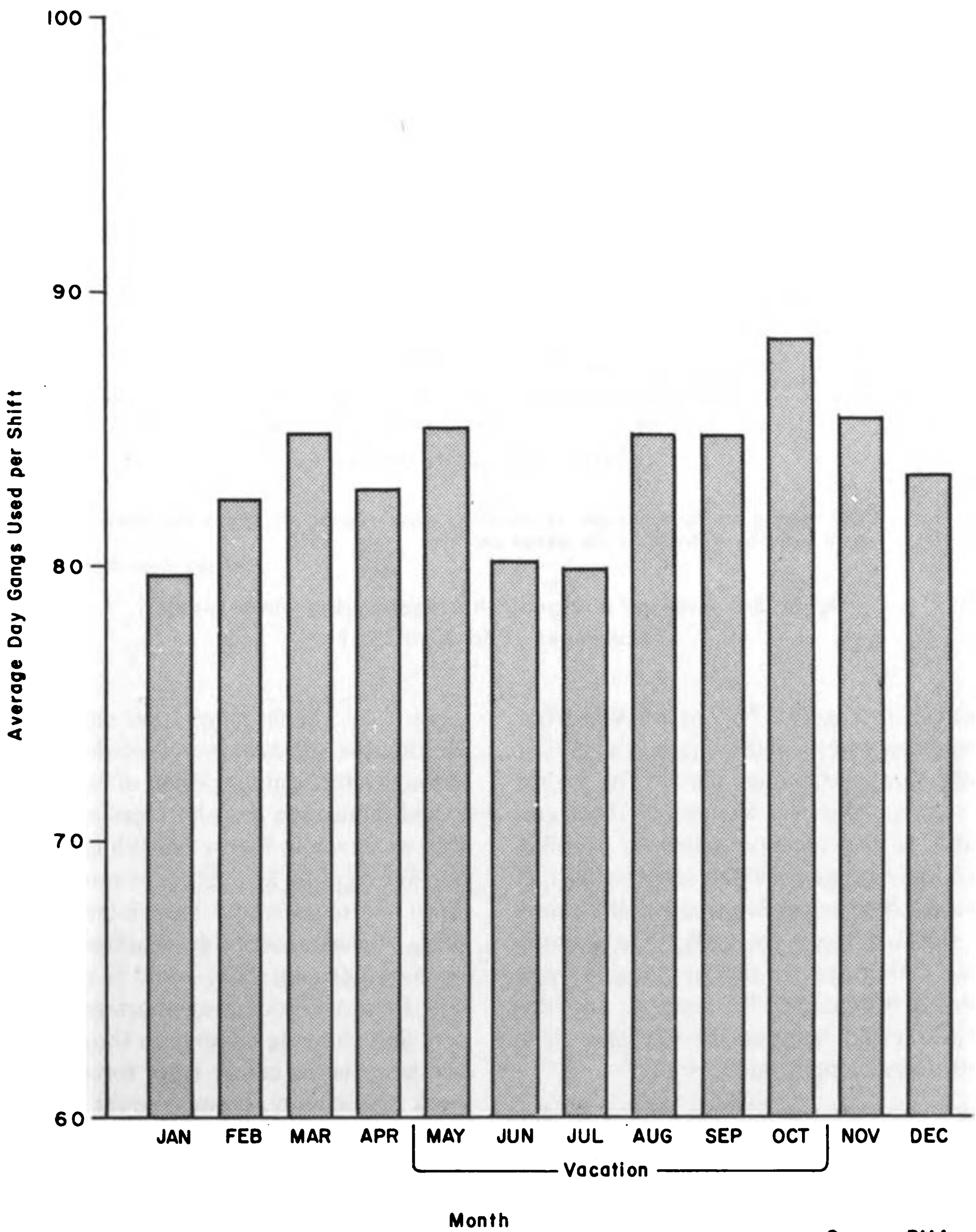
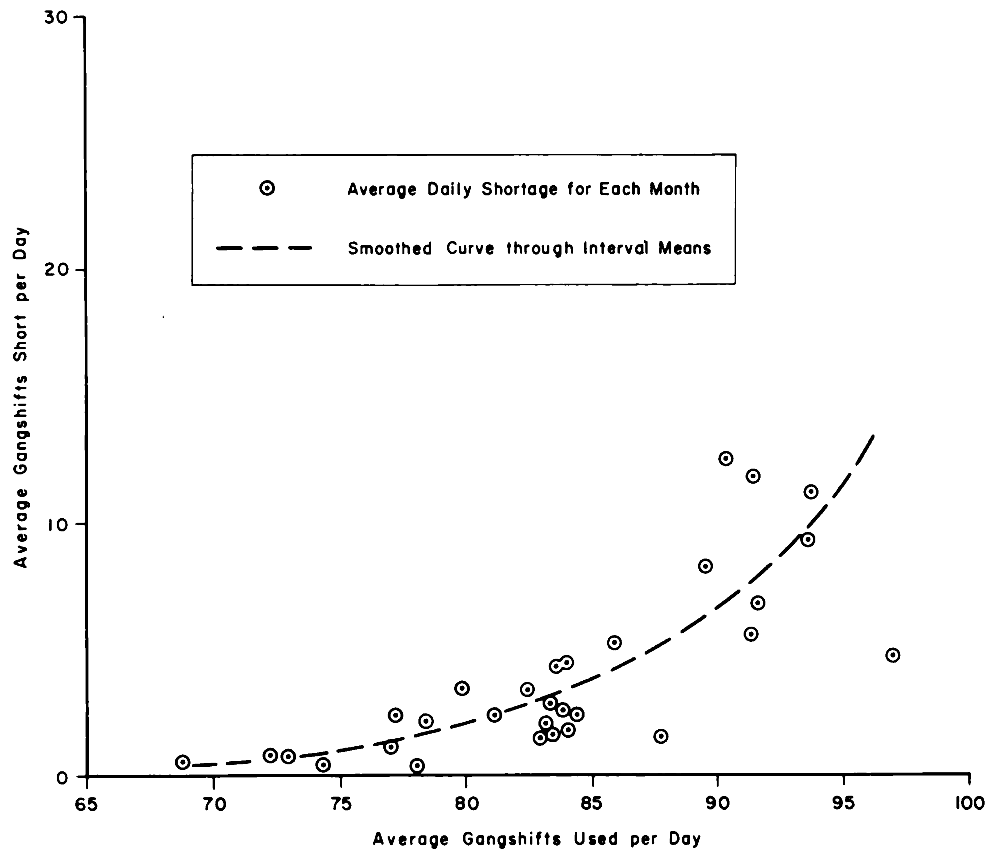


Figure 35. Seasonal fluctuations in day gangs used 1957-1961.



Data points are corrected for variations in labor supply. All points are referred to a labor availability of 119 gangs per day.

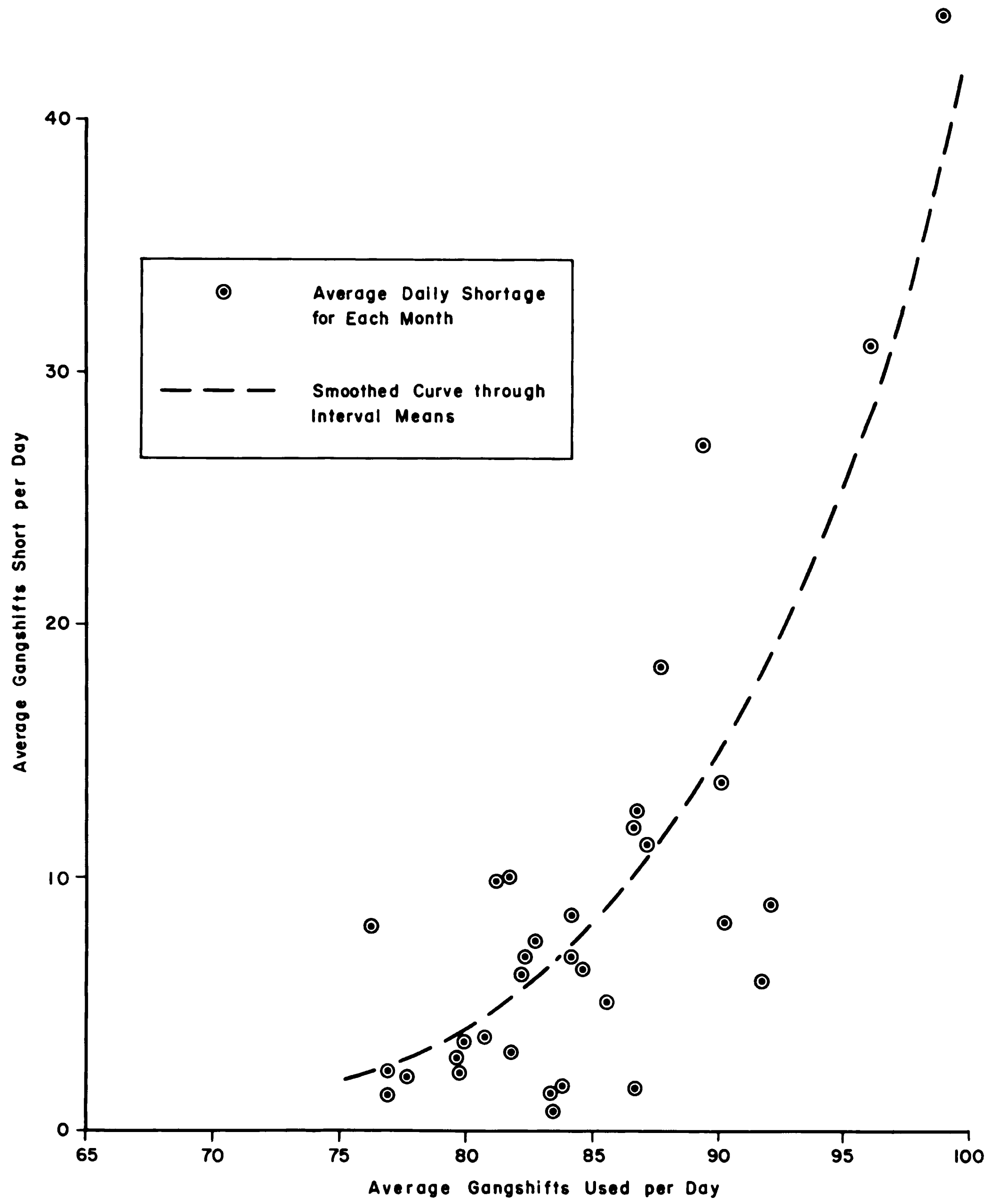
Derived from PMA records

Figure 36. Average day gang shortages during winter months. (November 1956-April 1961)

October) is shown in Figure 37. The records from which the comparisons were made covered the period from June 1956 through October 1961. The higher shortages in summer than in winter for the same demand are due to the vacation schedule. Similar comparisons of night gangs show the same pattern as day gangs, except that they reflect the smaller number of gangs working the night shift. The pattern of day and night shortages is similar because both shifts are affected by changes in demand, and the hiring hall adjusts gangs between the day and night shifts to equalize work opportunity.

When the gang shortages in Figures 36 and 37 are compared to the seasonal fluctuations in Figure 35, an interesting and costly aspect of the vacation schedule becomes apparent. The peak activity in October occurs when gangs are still on the vacation schedule, and according to Figure 37, shortages of about 12 day gangs (10½ night gangs) per shift can be expected. Shifting the vacation period so that it starts in April, putting October in the period of high gang availability, would reduce the day shortages to about 5 gangs per shift as shown in Figure 36. While reducing the October shortages by an average of seven per day shift, the April shortages would have increased three per day shift. A net reduction in shortages for both day and night of 200 gang shifts would be obtained for the season. Elimination of gang shortages benefits the shippers and shipping companies through shorter delays, and benefits the career labor force through increased work opportunity, because fewer casuals are needed to fill vacancies at peak demand periods.

This discussion provides a base for additional analysis of the process, and application of mathematical models to changes in the stevedoring industry. These subjects will be taken up in Part V of the study.



Data points are corrected for variations in labor supply. All points are referred to a labor availability of 109 gangs per day.

Derived from PMA records

Figure 37. Average day gang shortages during summer months. (June 1956-October 1961)

Part II

MEASUREMENT OF LONGSHORE PRODUCTIVITY CHANGE

Chapter 1

SUMMARY AND CONCLUSIONS

The West Coast "Mechanization and Modernization" agreement was signed in 1959 to improve stevedoring productivity, reduce costs, and share savings with the registered workers. The agreement created a need for more accurate measurements of productivity than were then available.

Measurement of longshore productivity on an area-wide basis is not new to the maritime industry. For instance, in 1936 Mr. Frank Foisie, then head of the West Coast Waterfront Employers Association, made a major effort to provide this measurement for the West Coast. A subsequent effort, stemming from Mr. Foisie's work, was made to develop valid productivity measures for the area, but the results were inconclusive. Little work on a productivity measurement method for the West Coast was done until 1959 when the Pacific Maritime Association (PMA) engaged Dr. Max Kossoris to develop a method.

Overseas, port-wide productivity measurement has been employed for some time in several major ports: Marseilles, Le Havre,[1] and Haifa.[2]

The Maritime Cargo Transportation Conference (MCTC), in developing a productivity measurement scheme for its study purposes, and PMA, in developing a method to meet its specific needs, arrived concurrently at similar systems. Differences in detail between the two solutions came about from the specific needs of the PMA, in contrast to the general orientation of the Port Study. PMA has successfully used their system to determine the productivity changes from 1960 to 1961 in the major areas of the West Coast.[3]

This report defines and illustrates a method for evaluating the effect of deliberate changes in the cargo handling system upon longshoring performance. The method applies to company or area-wide activities. It also points out several problem areas in evaluating longshoring performance and suggests methods for resolving them.

Existing record-keeping procedures were used wherever possible in developing the method outlined in this report. Needs for further data have been noted, so that the existing data collection system can be modified to permit their accumulation. The illustrations presented in this report are based on Bay Area shipping company operations. However, the methods presented can be applied to shipping companies and ports elsewhere.

The following has been concluded from the study:

1. It is both feasible and desirable to develop an area-wide measurement of change in longshoring productivity from company records now kept in the San Francisco Bay Area.

2. The collection of company records on man-hours and tonnages for all cargo handling operations within a given area can provide:

a. the man-hour change through productivity gain or loss caused by deliberate changes to the cargo handling system.

b. man-hour change in the longshoring task resulting from random occurrences beyond the control of the industry. The precise cause of the productivity gain or loss cannot be isolated if several methods are changed simultaneously—for example, if manning and equipment changes are made concurrently.

3. To identify effects caused by changes in cargo mixture and to measure changes in longshoring man-hours attributable solely to productivity gain or loss, the cargo comprising the longshore task and the associated man-hours must be categorized according to cargo handling characteristics.

a. units of measurement for each category may differ, but must be consistent from period to period.

b. large groups of miscellaneous or "Not Otherwise Specified" (N.O.S.) general cargo must be sepa-

[1] Pierre Bonnot, "Etude au Port de Havre 1953-58," Bureau d'Etudes Economiques et Sociales, Paris, April 17, 1958.

[2] Israel Ports Authority, Haifa Port Directorate, "Stevedoring Productivity at the Port of Haifa in 1960," July 1961.

[3] Pacific Maritime Association, *Longshore Productivity Study, Pacific Coast, 1960-1961*, San Francisco, March 1963.

rated either by commodity or stowage factor, to isolate effects of cargo mixture change.

c. segregation by load type (i.e., break-bulk, pallet unit, or container) as well as segregation by commodity or stowage factor, is necessary to distinguish changes in longshore man-hours caused by shifts from one load type to another.

4. Indirect longshoring activities (rigging, hatch opening and closing, dunnaging, etc.) must also be considered when evaluating longshore performance. For accuracy, it may be necessary to distinguish the indirect time related to the amount and type of cargo handled (i.e., shoring, dunnaging, lashing) from that which is independent of the amount or type of cargo handled (i.e., hatch cleaning, initial rigging, hatch opening and closing, and rigging rain tents).

5. Improvements in company record keeping can increase the accuracy of individual company and area-wide productivity measurement.

Chapter 2

THE STEVEDORING TASK

The performance of a port may be expressed and measured in terms of the longshore man-hours required for loading and discharging the ships passing through it. This labor requirement is affected by two related factors: the mixture and quantity of commodities moving through the port and the productivity of longshore labor. Consider the following hypothetical example. In 1957, longshoremen in a port worked 10,000,000 man-hours. In 1958, they worked 9,000,000 man-hours. Concurrently, the tonnage through the port decreased by 1,500,000 tons. One might say, at first glance, that the decline in longshore man-hour requirement resulted from the decrease in traffic. But is this necessarily so? The reduction in man-hours could have been caused by a number of things, such as a shift in load type to containers, a change in commodity mixture, a decline in the volume of trade, or any combination of these. The problem is to determine what caused the change in the man-hour requirement.

The mixture of commodities moving through the San Francisco port area was given in Part 1: *San Francisco Port Description*. However, data on longshore productivity on a port-wide basis were unavailable. For purposes of this study it was necessary to develop such data in the San Francisco area using existing record-keeping procedures.

Units of Measurement

In expressing longshore productivity, the *ton* is the measure of the task performed. The tonnage figure must be properly qualified, however. For example, quantities of individual commodities may be expressed in *short tons* (2,000 lb.), *long tons* (2,240 lb.), *measurement tons* (40 cubic feet), or *revenue tons* (weight or measurement tons upon which revenue is charged). In some cases, tons may not be the basic unit of measurement. Lumber, for instance, is often measured in units of *1000 board feet*. Thus, in determining the productivity of a task, the unit of measure for each commodity class must be uniform. For example, a composite productivity figure composed of coal (LT) and lumber (board ft.) would be meaningless.

A rate in tons per gang hour is useful in determining the time a vessel will spend working cargo; a rate in tons per man-hour is useful in ascertaining stevedoring costs. "Tons per man-hour" is a better expression of productivity because it provides a uniform basis for comparison.

Commodity Breakdown

The cargo constituting the port-wide tonnage varies not only in physical characteristics but also in handling characteristics. Consequently, a single port-wide productivity figure based upon total cargo passing through the port and total man-hours expended is useless. However, by measuring the productivity levels of logically grouped commodities, an evaluation of longshore performance can be obtained. Where commodities cannot be placed in separate commodity classifications, they are grouped in a classification labeled "General Cargo, N.O.S."[4] This category creates special problems of productivity measurement that are discussed in Section IV of this report.

Base Period

To measure changes in productivity for performing a task, it is necessary to select a base period. The productivity level in the base period becomes the standard, against which all comparisons are made.

To avoid seasonal variations, the length of the base period should be at least one year. If shorter periods are chosen they should only be compared to corresponding periods in another year.

LONGSHORE MAN-HOURS

The stevedoring operations measured here are the movement of cargo between the stowed position in the vessel and the cargo pile in the transit shed. In both loading and discharging operations cargo is in continuous movement between these two locations. The shoreside fork lifts, ship's gear and hold gang are all dependent upon one another, but the entire

[4] N.O.S. means Not Otherwise Specified.

operation is relatively independent of other operations.

The man-hours included in productivity measurements comprise the work hours of the hold gang, winch operators, signalmen, apron men, machine drivers and dockmen assigned to the gangs.

Direct and Indirect Man-hours

Longshore man-hours consist of direct and indirect work. *Direct* man-hours are the fundamental measure of the labor required to handle cargo. *Indirect* longshore man-hours are those spent in related tasks, such as opening and closing hatches, rigging, laying dunnage, shoring, and lashing. Both are part of longshore productivity.

Indirect man-hours contribute to the productivity level and may reflect important elements of the task. In some instances, indirect man-hours may be 40 per cent of total man-hours. Indirect man-hours will be discussed in detail in Chapter IV.

Chapter 3

A METHOD FOR EVALUATING THE PERFORMANCE OF THE PORT OF SAN FRANCISCO

A method for evaluating the performance of the Port of San Francisco is explained in this section. It makes use of PMA data collection and record-keeping procedures.

SOURCES AND NATURE OF PRODUCTIVITY DATA

On the West Coast, PMA introduced a uniform productivity data collection system in January 1960. Individual shipping companies report loading and discharging activities for each West Coast port call of every ship of the company. Their reports provide the following information:

1. Direct Longshore Man-hours—time directly involved in loading or discharging cargo, associated with:

   a. commodity class.

   b. load type (break-bulk or unitized).

   c. weight or measurement of each commodity class.

2. Indirect Time—man-hours involved in rigging, opening and closing hatches, gear changing, dunnaging, etc.

3. Dock Time.

4. Lost Time.

METHODS

The following hypothetical illustration demonstrates uses of productivity data for solving the following problems:

1. Distinguishing between changes in man-hours worked by longshoremen and related longshore workers such as, clerks, dockmen, and supervisors.

2. Determining the effects of operational changes upon direct longshore operations and indirect operations. Changes which would affect indirect operations include introduction of quick opening hatches, new types of cargo gear, and new types of tie down and dunnage equipment.

3. Identifying changes in man-hours caused by productivity change as opposed to those resulting from differences in traffic volume or commodity mix.

4. Assessing effects on man-hours of changes in load type (e.g., transition from break-bulk to palletized cargo).

In the illustration, operations occurring during 1957, the base period, are used as the standard against which 1958 operations are compared. The examples given for 1957 and 1958 approximate the actual performance of those years, but have been modified for purposes of illustration.

Direct Longshore Man-hours

Table 1 shows: (a) 1957 and 1958 volume of business, (b) direct longshore man-hours, (c) indirect longshore man-hours, and (d) computed productivity base rates in short tons per man-hour. "Direct Longshore Man-hours" covers only actual shipboard cargo handling. The Productivity Base Rates, given in Column 3, are the short tons per man-hour for 1957. The 1958 performance is then evaluated by comparing the actual man-hours required to handle the 1958 cargo with the number of man-hours which would have been needed to handle the same cargo at the 1957 "Productivity Base Rates."

Indirect Longshore Man-hours

To determine the *total* change in longshore man-hours between the base and comparison periods, *indirect* man-hours must be added to *direct* man-hours. Indirect man-hours include such activities as the time required to rig cargo handling gear, open and close hatch covers, secure cargo (dunnaging, shoring, and lashing), or removing dunnage and shoring in the discharging process. Indirect time can be handled as a part of the regular work task by assuming a constant ratio of indirect to direct man-hours and determining an average value. This "Base Allowance for Indirect Man-hours" in Table 1 (lines H and J), is computed as a ratio of Indirect Man-hours

TABLE 1

Measurement of Increase or Decrease of Longshore Man-Hours Due to Productivity Changes

Base Period: January 1-December 31, 1957 (Hypothetical illustration—Company A) *
Comparison Period: January 1-December 31, 1958 (" " " ") *

		1	2	3	4	5	6	7
		1957 Base Period			1958 Comparison Period			
Commodity Class	Load Type	Amount of Cargo (ST)	Actual Man-hours	Productivity Base Rates (ST/MH) (Col. 1/Col. 2)	Amount of Cargo (ST)	Actual Man-hours	Base Rate Man-hours (Col. 4/Col. 3)	Man-hours Increase or Decrease (Col. 5/Col. 6)
Load—Direct Longshore Man-hours								
Beans	Loose bags	15,041	6,510	2.3104	12,325	4,160	5,334	— 1,174
Oil	Loose drums	17,529	11,087	1.5810	23,283	12,231	14,726	— 2,495
Canned goods	Loose cartons	5,834	4,783	1.2197	4,878	4,219	3,999	+ 220
" "	Palletized	7,560**	2,401	3.1487	11,612**	2,507	3,688	— 1,181
" "	Containers	—	—	—	4,080**	420	(420)	0
General cargo, N.O.S. loose		53,994	78,724	0.6859	40,910	62,780	59,647	+ 3,133
(A) TOTAL—load *direct* man-hours			103,504			86,317	87,814	— 1,497
(B) TOTAL—load *indirect* man-hours			21,740			20,983	18,444 [See (H)	+ 2,539
(C) TOTAL—load *direct & indirect* man-hours			125,244			107,300	106,258 and (I)]	+ 1,042
Discharge—Direct Longshore Man-hours								
Old newsprint	Loose bales	2,613	3,602	0.7254	1,470	1,576	2,026	— 450
Canned goods	Loose cartons	46,297	44,515	1.0400	32,739	27,058	31,479	— 4,421
" "	Palletized	8,420**	5,403	1.5584	10,900**	6,027	6,995	— 968
" "	Containers	—	—	—	3,860**	395	(395)	0
Reefer	Loose frozen	16,063	21,590	0.7440	17,652	19,751	23,726	— 3,975
Vehicles	Unboxed	8,926	5,288	1.6880	6,512	3,274	3,858	— 584
(D) TOTAL—discharge *direct* man-hours			80,398			58,081	68,479	—10,398
(E) TOTAL—discharge *indirect* man-hours			25,814			17,482	21,987 [See (J)	— 4,505
(F) TOTAL—discharge *direct & indirect* man-hours			106,212			75,563	9,463 and (K)]	—14,903
(G) GRAND TOTAL—load & discharge including direct and indirect man-hours						182,863	196,724	—13,861

Computation of Indirect Man-hours, Loading

(H) 1957 Base allowance for indirect man-hours = 1957 indirect MH/1957 direct MH = 21,740/103,504 = 0.21004
(I) 1958 Base rate indirect man-hours = 1957 base allowance × 1958 base rate direct MH = 0.21004 × 87,814 = 18,444 MH

Computation of Indirect Man-hours, Discharging

(J) 1957 Base allowance for indirect man-hours = 1957 indirect MH/1957 direct MH = 25,814/80,398 = 0.32108
(K) 1958 Base rate indirect man-hours = 1957 base allowance × 1958 base rate direct MH = 0.32108 × 68,479 = 21,987 MH

* In this hypothetical illustration all cargo was measured in short tons (ST). The system of measurement demonstrated by the example does not require that the units of cargo be the same for each commodity. There could be a mixture of units, e.g., ST, LT, or MT, provided that a given commodity is measured in the same unit for both base and comparison periods.

** Net short tons excluding weight of pallets and containers.

(lines B and E, Col. 2) to Direct Man-hours (lines A and D, Col. 2) over the base period. In Table 1 the base allowances for indirect work are 0.21004 for loading and 0.32108 for discharging. These were obtained by dividing the 1957 indirect man-hours by the 1957 direct man-hours. When 1957 Indirect Work Base Allowances are applied to the 1958 Direct Base Rate man-hours (lines A and D, Col. 6), the result is Indirect Base Rate man-hours for 1958 (lines B and E, Col. 6). These are the man-hours required to perform 1958 indirect work at the 1957 "Base Allowance for Indirect Man-hours." Comparison of the 1958 total of direct and indirect actual man-hours (line G, Col. 5) with the 1958 total of Base Rate Man-hours (line G, Col. 6), shows that Company A saved 13,861 man-hours in 1958. This saving is a measure of changes in productivity for handling the listed commodities. The saving represents an improvement in Company A port performance of 7.6 per cent (13,861/18,863) for load and discharge operations and includes direct and indirect work.

Indirect man-hours are affected by factors other than direct man-hours. Certain commodities require more indirect man-hours than others. For instance, vehicles require more dunnaging and lashing time than goods in cartons. In such cases, indirect time is influenced by the direct man-hours associated with particular commodity types. A second factor, which may be expressed as a constant, is independent of direct man-hours. With each port call, a vessel expends indirect man-hours in opening hatches, rigging gear, removal of dunnage, and cleaning cargo spaces. This work must be performed regardless of the amount of cargo or the number of direct man-hours worked on the ship.

While refinements accounting for the various factors are possible, insufficient data were available to determine whether these refinements are worth the effort involved. As a consequence they have not been illustrated in this method.

Clerk, Dock, and Supervisor Activities

Clerk, dock, and supervisor activities can be determined as a part of the work task in a fashion similar to that used for indirect work. Provided there are no changes in the methods of cargo handling, the work available for these job categories is directly proportional to the work performed by regular longshoremen. As in the case of indirect work, base allowances can be calculated for clerk, dockwork, and supervisor activities. The base allowances are ratios of clerk man-hours, dock man-hours, and supervisor man-hours to the sum of direct and indirect longshore man-hours for the base period. The example in Table 2 shows how these base allowance ratios are developed and applied.

If the data are sufficiently detailed, it is advantageous to develop commodity productivity rates for dockwork in the same way that direct longshore rates are established. Dockwork data were not analyzed for this example to determine whether dockwork productivity rates are feasible. Allowance is necessary for that part of the cargo which is not handled by dockworkers when calculating dockwork productivity. For example, truck drivers may assist in unloading or loading trucks. The reporting system must provide detailed information on dockwork tonnage and man-hours by commodity, in order to compute dockwork productivity rates.

Clerks and supervisors are frequently assigned on the basis of number of gangs employed. Under the system described, a reduction in longshore gang size will affect the calculated clerk's and supervisor's man-hours. This may be corrected by translating longshore man-hour figures into gang hour figures for the base and comparison periods, and expressing *base allowances for clerks or supervisors* in the form of *man-hours per longshore gang hour*. The difference between the original base rate man-hour figure for clerks or supervisors, developed in Table 2, and the new figure using the longshore gang hour as the basis is a measure of the change in clerk and supervisor employment resulting from change in longshore gang size. For this reason, gang size information is important to the measurement system and should be recorded.

The data available did not permit separation of clerk and supervisor work associated with dock work from that associated with ship loading and discharging. If such a separation is desired, more detailed data are required.

Changes in Load Type

Load type is changed, for example, when canned goods which have customarily been shipped in individual cartons, are shipped on pallets or in containers. It is worthwhile to separate the effects of deliberate changes in load type, made for the purpose of improving longshore productivity, from the conse-

TABLE 2

Measurement of Increase or Decrease of Clerk, Supervisor, and Dockwork Man-Hours Due to Productivity Change

Base Period: January 1—December 31, 1957 (Hypothetical illustration—Company A)

	1	2	3	4	5	6	7	8
	1957 Base Period		1958 Comparison Period					
	Actual Man-hours		Actual Man-hours		Base Rate Man-hours *		Man-hour Increase or Decrease Col. 2/Col. 3	
	Load	Dischg.	Load	Dischg.	Load	Dischg.	Load	Dischg.
Total longshore (direct & indirect)	125,244	106,212	107,300	75,563	106,258	90,466	+1,042	−14,903
Clerk	27,867	25,465	23,422	22,750	23,642	21,690	− 220	+ 1,060
Supervisor	4,324	3,952	3,532	3,825	3,668	3,366	− 136	+ 459
Dockwork	10,365	16,969	8,865	14,216	8,794	14,454	+ 71	− 238
TOTAL	167,800	152,598	143,119	116,354	142,362	129,976	+ 757	−13,622
TOTAL—Load and Discharge	320,398		259,473		272,338		−12,865	

Calculations of Base Allowances for Job Categories

Clerk base allowance:	Load	=27,867/125,244=.22250
	Discharge	=25,465/106,212=.23976
Supervisor " :	Load	=4,324/125,244 =.03452
	Discharge	=3,952/106,212 =.03721
Dockwork " :	Load	=10,365/125,244=.08276
	Discharge	=16,969/106,212=.15977

* 1958 base rate man-hours are obtained by multiplying the base rate longshore man-hour figure by the appropriate base allowance, i.e., clerk base rate man-hours=(106,258)×(0.22250)= 23,642, with the exception of total longshore (direct and indirect) which were obtained from Table 1.

quences of random changes in commodity mixture which are beyond the control of the shipping companies or the stevedoring contractors.

The manner of handling the effects of changes in load type can best be demonstrated by an example. Table 3 illustrates the computations necessary to determine the man-hour changes between 1957 and 1958, produced by a shift in load type in the handling of canned goods.

To establish the 1957 to 1958 change in man-hours required for loading canned goods caused by a shift in load type, it is first necessary to determine what the 1958 man-hour requirement would have been had no changes in load type or productivity rate taken place. This man-hour requirement may be found by assuming that the 1958 canned goods were handled in the same tonnage proportions of break-bulk, pallet loads, and container loads as in 1957, and applying the 1957 base productivity rates for each load type to the calculated tonnages. Then the 1957 base productivity rates are applied to the actual 1958 tonnages of each load type to find the man-hours required to load the 1958 cargo at the 1957 productivity rates. Since the productivity between the two years has been held constant, the difference between the two man-hour figures is the change which was caused by the shift in load type. By confining the calculations to a single commodity, the effects of change in commodity mix are eliminated.

In Table 3 the base tonnage proportion is shown in Column 2 as the ratio of the 1957 individual load type tons to the total 1957 tonnage. The modified tonnage figure in Column 6 indicates how much of each cargo type would have been handled in 1958 if the 1958 tonnage had been generated in the same proportions as 1957. The 1958 modified tonnages are divided by the productivity base rates, in Column 3, to obtain the modified base rate man-hours in Column 7. The *modified* base rate man-hours in Column 7 are those which would have been required

TABLE 3

Measurement of Increase or Decrease in Man-hours Due to Shift in Load Type

Base Period: January 1-December 31, 1957 (Hypothetical illustration—Company A)
Comparison Period: January 1-December 31, 1958 (" " " ")

Commodity	Load Type	1	2	3	4	5	6	7	8
		Base Period			Comparison Period				
		Actual Short Tons	Ratio: Load Type Tons to Total	Productivity Base Rates ST/MH	Actual Short Tons	Base Rate Man-hours	Modified Tons	Modified Base Rate Man-hours	Man-hours Increase or Decrease
			Col. 1/ Tot. Col. 1			Col. 4/Col. 3	Col. 2 × Tot. Col. 4	Col. 6 ÷ Col. 3	Col. 5 — Col. 7
Load—Direct Longshore Man-hours									
Canned goods	Loose	5,834	.4356	1.2197	4,878	3,999	8,960	7,346	— 3,347
" "	Palletized	7,560*	.5644	3.1487	11,612*	3,688	11,610	3,687	+ 1
" "	Containers	0	0	(9.7182)‡	4,080*	420	0	0	+ 420
TOTAL—Load *direct* man-hours		13,394			20,570	8,107	20,570	11,033	— 2,926
TOTAL—Load *indirect* man-hours			(.21004)♦ × (—2926) →						= — 615
TOTAL—Load *direct & indirect* man-hours									— 3,541
Discharge—Direct Longshore Man-hours									
Canned goods	Loose	46,297	.8461	1.0400	32,739	31,479	40,189	38,642	— 7,163
" "	Palletized	8,420*	.1539	1.5584	10,900	6,995	7,310	4,691	+ 2,304
" "	Containers	0	0	(9.7751)	3,860*	395	0	0	+ 395
TOTAL—Discharge *direct* man-hours		54,717			47,499	38,869	47,499	43,333	— 4,464
TOTAL—Discharge *indirect* man-hours			(.32108)♦ × (—4464) →						= — 1,433
TOTAL—Discharge *direct & indirect* man-hours									— 5,897
Other Work Categories									
		Clerk	Load	=(.22250)**×(—3541)					— 788
			Discharge	=(.23976)×(—5897)					— 1,414
		Supervisor	Load	=(.03452)×(—3541)					— 122
			Discharge	=(.03721)×(—5897)					— 219
		Dockwork	Load	=(.08726)×(—3541)					— 309
			Discharge	=(.15977)×(—5897)					— 942
TOTAL = Load & Discharge: Longshore and other work categories									—13,232

* Net Tons, excluding weight of empty pallets and containers.
** See Table 2 for Base Allowance.
♦ See Table 1 for Base Allowance.
‡ Since there were no tons handled during 1957, the base year, the base rate is assumed to be the 1958 observed rate.

had there been *neither* a change in productivity *nor* a shift in load type. The base rate man-hours shown in Column 5 are the man-hours that would have been required to handle the *actual* 1958 tonnage listed in Column 4, had there been no change in productivity. Therefore, the man-hour differences in Column 8 are directly attributable to the shift in load type that occurred in 1958.

A change in direct man-hours caused by a shift in load type also affects indirect man-hours of the longshoremen and of the other associated work categories. Corrections for this influence must be made to the base rate man-hour figures derived in Table 1 for indirect time and in Table 2 for the other work categories.

The man-hour changes in Table 3 are the combined result of all changes in load type. It is possible to show the man-hour changes in load type from both loose-to-pallets, loose-to-containers and pallet-to-containers.

The foregoing method, illustrated for one of the many commodity groups which may be affected by palletization or containerization, can be used for each commodity category where there has been a change in load type.

Identifying Causes of Productivity Change

Productivity rates may be affected by the following:

1. Increased use of mechanical handling equipment.

2. Changes in supervision and manpower utilization.

3. Changes in working rules and contract restrictions.

If only one of these factors changed during a comparison period, all productivity changes could be attributed to that factor. However, all three types of changes usually need to be instituted simultaneously. Where more than one change is made, more detailed analysis is required to isolate the extent to which each contributed to man-hour savings.

Summary of Computations

Table 4 is a summary of the changes in man-hours, among four occupations, attributable to the various causes under discussion. Three major causes of the difference between 1957 and 1958 actual man-hours (60,925) are:

1. Productivity change produced a decrease in man-hours of 12,865.

2. Shifts in load type caused a decrease of 13,232 man-hours.

3. The balance of the difference, 34,828 man-hours, is caused by a change in task resulting from a decline in the volume of business *or* a change in commodity mixture.

Port- or Coast-wide Accumulation

A summary sheet such as Table 4 can be constructed for the operation of each company at a port or terminal. The information can be accumulated algebraically on a port-wide or coast-wide basis. Such data provide a measure of the performance of the port or area for the time periods involved, using *actual* man-hour differences as the basis for the evaluation.

USES OF RESULTS

The foregoing method has many uses. Among these are:

1. Measuring the effectiveness of new cargo handling systems compared to previous methods.

2. Measuring the reduction in work opportunity resulting from improvements to cargo handling methods.

3. Identifying some of the causes of change in longshore man-hours between time periods.

4. Estimating the quantitative results of potential changes in handling specific commodities.

TABLE 4

Summary of Man-Hours by Work Categories

(Hypothetical illustration—Company A)

	1	2	3	4	5	6	7	8	9	10	11
	Longshore		Clerk		Supervisor		Dockwork		Total		Total
	Load MH	Dischg. MH	Load MH	Dischg. MH	Load MH	Dischg. MH	Load MH	Dischg. MH	Load MH	Dischg. MH	Load & Discharge MH
1957 actual man-hours (direct & indirect) (from Table 2)	125,244	106,212	27,867	25,465	4,324	3,952	10,365	16,969	167,800	152,598	320,398
Change in man-hours due to productivity change (from Table 2)	+ 1,042	−14,903	− 220	+1,060	−136	+459	+ 71	− 238	+ 757	−13,622	−12,865
Change in man-hours due to load type change (from Table 3)	− 3,541	− 5,897	− 788	−1,414	−122	−219	− 309	− 942	− 4,760	− 8,472	−13,232
Change in man-hours due to change in task *	−15,445	− 9,849	−9,849	−2,361	−534	−367	−1,262	−1,573	−20,678	−14,150	−34,828
1958 actual man-hours (direct & indirect) (from Table 2)	107,300	75,563	23,422	22,750	3,532	3,825	8,865	14,216	143,119	116,354	259,473

* Change in task is the man-hour change not attributable to productivity or load shift and is due to change in volume of business or commodity mixture. It is derived as the quantity necessary to make each column add up algebraically to the 1958 actual man-hours.

Chapter 4

SPECIAL PROBLEMS

It was noted earlier that the measurement of man-hours required for General Cargo, N.O.S., and for indirect work time, might require special procedures. The preceding section, by use of a hypothetical illustration, presented a method for evaluation of longshoring performance in which General Cargo, N.O.S., and indirect time were handled in an elementary fashion. This section will indicate hazards of simplified handling of these factors, and suggest refinements in the method of measurement.

GENERAL CARGO, N.O.S., COMMODITY CLASSIFICATION

General Cargo, N.O.S., is a "catch-all" category that comprises all commodities not specifically covered by other classifications. It includes articles with a wide range of handling and physical characteristics. The N.O.S. category includes commodities or packaged units moving in quantities considered too small to warrant separate classification and new commodities just beginning to move in the trade. Therefore, its composition may vary greatly from time to time. This variation may lead to erroneous evaluation of performance. That is, a change in the man-hour requirement computed for the N.O.S. tonnage may be caused by change in its composition rather than change in productivity. The error may be slight if the N.O.S. tonnage is small, but it may be so great that it affects the evaluation of longshore performance.

In recent years some companies classified up to 65 per cent of the total tonnage handled in the Bay Area as General Cargo, N.O.S. One large company treated all of its cargo as one commodity group, equivalent to General Cargo, N.O.S. These figures show the importance of N.O.S. cargo to longshoring performance and underscore the need for a method to distinguish the effects of productivity change from the effects of variations in handling characteristics.

Identifying Commodity Groups in General Cargo, N.O.S.

For a number of shipping companies it is possible to segregate their N.O.S. cargo tonnages into commodity groups and obtain tonnage data from manifest records and other voyage reports. In the unlikely case that actual man-hours are available for the commodity groups, the method outlined in Section II may be used to compute the influence of N.O.S. cargo on longshoring performance. However, in many cases loading and discharging man-hour records are not available by individual commodities within the N.O.S. category and, therefore, specific productivity rates are unavailable.

The following paragraphs describe a method for developing usable productivity base rates in the absence of complete data on actual rates.

Table 5 (based on actual data) shows a typical component grouping of the N.O.S. cargo of Company B. Tonnage data was available for each of the component groups for the base and comparison periods, (Cols. 1 & 4).[5] However, only total man-hour data were available for General Cargo, N.O.S. (Cols. 2 & 5). Portions of the "totals" could not be identified with any of the component groups.[6] For each of the N.O.S. component groups, a characteristic productivity base rate used for planning was obtained from the stevedoring superintendent. The characteristic rate and base period tonnages of the N.O.S. cargo were used to compute the base period man-hours required to handle each of the component groups. The computed base period man-hours were totalled; and the ratio of the total computed man-hours to the total actual base period man-hours was applied as a correction factor to each of the stevedore's productivity rates. This ensured that for the base period the corrected rates (Col. 3) would yield a total computed man-hour figure equal to the actual total man-hours. Longshore performance for General

[5] Tonnage data for each component group can be assembled for the base and comparison periods from manifests for each ship visit to the port or area.

[6] Man-hour data is generally available only on a "totals" basis for the loading and discharging operations for each ship visit and cannot be assigned to any one component group of the N.O.S. cargo being handled. The total man-hour figure presented in Table 5 was obtained by summing all of the load totals for each ship visit.

TABLE 5

Change in Longshore Man-Hours for N.O.S. Segregated into Commodity Groups (Company B—San Francisco discharge)

	1	2	3	4	5	6	7
	Base Period *			Comparison Period **			
	Amount of Cargo ST	Actual Man-hours	Corrected Stevedore Prod. Rates ST/MH	Amount of Cargo ST	Actual Man-hours	Calculated Man-hours Col. 4/ Col. 3	MH Change + or — Col. 5- Col. 6
General Cargo N.O.S.*** TOTALS	91,510	90,860		85,020	92,180	89,600	2,580
1. Misc. Gen. N.O.S.	17,170		0.565	17,990		31,840	
2. Cartons—canned goods	2,450		1.227	2,110		1,720	
3. Cartons—light breakable items (more than 40 cartons per 2000 lbs.), such as glassware, drugs, toys	16,950		0.812	19,750		24.320	
4. Cartons and cases, heavy items (less than 40 cartons per 2000 lbs.), such as books, paper, chewing gum	10,340		1.227	8,220		6,700	
5. Bagged goods—coffee, dry paints, chemicals, etc.	5,570		1.342	5,250		3,910	
6. Reels and bundles, pails—rope cable, paints, etc. (less than 1000 lbs. each)	2,710		0.979	1,210		1,240	
7. Drums—chemicals, pitch, oils, etc.	4,980		1.629	3,170		1,950	
8. Cartons and cases—mostly machinery and plumbing items	3,520		1.473	3,310		2,250	
9. Reels, machinery, vehicles—(items 1000 lbs. or more each)	4,860		1.501	2,840		1,890	
10. Skids—printing paper	7,080		2.043	7,560		3,700	
11. Rolls—paper products	4,180		1.224	4,370		3,570	
12. Bundles—pipe, tubing, conduit, etc.	5,700		1.940	2,900		1,490	
13. Steel—plates, beams, angles, channels, etc.	1,730		1.779	1,110		620	
14. Pallet units—insulrock, toilet preps., etc.	970		0.835	2,630		3,150	
15. C-type containers	3,300		2.043	2,600		1,270	

* The data given for the Base Period is based upon actual information for Company B.

** The data for the Comparison Period is assumed.

*** The commodity breakdown of the General Cargo, N.O.S., category is based upon a comprehensive analysis of Company B records.

Cargo, N.O.S., has been evaluated in Table 5 by the same method used in Section III. There is a considerable difference between the results obtained by this approach (a 2,580 man-hour increase), and that derived by treating all N.O.S. cargo as a single commodity (7,750 man-hour increase). (See Table 6.)

A statistical approach to obtaining productivity base rates for the component groups—to be used in lieu of the stevedore's rates—was also evaluated. For the data used in the computations, it was necessary to solve 51 equations (one for each ship visit during the base period) with 15 unknowns (one for each component group productivity rate). The rates developed by this method (which involved the use of an electronic computer) only slightly improved the measurement accuracy obtained from using stevedore's rates for the N.O.S. cargo. Consequently, the stevedore's rates are preferred for their simplicity. A

TABLE 6

Change in Longshore Man-Hours for N.O.S. Treated as a Single Commodity (Company B—San Francisco discharge)

1	2	3	4	5	6	7
Base Period			Comparison Period			
				Man-hours		
Amount of Cargo ST	Man-hours. Actual	Productivity Base Rate ST/MH Col. 1/Col. 2	Amount of Cargo ST	Actual	Base Rate Col. 4/Col. 3	+ or — Col. 5-Col. 6
91,510	90,860	1.007	85,020	92,180	84,430	+7,750

measure of the accuracy of these productivity base rates can be made by applying the corrected stevedore rates to the corresponding component group tonnages for each ship visit and comparing estimated total man-hours with actual man-hours. Over a number of ship visits this comparison can be quantified by taking the square root of the sum of the squared differences between actual and estimated values for all ship visits. The greater the resulting number, the less confidence one can place on the rates used. The single commodity method has a root mean square error approximately double that of the methods using either the stevedore's rates or the statistical analysis, which were nearly equal.

Productivity base rates obtained from the stevedoring superintendent, or by the statistical approach, are estimates; thus, by nature, they are subject to error. It is desirable that every effort be made to obtain actual tonnage and man-hour data for each of the component groups of General Cargo, N.O.S., to develop actual productivity base rates. Cargo sampling methods can be used which will yield base rate information superior to the stevedore's or statistically calculated rates where complete measurement is impractical. Sampling would require taking man-hour measurements on commodity groups for every fifth or every tenth ship visit, depending upon the desired precision.

Use of Stowage Factor to Measure General Cargo, N.O.S.

Many shipping companies may be unable to subdivide their N.O.S. categories into logical component groups and obtain the requisite data. The inaccuracies inherent in the handling of N.O.S. cargo tonnage data as a single group are so great that further refinement is desirable. To meet such situations, an effort was made to determine whether a general relationship exists between productivity and stowage factor of N.O.S. cargo that could be used to measure change in N.O.S. man-hour requirement due solely to productivity change. For those companies maintaining both weight and cube information on General Cargo, N.O.S., this method may be useful.

Two companies supplied loading data covering a period of several months on weight tons, measurement tons, and gang hours, by ship, for their General Cargo, N.O.S., Classifications. The data of Company C comprised 72,000 long tons (LT); 165,000 measurement tons (MT); and 8,780 gang hours (GH). Company D data included 15,000 LT; 38,000 MT; and 2,200 GH.

The data from each company were analyzed separately. Productivity rates, expressed in LT/GH and MT/GH, were calculated for each ship and grouped according to the average stowage factor of N.O.S. tonnage handled for the ship. The data were then grouped by stowage factor interval and average productivity rates computed for each group. The results, plotted for Companies C and D are shown in Figures 1 and 2. Over-all average productivity rates calculated for each company are also shown.

A wide range of stowage factors—40 cu. ft./LT to 170 cu. ft./LT—are included in the General Cargo, N.O.S., tonnages of both companies. Except for highly specialized cargo that might occasionally fall into the N.O.S. category, this range of stowage factors is similar to the range of stowage factors in the General Cargo, N.O.S., category of other shipping companies.

The trend of productivity data in Company C (Figure 1), expressed in MT/GH, is nearly constant over the range of stowage factors shown. On the other hand, the trend in productivity data for this same tonnage, expressed in LT/GH declines with increasing stowage factor. The pattern for Company D is

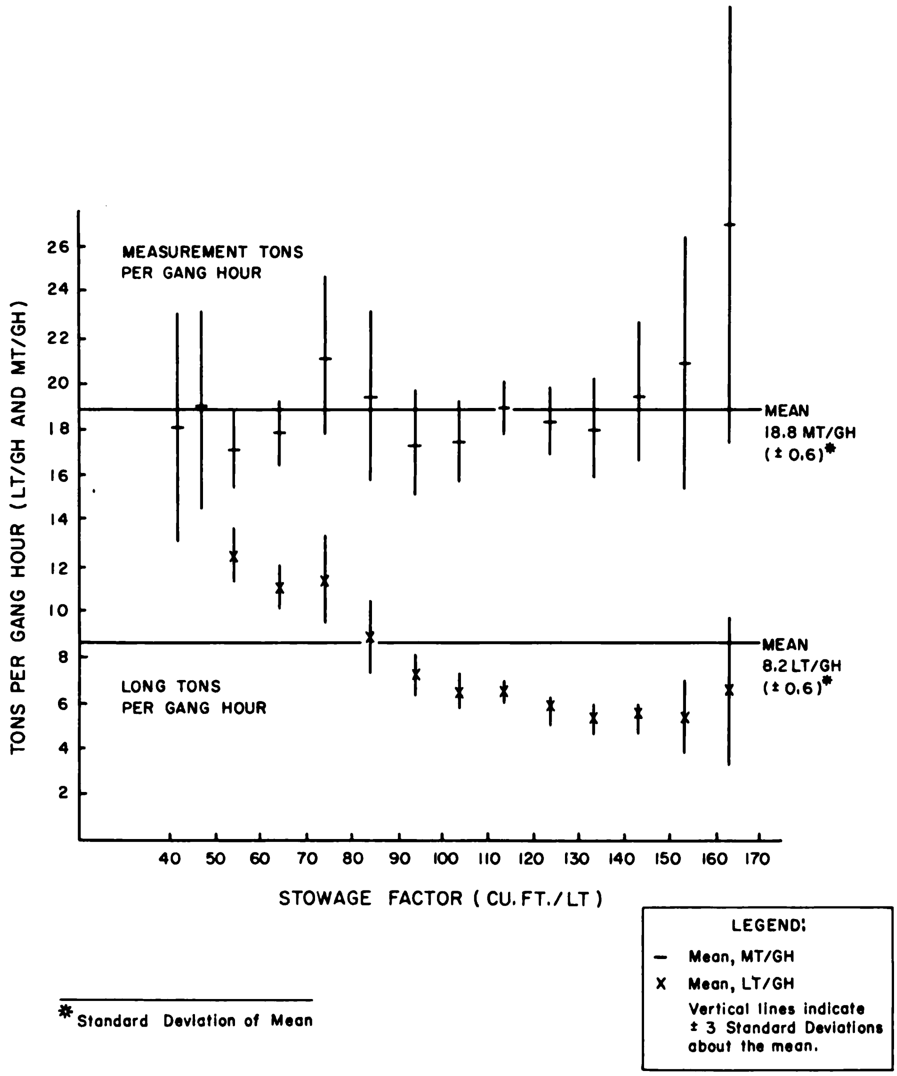


Figure 1. Average cargo handling rates vs. stowage factor, General Cargo, N.O.S., Company C. (with estimates of error at 99% confidence level)

the reverse (Figure 2). That is, the trend of productivity data expressed in MT/GH increases as stowage factor increases, and the trend of productivity data expressed in LT/GH is relatively constant over the range of stowage factors. These opposed results probably result from differences in the operations of the companies. Therefore, analysis of this type must be made separately for each company, to use this approach.

The probable variability among different companies prevents using this method of analysis for all companies operating in a port. However, the uniform use of this method may improve the data aggregated for a port-wide evaluation of longshore performance.

If productivity is constant, in either weight or volume measurement, over the entire range of stowage factors, General Cargo, N.O.S., may be treated as a single commodity in terms of the constant unit. Where productivity varies over the range of stowage factors on both a weight and volume basis, the General Cargo, N.O.S., category may be subdivided into stowage factor intervals. The cargo falling into each stowage factor interval can then be evaluated by the method

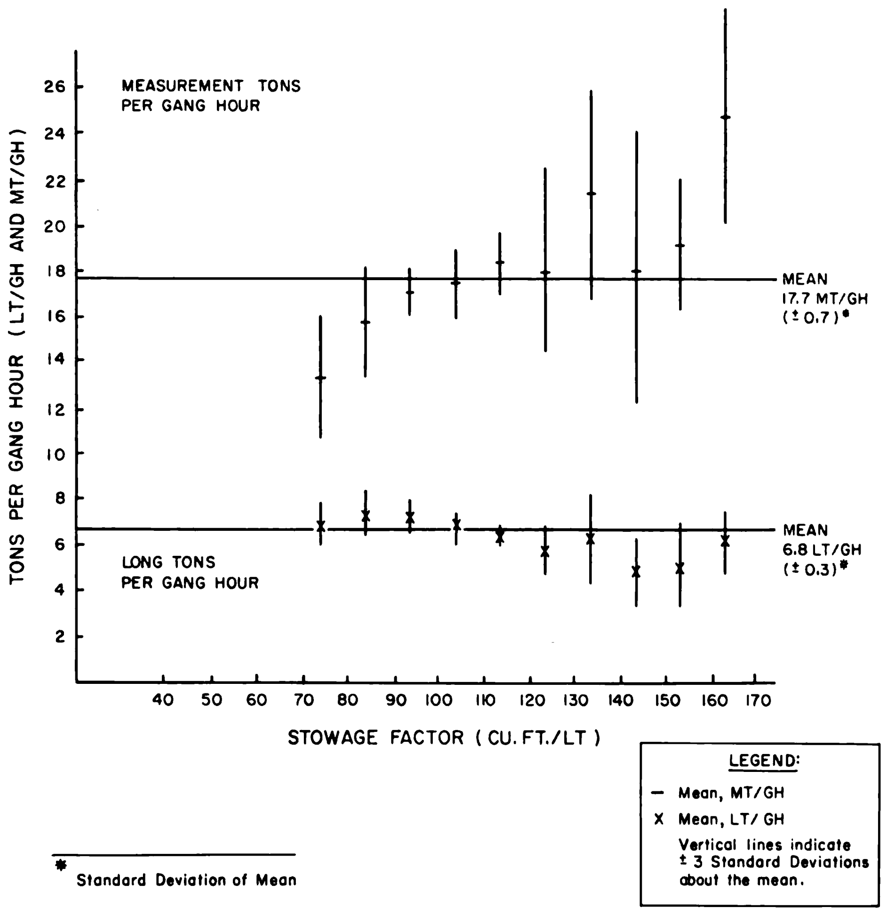


Figure 2. Average cargo handling rates vs. stowage factor, General Cargo, N.O.S., Company D. (with estimates of error at 99% confidence level)

of Section II, treating each interval as a separate commodity.

INDIRECT TIME MEASUREMENT

For a number of Bay Area shipping companies indirect man-hours consumed from 20 per cent to 50 per cent of total longshoring man-hours. The data presented in Table 1, Section II, which are based on actual facts, show that for Company A indirect man-hours constituted approximately 21 per cent for loading and 32 per cent for discharging operations. Indirect man-hours generally constitute such a large proportion of the total longshoring man-hours that they must be accurately accounted for to obtain valid information for evaluation purposes.

For many shipping companies the method of handling indirect time developed in Section II may be entirely adequate. However, a more accurate estimation can be made if indirect time is separated into two components, one based on the number of ship calls and a second based on the amount of direct commodity time.[7] The data in Figure 3 indicates that

[7] The equation use in Method 2 for indirect time estimation is:

$$\sum_{i=1}^{N} Y_i = Na + K\sum_{i=1}^{N} X_i$$

where:

$\sum_{i=1}^{N} Y_i$ = Total of indirect man-hours for the i[th] voyage (Y_i) summed over the base period for N voyages.

$\sum_{i=1}^{N} X_i$ = Total of direct man-hours for all commodities handled in the i[th] voyage (X_i)

even when direct longshore man-hours approach zero there still must be a certain number of indirect man-hours to open up and close the ship regardless of the amount of cargo to be handled.

A further refinement of the above method of estimating indirect time accounts for differences in dunnaging, shoring time, and other indirect time related to differences in commodity types.[a] This refinement may be desirable for a company handling a number of commodity types with different dunnaging and shoring requirements. It does involve measuring the amount of indirect time as well as direct time during the base period for each commodity group handled.

Figure 4 compares the accuracy of the three methods of estimating indirect time by the month for the same data shown in Figure 3. If Method 1, the overall mean ratio of indirect to direct time, had been used, the actual monthly ratios would lie in a band about 4 per cent on either side of the estimated value (at the 95 per cent confidence level). Method 2 would produce a band about 3 per cent on either side of the line of perfect estimation under the same conditions and Method 3 would produce a band about 2 per cent wide. Of course, the smallest band width represents the most nearly perfect estimation method for this company. Operations of other companies might not be as sensitive to the factors accounted for in the refined methods. Hence, each company should carefully analyze its operations before choosing a method of estimating indirect time.

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summed over the base period for N voyages.

K = Base period relationship between indirect man-hours and total direct man-hours for all commodity types handled.

N = Number of ship calls, base period.

a = Average indirect man-hours involved in initial opening and final closing operations (independent of commodity time).

[a] The equation used in Method 3 for indirect time estimation is:

$$\sum_{i=1}^{N} Y_i = Na + \sum_{i=1}^{N}\sum_{j=1}^{m} K_j X_{ij}$$

where:

$\sum_{i=1}^{N} Y_i$, N, and a are as in Method 2 above and

X_{ij} = Direct man-hours required to handle the j^{th} commodity type for the i^{th} ship call.

K_j = Base period relationship between indirect and direct man-hours for the j^{th} commodity (where j = 1, 2, . . . m; and m is the number of commodity types handled by a shipping company).

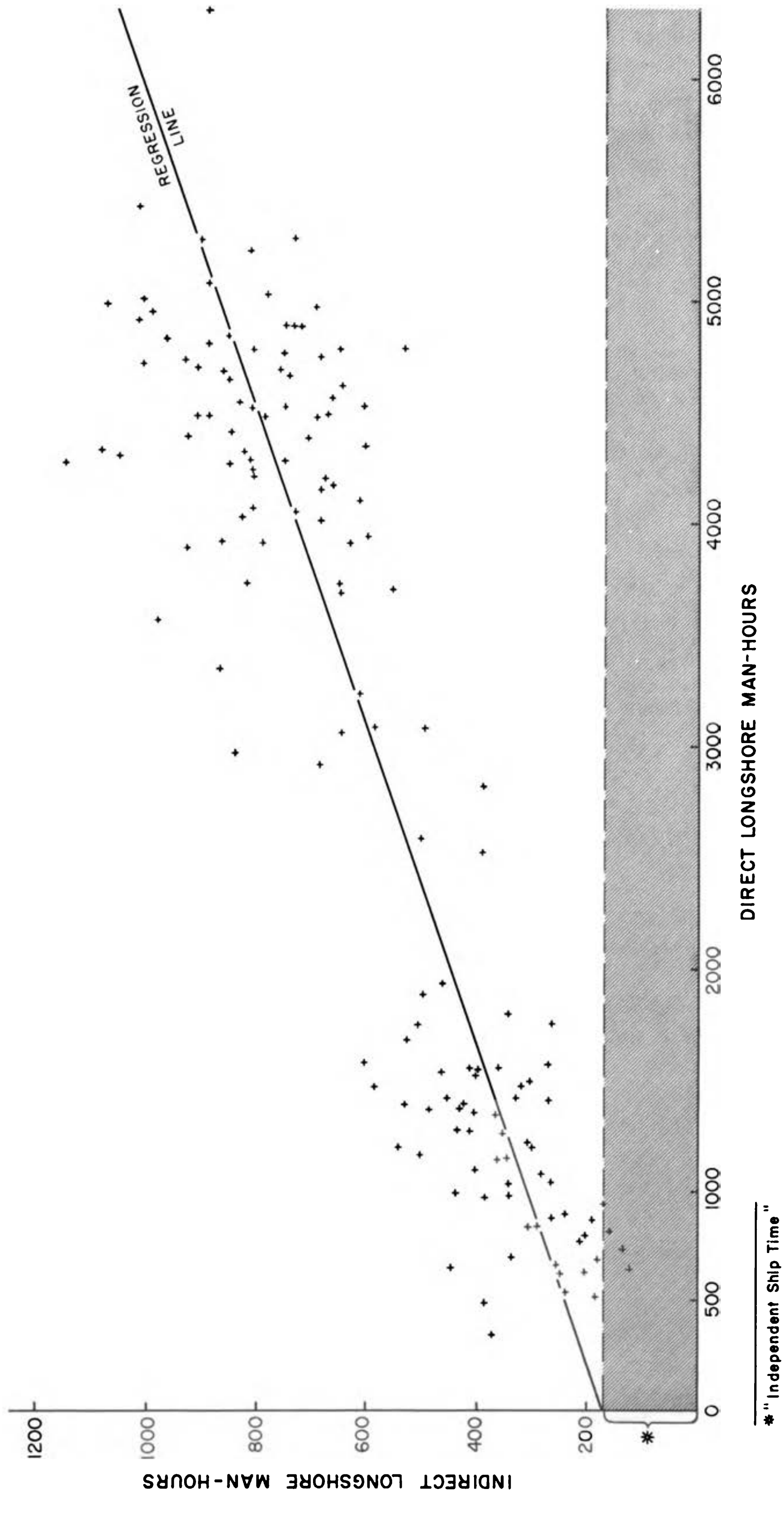


Figure 3. Actual indirect man-hours vs. direct man-hours, by voyage, Company E—San Francisco, load only. (18 month period)

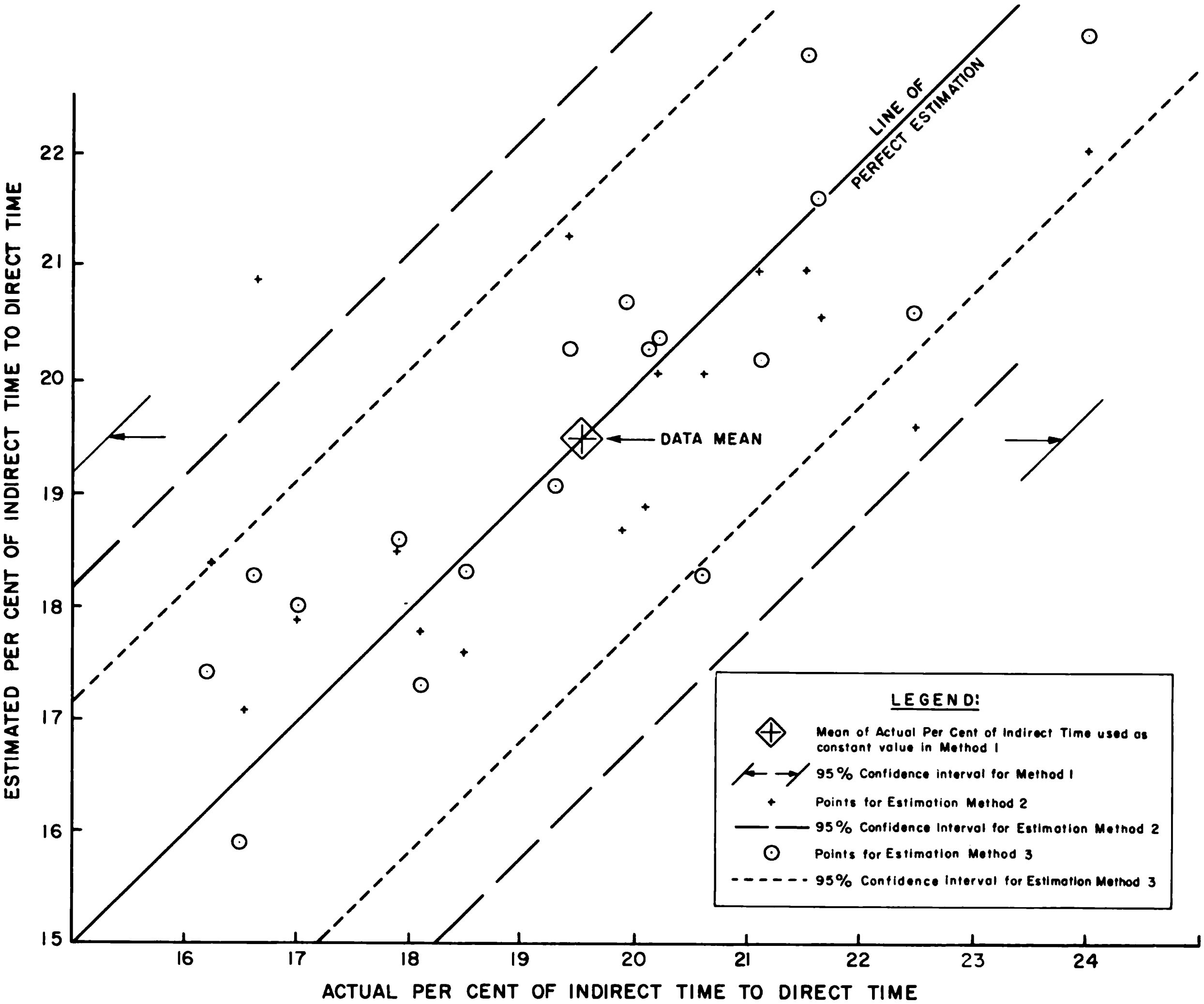


Figure 4. Comparison of methods, Company E, on a monthly basis.

Part III

ANALYSIS OF CARGO HANDLING

Chapter 1

SUMMARY AND CONCLUSIONS

One of the first projects undertaken as a part of the San Francisco Port Study was an analysis of cargo handling operations, to describe the present system, locate bottlenecks in the operations, measure the potential for improvement, and suggest specific improvements. Quantitative information was accumulated to evaluate current cargo handling methods.

The elements of cargo handling tasks were timed by specially trained union clerks. The apron, hook, and hold phases of the loading and discharging processes on general cargo ships were examined. Included were opening and closing, cargo handling, and related work.

Observations of the work time elements, weight and measurement of the cargo, equipment used, number of men working, work location within the ship, and a description of the work elements of the process were recorded. Seventeen variables associated with commodity, ship, worker, shift, weather, etc. were segregated in the compilation.

Many bottlenecks in the system were observed during the data taking phase in 1958 and 1959. Since then, many changes and improvements have been made. The Pacific Maritime Association (the employer's bargaining agent) has instituted a contract conformance program to eliminate extracontractual work practices (e.g., the 4-on, 4-off practice, unauthorized late starts and early quits) which were detrimental to productivity. The 1960 longshore labor contract has eliminated most of the manpower restrictions of earlier contracts which affected productivity, and has provided a basis for mechanizing the industry.

This analysis describes the cargo handling system prior to 1959, and provides a basis for evaluation of many of the changes made since that time. The methods of the analysis are useful as study procedures for others in the San Francisco Bay Area and elsewhere.

The following conclusions have been drawn from analysis of the time measurements:

1. The cargo handling system in the San Francisco Bay Area in 1958 and 1959 was operating well below its capability. The deficiency could not be attributed to any single cause. It was the sum of worker, supervisory, and contractual shortcomings. Specific factors which affected productivity:

a. Delays and lags consumed about 43 per cent of the working time in the hold.

b. The practice of four of the eight-man hold gang resting at one time while the others worked (4-on, 4-off) drastically reduced performance on loading operations.

c. Little mechanical equipment with lifting capability was provided to help men in the hold.

d. Drafts were limited by contract to inefficient sizes and loads even smaller than permitted were generally placed on the pallets.

e. The rigid practice of alternating drafts between the two sides of the hold stopped one side of the hold gang from working when the other side was delayed.

f. Unproductive time at the beginning and ending of the work shift, including unauthorized late starts and early quits, claimed approximately 7 per cent of the 9-hour work shift.

g. Inflexible gang size prevented the efficient utilization of manpower.

h. Little modern equipment was provided for dunnaging, shoring, work platforms, running plates, etc.

i. No provision was made for having more than one draft ready for handling, on the apron or in the hold, even though space permitted.

2. Productivity rate differences between companies were noticeable within certain commodity groups. No one company was consistently better than the others for all commodities, however.

3. The methods of handling general cargo on the San Francisco waterfront can be improved without

requiring greater energy expenditure by the longshoremen. For some commodities the gang hour productivity can be doubled and the handling cost per ton reduced by 25 per cent or more. This improvement can be accomplished by:

a. leaving as much cargo as possible on pallets when stowing aboard ship.

b. using more labor-saving equipment such as fork lifts or pallet jacks in the hold.

c. improving supervision and selection of work methods.

d. improving dunnaging, cargo shoring, and blocking techniques; using block stow, plywood dunnage, cargo nets, running plates, etc.

e. improving communications between the men in the hold and other gang members, including the clerks on the dock.

f. establishing a cargo reservoir on the apron and in the square of the hold.

g. providing more flexible assignment of manpower, both in numbers used and in job assignment.

4. Cargo handling rates can be improved, costs reduced, and safety increased by modifying shipboard cargo handling facilities to provide:

a. mechanical hatch covers.

b. flat obstructionless decks with surfaces prepared for the use of powered equipment.

c. larger reefer and locker openings with flush sills.

d. flush cargo tie-down fittings.

e. topping lift and vang winches for rigging booms.

f. improved, built-in lighting in the far reaches of the compartments.

g. rectangular cargo spaces away from bow or stern hull shaping.

h. high-capacity ventilation system in cargo spaces.

5. Changes in methods of using men and existing equipment promise more immediate improvement in cargo handling productivity than changes requiring sophisticated equipment and new ship designs.

Chapter 2

PHYSICAL DESCRIPTION OF THE CARGO HANDLING SYSTEM

LOADING AND DISCHARGING CYCLES

For both loading and discharging, the hold gang was split into two teams—one working on the starboard side of the ship and the other on the port. The activities of one team mirrored those of the other. Each team received alternate service from the hook. This work procedure simplified data taking for the study, since it was only necessary to time one team and adjust the tonnages.

For purposes of the study, the loading and discharging systems were divided into two phases, the hook cycle and the hold cycle. The hook cycle, for both loading and discharging, started when the hook left the apron on its way to the hold. The hold loading cycle started with the arrival of the hook carrying the cargo. It ended when the same team in the hold received their next load from the hook. Each hold discharging cycle commenced when the team started to move its stevedore wagon to the position in the hold where it was to be loaded. The hook made two cycles for each hold team cycle.

COMPOSITION OF GANGS

The standard longshore gang in 1958 and 1959 comprised 12 men for discharging and 14 for loading. The work assignments were:

	Loading	Discharging
Gang boss	1	1
F/L driver on pier	1	1
Hook-on men on pier	2	2
Winch driver	1	1
Hatch tender	1	1
Holdmen	8	6
TOTAL	14	12

Spare hook-on men must be provided on the pier in sufficient numbers to give each hook-on man 15 minutes relief out of every two hours.

WORK PROCEDURES AND EQUIPMENT

The standard working practice in 1959 was for only four men to work in the hold at one time, two men to each team. Two men from each loading team or one man from each discharging team would either leave or rest in the hold. This practice was referred to as 4-on, 4-off, even though in discharging operations there were only six men assigned with two men "off."

When loading, the hook delivered alternate loads to each team. If a team which had received the previous load was ready for another load before the team on the other side of the hatch, it waited, even though it meant several minutes delay. The alternating procedure continued during all work in the wings. When the teams were working in the square of the hatch, the two teams joined. The alternating procedure was also used when the hook was taking cargo out of the ship during discharging operations.

The conventional cargo handling equipment used aboard ship in 1959 was the four-wheeled hand truck, or stevedore wagon, having no lifting capability. It was used solely to transport cargo between the point where the hook deposited or picked up cargo and the point of stowage in the hold. The cargo was manhandled onto and off the truck, one piece at a time. At times, one company used electric jitneys in place of the hand trucks. The jitney had no lifting capability, so that its only advantage was to provide power and braking for the transporting of loads. The cargo still had to be manhandled at stowage position. Few fork lifts were in use aboard ship in 1959.

When cargo was available in sufficient quantity and there was no problem of overstowing, tier stowage was used to reduce the arduousness of manually lifting cargo. A tier was built to a convenient lifting height over the entire stowage area. The cargo was then "floored off" by laying dunnage over the top. Walking boards were laid on the dunnage and the stevedore wagon was pushed over the first tier with its loads. If the stowage area did not extend into the square, it was necessary to build a stage or "leg" to the height of the cargo tier so that the stevedore wagon could come under the hook to receive cargo. The stage was usually built of stacked pallets, topped with plywood walking boards. When working in spaces with confined headroom, it was often necessary for one man to pass the cargo to the other, so that both men handled each piece of cargo. Productivity under these conditions was low.

Bales of cotton were sometimes transported within the hold on the stevedore wagon, and at times were rolled into place by hand. Oil drums were almost always delivered to the hold on their sides. They were then rolled to the stowage area and upended into position by hand.

Conventional married-fall cargo handling gear was used on all of the ships in the study. This gear consisted of two guyed booms each with its own fall and winch. The falls were joined to a single hook. The booms were rigged, so that by coordination of the two winches the cargo could be lifted off the dock and deposited in the square of the hatch on either the port or starboard side. The load was positioned in the hatch, forward or aft of the line between the heads of the booms by manually swinging it.

When discharging, the hook was sometimes used to drag heavy cargo from the wings, and then lift it from the square. Cargo could be picked up by the hook from any spot in the square by first dragging it to a spot on a line between the boom heads, so that a direct lift could be made.

The winch driver and the hatch tender alternated roles throughout the day. The hatch tender was usually relieved by the gang boss when it was necessary for him to leave his post.

Chapter 3

PRODUCTIVITY ANALYSIS

Cargo handling productivity can be measured in many ways and have many meanings, depending on the purpose for which it is being measured. Cargo units moved can be measured by weight, cube, or by draft. Time units can be related to ship time, gang time, or man time, depending upon which is the most useful for the analysis. Regardless of the method used to measure it, longshore productivity greatly affects the cost of shipping cargo. Therefore, in a study of longshore operations, it is important to isolate the factors which influence productivity.

For the purposes of this study, productivity comparisons were made within commodity groups. Commodity groups were defined to include package type and handling characteristics. Comparison within a commodity group provided the most meaningful basis against which changes could be evaluated. For some purposes, other measures of productivity may be more useful. For instance, productivity by area of the ship may have special significance to a planner who is trying to balance out the work to be done and to minimize the ship time at berth. Even in this case, however, commodity productivity is one of the variables that the planner will take into account in laying out the stowage plan.

The details of sample size, commodity breakdown, and companies observed are given in Appendix A.

VARIABILITY OF PRODUCTIVITY DATA

The foremost characteristic of the productivity data gathered in the San Francisco Bay Area was the wide range of values observed. The differences in productivity occurred within commodity groups, and within the data associated with each of the variables tested. Some of the factors which were tested for their effects on productivity were: night work versus day work, stowage in the wing versus stowage in the square, type of ship, size of the sling load, number of men working, and the percentage of time worked.

NIGHT WORK VS. DAY WORK

Six of the thirteen commodities examined for difference between day and night productivity showed significantly higher productivity for day work. The differences ranged from three measurement tons per hour for loading canned goods to 18¾ measurement tons per hour for loading unitized cargo (Figure 1). Seven of the commodities showed no significant difference between day and night loading rates. Samples of other commodities tested were too small for statistical verification of the differences. There were no samples where night productivity rates were measurably superior to day rates. Figure 1 shows the productivity comparison and variability for samples of the 13 commodities which were of sufficient size to permit analysis. The center mark on each line is the mean productivity for the commodity. The length of the line shows the range within which approximately 96 per cent of the means of samples taken under similar conditions could be expected to fall.

The indication here that night work may be less productive than day work suggests that additional costs, other than premium wages, are incurred in working at night.

STOWAGE IN THE WING VS. STOWAGE IN THE SQUARE

No consistent difference between stowage in the wing or in the square was found for most commodities. Vans and very large boxes did show a higher productivity in the square, as might be expected. The ability to spot the large units in stowage position with the hook constituted a time saving. Small units were often used for fill between large units in the square, so that their average stowage rates did not improve much. In addition, the hook was not as free to move into the square when the men were working there as it was when the men were in the wing. Furthermore, when the men were working in the wing, the team on one side could be receiving cargo while the

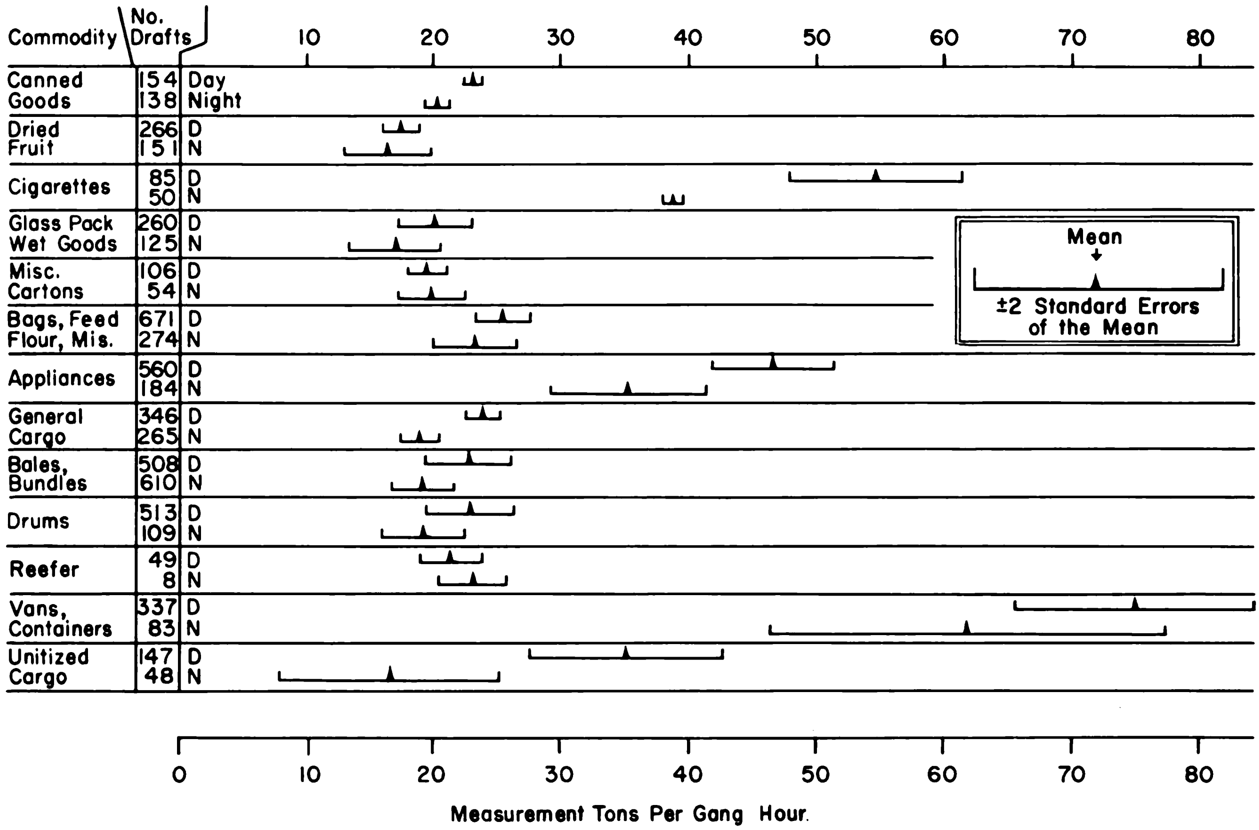


Figure 1. Cargo handling productivity, day vs. night comparison—loading.

other was stowing, so that the hook could move at a more rapid pace. Figure 2 shows the comparison between wing and square stowage work for several representative commodities.

PRODUCTIVITY VS. PERCENTAGE OF TIME WORKED

In the *Cargo Ship Loading Study* (NAS-NRC Pub. 474), a relationship was shown between the percentage of operating time during which the men were actually working and the rate at which they worked. The greater the percentage of time that the men were working, the lower the work rate while they were working. The decrease in work rate—as the percentage of time worked increased—was so sharp that when the men worked more than 55 per cent of the time the over-all productivity per man (work rate x per cent of time worked) no longer increased. In the conclusions on break-bulk loading productivity of the *Cargo Ship Loading Study*, this decline in work rate and in over-all productivity was interpreted as being due to fatigue caused by the increased work to rest ratio.

An examination of the San Francisco Port Study data was made to determine whether the findings of the earlier study were valid for this port. Samples of loading data for general cargo and canned goods were analyzed for this purpose. For both commodities, it was found that the statistical relationship between percentage of time worked and productivity was too weak to assert the same conclusion. The difference between the findings of the two studies might be explained by the influence of the 4-on, 4-off work pattern of the gangs in the San Francisco area. The actual work rates per man while on the job (see Table 2) were not far different on the two coasts for the time that the men were actually working. The longshoremen in San Francisco were only available to work half the time however, reducing the actual percentage of time worked to less than 30 per cent.

The above comparisons were made on cargo handling time only, and did not include time used for opening and closing or housekeeping.

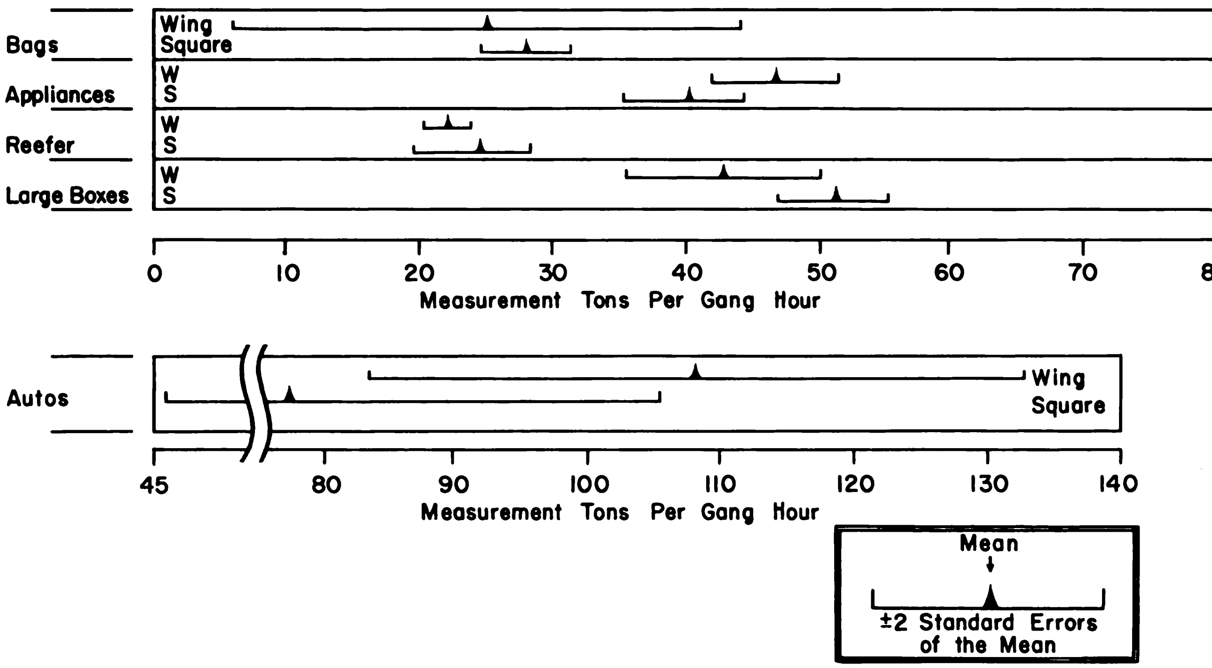


Figure 2. Cargo handling productivity, wing vs. square loading. (one company only)

DRAFT SIZE

A relationship was observed between the size of the draft and the tons of cargo loaded per gang hour. Figures 3, 4, and 5 all show an increasing productivity as the size of the draft increases. For this presentation, measurement tons have been used because in the higher stowage factor range, where most packaged cargo lies, draft size is limited by volume rather than by weight. Figures 6a and 6b, calculated on a smaller sample, show that the relationship between hook load and productivity is similar whether calculated by weight or measurement units. The longshore labor contract placed limits on the number of pieces which may be placed on a pallet for many commodity groups. Gang hour productivity in Figures 3, 4, and 5 is based on a gross work cycle which includes all of the delays and lags occurring during the cargo handling operations. The position of points with reference to the sloping lines of constant drafts per hour indicates average draft rate as well as showing the measurement ton rate. In most cases the larger draft sizes in Figures 3, 4, and 5 are high stowage factor cargo. Most of the points fall in a narrow range of drafts per hour, indicating that the drafts per hour rate is relatively insensitive to draft size or stowage factor variations.

The relationship between draft size and productivity agrees substantially with the findings reported by MCTC in the *Cargo Ship Loading Study*.

COMPANY COMPARISONS

Differences in productivity between companies cannot be evaluated directly. Draft size, which may be beyond company control, may affect the performance measurements. When draft size effects are isolated, other differences in stevedoring methods can be separated.

Figures 7a through 10 compare company productivity rates for typical commodities. Average productivity in measurement tons per gang hour for each company has been plotted against average draft size in measurement tons. Straight diagonal lines through the origin represent lines of constant draft rate. The steeper the slope of these lines, the higher the draft rate. On each graph, the weighted average draft rate has been drawn in. Companies above this diagonal line have higher than average draft rates and those below have lower than average draft rates. All points on Figure 7a through Figure 9 represent at least one hour of cargo operations and most of them cover more than six hours of cargo time. Figures 7a through 8b cover loading operations; Figures 9a through 10, discharging.

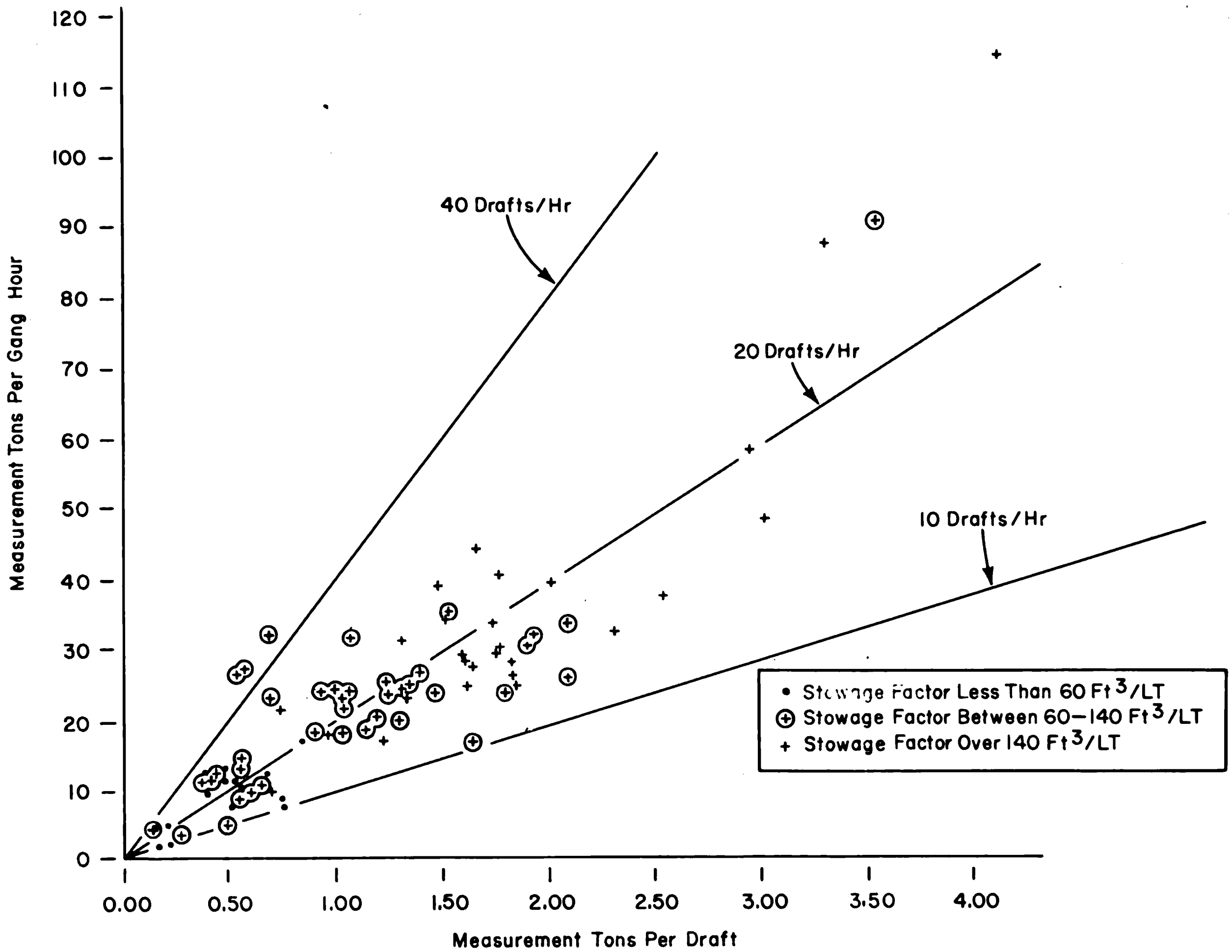


Figure 3. Gang productivity vs. draft size—general cargo and machinery.

These figures show that certain commodities are handled by different companies at different productivity rates. These differences may be due to draft size, draft rate, or both.

A conclusion not evident from the figures (since for proprietary reasons, points were not identified) is that no one company was consistently better or worse than others for all commodities. A company which excelled in one situation may have been below average in another. Superiority by one company in handling a particular commodity may have resulted from specializing in that commodity and gearing stevedoring operations to it. The best company productivity rates shown here are well below system potential. This is discussed further in Chapter 5.

All company data within commodity groups has been combined for the cycle time analysis in the next section.

OTHER VARIABLES TESTED

Tests for relationships between productivity and the type of ship in which the work was being performed, and between productivity and the number of men working in the hold proved inconclusive.

Tests of productivity versus the number of men working were not definitive because of the 4-on, 4-off work pattern. The number of observations in which more than four men were working in the hold was too small to make reliable comparisons between gang sizes within a commodity group. For all practical purposes, the working gang size during cargo handling operations in the San Francisco Bay Area proved to be four men in the hold.

Cargo handling productivity was apparently not affected by characteristics of the various ship types. As will be shown in the Time Analysis section of this report, the Mariner class proved to have some ad-

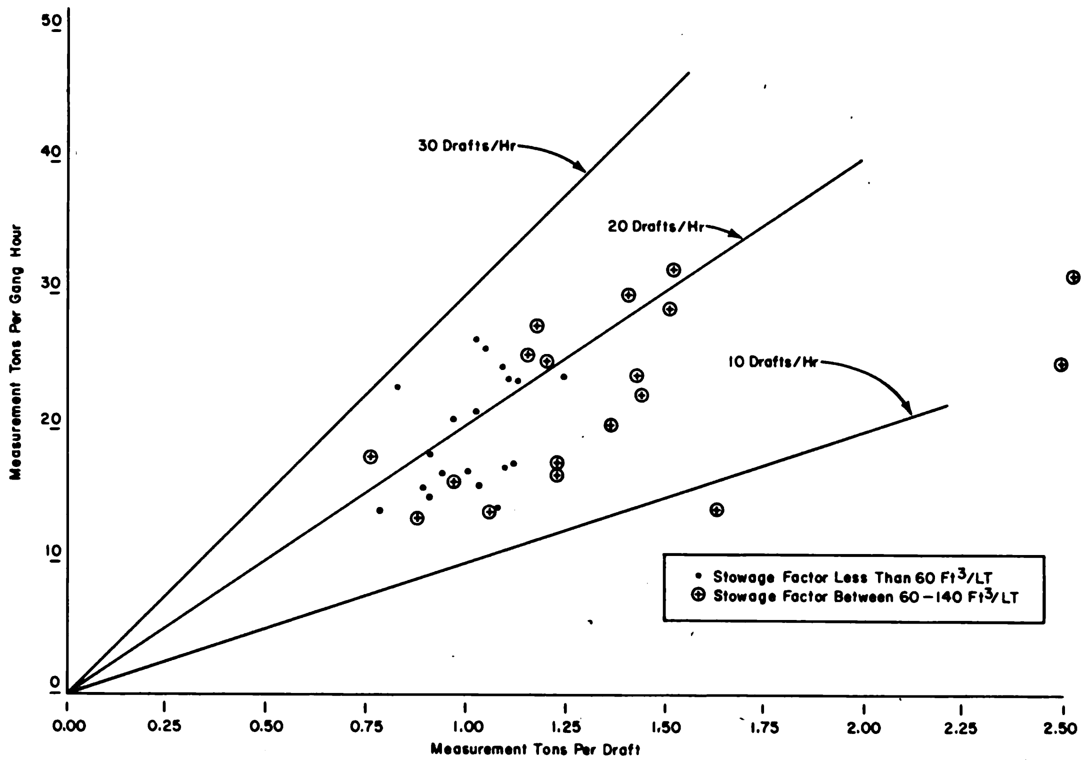


Figure 4. Gang productivity vs. draft size—canned goods.

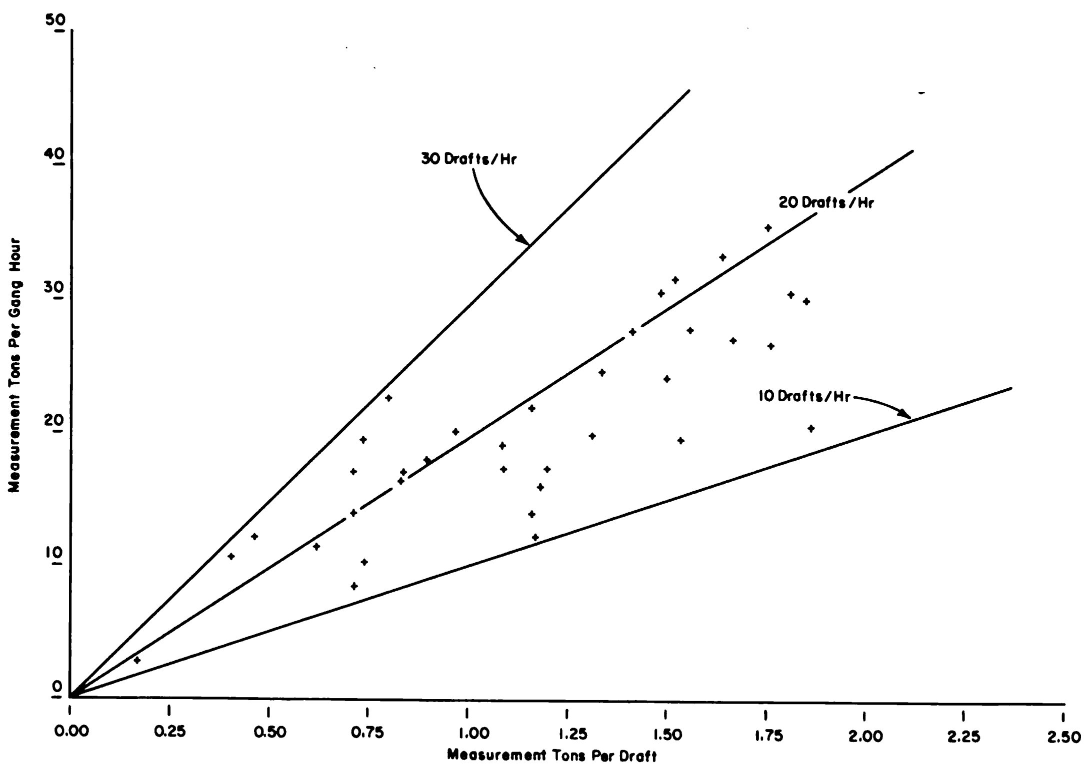
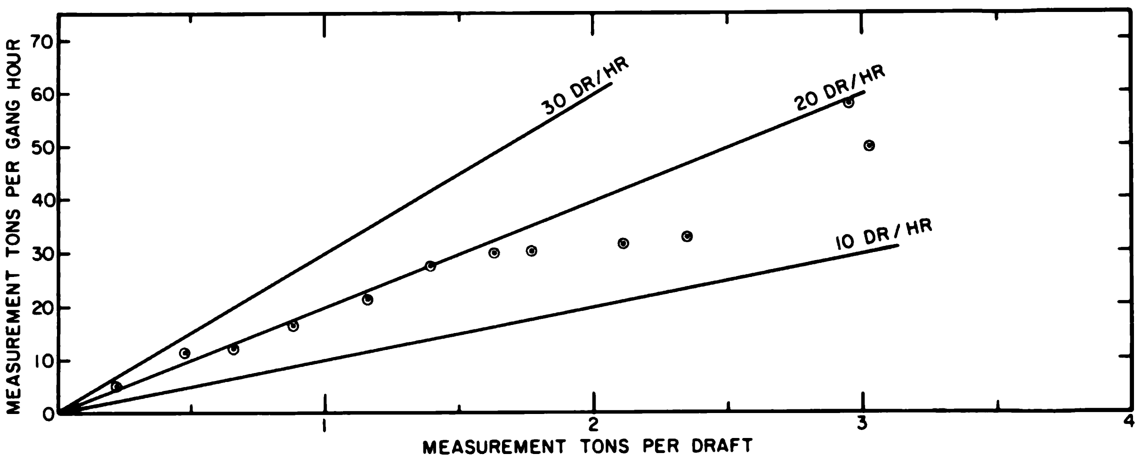


Figure 5. Gang productivity vs. draft size—miscellaneous cartons and cases. (over 50 ft^3/LT)

(a)

GENERAL CARGO

GANG PRODUCTIVITY VS. DRAFT VOLUME
(MT/GH VS. MT/DR)

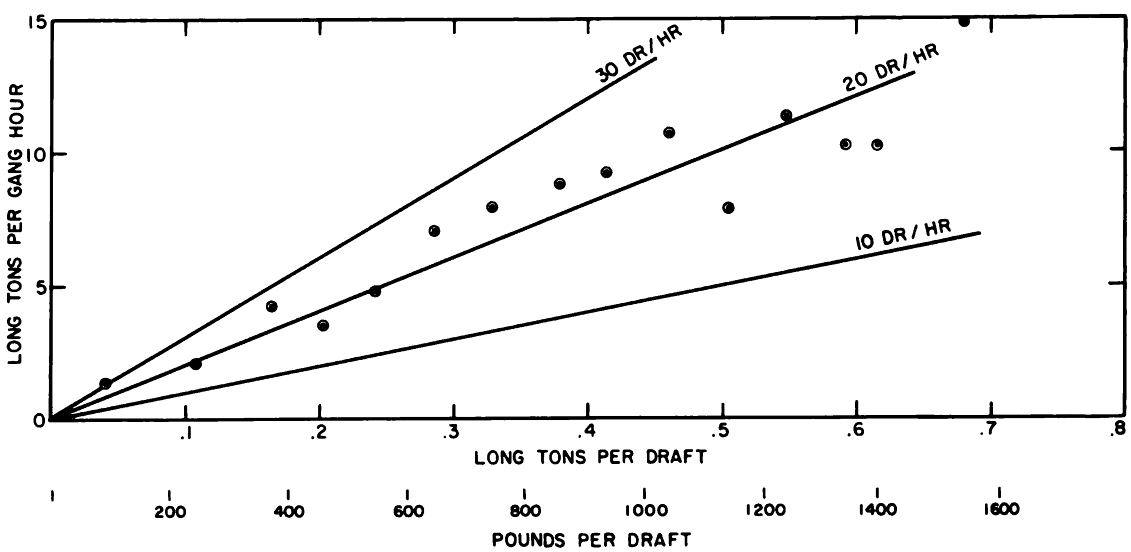


Interval Means for 1/4 M.T., or 10 cu. ft. intervals

(b)

GENERAL CARGO

GANG PRODUCTIVITY VS. DRAFT WEIGHT
(LT/GH VS. LT/DR)



Interval Means for 100 lb. intervals

NOTE : CALCULATIONS BASED ON 922 DRAFTS AT ONE TERMINAL

Figure 6. Gang productivity vs. draft size.
(weight and volume)

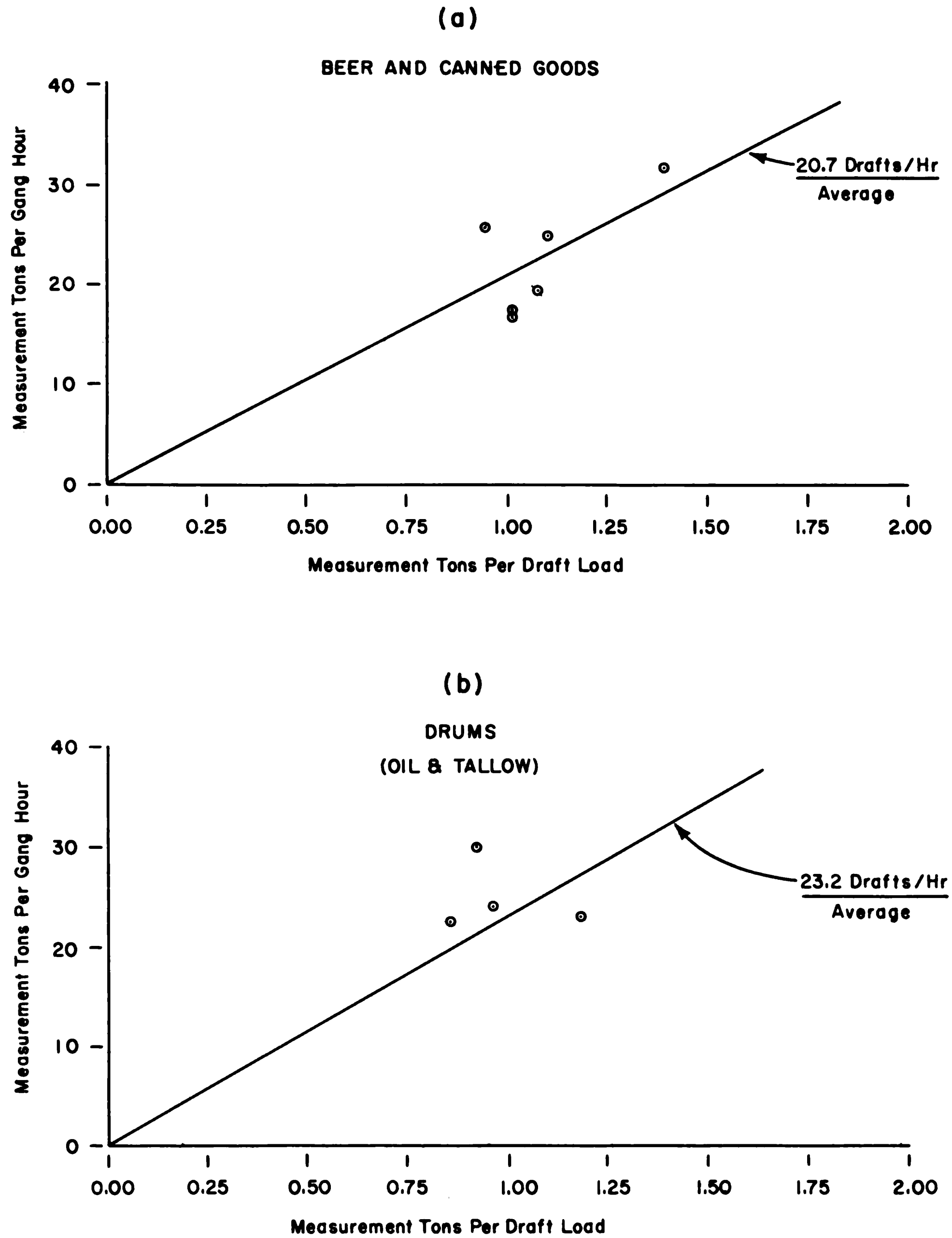


Figure 7. Comparison of productivity by company—loading.

vantage over other types in opening and closing ship and in gear rigging time. Differences in effects may exist between ships even though not identifiable in this data. The productivity rates of the longshore gangs may have been too low to tax the design limitations of some of the older ship types. At a considerably higher output of the gangs, differences between ship types may have influenced productivity.

The type of operation (predominantly hand stow) may also have covered up differences in productivity potential due to ship type. Introduction of mechanical

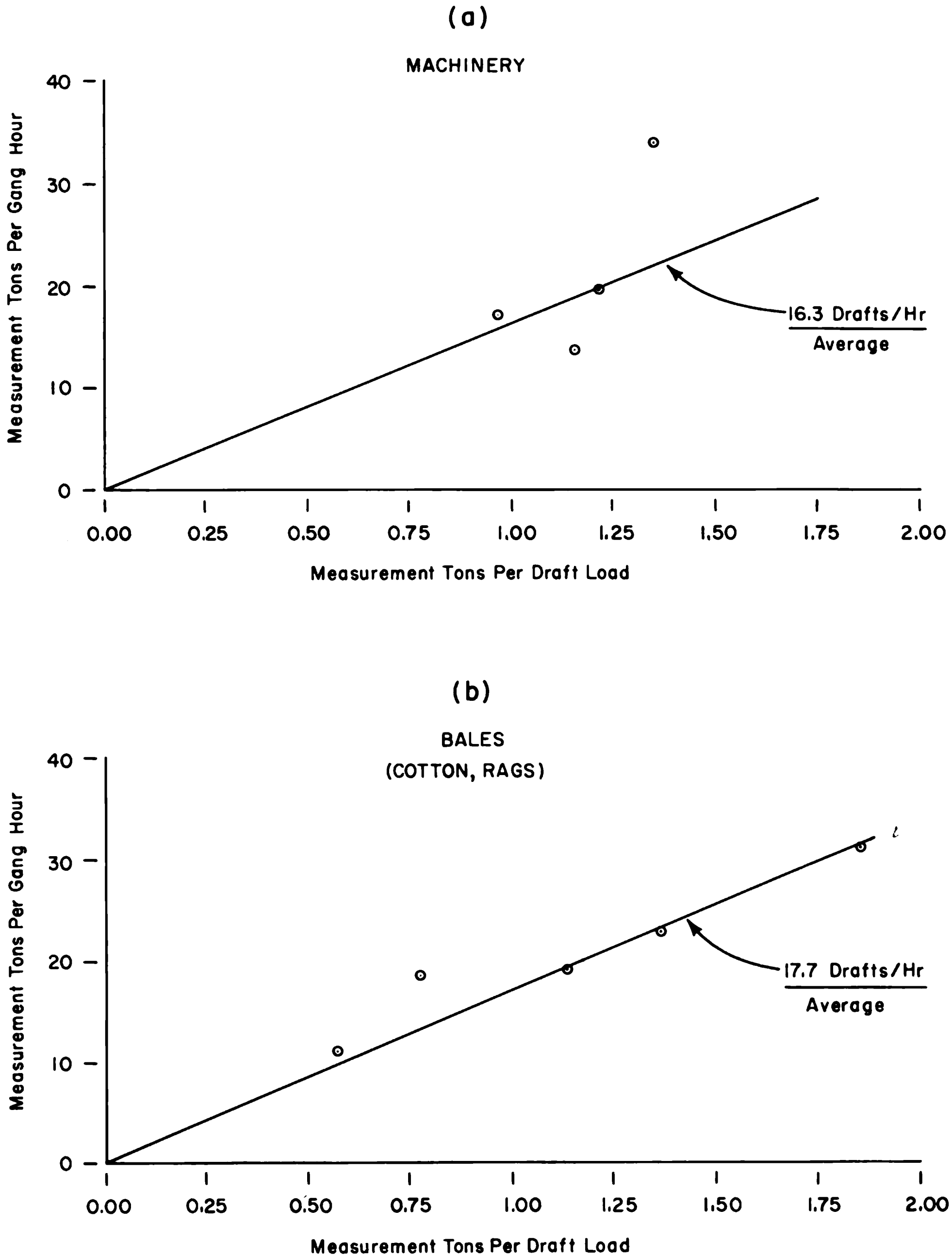


Figure 8. Comparison of productivity by company—loading.

equipment into the holds would undoubtedly have shown that ships with smooth decks and adequate hatch sizes provided more potential for improved productivity.

Many other variables were classified during the data taking phase of the study. Analysis was omitted in some cases because the results would not provide decision rules for improvement of work methods. In other cases the sample size of the deviations from standard practice was too small to make significant comparisons. Among the latter were such things as the type of equipment used in the holds and the type of equipment on the ship's hook.

The inconsistency of the productivity comparisons when related to certain variables, and the wide range

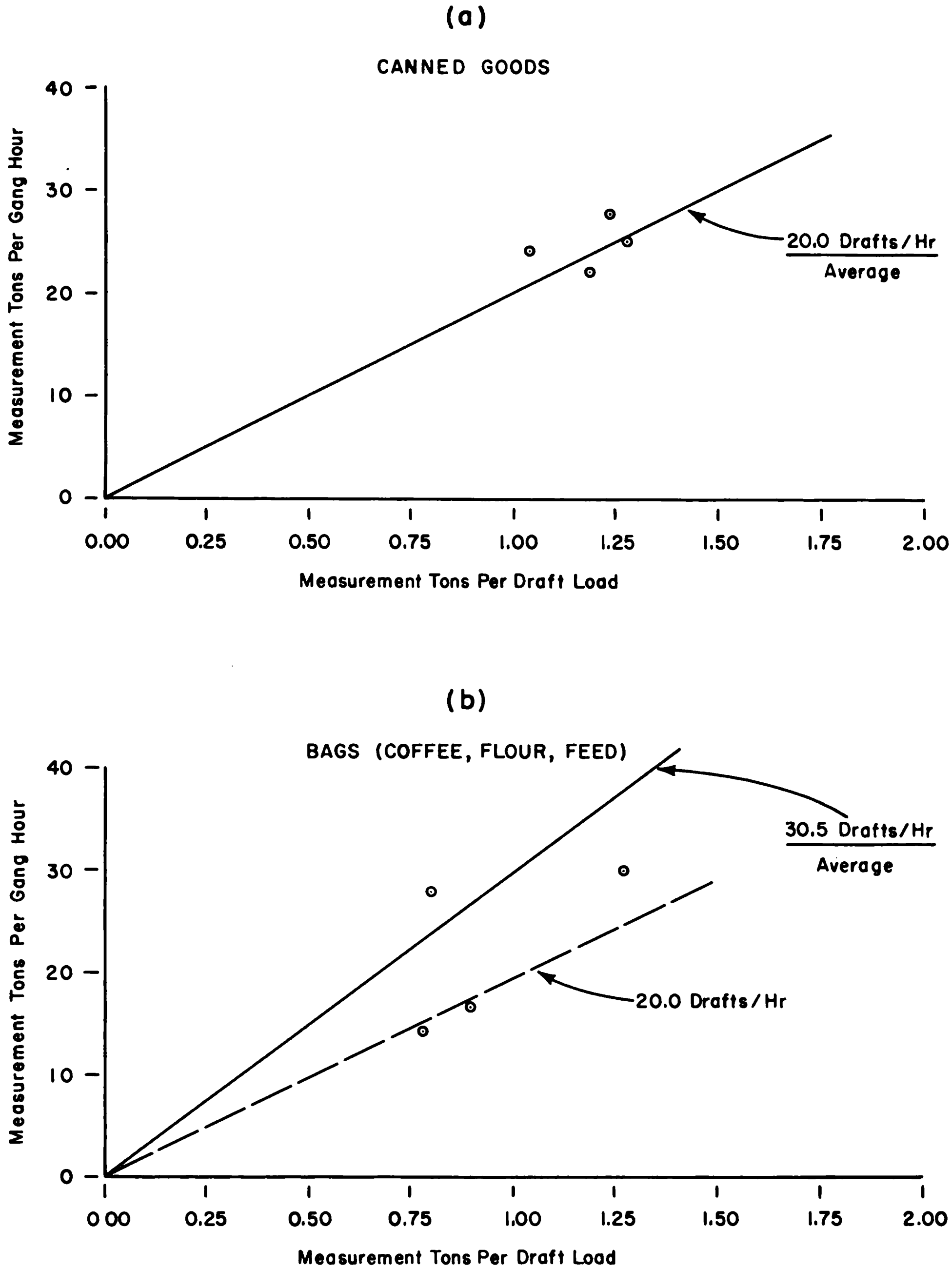


Figure 9. Comparison of productivity by company—discharging.

of the results within all of the variables, indicated a need for a detailed time analysis of the system.

COMPANY RECORD ACCURACY

The detailed time data accumulated for the operations analysis was used to evaluate the hatch logs kept by the companies. The purpose of the evaluation was to determine whether the hatch logs were suitable for accurate measurement of stevedoring productivity. The time data provided a standard, against which the hatch log accuracy could be measured.

The time required for the performance of each activity and the time spent handling each commodity, as shown on the hatch log, was compared with similar times obtained during the operations analysis. Figure

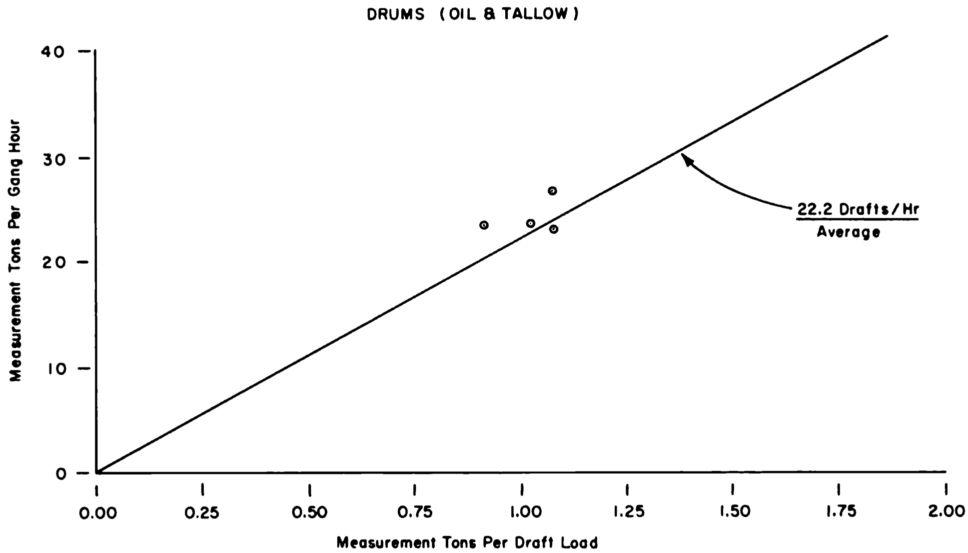


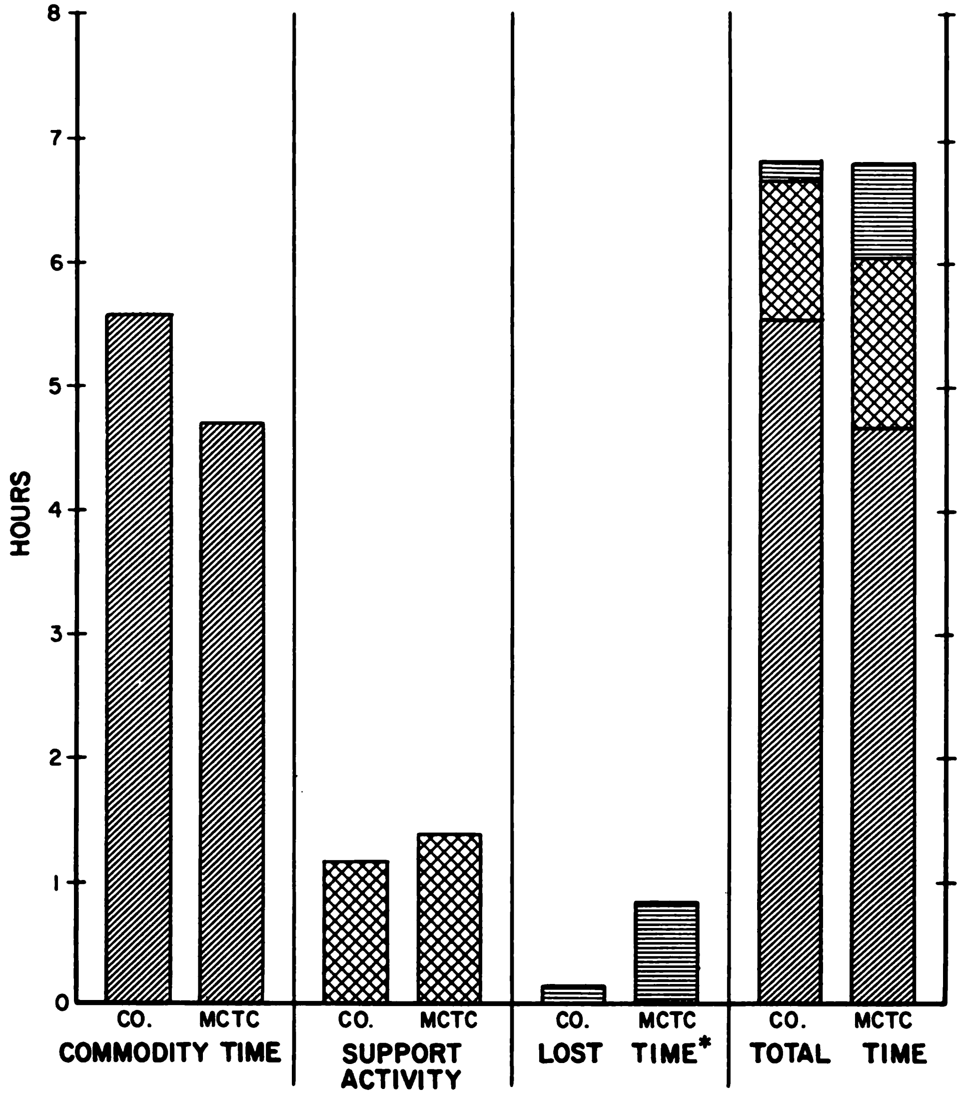
Figure 10. Comparison of productivity by company—discharging.

11 shows the average time recordings made for each of the activities by the company clerks compared to those made for the same activities by the MCTC data-takers. These averages cover 122 hatch logs.

The company records tended to overstate the time used in handling cargo. The over-all difference between the hatch logs and the MCTC time records was about 10 per cent. Some of this overstatement of commodity time resulted from a practice of rounding the time to the next 15-minute period. Almost all company hatch log times were recorded in even multiples of quarter-hours. That part of the overstatement of commodity time which is not due to rounding the entries can be accounted for by an almost complete failure to indicate late starts and early quits, lost time when changing from one activity to another, and understatement of the time used in support activity. The systematic nature of the errors is evident in Figure 12.

The time used for support activity was understated about 15 per cent on the over-all average. The inaccuracies in recording of support activity were much more random, and of greater magnitude than the recordings of commodity time. Less than one-fourth of the support activity time notations were within 15 per cent of the true time. Figure 13 shows the random nature of the errors in recording support activity times. When large errors occurred, the times recorded appeared to be hatch clerks' guesses rather than measurements.

Although there were many inaccuracies and anomalies in the recording of the logs, the over-all average times for a great number of entries were surprisingly close to the actual averages, as shown by the "Total Time" in Figure 11. This tendency for the unevenness in the logs to smooth out over a large accumulation of data indicates that they may safely be used for long term estimates of stevedoring productivity. They are not reliable for determining the productivity of any one commodity over a short period. More accurate entries in the hatch logs would greatly increase their usefulness in analysis of stevedoring work methods.



*Lost time does not include delays & lags which occured during cargo handling or support activity. Lost time occurs at the beginning and end of shift and when changing from one activity to another.

Figure 11. Comparison of company hatch logs with MCTC time data. (average time recordings—for 122 hatch logs)

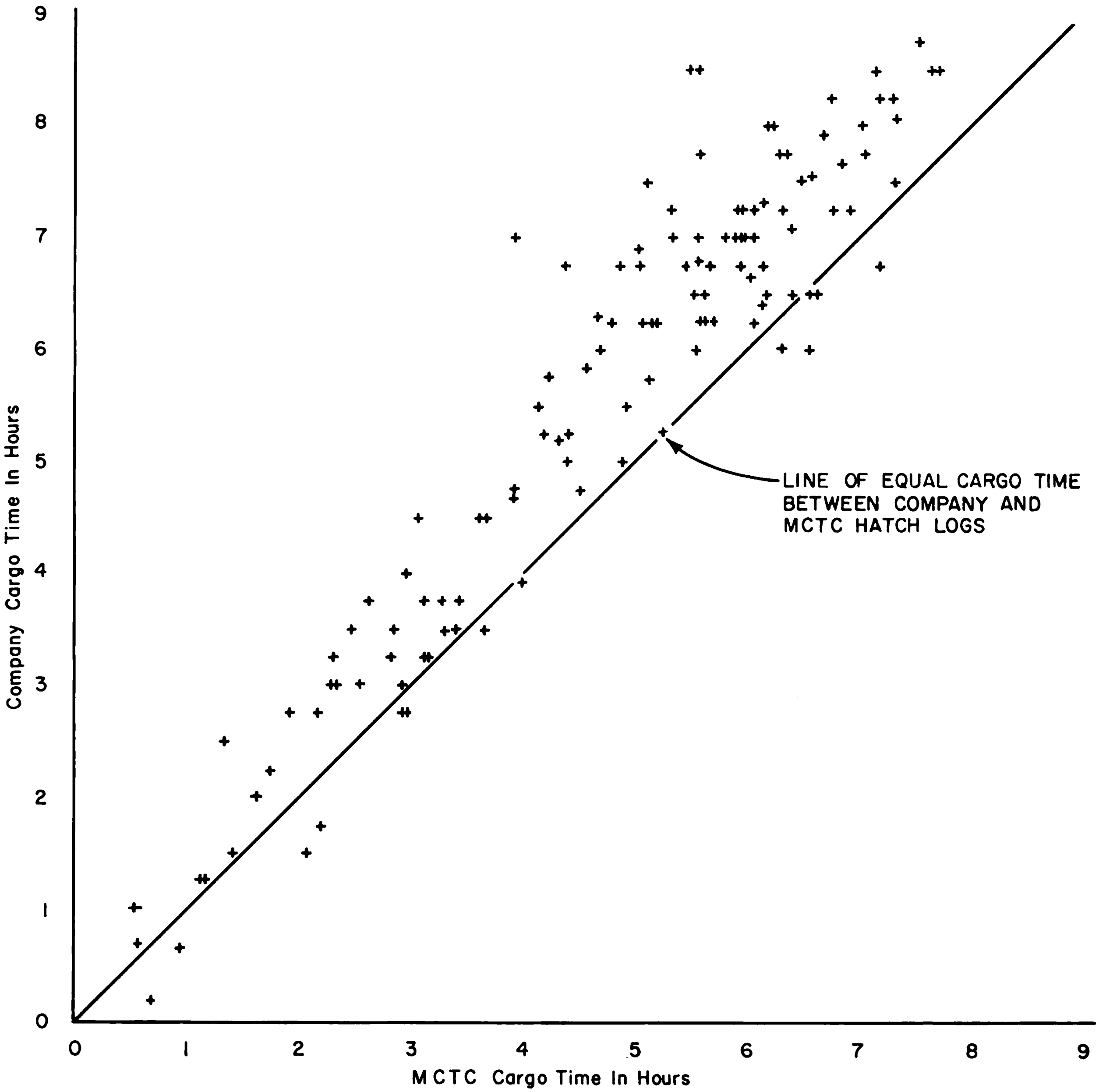


Figure 12. Comparison of company hatch logs with MCTC time records—commodity time. (122 hatch logs)

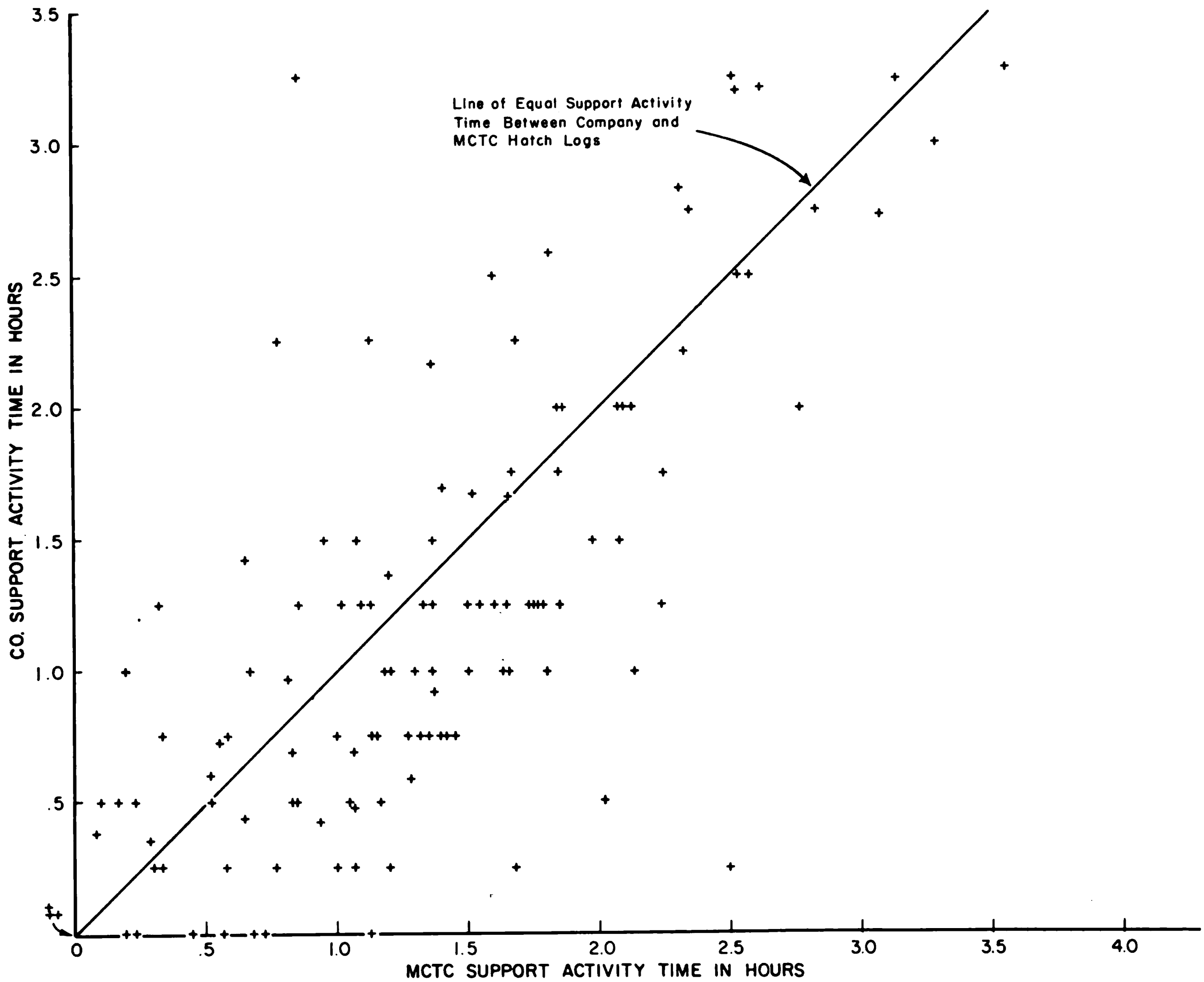


Figure 13. Comparison of company hatch logs with MCTC time records—support activity. (122 hatch logs)

Chapter 4

TIME AND ACTIVITY ANALYSIS

The detailed time study provided a means for examining the activities of the men and the ship's gear separately and in their relation to one another. Separation of the time elements helped to determine which activities could be improved and what could be done to achieve the improvement.

The time associated with handling and securing of cargo is the major portion of the longshore work shift. The following chapter emphasizes the cargo handling portion, since improvements in this portion are dependent on precise, detailed knowledge of the system. In addition to the cargo handling time, a longshore gang often spends time before and after cargo handling in rigging the booms and opening and closing hatches. The amount of time required for this operation was often more than two hours of hatch time per port visit, depending on the type of ship and equipment. This segment was studied and will be discussed briefly. However, significant time saving in opening, closing, and rigging depends on new types of equipment, more than revised methods.

A third part of the longshore work shift observed in 1958 was the unproductive time at the beginning and end of work periods. This lost time represented, on the average, about 40 minutes or 7 per cent of the nine hour shift. Reduction of this lost time is beyond the scope of this study; however, some data is presented to show the amount of time lost.

UNPRODUCTIVE TIME AT THE START AND END OF WORK PERIODS

Unproductive time at the start and end of work periods could be easily identified. Late work starts were measured from the official start of the shift, or end of lunch period, until the gang was aboard ship ready to start work. Early stops were measured from the time that the gang knocked off for lunch, or at the end of the shift, until the scheduled lunch hour or the time the shift was officially over. A gang knocking off early because of a completed hatch was not considered as stopping early. A gang arriving or leaving on schedule was recorded as zero minutes late or early and was included in the calculation of the average.

No standard starting or quitting policies were found among Bay Area terminals and shipping companies. Many companies required attendance only within the terminal at starting time and allowed a reasonable time from the gate to the ship. Some permitted five or more minutes off for wash-up before lunch or at the end of the work shift. Additional problems existed in East Bay terminals where part of the work force was carried from San Francisco in hired busses which had allowances for arrival and departure. Because of this variation in policy no effort was made to segregate authorized lost time from unauthorized late starts and early quits. Table 1 shows the unproductive time which is frequently not recorded on hatch logs.

The lost times shown in Table 1 were obtained from the commercial terminals during 1957-58 when the nine-hour shift was still the rule in the Port of San Francisco. For comparison purposes, similar data was collected from a single terminal in 1959 when the shift had been reduced to eight hours. The lost time remained approximately the same when the shift length was reduced, resulting in a higher percentage of time lost. Early stops were a cause of two and a half times greater time loss than late starts. The total time lost because of these rules and practices averaged 38 minutes per shift, regardless of the shift length.

In 1959, management began a contract conformance campaign to eliminate inefficient practices not supported by contract. The illegal portion of lost time due to late starts and early quits was considerably reduced, according to employer claims. To further this program, the portion of unproductive time permissible under the contract should be appropriately labeled in stevedoring hatch logs, and not included in commodity or support activity time as is the current practice.

TABLE 1
Summary of Late Starts and Early Knock-Offs
Summary and Average Lost Time in Minutes

	Start		Stop		Total
	Begin Shift	After Lunch	Before Lunch	Before Shift End	
1957-1958 data (9 hour shift)	(66) 281.1	(54) 476.2	(66) 881.4	(86) 1100.7	
Mean	4.3	8.8	13.4	12.8	39.3 = 7.3% of 9 hr. day 8.2% of 8 hr. day
1959 data (8 hour shift)	(77) 298.5	(81) 449.3	(81) 1063.1	(90) 1415.1	
Mean	3.9	5.5	13.1	15.7	38.2 = 8% of 8 hr. shift
All combined	(143) 579.6	(135) 925.5	(147) 1944.5	(176) 2515.8	
Mean	4.1	6.9	13.2	14.3	38.5 = 8% of 8 hr. shift

( ) Number of cases observed.

RIGGING, HATCH OPENING, AND CLOSING

The first activity of the gang after boarding ship is usually opening hatches and rigging cargo handling gear. At certain seasons of the year, the hatches may be left open between work shifts so that they need not be opened again unless the ship changes berths. During the rainy season hatch tents are often rigged as part of the opening process. The tents are left up between work shifts, except when the ship changes berths. The gangs may have to open the hatches to the lower decks during the work shift. Because of difficulties in obtaining ship opening and closing times on the same shifts in which the cargo handling data were being taken, this phase was studied separately. The results of the special study are summarized in Figure 14 and presented in more detail in Table B-1 of Appendix B. The data were classified by ship type.

Mariner Superiority

Mariner ships with mechanical hatch covers and topping lift winches required less than half the time

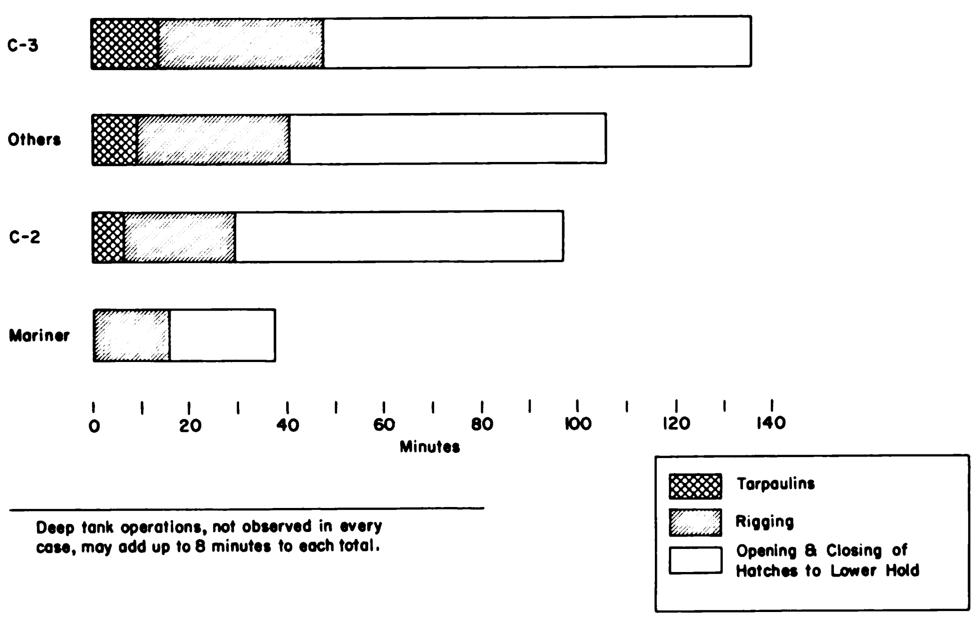


Figure 14. Summary of average hatch preparation time for various ship types. (opening and closing three levels to lower hold)

necessary for rigging, opening, and closing ships without this equipment (Figure 14). On a complete job of rigging, opening, and closing to and from the lower hold, the Mariner saved from 58 to 75 minutes. Six to 13 minutes were saved because no tarpaulins were required. The powered topping lift winches saved from 7 to 18 minutes on rigging booms and securing them. The mechanical hatch covers saved 43 to 66 minutes on initial hatch opening and final closing operations. Thus, for the Mariner, the total time saving per ship turn-around was on the order of an hour or more. Other savings accrue to the Mariner from reduced time spent rigging gear for different hook positions while loading and discharging, and from reduced time in hatch opening and closing at the beginning and end of a work shift. These Mariners were equipped with the early type mechanical hatch covers which were opened and closed with the falls. Newer, automatic hatch covers might provide further time savings.

Rain Tents

Rigging rain tents seemed unnecessarily clumsy by modern standards. This is an area where ingenuity of design could make improvements of 30 to 90 minutes per rainy shift. The tent when rigged provides only partial protection to the men and cargo. The direct labor cost of tent handling for a single port call can easily exceed $500. In the port of San Francisco with its relatively short rainy season, there is an annual labor bill for handling rain tents in excess of one-half million dollars. Consideration also might be given to equipping terminal facilities with quickly adjustable shelters.

CARGO TIME

This portion of longshore work time requires coordination between equipment on the dock, the hook moving cargo between dock and hold, and the gang handling cargo in the hold. Delays in one part are usually relayed to the others. The performance of each part must balance that of the others. In the following section delays and activities of hook and hold work segments are discussed separately, although a change eliminating delays or accelerating the performance of one is only useful to the extent the performance of the other can be made to match it.

Pier Delays

The hook data shows that the hook was delayed, on the average, only 4 or 5 per cent of the time at the apron by causes attributable to pier delays. This time loss is insignificant compared to that observed elsewhere in hook and hold cycles, although it might not remain so if the others are improved.

Hook Delays

Figure 15 shows the hook delays and activity periods while loading and discharging. The relatively small hook delay at the apron has already been pointed out. This small delay has little effect on the rest of the system since the hook is normally working only 48 per cent of the time in loading and 60 per cent of the time in discharge. Figure 16 presents hook work and wait percentages by commodity group. This figure shows that, for loading, most commodities have a percentage of delay time about the same as the over-all average in Figure 15. For discharging, the two different types of bagged commodities provided the most significant departures from the over-all average.

Wait for Hold

The "load" diagram in Figure 15 shows that the time the hook is delayed during transit is greater than the time which it moves during transit. The "transit delay" time is mostly time that the hook is waiting for the hold gang, so that it can deliver cargo. The large combined percentage of hook-wait-for-hold time (50 per cent for loading and 35 per cent for discharging) is an indication that the capability of the hook far exceeds the performance of the hold. In San Francisco, improvements in the hook cycle are not likely to increase system productivity, except where the hold cycle is also accelerated. An exception is possible in certain situations where there is interaction between the two cycles. Interaction is discussed later in this chapter.

Hook Activity Time

While it has been shown that the hook was apparently not the system bottleneck, analysis of hook performance is still desirable. Improvements in hold performance could easily press hook performance to the limit of its capability. Figure 17 compares hook cycle segments by commodity. Average draft sizes, in measurement tons and in short tons, are also given for each commodity. With the exception of vans, all hook work cycles lie between 1.2 and 2 minutes, with the majority in the vicinity of 1.5 minutes. This places hook work cycle observations in the Port of San

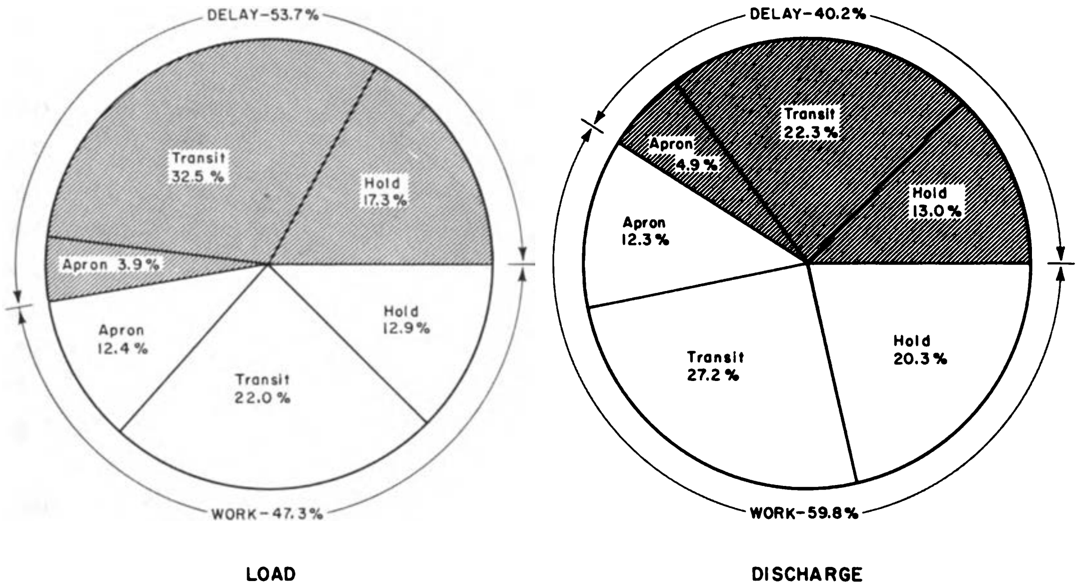


Figure 15. Analysis of load and discharge time—hook.

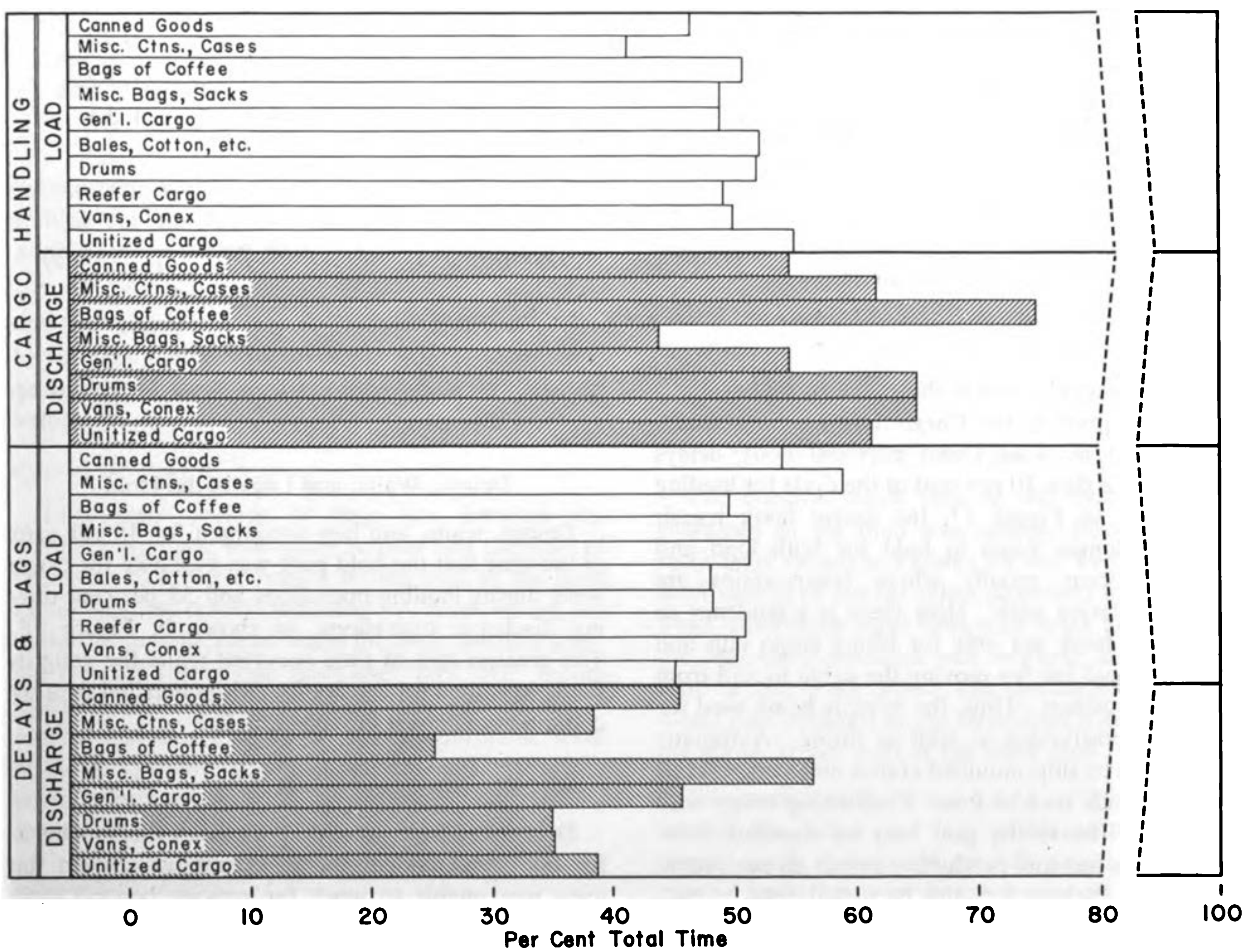


Figure 16. Systems time analysis for hook cycle.

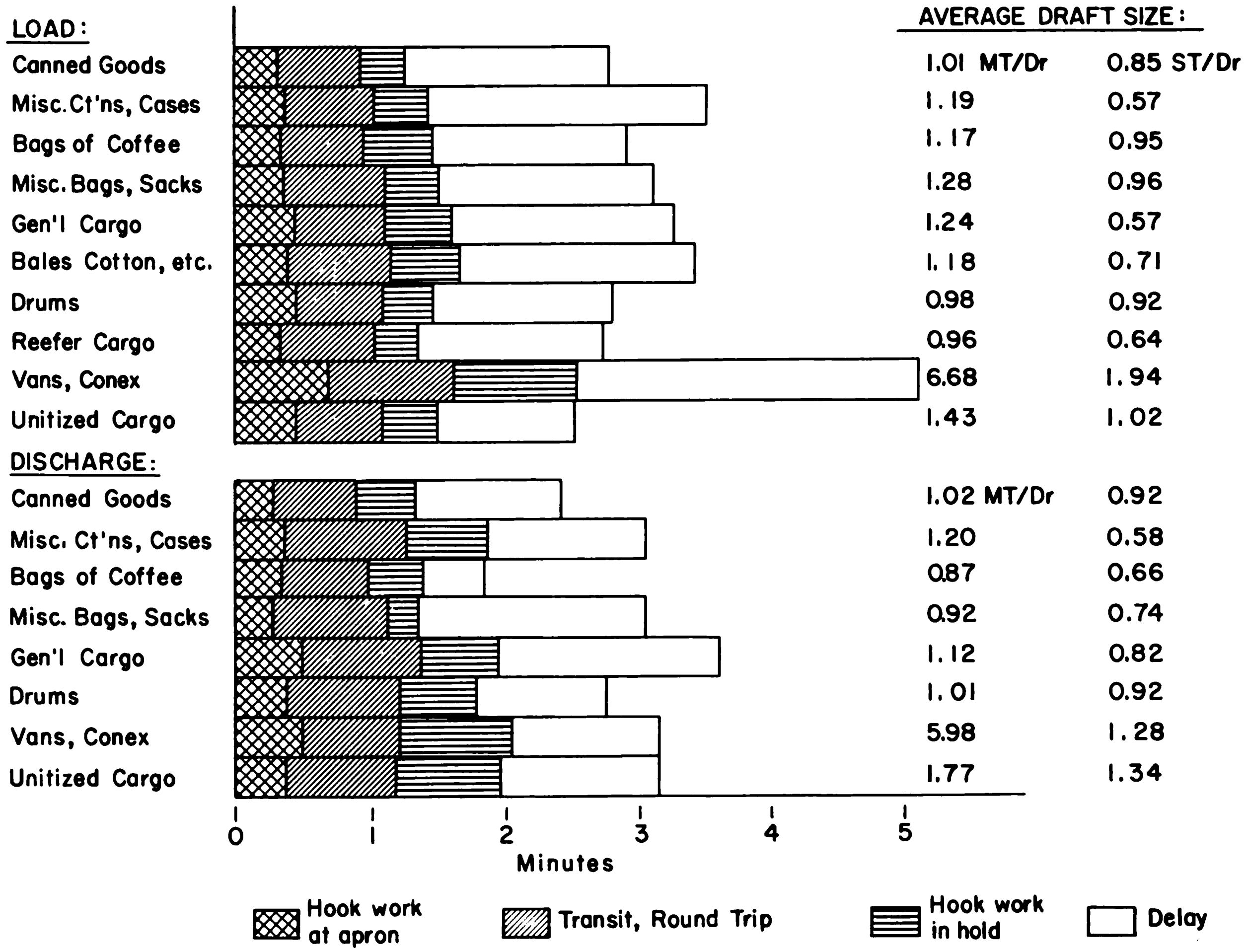


Figure 17. Average hook cycle time by commodity group.

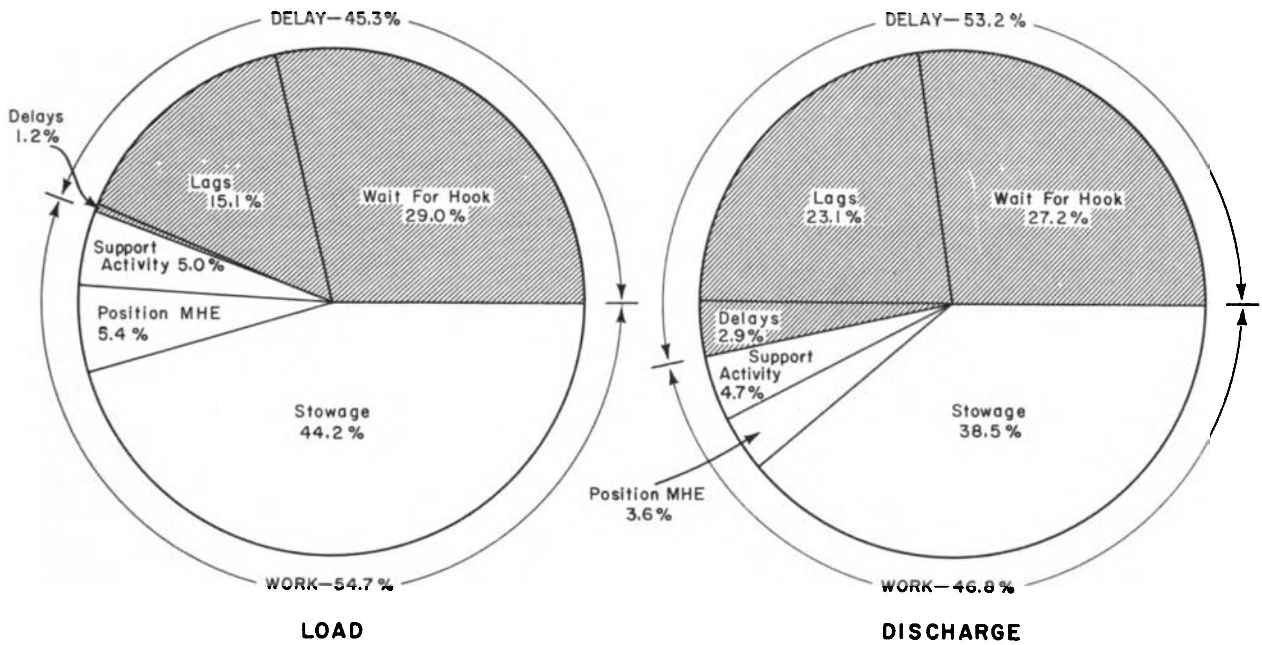
Francisco precisely within the range of observations at all other ports in the *Cargo Ship Loading Study*. However, at no East Coast port did hook delays average more than 30 per cent of the cycle for loading operations. In Figure 17, the longer hook transit times and longer times in hold for both load and discharge occur usually where commodities are handled in larger units. Here there is a tendency to employ the hook not only for lifting cargo into and out of the hold but for moving the cargo to and from its stowed position. Thus, the hook is being used for horizontal positioning as well as lifting. Automatic topping-lifts or ship-mounted cranes may perform this operation with no lost time. Positioning cargo with conventional burtoning gear may be wasteful, however. It may be more productive to rely on equipment in the hold, such as fork lifts or pallet jacks, to take care of this horizontal transfer problem rather than on the hook. Also, it is harder to engage or disengage the sling or pallet bars when the load is spotted up against other cargo.

Delays, Waits, and Lags in the Hold

Delays, waits, and lags accounted for 45 per cent of the time that the hold gang was available for cargo work during loading operations and 53 per cent during discharge operations, as shown in Figure 18. The greatest loss of time occurred while the gang in the hold waited for the hook. (More detailed data by commodity is given in Appendix B.)

Causes of Delays and Waits

Delays and waits were 30 per cent of the hold cycle for both load and discharge operations. When the gang was unable to work for reasons beyond their control, the time loss was recorded as "delay" or "wait." Examples of hold delays were equipment



Note:

For loading, one-half of the hold gang is still resting in 4-on 4-off practice. In discharging one-third of the hold gang is still resting in 4-on 2-off practice.

Figure 18. Analysis of load and discharge time—hold.

breakdown, waiting for supervisory decision, and waiting for the hook to deliver cargo ("wait for hook").

Lack of communications between the hold gang and the men on the pier or on deck also contributed to the delay time. Shouted instructions were often drowned out by the noise of winches or chipping hammers.

Causes of Lags.

Lags were periods of time lost between the completion of one hold gang activity and the start of the next. Lags were caused by the men in the gang rather than by outside influence. A common lag occurred in loading cargo when the men finished stowing the cargo from one draft and "took five" before signalling the winch driver that they were ready to receive the next load. For analysis purposes, most of the delays were combined with the lags. "Wait for hook," because of its importance, was treated separately.

Commodity Effects

Figure 19 shows the percentage of time taken by the segments of the hold cycle for each of the principal commodity groups covered by the study. While variation by commodity is to be expected, there is a remarkable degree of consistency among the commodity groups. Perhaps the most noticeable difference one can detect is that, for most commodities, the percentage of work time is larger for loading than for discharge.

4-On, 4-Off Practice

The effective work time of the individual longshoremen in the hold was reduced below the gang work level shown in Figures 18 and 19 by the 4-on, 4-off system of worker relief, described in Chapter 1. Thus, combining relief time with delay and lag time, the individual holdman was working about 27 per cent of the work shift. On discharge operations, 4-on, 2-off resulted in the individual holdman working about 31 per cent of the work shift.

Elimination of the 4-on, 4-off practice and reduction of the delays and lags which occurred in the regular work cycle could provide a potential for increased work time, and, hence, increased productivity with no capital outlay for new equipment. This potential will be discussed with other changes in

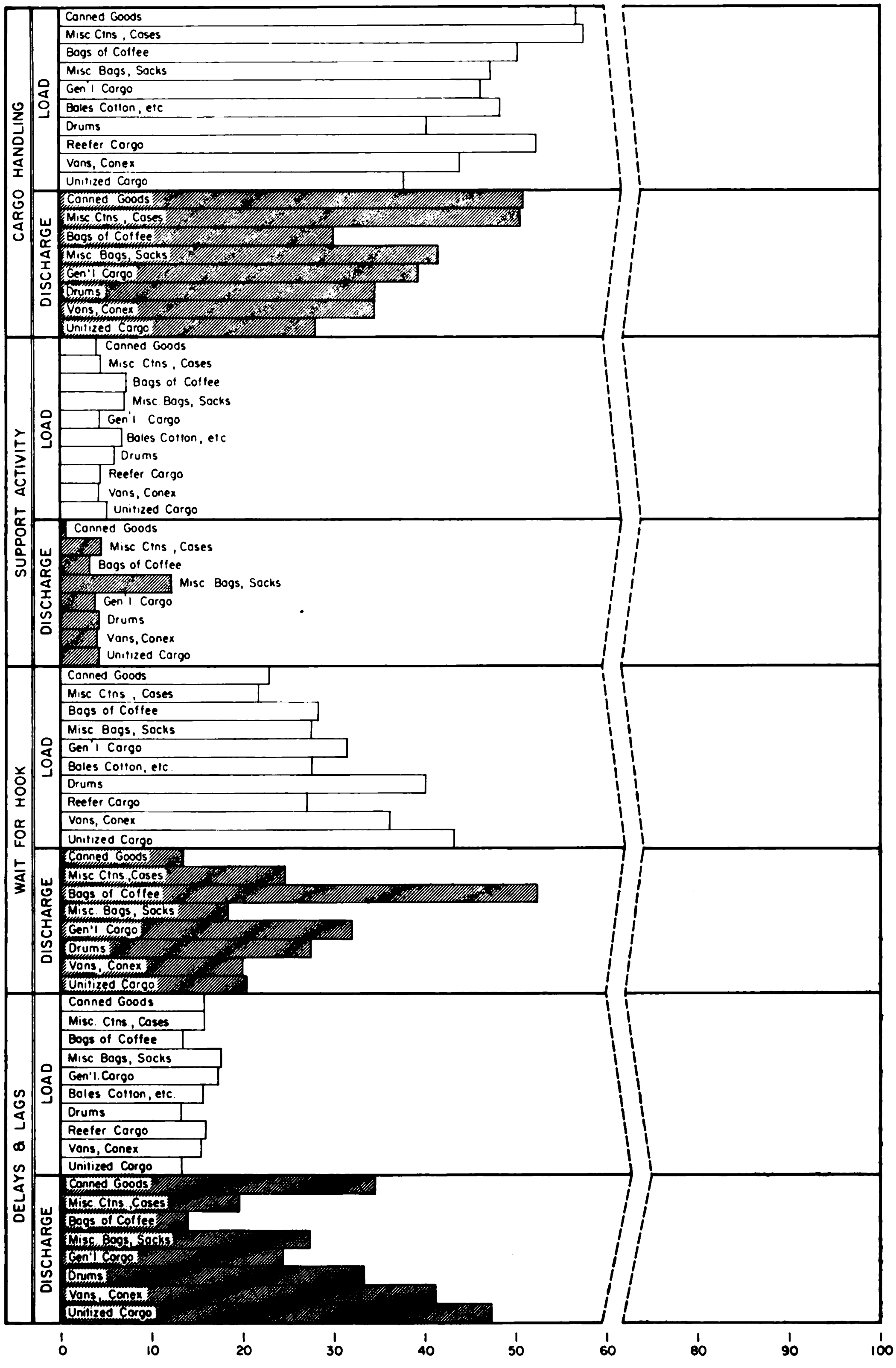


Figure 19. Systems time analysis for hold cycle.

Chapter 5. Efforts at reduction in lost time must take into account the physical demands of longshoring work. The workers' rest must be maintained at a fairly high level as long as the task remains a predominantly manual one. Forty per cent of the time in the hold was taken for rest during the smoothest, most productive manual operations observed at many other ports in the course of *Cargo Ship Loading Study*.

Hold Activity Time

In addition to examining the potential for gains through reduction of delay and lag time, it is important to investigate the possibilities for improving operations during activity, or work time. Work time was divided into two major categories for analysis. They were cargo handling and support activity, both of which were analyzed in relation to specific commodity groups. The percentage of total hold time needed for cargo handling is 50 per cent for loading and 42 per cent for discharging. Support activity claims only about 5 per cent of hold time in both loading and discharging operations(Figure 18).

Cargo Handling

Cargo handling performed by the hold gang comprised servicing the hook, transporting cargo to or from the point of stowage, and stowing or breaking out cargo. Except when handling large units, the only equipment observed in use was stevedore wagons or electric-powered jitneys with no powered lifting capability. Cargo was transferred to and from pallets on wagons or jitneys by hand, a piece at a time. Large units and strapped pallets were sometimes handled by fork lifts.

Figure 20 shows the average size of the segments in the hold cycle. The average hold cycle times in Figure 20 are twice as long as the corresponding hook cycle times in Figure 17 because the hold gang is generally split into two sections supplied alternately by the hook. "Preposit" time refers to time spent in loading operations positioning a loaded pallet near the stowage position. "Reposit" time refers to time spent returning the empty wagon or jitney to a position where it can receive a load from the hook. For discharge, the same terms apply except the direction of movement is reversed. The loaded pallet goes from stowage position to hook on "preposit" and the empty pallet is returned from hook to stowage position on "reposit." Neither of these time elements is large. The major time segment is that required for the two holdmen working on a side to stow the cargo in loading or stack it on the pallet in discharging. The combined hold work cycle times for loading, including all shaded portions in Figure 20, are generally a minute or so longer than equivalent operations observed at most East Coast ports in the *Cargo Ship Loading Study*. This is to be expected because in

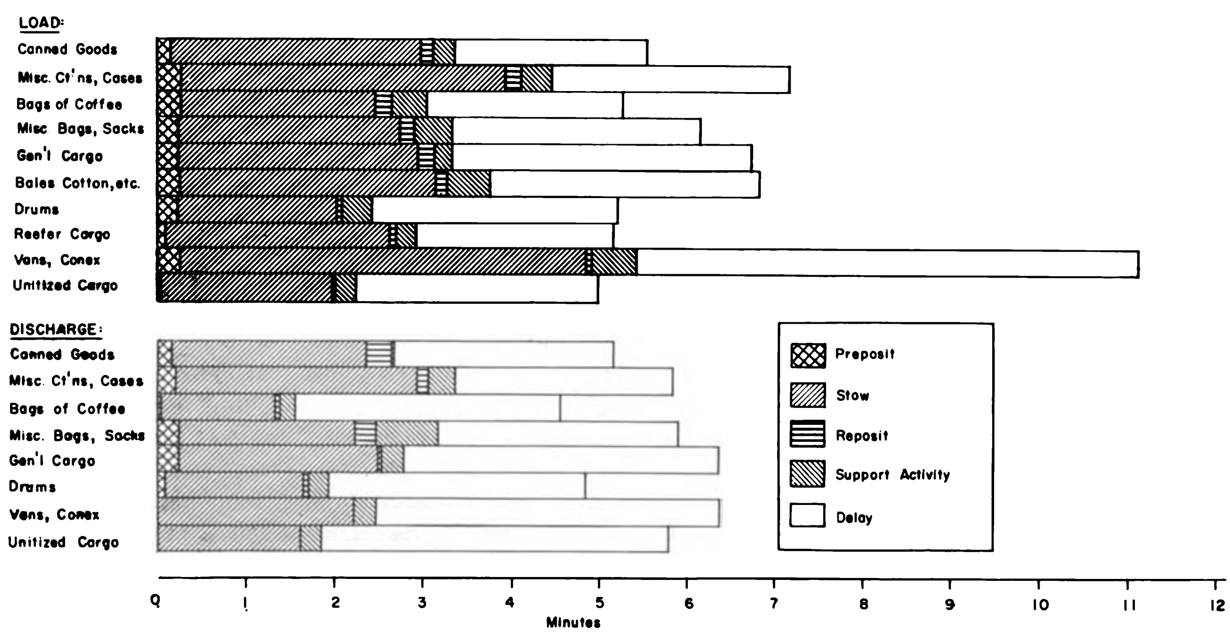


Figure 20. Average hold cycle time by commodity group.

East Coast operations in the hold, more than twice as many men were generally available to handle the loads. Table 2 shows, however, that in San Francisco the productivity per man while working is essentially equivalent to that measured in other ports. These figures in Table 2 were obtained by dividing the

TABLE 2
Productivity per Man While Stowing Cargo
San Francisco vs. East Coast Ports

	San Francisco MT/MH	East Coast Ports * MT/MH
Cartons and boxes	6.2	6.9
Bags	13.2	10.8
Drums	14.0	15.6
Bales	10.7	13.9

* Taken from Table 12, *Cargo Ship Loading Study* (NAS-NRC Pub. 474).

average amount of cargo per draft by the average time spent in handling and stowing a draft and also by the number of men doing the job. In San Francisco, only the four men "on" were considered to be doing the job.

Suggestions for Improving Cargo Handling in Ship's Holds

Two possibilities for improving work output and making the task less arduous are: (1) introduction of powered devices with lift capability for moving and stowing cargo, and (2) reassignment of work tasks to provide the best team effort. Methods devised to improve cargo handling must be sufficiently flexible to cope with the wide range of conditions encountered aboard a cargo ship.

Powered Equipment

Use of equipment such as fork-lifts for transporting and stowing cargo in the hold, where space permits, promises improvement in the stowage rate of cargo. At the same time, the fork lift permits a greater amount of block stowage, thereby reducing dunnaging requirements. Pallet jacks often can be a promising substitute where space restrictions prevent the operation of fork lifts. There are other advantages in using powered mechanical equipment to move and lift cargo. Men can perform dunnaging and other miscellaneous duties while stowage work is going on rather than push wagons. Use of powered equipment may reduce hazards of toppling loads, thereby permitting larger loads. There would also be less exposure to strain injuries from pushing wagons. The powered equipment, being equipped with brakes, would provide greater control under a wide range of shipboard conditions. The major disadvantage is carbon monoxide and other exhaust fumes. This disadvantage can be eliminated by proper use of blowers, or by change of equipment. Fork-lift equipment observed on the San Francisco waterfront in 1958 was gasoline powered.

Task Assignments

Rearrangement of the holdmen's duties can provide smoother operation by preventing interference of one work element with another. An instance of such rearrangement would be locating two men in the square to receive cargo. This change permits establishment of a cargo reservoir in loading operations so that cargo is always available to a stowage team when it is needed. Since the stowage team would then not have to wait for the hook, the mutual dependence of the hook and the hold gang would be reduced.

Gang Size

Manpower productivity in manhandling cargo in the hold varies greatly for different situations with different types of commodities. Thus, in some cases more men than the standard eight-man hold gang might be effective, while in others, fewer would be required. The number of men needed is influenced by the type of cargo, the type of equipment used, and by the character of the space in which the work is being done.

Support Activity

Support activity consists of miscellaneous work functions such as dunnaging, housekeeping, and gear changing. Support activities of less than 10-minute duration are treated as part of the hold cycle in the analysis. Figure 18 shows that these activities took about 5 per cent of hold cycle time for both loading and discharging operations. Support activities requiring a break of 10 minutes or more were treated separately and excluded from the hold cycle analysis. These larger breaks represented 7 per cent of the operating time for loading and 12 per cent for discharging. This essential work cannot be eliminated, but improved methods may reduce the time requirements materially. Dunnaging time might be reduced by changing work patterns, so that dunnaging can be performed simultaneously with the cargo stowage. Block stowing, rather than tier stowing, will reduce the amount of dunnaging required. New types of dunnage, such as plywood or portable dunnage, might also reduce the time requirements for this task. The use of more modern dunnaging materials might also reduce the time required for housekeeping duties. Much of the trash which accumulates in the ship is scraps of dunnaging lumber and paper used for separating cargo lots.

Another time-consuming support activity was the building of "legs" or work platforms from which loads could be moved or placed on top of other cargo. These work platforms were usually jury rigged by placing piles of pallets together. The pallets were covered with plywood "walking boards" to provide a smooth surface for rolling a stevedore wagon. On occasion, 30 minutes or more would be consumed in rigging a platform. Another disadvantage to these temporary platforms, besides the time lost in rigging them, is their inherent instability and uneven work surface when they are placed on an uneven deck or floor. Lightweight, portable stages with adjustable leg lengths would probably reduce set-up time and provide a safer, more stable work platform. Increased stability and safety could also have a favorable effect on stowage productivity in the hold, thereby providing additional savings.

Hook and Hold Interaction

The time that the hold gang waited for the hook to deliver cargo was of such importance that special attention was given to it in the analysis. Over one-fourth of the time that the men were available for work was consumed in waiting for work to do. A sample of 377 drafts taken at random showed that 38 per cent of the time the gang was waiting for cargo, the hook was also waiting to deliver cargo. This situation resulted from two causes. The hook often waited for one of the teams to finish working so that a load could be delivered. When the gang finished its activity, the men took a short rest before signaling the hook that they were ready for the next load. This appears in the data as simultaneous waiting. Simultaneous waits were also recorded when the team on one side of the hatch waited for cargo while the hook waited to deliver a load to the team on the other side of the hatch. This condition arose out of the custom of delivering alternate drafts to each team, regardless of the activities of the teams. The hook did not enter the hatch until the team which was to receive the load signaled that they were ready for it. This lengthened the hold gang delay slightly while the men waited for the hook to get in motion and deliver the load from its waiting position over the deck. Reduction of the time lost to this mutual interference between the hook and the hold gang could save up to one gang hour per working day. This saving can be accomplished by revising the system: (1) so that the hook delivers its load or picks it up in the hold without waiting for holdmen handling cargo elsewhere to do the hook-on or hook-off task, and (2) so that alternate port and starboard deliveries by the hook are not required.

SUMMARY

In 1958-59 there was much room for improvement in the cargo handling system used in the San Francisco Bay Area. To achieve the improvement, changes were required in work methods, procedures, use of mechanical equipment, and training of supervisors and workers.

To improve productivity it is specifically suggested that the following be done:

1. Use fork lifts or other mechanical equipment aboard ship whenever the cargo, space, and operating conditions permit.
2. Stow cargo on pallets whenever possible.
3. Organize manpower to supplement the work of machines, when they are used.
4. Organize the work of the holdmen to eliminate interference with the hook and between the port and starboard teams.
5. Adjust the size of the gang to fit the task and space requirements.
6. Use modern dunnaging and shoring techniques and materials such as plywood, pneumatic dunnage, built-in shoring posts, cargo nets, and tie-downs spaced on a modular grid.
7. Perform support activity, such as dunnaging, simultaneously with cargo handling tasks, whenever manpower is available, by rearranging work patterns.
8. Use portable stages, with suitable safety features, rather than pallets for building legs.

9. Increase training of supervisors and equipment operators so that more equipment and changed work patterns can be used effectively.

10. Improve supervisory control over lost time due to delays and lags during the work cycle.

11. Provide positive means of communication between the holdmen, winch driver, and dock workers.

These proposals were tested aboard ship during normal operations. The tests are reported in Part IV of the *San Francisco Port Study*, "Test Results of Modified Cargo Handling Methods."

Chapter 5

SHIP DESIGN CONSIDERATIONS

Changes in ship design which might improve cargo handling became evident during the Port Study. Some of these changes have been made in ships recently launched and in ships now in the design stage. The large savings possible through improved cargo handling methods emphasize the importance of designing ships specifically for the cargo handling function. No efforts are made to quantify costs or savings, since they are dependent upon the use to which the ship will be put and the trade in which it will operate.

HULL

Cargo Space Location

Cargo stowage is complicated by the convention of placing the engines amidships and relegating the cargo to less desirable areas at the bow and stern. Where other conditions permit, reserving the maximum midbody for cargo stowage would simplify cargo handling. The shape of the resulting compartments would increase the benefits of unitized stow by eliminating much lost space. Larger clear areas in the hold would permit better utilization of mechanical equipment. Although present hull designs preclude construction of a ship with all rectangular cargo compartments, the ideal cargo handling configuration should be given great weight in arriving at the ship design.

Compartments

The wide variety of shapes and sizes of cargo compartments on conventional freighters complicates the management of manpower and equipment in the stevedoring process. More nearly rectangular compartments constructed to module standards and compatible with standards for cargo unitization would simplify the process and provide protection for the cargo while minimizing lost space. In addition to being rectangular, all cargo spaces should be of sufficient size to permit the operation of mechanical equipment in the compartment.

Deep tanks are used more often for general cargo than for bulk shipments, by many companies. Their limited access and restricted working space ill suit them for cargo handling. The question arises whether deep tanks are economically justified under these conditions. The additional cost of loading general cargo into deep tanks, over what the cost would be if there were no deep tanks, may more than offset the revenue from bulk cargo which determined the need for deep tanks. In this situation, it may be worthwhile to eliminate the bulk trade and create a more suitable general cargo hatch in the area. The cost differential for using deep tanks as general cargo holds should also be considered in relation to the cost of carrying bulk in containers.

Decks and Obstructions

The use of mechanical materials handling equipment on board ship is seriously restricted by such obstacles as raised hatch coamings, pillars, ventilation ducts, deep tank and manhole covers, and board and strongback hatch covers. Use of such equipment requires that all access hatch covers below the main deck be flush with the surrounding deck, with clearances small enough so that the small wheels of a fork lift or pallet jack will have no difficulty in passing over the joints. It is desirable that the surfaces of all decks on which mechanical equipment is to be used be treated to prevent wheel slippage, for safety and efficiency. Load bearing characteristics of all decks and hatch covers should be suitable to withstand the wheel loads imposed by mechanical equipment when loaded to capacity. If this specification imposes undue hardship on the ship designer, effort should be made to solve the problem through redesign of the materials handling equipment. Switching from solid to pneumatic tires on a fork lift, for instance, may greatly decrease the amount of steel which would have to be used in the deck.

The wooden gratings normally found in reefer compartments are unsuitable for carrying the loads imposed by mechanical cargo handling equipment. Another type of surface that will support the required loads is needed. The surface can be designed to provide ventilation, or this requirement can be accomplished by palletizing. The raised sill of wedge-type reefer doors must be bridged with a portable device for vehicle access on present ships. New types of gaskets should make it possible to seal a reefer door without resorting to the raised sill.

Coaming girders proved to be a formidable obstruction to the use of fork lifts in the 'tween deck areas. If the stress requirements of the hatch area can be met in some manner which will reduce the web of the girder, the efficiency of the space will be greatly enhanced.

Hatch Covers

The time saved in opening and closing a ship equipped with mechanical hatch covers, compared to one with board and strongback or pontoon hatch covers, is impressive. Average time savings from 58 to 92 minutes were recorded for the opening and closing of Mariners [1] over typical C-3's. This one and one-half gang hours per hatch multiplied by the average number of hatches worked per ship adds up to impressive annual savings in direct labor. Even greater savings in time can be anticipated on ships with completely automatic hatches. The mechanical and automatic hatch covers considerably reduce the exposure of the workmen to a hazardous operation. Conversion to mechanical hatch covers may be economical on existing ships with most of their service life ahead of them.

Winch Operator's Station

The winch operator's station on most U. S. ships is located on the centerline of the ship, on the main deck, and immediately adjacent to the hatch. From this position the operator has a reasonably good view of the hook while it is over the deck or in the hold. He is usually completely unable to see the hook from the deck line down to the apron. While the hook is operating in the blind area, a signalman must be used to relay information needed for safe operation of the hook. This problem is aggravated when the deck cargo is loaded higher than the winch operator's eye level.

A winch operator's station elevated above the deck far enough to provide a view of the hook through its full range of travel would increase the safety and efficiency of the operation, as well as eliminate the need for the signalman. Some thought should be given to the value of placing the winch operator's station at the opposite end of the hatch from the gear it controls, so the winch operator could watch the gang further back into the wings than is now possible. Making both sets of winches at a hatch controllable from either set of controls, at the operator's option, would increase the flexibility of the gear.

Very few ships are equipped with seats or weather shelters for the winch driver. As a result, many man-hours are spent in jury-rigging wind breaks, seats, and rain shelters. Often the time spent in providing these rudimentary comforts delays the activities of the rest of the gang with a consequent reduction in productive time. Permanent seats and weather shelters provided for the winch driver could eliminate these delays.

CARGO GEAR

It was not possible to evaluate the cargo gear by the results of the operations analysis as the system was almost always working well below the capacity of the cargo hook, except in the movement of large unit loads. *The Cargo Ship Loading Study,* NAS Publication 474, reports on a cargo handling system which was mainly hook limited and presents recommendations for improving hook performance.

The frequent doubling up required for lifting of large unit loads and fork lift trucks indicated that cargo gear of greater capacity could save time in rigging gear. This saving will increase as the trend toward unit loading of cargo continues, and as more equipment is used in the hold.

ACCESSORIES

Electric Outlets

There is an increasing need for electric outlets in all parts of the ship, particularly below decks in the cargo areas. Electric power is needed for portable lights, auxiliary ventilation blowers, and materials handling devices, as well as for powered tools for the carpenters and maintenance personnel.

Ventilation

The Bureau of Labor Standards regulations on longshore health and safety require that, when internal combustion engines are used in the ship's cargo holds, sufficient ventilation must be provided by the ship's ventilation system or by portable blowers to keep the

[1] "Mariner" refers to the original Mariner Class built from 1952-54.

carbon monoxide concentrations below one hundred parts per million. In most cases, two 500 cfm blowers will provide enough circulation to prevent carbon monoxide accumulations in excess of these standards when two fork lifts in reasonably good condition are being used. Other products of combustion may accumulate in sufficient quantities to cause unpleasant odors or to increase the humidity in the work space. Such accumulations cause no physiological damage, but can have a depressing effect on the workers. The 500 cfm blowers do little to eliminate the odors or overcome the effects of high temperature or humidity. Physiological studies of longshore work made by the University of California at Los Angeles report that high temperatures and high humidity in the hold materially reduce the capacity of the cargo handlers to perform their work.[2]

To provide a wholesome working environment, it is desirable to have a fresh air circulating system with a capacity of 4,000 to 5,000 cfm. Ideally, the system should be useable as a blower or as an exhaust. Separate deck level controls are desirable, so that ventilation can be provided where it is needed. The system could also incorporate a monitor to measure and warn of accumulations of hazardous gases.

[2] F. C. Hale, J. J. O'Hara, *An Engineering Analysis of Cargo Handling*, Report 59-20, "Energy Expenditure of Longshoremen," Department of Engineering, UCLA, June 1959.

Lighting

Under-deck lighting is often inadequate. It is desirable to have a fairly uniform light level in all parts of the below-decks compartments. Supplementary light is important during the day, as well as at night, when fork lifts are being used. The strong contrast of brightness and shadow in the hold on a bright day can prevent a fork lift driver from seeing an obstacle or a worker until too late to avoid an accident.

Communications

Communications were either inadequate or nonexistent between the men in the hold and those on the deck or on the apron. Many cargo delays could have been eliminated if a portable intercommunication system or sound powered telephone had been available. Shouted instructions were difficult to transmit over the noise of the winches and maintenance work.

Chapter 6

ESTIMATION OF SYSTEM CAPABILITY

In Chapter 3, the dock, hook, and hold operations were examined as individual parts of the system, and methods for improving performance were suggested. The operation must also be examined as an integrated system. The interrelationship of the hook and hold affects estimates of productivity increases. In this chapter time and productivity data from observed operations are used as a basis for calculating new cycles for both hold and hook operations.

ANALYSIS OF OBSERVATIONS

The upper diagram in Figure 21 was constructed for a sample commodity from observed time elements listed in Appendix B. A similar multiple activity diagram is shown for a revised system in the lower diagram. These diagrams are used to analyze the balance between hook and hold performance. Hook activities and waits are indicated in sequence in the center of the three bars. Work teams on either side of the hatch are represented by top and bottom bars. These teams are served alternately by the hook. The dark areas on the charts represent delays and lags. The light areas represent work activities as indicated by the number codes. As shown on the figures, the hook goes through two complete cycles while each half of the hold gang goes through one cycle. In both diagrams the hook is assumed to be feeding the port gang first. The top diagram of actual conditions was typical of San Francisco area operations at the time of data collection. A draft was unhooked by the port gang as indicated by Activity 1. The hook then usually waited in the hold for an empty pallet from the starboard gang, transporting it empty to the apron in Hook Activity 2. After a short wait it hooked onto the next load for Activity 3 and then waited for the hold gang on the starboard side both before and after its loaded trip, Activity 4. Then, of course, the hook cycle was repeated.

The port hold gang unhooked the load for hold Activity 1 and transported the load to stowing position with wagon or jitney in Activity 2. There was often a short lag before the cargo was stowed in Activity 3. The delay shown after cargo stowage is the average delay due to a number of causes which occurred during stowage. It is shown in this position only for convenience in charting. A deliberate lag often occurred before Activity 4 when the wagon and pallet are returned empty to the hook. The port gang often waited for the hook to serve the other gang and on occasion placed dunnage or paper on the loaded cargo in support activity shown as Activity 5 in the sequence. The starboard hold gang duplicated the activity sequence of the port gang, but phased to the alternate movement of the hook.

The notable feature of this diagram is the large number of delays in the hook cycle. In the preceding chapter it was indicated that the hook activity or work elements in San Francisco are comparable to those of other ports. The hook wait is not. There is 40 to 50 per cent wait, or slack time, in hook operations.

Because of the 4-on, 4-off system, each holdman was at his post only half the shift. However, the four men on were working over 50 per cent of the time they were in the hold. In most other ports covered by the earlier MCTC study, the hold gangs worked less than 50 per cent of the time they were in the hold. Over-all productivity was better at these other ports, because more men were available for work in the hold. The data from both studies, taken together, suggests that protracted relief as in the 4-on, 4-off system does not improve productivity. To match hold capability to hook capability in San Francisco, the four men working in the hold must be augmented with men or equipment.

ESTIMATED HOOK AND HOLD CAPABILITY

In Figure 21 the revised cycle was constructed by using the activity elements of the observed hook cycle and eliminating all delays. It was assumed that draft size was increased to the maximum within safety limits. The revised hook cycle set the pace for the hold cycle. In the hold cycle all activity elements except the stowing activity (Activity 3) were left

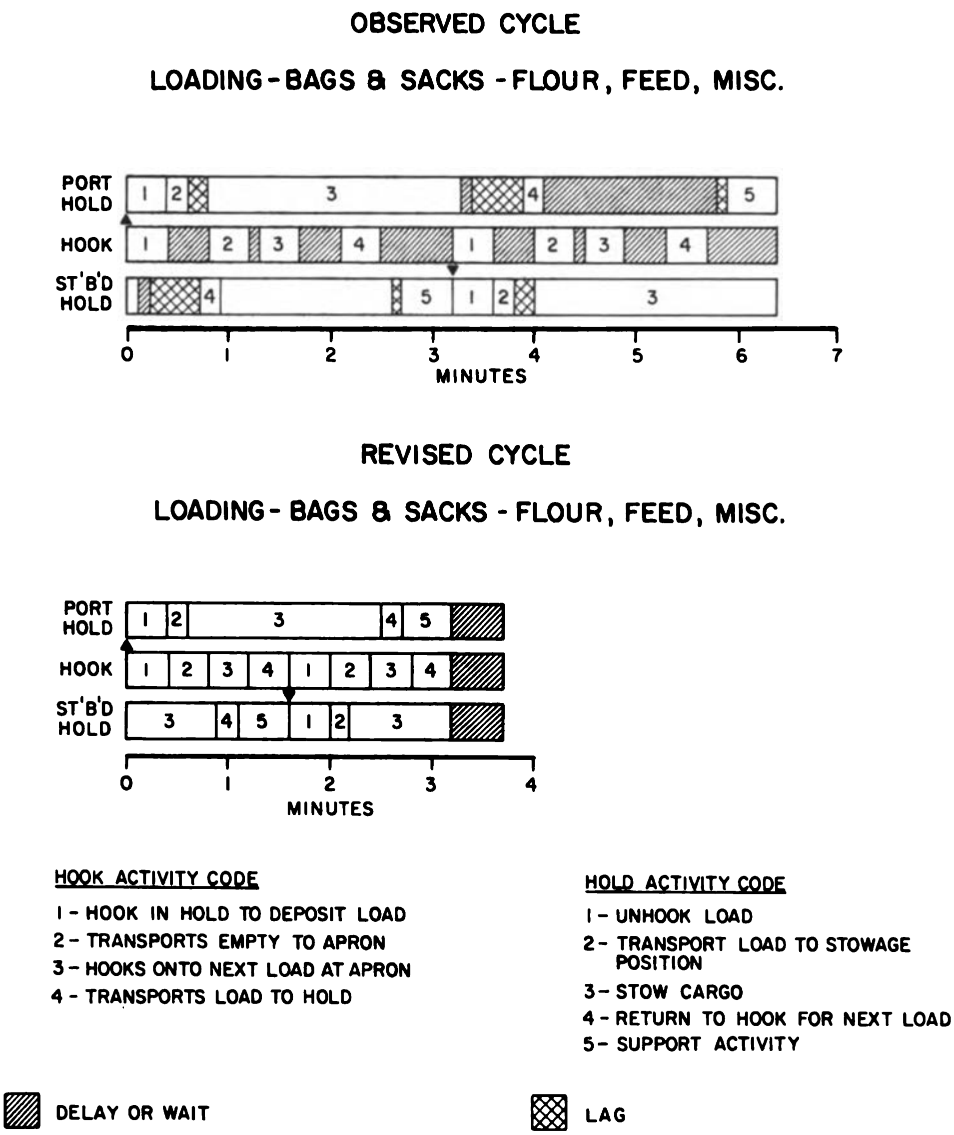


Figure 21. Analysis of hook and hold activities and estimate of capability.

unchanged. Since the sum of the hold activity elements must agree with the double hook cycle, the time available for stowing a draft was determined by the time remaining when other hold activity segments were accounted for. To make possible a balance between hold and hook performance, hold capability must be increased by adding men or machines to permit the stowing of a single draft in the time allowed in Hold Activity 3 of the revised cycle. This segment is smaller than the corresponding segment in the observed data, and the assumed draft size is larger than observed. To take care of unavoidable delays, a 15 per cent allowance was applied to both hook and hold cycles. This allowance is considered to be the minimum which can be achieved in practice. It is about typical of cases where the hook is the bottleneck.

Hand Stow Simulation

The hand stow capability in Figure 21 was increased by using more men, so that it balances hook capability, and by adjusting gang operations, so that hook and hold cycles do not delay each other. Compartment size will limit the number of men that can be added to the hold gang.

Table 3 shows that the gang size chosen for the revised hand stow operation was 21 men. It also

TABLE 3

Basis of Estimated Hook and Hold Capability—Revised Cycle

	Actual	Revised Hand Stow	Revised Machine Stow
Gang size	14	21	15
Average draft size, MT/Dr	1.28	2.40	2.40
Average draft size, ST/Dr	0.96	1.80	1.80
Relief pattern, in hold	4-on, 4 off	10 stow, 4 ra *	4 stow, 4 ra *
Stow time per hold gang (%)	39%	51%	51%
Stow time per holdman (%)	20%	37%	26%
Gang hr. productivity, MT/GH	24	78	78
Gang hr. productivity, ST/GH	18	59	59
Man-hour productivity, MT/MH	1.72	3.70	5.20
Man-hour productivity, ST/MH	1.29	2.81	3.90

* "ra" means related activity: two men serve as hook on men in the hold, and two serve as fork lift or pallet jack operators. The men stowing cargo interchange positions regularly with the men doing related activities.

shows the draft size, per cent stow time, and estimated productivity rates per gang hour and per man-hour. If the hold men in the larger gang handle cargo at the same rate per man as in the smaller gang, the gang hour productivity rate will be more than three times the observed rate and the over-all man-hour productivity will be over twice that observed.

Disposition of the seven extra men in the gang is given in Table 4.

Pier Manpower Requirements

One extra man is used on the pier as a fork lift driver, to help feed the hook. A single 4,000 pound fork lift is capable of delivering as much as 30 weight tons per hour (see *Cargo Ship Loading Study*) where the terminal is not congested and cargo distance from ship hatch is nominal. If anticipated productivity rates exceed this value, then more than one fork lift or some other method of feeding the hook may be needed to sustain the higher rates. Since the modified system calls for a delivery rate of 59 short tons per gang hour, it is apparent that under most conditions one standard fork lift would be inadequate.

Since the revised cycle makes practically no allowance for hook delays at the apron, measures are necessary to eliminate such delays which claimed 4 or 5 per cent of the time in observed operations. One method of achieving this would be to provide a conveyor at the hook service position so that more than one draft can be stored in position near the hook. The hook-on men can then position the extra load without the need for a fork lift. This system makes the hook less dependent on having a fork lift on hand to place a new draft on the pick-up spot at every

TABLE 4

Standard Gang Size Compared to Revised Gang Size for Hand Stow when Loading Bags of Flour and Feed

Standard No. of Men	Simulated No. of Men	Job	Location	Function
1	2	Fork lift driver	Apron	Feed hook
2	2	Hook-on man	Apron	Service hook
1	1	Signal man (hatch tender)	Ship	Signal hook motions
1	1	Winch driver	Winches	Control hook motions
1	1	Gang boss	Ship	Direct gang
0	2	Hook-off men	Hold	Service hook in hold
0	2	Transport equipment operator	Hold	Transport loads to and from hook
8*	10	Holdmen	Hold	To stow cargo

* Holdmen handle cargo as well as drive transport equipment.

cycle. In other words, provision for storage of drafts at the apron may eliminate the need for the hook cycle and fork lift cycles to be in perfect phase.

Unchanged Jobs

In Table 4 the number of men and their function for the revised operation remains unchanged for positions of apron hook-on men, gang boss, signalman, and winch driver.

Hook-off Men in the Hold

Table 4 lists two hook-off men in the hold for the modified gang. In the case of the standard gang this function is performed by the same men who stow cargo. The purpose of the new assignment of men in the hold is similar to that of the hook-on men at the apron. It is desirable to make the hook cycle independent of the hold cycle as well as the fork lift cycle on the pier. By providing two men with a primary assignment to service the hook in the hold, the hook can deliver one load and return for another without disturbing stowing operations except when the gang is working in the hatch square. Thus, it is possible to store at least one extra draft in the hatch square, so that neither stowing team will have to wait for cargo. The advantages to be derived from this storage operation have been shown in studies made by the University of California, at Los Angeles.[3]

Another consideration is the handling of empty pallets. In observed loading operations, the hook often delivered a load to one side of the hold and picked up an empty pallet from the other side on each trip. If the hold capability is brought up to hook capability the time for removal of an empty pallet in exchange for every full pallet can become a limiting factor. Hence, to the extent possible, empty pallets should be accumulated in the hatch square or at stowing position and removed on every fourth or fifth draft. Under these assumptions delays no larger than the 15 per cent allowed in the simulation should be possible.

Mechanical Handling Equipment Operators in the Hold

In the modified gang two men are assigned to operate hold transport equipment. Since neither the electric jitneys or stevedore wagons commonly used are able to pick up drafts which are already deposited in the square, operations with these vehicles have to be altered in order to use the cargo reservoir. Extra wagons can be inserted, where space is available, and managed so that one or two empty wagons are always on hand in the square for receiving loads from the hook. When using electric jitneys, it is usually not possible to use additional pieces of equipment. The problem is not encountered when pallet jacks, or fork lifts are used since these vehicles are equipped to lift a pallet load or skid from the deck.

For estimation purposes, the mechanical handling equipment in the hold for the revised system need not be specified, so long as it is powered and capable of working from the storage reservoir.

Hold Gang for Stowing Cargo

Table 4 shows that the revised system for *hand stow* calls for 10 holdmen in addition to hook-off men and equipment operators just described. This need for 10 men to stow cargo is derived from the assumption that each man, while working, stows by hand at the rate developed from observed data and shown in Figure 17. The 10 men bring hold gang capability on hand stow operations for this commodity up to the hook capability. The assumption of a constant rate per man for the larger hold gang is compatible with the productivity comparison in Table 2. The East Coast rates in this table were attained with hold gangs of 10 and 12 men. No data are available to project rates beyond a 12-man hold gang size. The calculations used for gang capability are given in Appendix E. To determine the number of men required for stowing operations, the number of men in the hold is adjusted so that no team is required to work more than 65 per cent of the time. There is an indication from data examined in the *Cargo Ship Loading Study* that when teams are required to do heavy stowing work there is no improvement in productivity when their per cent of work time exceeds about 65 per cent. The revised system can provide additional relief from heavy work for individual holdmen if they interchange jobs regularly with transport equipment operators and hook-off men. At the bottom of Table 3 the effect of this method of relief is indicated in the difference between the 51 per cent of stow time per hold gang and the 37 per cent of stow time per holdman.

[3] Department of Engineering, UCLA, *An Engineering Analysis of Cargo Handling*, Report 56-37, "Simulation of Cargo Handling Systems," Sept. 1956; and Report 61-35, "A Deterministic Mathematical Model for a Two-Link, One-Node System," June 1961.

Comparison Between Observed and Revised Systems

The major difference between the two systems is that the observed system used only four men at a time in the hold, while the revised system calls for 14 men in the hold to balance the hook operation. The difference in manpower is a measure of the degree to which the observed system has been unbalanced. The large manpower requirement is a measure of the penalty paid for the arduous hand work still used to move cargo on and off ships. It may not be possible to use the large gangs necessary to balance the hook in situations where space is confined. This emphasizes the need for flexibility in gang size and the desirability of using machines, where possible.

Simulated Machine Stow

A revised system for machine stow operations is also shown in Table 3. For this system it is assumed that no more than the standard eight-man hold gang is needed. One extra man is placed on the pier to drive an additional fork lift to supply the hook with cargo. Two machines, transporting and stowing cargo, and eight men (two receivers, two machine operators, and four stowers) in the hold are assumed to be equivalent to 14 men (two receivers, two transport equipment operators, and 10 hand stow men) for hand stow operations.

The machine stow estimate shown in Table 3 indicates the system potentialities if mechanical ingenuity can solve the machine stow problem. In the machine stow operation with a gang size one more than standard, the calculated productivity per man-hour is about three times the actual observed productivity per man-hour. By comparison the simulated hand stow system could only achieve twice the actual productivity per man-hour.

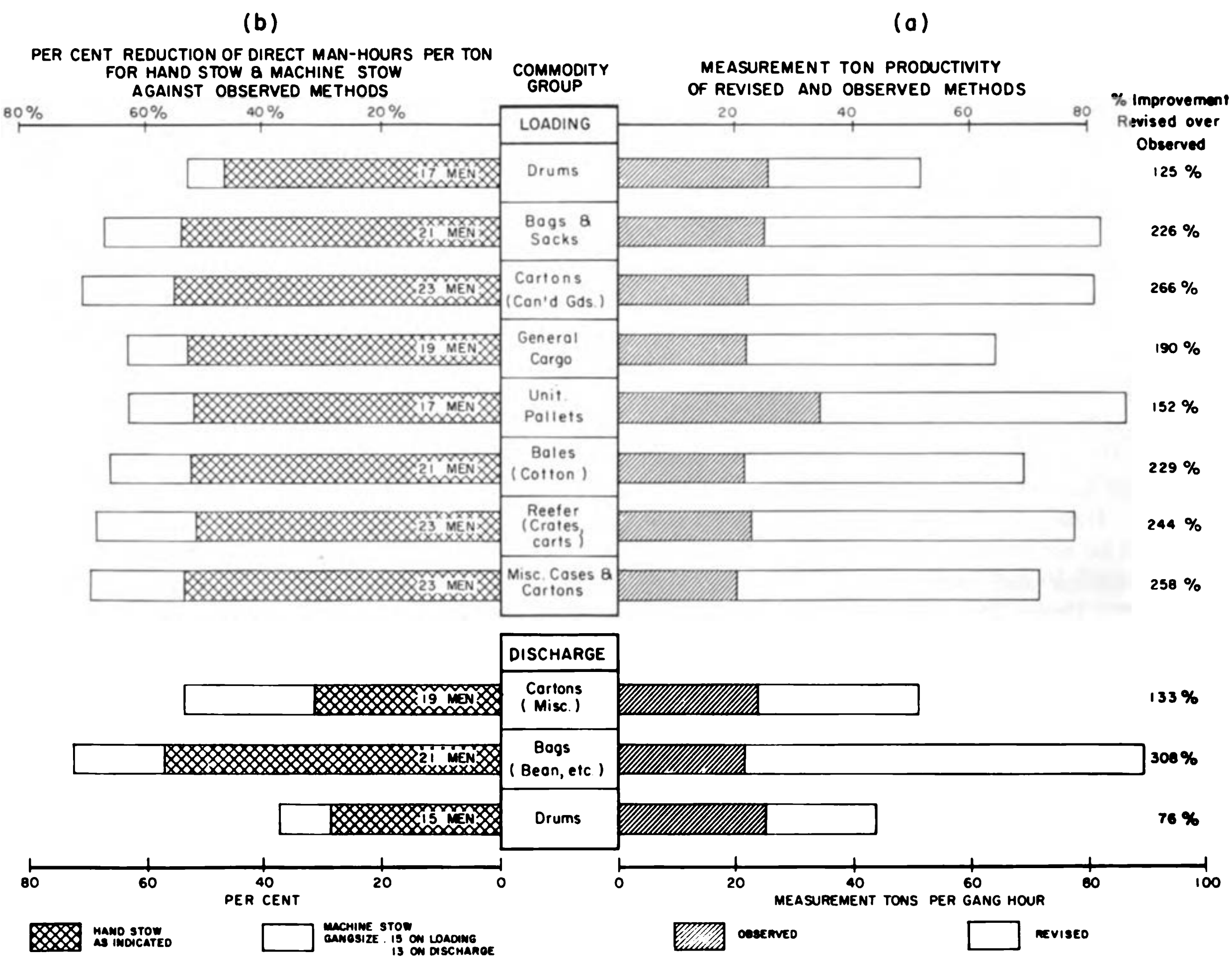


Figure 22. Man-hour and gang hour productivity improvement.

ESTIMATED MAN-HOUR SAVINGS AND GANG PRODUCTIVITY

A productivity comparison between the observed operations and those calculated by the method just described is shown in Figure 22a (details of the calculations are shown in Appendix E). The productivity for the revised system is determined by the hook cycle time and draft size. It is assumed that sufficient manpower or machinery can be made available in the hold to match the hook performance.

The decrease in man-hours per ton which can be achieved by these changes to the system is shown in Figure 22b. Man-hours per ton are used here because they are related directly to stevedoring labor cost. The estimated total gang sizes to match hook performance are shown in each bar. There is no basis for determining machine stow gang requirements without running tests, so the gang size shown is the standard gang with an extra fork lift driver on the pier. It is possible that machines in the hold could match the hook performance with a smaller than standard gang size.

CONCLUSIONS

The following conclusions concerning the capabilities of the cargo handling system are drawn from an examination of Figure 22:

1. Gang hour productivity may be more than doubled for most commodities by using the full cargo hook capability.

2. Increasing productivity to the full capability of the hook may require increasing the size of the hold gang when stowing by hand.

3. Machines may possibly be used to balance the capability of the hold to that of the hook using standard or smaller hold gangs.

4. Cost may be halved in many cases, by reducing the man-hours per ton of cargo stowed, despite the use of larger gang sizes.

5. Ideal gang size may vary with the commodity encountered, equipment utilized, and work space available.

6. Where alternate methods exist, choosing the proper combinations of manpower and machinery imposes increased demands on stevedoring planners.

Appendix A

SAMPLE SIZE

A selected sample of cargo handling operations was taken which approximated the range of commodities and techniques prevailing in the port. This sample comprised data for 25 commodities loaded and 18 commodities discharged. The sample also reflected the port ratios of day to night work, loading to discharging, and U. S. to foreign flag ships.

Data were collected on 92 work shifts, during which 26,745 measurement tons of cargo were handled. The 92 shifts were worked on five ship types. All of the work was performed by union longshoremen. The ships on which observations were made were berthed at San Francisco, Alameda, Oakland commercial piers, and the Oakland Army Terminal. At the time of the study two of the shipping companies had house stevedores; the others used contractors.

Tables A-1 and A-2 present a detailed breakdown of the data sample. Table A-3 lists the shipping and terminal companies selected as data sources, identifies the trade routes served by these companies, and names the types of vessels in the study. (The trade routes are representative of those serviced by Bay Area ports.)

The data for loading and discharging operations was treated separately throughout the study. No attempt was made to compare the load and discharge operations.

TABLE A-1
Data Sample Size in Time and Cargo Units

Operation	Number of Shifts			Number of Drafts			Measurement Tons			Short Tons		
	SFC	OART	Total	SFC	OART	Total	SFC	OART	Total	SFC	OART	Total
Load												
Day	20.5	23.5	44	3,769	5,514	9,283	4,466.5	10,612.8	15,079.3	3,096.8	4,490.5	7,587.3
Night	13	16	29	2,478	2,799	5,277	2,643.0	3,588.8	6,231.8	1,800.4	1,908.7	3,709.1
TOTAL	33.5	39.5	73	6,247	8,313	14,560	7,109.5	14,201.6	21,311.1	4,897.2	6,399.2	11,296.4
Discharge												
Day	9.5	2	11.5			1,901			3,529.6			1,527.0
Night	7	1	8			1,219			1,904.4			839.9
TOTAL	16.5	3	19.5			3,030			5,434.0			2,366.9
Load & Discharge	50	42.5	92.5			17,590			26,745.1			13,663.3

TABLE A-2
Data Sample Size in Shifts Observed by Ship Type

Operation	C-2			C-3			MARINER			VICTORY			OTHER		
	SFC	OART	Total	SFC	OART	Total	SFC	OART	Total	SFC	OART	Total	SFC	OART	Total
Load															
Day	4	6	10	7	12	19	1.5	5	6.5	2	1	3	5	—	5
Night	1	5	6	7	3	10	1	1	2	—	5	5	4	1	5
TOTAL			16			29			8.5			8			10
Discharge															
Day	2	1	3	2	—	2	1.5	1	2.5	—	—	—	5	—	5
Night	—	—	—	3	—	3	1	—	1	—	—	—	3	1.5	4.5
TOTAL			3			5			3.5						9.5
Load & Discharge			19			34			12			8			19.5

TABLE A-3
Cooperating Companies and Agencies

Company	Trade Routes Served	Ship Types
Matson Navigation Co.	West Coast—Hawaii	C-3
Oceanic Steamship Co.	West Coast—Australia	C-2
American President Lines	Trans-Pacific—Around the World—Atlantic Straits	VC-2, P-2, C-3 Mariner
Luckenbach Steamship Co.	Intercoastal	C-3, C-4
Grace Line, Inc.	West Coast—South America	C-2
Holland America	West Coast—Europe	Cargo/Passenger
Royal Mail	West Coast—Europe	Cargo/Passenger
Oakland Army Terminal	All Pacific trade routes	All ships
Encinal Terminals	All Pacific trade routes	All ships
Howard Terminals	All Pacific trade routes	All ships

Appendix B

SUMMARY OF NUMERICAL DATA

This section presents complete data from hatch opening and closing operations and from cargo handling operations. Data from the various companies listed in Appendix A have been accumulated by ship type for *opening and closing* operations and by commodity group for *cargo handling* operations. Where cargo handling data are presented, a number code has been indicated to designate various commodity groups.

Ship Opening and Closing Summaries

Table B-1 shows the average times recorded for opening and closing several classes of vessels. The times are the averages for the particular operation and are not cumulative. The average total time required to open a ship all the way to the deep tanks would, therefore, be approximately the sum of the times given on the line for that class of ship.

Cargo Handling Data

Tables B-2 through B-7 present cargo handling data by commodity group. Tables B-2 and B-3 show observed *hook* activity and delay times for load and discharge operations. Tables B-4 and B-5 show observed *hold* activity and delay times for load and discharge operations. Cargo characteristics, in terms of weight and volume, are also indicated on the latter two tables. Tables for both hook and hold operations list the number of drafts observed in each commodity group sample. Often, there are differences between number of drafts observed for hook and for hold observations in the same commodity group. Major differences are due primarily to situations where hook data or hold data had to be invalidated because of inaccuracies or improper data-taking procedures. Some minor discrepancies were inevitable because of the data-recording techniques. The hook observer recorded every draft handled regardless of work methods in the hold. On the other hand, when the hold gang was split into two teams, the hold observer recorded only the drafts delivered to one of the teams, and it was assumed that the other team got an equal number of drafts.

Tables B-6 and B-7 present total gang hour productivity rates in weight and volume units for each commodity group. The total figures are derived from the information accumulated in Tables B-4 and B-5 using Column 4 as the time denominator for "gross cycle" information. These total figures have also been separated into day shift and night shift components for comparison purposes. Average draft sizes are indicated in weight and volume units.

TABLE B-1

Average Ship Opening Times
(Time in Minutes)

Type of Ship	Rig Booms	Remove Tarpaulins	Shelter Deck	Lower 'Tween	Lower Hold	Deep Tanks
C-2	18.8	3.5	7.1	10.0	5.7	5.9
C-3	24.6	6.4	12.1	18.9	19.7	Not ob.
Miscellaneous	24.7	6.3	6.3	17.0	4.4	Not ob.
Mariner	14.1	—	2.9	2.9	3.6	4.0

Average Ship Closing Times
(Time in Minutes)

Type of Ship	Deep Tanks	Lower Hold	Lower 'Tween	Shelter Deck	Swing Booms	Lay Tarpaulins
C-2	4.2	16.1	10.4	8.2	4.4	2.9
C-3	Not ob.	12.3	16.8	8.5	9.5	7.2
Other	1.7	9.4	18.5	9.0	7.4	2.7
Mariner	Not ob.	Not ob.	5.5	1.4	1.7	—

TABLE B-2

Hook Activity and Delay Times for Loading Operations San Francisco Bay Area Commercial Stevedoring
(Time in Minutes)

	1	2	3	4	5	6	7	8	9
		Apron Time		Hook Transit		Hold Time			
Commodity	Number of Drafts	Delay	Work	Delay	Work	Delay	Work	Work Time	Total Time
Beer	442	40.2	133.1	521.0	301.6	61.8	136.8	571.5	1,194.5
Canned goods	2,712	171.9	854.8	2,859.5	1,676.9	1,870.7	969.7	3,501.4	7,593.5
Dried fruits	376	35.5	125.8	572.2	245.9	175.2	141.0	512.7	1,295.6
Glass packed wet goods	375	33.8	146.0	403.2	244.2	229.7	144.6	534.8	1,201.5
Misc. cartons & cases	1,252	155.0	469.5	1,521.7	848.5	909.8	498.5	1,816.5	4,403.0
Bags of beans & coffee	133	13.0	46.9	92.8	82.9	87.5	68.8	198.6	391.9
Bags of flour, feed, & misc.	911	44.5	345.9	751.5	673.6	671.1	376.6	1,396.1	2,863.2
Appliances, & misc. (over 200 s.f.)	692	110.6	278.0	618.3	448.4	403.4	276.3	1,002.7	2,135.0
Misc. general cargo (less than 200 s.f.)	2,456	293.1	1,051.9	2,363.6	1,695.8	1,466.8	1,205.3	3,953.0	8,076.5
Bales—cotton, misc., paper	1,121	111.0	440.3	1,170.5	880.2	573.3	688.4	2,008.9	3,863.7
Drums (55 gal. only)	410	59.7	182.8	274.3	267.7	43.2	153.1	603.6	980.8
Misc. drums	162	23.5	68.7	309.3	109.5	74.4	61.7	239.9	647.1
Drums, fiber	77	2.7	35.4	48.0	48.6	56.6	48.0	132.0	239.3
Reefer cargo—crates & cartons	1,215	74.0	384.6	1,410.7	868.8	225.4	396.1	1,649.5	3,359.6
Lumber	51	3.8	17.4	31.6	46.0	—	19.9	83.3	118.7
Iron & steel, N.O.S.	23	4.4	18.1	6.1	22.3	23.4	19.1	59.5	93.4
Iron & steel, pipes	42	53.8	29.1	43.4	35.3	26.3	32.3	96.7	220.2
Reels & coils	45	1.1	22.1	87.8	25.5	25.0	20.6	68.2	182.1
Autos	90	131.8	68.0	94.4	128.5	124.0	77.6	274.1	624.3
Vans, Conex	393	175.8	271.4	631.9	363.9	199.9	368.5	1,003.8	2,011.4
Unitized cargo (palletized)	171	25.5	85.3	110.8	118.3	76.2	90.0	293.6	506.1
Unitized cargo (canned goods)	510	27.5	201.5	363.8	345.1	93.4	185.6	732.2	1,216.9
Unitized cargo (single pieces over 40 cu. ft. each)	448	123.3	278.0	350.2	362.6	333.3	167.0	807.6	1,614.4

TABLE B-3

Hook Activity and Delay Times for Discharge Operations San Francisco Bay Area Commercial Stevedoring
(Time in Minutes)

	1	2	3	4	5	6	7	8	9
		Apron Time		Hook Transit		Hold Time			
Commodity	Number of Drafts	Delay	Work	Delay	Work	Delay	Work	Work Time	Total Time
Beer	38	—	8.8	94.8	25.1	3.5	8.7	42.6	140.9
Canned goods	136	12.7	38.4	72.3	83.1	65.4	58.8	180.3	330.7
Liquor & wines	111	3.3	30.6	124.4	89.6	24.3	44.3	164.5	316.5
Misc. cartons & cases	698	73.4	238.2	436.5	644.0	307.1	433.5	1,315.7	2,132.7
Bags of beans & coffee	660	11.8	200.8	198.5	440.8	94.4	265.5	907.1	1,211.8
Bags of feed	20	1.0	4.8	20.7	14.0	1.6	6.7	25.5	48.8
Misc. bags	128	17.5	30.3	142.0	99.5	76.7	48.7	178.5	414.7
Appliances, & misc. (over 200 s.f.)	71	26.9	29.4	52.3	50.1	39.4	42.2	121.7	240.3
Misc. general cargo (less than 200 s.f.)	205	92.4	98.0	149.5	184.4	94.4	119.3	401.7	738.0
Misc. drums	176	23.0	65.7	106.0	146.7	40.6	104.3	316.7	486.3
Barrels	68	5.0	17.8	47.0	65.5	5.1	39.7	123.0	180.1
Reefer cargo—crates & cartons	85	—	21.6	196.9	48.1	24.6	28.1	97.8	319.3
Reels and coils	145	16.3	50.1	84.5	118.1	79.0	108.6	276.8	456.6
Autos	48	37.5	48.6	78.7	49.3	36.2	97.6	195.5	347.9
Vans, Conex	317	70.4	153.4	127.2	228.1	151.5	268.4	649.9	999.0
Misc. unitized cargo	80	5.6	27.5	53.9	60.4	14.5	57.6	145.5	219.5
Misc. unitized cargo (paper products)	113	39.0	40.0	18.9	96.0	104.5	91.6	227.6	390.0

TABLE B-4

Hold Activity and Delay Times for Loading Operations San Francisco Bay Area Commercial Stevedoring
(Time in Minutes)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Commodity	Number of Drafts*	Weight, Lbs.*	Volume, Ft.^{3}*	Total Time Σ Cols. 6 thru 15	Work Time Σ Cols. 6 thru 9	Pre-position	Stow	Re-position	Internal Support Activity	Wait for Hook	Misc. Delays	Pre-position Lag	Stow Lag	Re-position Lag	Internal Support Activity Lag	External Support Activity
Beer	419	669,173	16,325	1,200.5	711.6	61.8	568.0	49.6	32.2	217.1	23.1	70.8	40.6	137.0	0.3	13.0
Canned goods	2,752	4,673,516	112,372	7,631.5	4,659.7	225.4	3,920.2	194.4	319.7	1,762.0	38.8	313.4	354.3	443.7	59.6	253.8
Dried fruits	417	752,656	16,375	1,429.9	911.9	30.3	785.2	27.1	69.3	307.2	14.7	62.9	60.7	69.8	2.7	81.3
Cigarettes	135	155,578	9,248	293.7	171.0	10.3	143.7	8.1	8.9	87.4	—	10.8	9.7	9.0	5.8	12.5
Glass packed wet goods	383	666,240	16,123	1,269.8	816.2	40.5	683.2	34.3	58.2	255.4	10.3	51.8	44.0	85.2	6.9	85.2
Misc. cartons & cases	1,194	1,372,943	56,635	4,269.3	2,657.1	170.4	2,172.5	113.6	200.6	934.9	25.6	189.7	190.1	237.5	34.4	368.9
Bags of beans & coffee	98	185,634	4,596	258.6	150.0	13.7	107.4	9.6	19.3	73.7	—	13.4	8.8	12.4	0.3	131.2
Bags of flour, feed & misc.	945	1,805,297	48,215	2,899.8	1,585.2	110.9	1,187.9	78.1	208.3	807.7	23.5	129.7	109.1	214.7	29.9	349.3
Appliances, & misc. (over 200 s.f.)	744	490,272	61,724	2,131.7	933.7	62.6	743.6	50.4	77.1	751.6	24.6	83.5	112.9	185.7	39.7	55.2
Misc. general cargo	2,508	2,840,584	124,665	8,424.5	4,321.9	310.0	3,380.3	231.3	400.3	2,659.5	126.2	346.7	390.1	524.5	55.9	624.0
Bales—cotton, misc., paper	1,118	1,581,026	52,839	3,811.3	2,113.9	146.2	1,619.4	82.4	265.9	1,063.6	54.3	157.0	209.8	192.3	20.4	515.6
Drums (55 gal. only)	455	806,934	16,788	980.5	336.5	13.6	261.1	0.1	61.7	536.3	31.5	2.7	63.7	0.1	9.7	471.3
Drums, misc.	167	340,719	7,504	644.1	421.7	25.8	336.2	21.3	38.4	114.9	1.3	23.1	29.2	38.4	15.5	30.5
Drums, fiber	77	110,970	3,861	224.1	132.2	13.4	80.2	7.9	30.7	54.3	0.2	9.4	5.4	21.6	1.0	—
Reefer cargo—crates & cartons	1,292	1,654,197	49,802	3,346.8	1,904.3	61.8	1,634.0	57.7	150.8	912.4	17.6	124.1	196.9	171.4	20.1	220.4
Lumber, unstrapped	28	63,004	2,270	166.1	103.4	5.1	96.5	1.0	0.8	28.0	0.5	15.2	15.2	3.5	0.3	—
Lumber, strapped	52	141,321	4,509	125.1	44.9	32.3	12.6	—	—	59.8	5.5	14.9	—	—	—	—
Iron & steel pipes	50	101,049	1,513	238.5	125.4	5.6	77.5	30.3	12.0	88.5	3.0	8.4	10.1	1.0	2.1	—
Reels & coils	46	65,660	1,348	198.5	134.6	9.1	83.0	6.7	35.8	19.4	—	10.7	9.1	21.1	3.6	—
Autos	85	289,901	41,824	675.9	241.1	8.0	209.3	—	23.8	327.2	32.6	1.5	52.5	—	21.0	20.7
Vans, Conex	420	1,634,209	112,175	2,333.0	1,132.2	58.1	956.0	14.7	103.4	844.0	82.2	50.1	170.8	22.8	30.9	169.5
Unitized cargo (palletized)	195	352,194	10,445	542.4	213.5	20.1	168.1	5.6	19.7	251.7	22.6	27.4	20.5	1.2	5.5	45.5
Unitized cargo (canned goods)	507	1,076,581	29,793	1,210.5	578.6	0.4	512.4	1.6	64.2	466.5	6.4	0.9	153.7	0.6	3.8	54.3
Unitized cargo (single pieces over 40 cu. ft. each)	461	700,043	50,819	1,691.4	706.7	40.9	550.9	10.1	104.8	770.3	12.8	45.9	80.5	49.9	25.3	114.7

*These figures represent total amounts handled by both sides of the hold gang, although only one side was generally observed.

TABLE B-5
Hold Activity and Delay Times for Discharge Operations San Francisco Bay Area Commercial Stevedoring
(Time in Minutes)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Commodity	Number of Drafts*	Weight, Lbs.*	Volume, Ft.³*	Total Time Σ Cols. 6 thru 15	Work Time Σ Cols. 6 thru 9	Preposition	Stow	Reposition	Internal Support Activity	Wait for Hook	Misc. Delays	Preposition Lag	Stow Lag	Reposition Lag	Internal Support Activity Lag	External Support Activity
Beer	39	61,446	1,794	147.6	118.4	9.6	97.8	9.0	2.0	16.0	—	7.4	4.5	1.3	—	—
Canned goods	144	265,004	5,849	369.7	191.9	12.5	158.2	18.1	3.1	50.3	—	53.2	41.1	33.2	—	60.2
Liquor & wines	96	166,286	4,993	325.0	208.8	10.2	164.1	9.9	24.6	48.0	2.8	34.1	8.3	20.4	2.6	—
Misc. cartons & cases	703	809,905	33,808	2,129.2	1,182.6	80.4	953.6	45.7	102.9	527.7	27.9	161.3	141.4	83.0	5.3	292.4
Bags of beans & coffee	521	686,228	18,154	1,200.6	404.6	3.2	344.6	15.2	41.6	628.7	7.0	27.1	101.6	27.4	4.2	149.4
Bags of flour, feed & misc.	115	170,400	4,242	341.4	184.9	14.8	114.4	13.8	41.9	63.6	3.8	23.9	8.6	54.9	1.7	50.5
Appliances, & misc. (over 200 s.f.)	91	57,390	7,353	368.1	112.4	3.7	98.8	3.7	6.2	125.4	0.8	29.0	52.7	40.9	6.9	—
Misc. general cargo (less than 200 s.f.)	193	173,340	7,740	617.5	269.6	22.2	218.3	4.7	24.4	197.7	29.7	23.0	91.2	6.1	0.2	22.0
Bales, misc.	14	22,850	516	37.8	15.2	0.3	14.8	0.1	—	12.7	0.1	0.2	9.3	0.1	0.2	23.5
Drums (55 gal. only)	85	158,944	3,837	219.6	81.4	1.6	67.9	1.3	10.6	54.2	1.9	2.6	70.9	6.9	1.7	22.7
Drums, misc.	90	162,600	3,226	209.1	86.6	6.4	67.4	4.9	7.9	64.0	6.1	31.8	12.0	8.3	0.3	58.6
Barrels	79	129,990	3,534	241.5	68.5	1.6	65.2	—	1.7	112.2	10.3	3.4	48.1	—	—	39.1
Reefer cargo—crates & cartons	123	167,017	5,804	557.9	397.6	7.1	348.2	6.8	35.5	60.2	7.3	16.4	71.3	3.7	1.4	46.5
Reels & coils	152	167,706	2,612	440.5	171.6	14.3	132.8	8.8	15.7	179.1	37.5	13.1	18.8	18.3	2.1	22.8
Autos	48	134,386	22,880	334.1	201.5	—	154.8	0.8	45.9	26.6	21.5	1.2	72.2	—	11.1	96.0
Vans, Conex	329	844,379	78,347	1,047.2	407.6	—	364.5	—	43.1	209.5	63.2	—	344.3	—	22.6	167.7
Unitized cargo (palletized)	91	73,687	5,512	227.3	74.1	0.1	61.7	0.1	12.2	52.5	5.4	—	88.6	—	6.7	28.9
Unitized cargo (paper products)	116	482,381	9,151	373.5	121.2	—	106.1	1.2	13.9	68.7	42.8	—	139.5	—	1.3	141.7

*These figures represent total amounts handled by both sides of the hold gang, although only one side was generally observed.

TABLE B-6
Gang Hour Productivity by Commodity, Load

Commodity		1 Ft.³ per Draft	2 Drafts per Hour (Gross Cycle)	3 Number of Drafts	4 Pounds per Draft	5 Short Tons per Gang Hour (Gross Cycle)	6 Measurement Tons per Gang Hour (Gross Cycle)
Beer	Total	39.0	21	419	1,597.1	16.72	20.40
	Day	42.1	17	193	1,754.9	14.80	17.75
	Night	36.3	26	226	1,462.3	19.28	23.92
Canned goods	Total	40.8	22	2,752	1,698.2	18.37	22.09
	Day	41.3	23	1,565	1,713.3	19.36	23.33
	Night	40.2	20	1,187	1,678.3	17.19	20.60
Dried fruits	Total	39.3	17	417	1,804.9	15.79	17.18
	Day	38.2	18	266	1,813.2	16.63	17.54
	Night	41.1	16	151	1,790.3	14.48	16.62
Cigarettes	Total	68.5	28	135	1,152.0	15.89	47.23
	Day	67.4	32	85	1,106.0	17.91	54.55
	Night	70.4	22	50	1,231.0	13.56	38.77
Glass packed wet goods	Total	42.1	18	383	1,739.5	15.74	19.05
	Day	43.9	18	260	1,818.3	16.64	20.08
	Night	38.3	18	123	1,573.0	13.90	16.94
Misc. cartons & cases	Total	47.4	17	1,194	1,149.9	9.65	19.90
	Day	46.3	17	726	1,082.0	9.22	19.75
	Night	49.1	16	468	1,255.2	10.28	20.13
Bags of beans & coffee	Total	46.9	23	98	1,894.2	21.54	26.66
	Day	43.5	18	4	1,633.5	14.41	19.19
	Night	47.0	23	94	1,905.3	21.93	27.07
Bags of flour, feed, & misc.	Total	51.0	20	945	1,910.3	18.64	24.89
	Day	53.2	19	671	1,900.4	18.24	25.53
	Night	45.7	20	274	1,934.7	19.68	23.22
Appliances & misc. furn.	Total	83.0	21	744	659.0	6.90	43.45
	Day	86.0	22	560	672.9	7.30	46.65
	Night	73.8	19	184	616.5	5.84	34.95
Misc. general cargo	Total	49.7	18	2,508	1,132.6	10.12	22.20
	Day	54.4	18	1,611	1,173.0	10.28	23.85
	Night	41.2	19	897	1,060.1	9.81	19.07
Bales—cotton, paper, misc.	Total	47.3	18	1,118	1,414.2	12.44	20.41
	Day	49.4	19	508	1,544.0	14.36	22.95
	Night	45.5	17	610	1,306.0	11.04	19.23
Drums—all types except fiber	Total	39.0	23	622	1,845.1	21.10	22.32
	Day	39.8	23	513	1,929.4	22.42	23.15
	Night	35.2	22	109	1,448.3	15.81	19.22
Fiber drums	Total	50.1	21	77	1,441.2	14.86	25.84
	Day	50.3	19	67	1,417.8	13.56	24.04
	Night	49.2	38	10	1,598.0	29.96	46.13
Reefer—crates & cartons	Total	38.5	23	1,292	1,280.3	14.83	22.32
	Day	39.7	22	594	1,398.7	15.17	21.50
	Night	37.6	25	698	1,218.2	14.98	23.11

TABLE B-6 (continued)

Commodity		1 Ft.³ per Draft	2 Drafts per Hour (Gross Cycle)	3 Number of Drafts	4 Pounds per Draft	5 Short Tons per Gang Hour (Gross Cycle)	6 Measurement Tons per Gang Hour (Gross Cycle)
Strapped lumber	Total Day	86.7	25	52	2,717.7	33.92	54.11
Iron & steel	Total Day	11.4	18	21	2,477.0	21.89	5.05
Pipes	Total	30.3	13	50	2,021.0	12.71	9.52
	Day	26.3	12	32	1,395.0	8.09	7.62
	Night	37.3	15	18	3,133.9	23.18	13.81
Reels & coils	Total	29.3	14	46	1,427.4	9.92	10.18
	Day	31.9	13	40	1,528.7	10.25	10.69
	Night	12.0	18	6	752.3	6.91	5.51
Autos	Total	492.0	8	85	3,410.6	12.87	92.82
	Day	487.0	7	76	3,280.2	11.89	88.19
	Night	537.0	12	9	3,511.1	20.30	155.14
Vans, Conex	Total	267.0	11	420	3,890.9	21.02	72.12
	Day	283.0	11	337	4,304.9	22.64	74.30
	Night	204.0	12	83	2,210.2	13.41	61.95
Unitized cargo (palletized)	Total	53.6	22	195	1,806.1	19.48	28.88
	Day	57.2	25	147	1,938.4	23.89	35.27
	Night	42.3	16	48	1,400.9	10.93	16.50
Unitized cargo (canned goods)	Total	58.8	25	507	2,123.4	26.68	36.92
	Day	58.8	26	488	2,119.0	27.22	37.78
	Night	57.6	16	19	2,236.8	17.96	23.13
Unitized cargo (units over 40 ft³)	Total	112.0	16	464	1,535.8	12.48	45.63
	Day	112.0	17	405	1,576.4	13.24	47.07
	Night	113.7	13	59	1,257.3	8.37	37.82

TABLE B-7
Gang-Hour Productivity by Commodity, Discharge

Commodity		1 Ft.³ per Draft	2 Drafts per Hour (Gross Cycle)	3 Number of Drafts	4 Pounds per Draft	5 Short Tons per Gang Hour (Gross Cycle)	6 Measurement Tons per Gang Hour (Gross Cycle)
Beer	Total Day	46.0	15.9	39	1,575.5	12.49	18.23
Canned goods	Total	40.6	23.4	144	1,840.3	21.50	23.73
	Day	38.2	22.9	82	1,709.2	19.54	21.86
	Night	43.8	24.1	62	2,013.7	24.24	26.34
Liquor and wines	Total	52.0	17.7	96	1,732.1	15.35	23.04
	Day	47.9	17.1	56	1,370.1	11.70	20.48
	Night	57.7	18.7	40	2,239.0	20.94	26.98
Misc. cartons & cases	Total	48.9	19.8	703	1,152.1	11.41	23.82
	Day	52.8	19.6	295	1,160.6	11.38	25.89
	Night	44.7	20.0	408	1,145.9	11.43	22.30
Bags of beans & coffee	Total	34.9	26.1	521	1,317.1	17.15	22.72
	Day	34.7	26.7	448	1,312.4	17.51	23.14
	Night	36.3	22.6	73	1,346.7	15.23	20.53
Bags of flour & misc.	Total	36.9	20.2	115	1,481.7	14.97	18.64
	Day	37.1	19.9	111	1,475.7	14.70	18.46
	Night	32.0	33.3	4	1,650.0	27.50	26.67
Appliances, misc. furn.	Total	80.8	14.8	91	630.7	4.68	29.96
	Day	85.3	15.9	75	675.2	5.36	33.83
	Night	60.0	11.4	16	422.0	2.40	16.97
Misc. general cargo	Total	40.1	18.8	193	898.1	8.42	18.80
	Day	41.4	17.8	66	949.2	8.43	18.39
	Night	39.4	19.3	127	871.6	8.42	19.03
Bales, paper	Total	36.9	22.2	14	1,632.1	18.13	20.48
	Day	36.3	20.1	12	1,800.0	18.05	18.22
	Night	40.0	63.2	2	625.0	19.74	63.16
Drums	Total	40.4	24.5	175	1,837.4	22.50	24.71
	Day	37.1	24.9	58	1,508.4	18.80	23.14
	Night	42.0	24.3	117	2,000.5	24.29	25.47
Drums, fiber	Total Day	44.7	19.6	79	1,645.4	16.15	21.95
Reefer	Total	47.2	13.2	123	1,357.9	8.98	15.60
	Day	47.0	14.8	83	1,259.5	9.31	17.35
	Night	47.7	10.9	40	1,562.1	8.49	12.95
Pipes	Total Night	15.0	35.3	1	600.0	10.59	13.24
Reels & coils	Total	17.2	20.7	152	1,103.3	11.42	8.89
	Day	14.8	20.1	136	1,124.8	11.31	7.49
	Night	36.5	27.7	16	921.3	12.78	25.32
Autos	Total	477.0	8.6	48	2,799.7	12.07	102.72
	Day	546.0	10.5	25	3,277.0	17.16	143.09
	Night	400.1	7.2	23	2,280.9	8.24	72.45
Vans & Conex	Total	238.0	18.9	329	2,566.5	24.19	112.22
	Day	284.0	17.7	194	3,359.4	29.80	126.00
	Night	172.0	20.7	135	1,427.1	14.78	89.06
Unitized cargo	Total	60.6	24.0	91	809.7	9.73	36.37
(palletized)	Day	71.9	21.9	65	993.0	10.89	39.43
	Night	32.2	31.5	26	351.5	5.54	25.39
Unitized cargo	Total	78.9	18.6	116	4,158.5	38.75	36.75
(paper products)	Day	75.3	22.1	76	3,599.8	39.75	41.56
	Night	85.7	14.4	40	5,220.0	37.51	30.80

Appendix C

DATA COLLECTION AND ANALYSIS METHODS

DATA COLLECTION CONSIDERATIONS

The technical objective of the data collection program was to get accurate draft-by-draft time and cargo data for a typical cross-section of San Francisco break-bulk loading and discharging operations. Neither the time data nor the cargo data kept by companies on stevedoring hatch logs were detailed or accurate enough for this purpose.

The amount of data collected was limited by budgetary considerations. MCTC, through Pacific Maritime Association, paid regular wages to the union clerks used as data takers. Within the framework of a fixed total expenditure for data taking, an attempt was made to allocate effort to each type of cargo handling operation in proportion to its occurrence on the waterfront. Thus, about half as much data was collected on night operations as on day operations because this was the general proportion of night work to day work. The same principle was followed in connection with relative amounts of data from different trade routes, cargo types, and ship types.

During the planning of the data collection, little specific information was available concerning which variables in the system measurably influenced cargo handling. In the data collection process therefore, as many variables as possible were isolated so that their effect could be determined. The system used for recording and coding data permitted separation of 100 classifications of variables such as ship type, terminal, commodity type, area of stow, equipment used, etc. Previous studies had shown that each commodity group with unique handling characteristics had to be treated as a separate problem. Each group could require a unique method of handling, stowing and dunnaging.

The data collected yielded measurements of the time required for each element of the work cycle in addition to identifying the many variables in the system. Weight and measurement of the drafts completed the data required for the productivity calculations.

DATA COLLECTION FORMS

Forms for the data-takers aboard ship consisted of a set of three: "Loading Observations-Hatch Cycle," "Discharge Operations-Hatch Cycle," and "Loading Discharge Operations-Hook Cycle." The first two were used to record the time elements of the activities of the men working in the ship's hold. The last form was for recording the movements of the hook. Instructions for use of each form were printed on the back of the form.

Figure C-1 is an example of the form used to collect data on hook movements.

Figure C-2 shows the form which was used to collect data on the activities of the hold gang during loading. The heading information on the hatch sheets is the same as for the hook sheets.

Figure C-3 is the Hatch Cycle Sheet for discharge operations. The information is essentially the same as on the Hatch Cycle Sheet for loading except that the columns are rearranged to reflect the difference in the direction of movement of the cargo.

EQUIPMENT USED

Ordinary legal size clipboards, to which an eight-day aircraft clock had been attached were used for data-taking aboard ship. The aircraft clocks proved to be superior to pocket watches which were used originally for this purpose. The clocks were more rugged, more accurate, and less affected by rough handling. In addition, the clocks were much easier to read than the watches, especially in the poor lighting conditions in the ships' holds. The clocks were attached to the clipboards by an aluminum bracket which had a wide flange around the face of the clock. The flange was marked-off into tenths of a minute. All time records were kept in minutes and tenths, this being the smallest practical unit for purposes of the study. Figure C-4 is a photograph of the clipboard and clock used for the data collection.

Whenever possible, company documents were checked to verify the information on the data sheets. These company papers include pile tags, manifests, hatch logs, and stow plans.

DATA COLLECTORS

Data were collected by teams of specially trained union Hatch Clerks supervised by an MCTC staff analyst. The team consisted of one or two staff analysts and three or five data takers. The larger

LOADING/DISCHARGE OBSERVATIONS HOOK CYCLE

EXPT. NO.* ____________
OBSERVER* ____________
WATCH NO. ____________
EDITOR ____________
TRANSCRIBED BY ____________

SHIP NAME & TYPE ____________
COMPANY & STEVEDORE ____________
DATE ________ DAY/NIGHT HATCH, DECK* ________ (☐ /WNG/LKR) FWD/AFT

SHEET NO.* ____________
TERM & PIER ____________
DRY/ RAIN/ DRY-TENTS ____________

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
	LV	DELAY			ARR.	DELAY			HOOK		LV.	DELAY			ARR.	DELAY			HOOK		APRON	HOOK	
Dr.No.	APRON	BEG	CODE	END	HOLD	BEG	CODE	END	OFF	ON	HOLD	BEG	CODE	END	APRON	BEG	CODE	END	OFF	ON	MHE	GBAR	*Commodity & Remarks*

DELAY CODE: W – WAIT FOR HOLD S – SUPERVISORY DELAY D – MATERIAL DAMAGE A – APRON O – OTHER WINCHES: 1 OPERATOR – 2 OPERATORS ELECTRIC / STEAM

Figure C-1. Hook cycle data sheet.

INSTRUCTIONS

Loading/Discharging Operations—Hook Cycle

Fill out heading. Cross out Loading or Discharge depending on operation observed.

1. *Draft No.*—Fill out consecutively as you observe. Each round-trip of the hook is one draft.

2. *Lv. Apron*—Record time the hook leaves apron.

3-4-5, 13-14-15. *Delay*

(3) (13) *Begin*—Time hook stopped traveling.

(4) (14) *Code*—Code indicating reason for delay. If "O" (other) is used, explain cause in column (24), Remarks.

(5) (15) *End*—Time when hook starts to move again.

6. *Arr. Hold*—Record time hook arrives within control of hold gang.

7-8-9, 17-18-19. *Delay*

(7) (17) *Beg.*—Time work with hook stops.

If same as column (6) (16), leave blank.

(8) (18) *Code*—Code indicating reason for delay. If "O" explain cause under Remarks.

(9) (19) *End*—Time work with hook is resumed.

10. *Hook Off*—Discharge operation only. Indicate time empty pallets are removed in hold.

11. *Hook On*—Loading operations only. Indicate time empty pallets are attached to hook for removal from hold.

12. *Lv. Hold*—Indicate time hook leaves control of hold gang.

16. *Arr. Apron*—Indicate time hook arrives within control of apron gang.

20. *Hook Off*—Loading Operations only. Indicate time empty pallets are removed on apron.

21. *Hook On*—Discharge Operations only. Indicate time empty pallets are attached to hook for transport to hold.

22. *Apron MHE*—Record number and type of materials handling equipment used on pier to carry goods to or from the loading point.

23. *Hook Gear*—Type of gear used with hook to carry load (example: pallet and sling, net, drum clamp, etc.)

24. *Remarks*—Use this column to describe "other" delays, any unusual circumstances occurring, etc. Use "Remarks" liberally; if necessary, write across a whole row.

LOADING/OBSERVATIONS HATCH CYCLE

Expt. No. ____________ Sheet No. ____________

Observer ____________ Ship Name & Type ____________ Term & Pier ____________

Watch No. ____________ Dry/ Rain/ Dry-Tents

Editor ____________ Company & Stevedore ____________

Transcribed by ____________ Date ____________ Day/Night Hatch. Deck ____________ (☐ /WNG/LKR) FWD/AFT PT/STBD

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
			PRE-POSIT.				STOWAGE WORK					RE-POSIT.		SUPPORT ACCT.						
								DELAY												
DR. NO.	HOOK ARR.	HOOK ON	BEG.	END	P-P DIST.	M.H.E. TYPE	BEG.	BEG.	CODE	END	END	BEG	END	BEG.	END	NO. of MEN	NO. of PIECES	WT	CUBE	*Commodity & Remarks*

DELAY CODE: H – WAIT FOR HOOK S – SUPERVISORY DELAY D – MATERIAL DAMAGE O – OTHER

Figure C-2. Hatch cycle data sheet for loading operations.

INSTRUCTIONS

Loading Operations—Hatch Cycle

1. *Leave blank.*

2. *Dr. No.*—Note consecutive or alternate draft numbers here together with code of team which you are observing, port or starboard (P or S).

3. *Hook Arr.*—Record observed watch time when hook arrives within the *control* of the hold gang.

4. *Preposit., Beg.*—Record observed watch time of beginning of prepositioning draft for work by swinging of draft, moving on rollers, dolly, or conveyor.

5. *Preposit., End*—Leave blank if it is the same time as Hook Arr. Record observed watch time when draft is positioned in area ready for individual item stowage.

6. *P—P Dist.*—Record estimated distance in feet between point at which draft arrives and stowage spot.

7. *MHE Type*—Enter type of handling equipment used to preposition the draft.

8. *Hook On*—Note observed watch time when empty pallets or other items are attached to outgoing hook.

9. *Stowage Work, Beg.*—Record observed time at which first unit is moved from draft for stowage. If this observed time coincides with time noted in column (6), leave blank.

10. *Delay, Beg.*—Enter observed time of beginning of any delays occurring after stowage work begins.

11. *Delay, Code*—(same as Code for Discharge Operations—Hatch Cycle)

S—*Supervisory Delay*

H—*Hook Influence*

D—*Material Damage*

O—*Other*

12. *Delay, End*—Record observed time at which the delay ends and stowage work resumes.

13. *Stowage Work, End*—Record observed time at which stowage work ends, this is, the time at which the last piece is finally placed in stowed position.

14. *Reposit., Beg.*—Record observed watch time of commencement of repositioning of empty pallet or other gear in the hatch square, including stacking of empty pallets after completion of stowage work. If reposit begins simultaneously with end of stowage work, leave this space blank.

15. *Reposit., End*—Record observed watch time at which repositioning of empty pallet or other gear and stacking of empty pallets is completed.

16. *Support Activity, Beg.*—Record observed watch time at which additional work, such as dunnaging, laying separator paper, marking, and other activity begins. If this time coincides with End, Reposit, leave blank.

17. *Support Activity, End*—Record observed time at which support activity ends.

18. *No. Men*—Here note the actual number of men physically involved in the work situation observed. Do not include gang bosses, and other supervisory personnel not actually engaged in preposition, stowage or support activity.

19. *No. Pcs.*—Indicate here the estimated number of packages or other units on the draft.

20. *Cmdty.: Pkg., Wt., Cube*—Note here the type of commodity being marked, the package type, the estimated weight in pounds per unit and the estimated cube per unit. Use Remarks column if necessary, or if a run of the same commodity follows, use more than one line in Column (19). Use (√) to indicate repetitive entries.

21. *Remarks*—Use Remarks column to explain "other" delays, any unusual circumstances of stowage, stowage location, wings or square, blocking out, first work tier or second work tier, etc. Use Remarks liberally; write across the whole page.

DISCHARGE OBSERVATIONS—HATCH CYCLE

SHEET NO. ____________

SHIP NAME & TYPE ________________________ OBSERVER ________________________

HATCH & DECK ____________ (FWD/AFT) WATCH NO. ________ CORR. ________ DATE ________

Delay Code: S—SUPERVISORY DELAY; H—HOOK INFLUENCE; D—MATERIAL DAMAGE; O—OTHER

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
BLANK	DRAFT # TEAM	PRE-POSIT		P.P DIST	MHE TYPE	STOWAGE WORK					PRE-POSIT		HOOK OFF	HOOK LVS	SUPPORT ACTIVITY		NO. MEN	CMDTY PKG. WT CUBE	NO. PCS	REMARKS
							DELAY													
		BEG	END			BEG	BEG	CODE	END	END	BEG	END			BEG	END				

Figure C-3. Hatch cycle data sheet for discharging operations.

INSTRUCTIONS

Discharge Operations—Hatch Cycle

1. *Leave blank.*

2. *Dr. No.*—Record consecutive or alternate draft numbers together with indication of team which you are observing, port or starboard (P or S).

3. *Preposit., Beg.*—Record observed watch time of beginning of prepositioning empty pallet, or other gear by swinging, moving on rollers, dolly, conveyor of jitney from the hatch square to the area at which the pallet is to be loaded.

4. *Preposit., End*—Note observed watch time when empty pallet, etc., arrives loaded by the hold gang.

5. *P-P Dist.*—Record estimated distance in feet between point at which draft arrives and stowage begins.

6. *MHE Type*—Indicate type of materials handling equipment used to preposition the empty pallet or other gear.

7. *Stowage Work, Beg.*—Record observed time at which the first unit of cargo is broken out for placement on the pallet. If this time coincides with the time noted in column (4), leave blank.

8. *Delay, Beg.*—Record observed time of beginning of delays which occur after stowage work begins.

9. *Delay, Code*—Note cause of delay using the following code symbols which also appear on the front of this sheet:

S—*Supervisory Delay*—Any delay occurring as a result of gang boss, walking boss, stevedore superintendant or others stopping the work to explain work methods, or for any other reason.

H—*Hook Influence*—Any delay to the work caused by action of the hook, such as a loaded draft moving out of the square while men are present in the square, thereby forcing them to cease work and move out of the way of the draft.

D—*Material Damage*—Delays in stowage work caused by breakdown or adjustment of equipment, tumbling of drafts, or broken pallets or goods.

O—*Other*—Delays caused by any other reason, such as personal injury, workmen arguments, etc. Specify in "Remarks" column what caused the "other" delay.

10. *Delay, End*—Record the observed time at which the delay ends and stowage work resumes.

11. *Stowage Work, End*—Record the observed time at which the last piece of cargo is placed on the pallet or other carrying apparatus.

12. *Reposit., Beg.*—Record observed watch time of commencement of repositioning of loaded draft from stowage work area to hatch square for lift-out by the hook. If reposit begins simultaneously with end of stowage work, leave this space blank.

13. *Reposit., End*—Record observed watch time at which repositioning of loaded draft is completed.

14. *Hook Off*—Record observed time at which empty pallets or other gear is removed from incoming hook.

15. *Hook Lvs.*—Note watch time at which the loaded draft leaves the control of the hold gang.

16. *Support Activity, Beg.*—Record observed watch time at which additional work, such as removing dunnage, stacking empty pallets, etc., begins.

17. *Support Activity, End*—Note time when additional work ends.

18. *No. Men*—Here note the actual number of men physically involved in the work situation. Do not include gang bosses, walking bosses, or other supervisory personnel.

19. *No. Pcs.*—Indicate the estimated number of units of commodity on the draft.

20. *Cmdty.: Pkg., Wt., Cube*—Here note the type of commodity being worked, the package type, the estimated weight in pounds per unit and the estimated cube per unit. Use Remarks column if necessary, or if a run of the same commodity ensues, use check mark (√) to indicate repetitive entries.

21. *Remarks*—Use Remarks column to explain "other" delays and any unusual circumstances of the work. Also indicate the area from which cargo is being discharged, i.e., wings or square. Use Remarks liberally; write across the whole page.

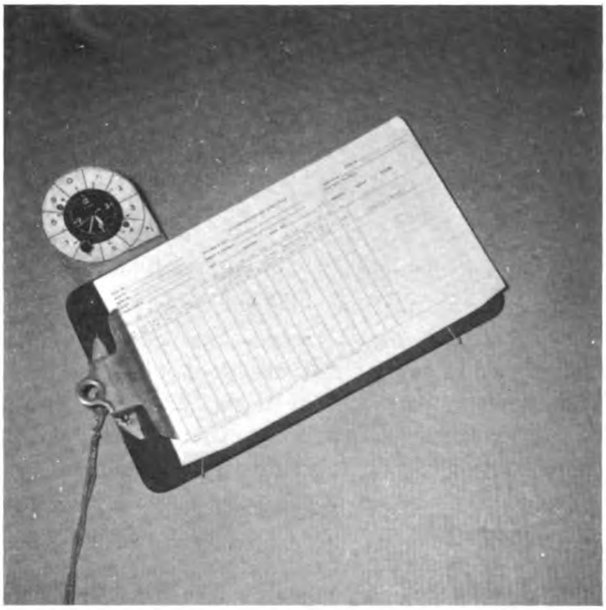


Figure C-4. Clipboard and clock used for data taking.

team was used when data were being taken in two compartments of the ship.

The data takers were selected from the membership of the ILWU Ship's Clerks and Checkers Union, Local 34. The advantages of using union checkers were evident from the earlier *Cargo Ship Loading Study* (NAS-NRC Pub. 474). They were familiar with the ships and the hazards involved in working around the gear; they were readily accepted by the longshoremen because of their community of interest; and they were familiar with the documentation and language of the business. Having had experience in keeping hatch logs, the clerks found the transition to the more detailed time sheets fairly simple.

Eighteen men were selected from the B list of the union for training as data takers. A few of the trainees decided they were not interested in the study after the original indoctrination lecture, and several dropped out during the study for various reasons. The final group consisted of twelve trained men from which teams were drawn.

The training sessions consisted of an indoctrination lecture, at which all of the men were present, followed by instruction in time-keeping techniques aboard ship. The first few data-taking sessions were very carefully supervised by at least two staff members who were available to answer questions and interpret situations as they arose. During the training period the men were given opportunity to take data on both the hook and hatch cycles.

Usually, one data taker was stationed on deck where he could observe the movement of the hook from the apron to the hold. Another data taker was stationed in the hold where he could observe all of the work being done by the team on one side of the hold. A third data taker was used for relief. A half hour pattern of rotation between hold, deck and relief was usual when only one hatch was being worked. When two hatches were under observation, one relief man was provided for both hatches.

Time data were taken on only one side of the hold because the work being done on the other side was a mirror image. The custom of each side taking alternate drafts assured an even distribution of the work between Port and Starboard teams. Previous data had shown that the difference between two teams in the same hatch was of such insignificance that collection of data on both sides was a needless expense. This simplification in data taking might not be possible if procedures are changed so that the two hold teams operate independently.

In the early stages of the study it was necessary to have two staff members on the ship to supervise the data collection. This was particularly true when working in more than one hatch. After the union data takers had become familiar with their duties, one MCTC staff member was able to supervise all of the data collection on the ship, still have time to interview longshoremen, and to make a subjective evaluation of the work being performed. The staff member also kept in close contact with the supercargo and the walking boss, so that he was aware of any changes in the stow plan or work schedule which might affect the team being observed.

In addition to the data taken aboard ship, supplementary data were gathered from company documents. The company records which were copied or used for reference included pile tags, manifests, hatchlogs, and stow plans. These records provided additional information for a check on the accuracy of the recordings of the data takers. Tonnage information was required in both weight and measurement units, so that it was sometimes necessary to refer to more than one record to find the necessary information.

As soon as possible after the data had been collected for a shift, the staff supervisor who had been aboard the ship edited each of the data sheets. The editing consisted of checking for accuracy of the entries, drift of the clocks, completeness, and weight and cube per draft. The editor also checked to ensure that all of the cargo was accounted for. Any special notes which would be required by the persons who would be analyzing the data were entered on the sheets during the editing. The hook sheets and hatch sheets were coordinated by comparing the time entries which the two had in common. These entries were the "hook arrives in hold" for loading operations and "hook leaves hold" for discharge operations.

DATA REDUCTION

The time data on the forms were reduced to elapsed times for the various segments of the cycle. These elapsed times were recorded on specially prepared Keysort cards, so that the information could later be segregated according to the meaningful variables.

Figure C-5 is a reproduction of the key used for coding the cards. It shows the variables by which the cards could be segregated. The Keysort card is designed to provide a simple mechanical method of making such segregation without using complex machinery. The cards have rows of holes around the periphery which can be identified with the variables to be recognized. By use of a simple hand tool, the classification is done by notching the holes relating to the desired variable. To sort the cards, they are aligned and a long needle run through the hole designating the desired information. By lifting and shaking the needle slightly, those cards which have been notched at that point drop out of the pile, thereby segregating the cards relating to the classification in question.

For the purposes to which the cards were put, they had several advantages over machine cards. The transcription of information onto the cards was easily done by students, without machinery, after a brief indoctrination. The sorting could be done in the office at any time, without resorting to machinery. The cards were of a size which allowed entry of qualitative and quantitative information. The punching was done on the perimeter of the card, so there was no obliteration of the data.

Figure C-6 shows the front and back of the card which was used for hatch loading cycles. Figure C-7 shows the card which was used for hatch discharge cycles. The information on these cards is essentially the same except for the sequence in which the segments of the cycle occur. The numbers in parentheses indicate the columns on the data sheets and indicate the arithmetic performed to calculate the elapsed time. On the Preposit lag line of the Hatch Analysis Loading card, (5 – 3) means subtract the time in Column 3 from the time in column 5. When appropriate, an allowance of 0.1 of a minute was deducted from the lags to provide for the time taken in unhooking the loads and hooking on empty pallets for removal from the hold. The elapsed times are entered for each draft on the back of the card. The lines on the back were totaled and these totals entered on the front of the card. Column totals on the back, which provided the Gross Cycle and Net Cycle entries for each draft, when totaled across, had to check with the column totals on the front of the card. Discrepancies were checked out until all totals cross checked. When the cards were printed, it was thought that the average times for each segment on the card should be entered on the front also. After the data reduction work got under way, it was discovered that this information was not needed because the averaging was more properly done at a later summary step in the reduction.

In addition to the time data, the front of the hatch cards also bore a notation of the total weight and cube, and the stowage factor of the drafts on the card. In a later stage of the analysis the average productivity of the subsample on the card was also entered.

Figure C-8 shows the front and rear of the hook cycle data card. The time information was entered on this card from the hook sheets in the same manner in which the hatch data were transferred to the hatch cards.

Each card had drafts entered on it pertaining to only one commodity, although there were many cards with the same commodity. The commodities were segregated by their handling characteristics in general conformity to the commodity list of the Pacific Maritime Association. In later steps of the analysis, commodity groups that had similar handling characteristics were grouped together and treated as a unit, making a larger subsample.

The data were collated from the cards according to the uses to which they were put. Standard ac-

CODING FOR VARIABLES USED IN KEYSORT ANALYSIS

Note

When coding card, always start in **upper left hand corner** (where card is cut) and proceed counterclockwise.

Code explanation:

L = left vertical nos.
R = right vertical nos.
UP (1-4) = Upper horizontal nos. Banks 1-4 Right to Left
Low (1-4) = Lower horizontal nos. Banks 1-4 Left to Right

	Code
A. Operation	
Load	L-1
Discharge	L-2
B. Company (ship and stevedoring company do not vary)	
APL	L-3
Matson	L-4
Grace	L-5
Luckenbach	L-6
Holland-America/Royal Mail	L-7
Other Company	L-8
C. Terminal	
San Francisco	L-9
Howard	L-10
Encinal	L-11
Army	L-12
Navy	L-13
D. Weather	
Dry	L-20
Rain	L-21
Dry-Tents Rigged	L-22
E. Time	
Day	L-23
Night	L-24

Hours of Day	Code
7-8	L-25
8-9	L-26
9-10	L-25 & L-26
10-11	L-27
11-12	L-25 & L-27
12-1	L-26 & L-27
1-2	L-28
2-3	L-25 & L-28
3-4	L-26 & L-28
4-5	L-29
5-6	L-25 & L-29
6-7	L-26 & L-29
F. Hatches	Lower (1)
1	1
2	2
3	1 & 2
4	4
5	1 & 4
6	2 & 4
7	7
G. Levels or decks	Lower (2)
1. Upper 'tween (or shelter)	1
2. Lower 'tween	2
3. Orlop	1 & 2
4. Hold	4

Figure C-5. Key for coding variables on Keysort cards.

Figure C-5 (continued)

	Code
5. Deep tank	1 & 4
6. Other	2 & 4
H. Compartment area	Lower (4)
Wing	1
Square	2
Forward	4
Aft	7
Freezer or Locker	Low (5)-1
I. Commodity	
Uniform sizes per load	R-1
Mixed sizes per load	R-2
Unitized load	R-3
Single unit per load	R-4
Type of package	
Boxes or cartons	R-7
Bales	R-8
Bags	R-9
Barrels	R-10
Unpackaged	R-11
Bundles	R-12
Drums	R-13
Reels & Rolls	R-14
Crates	R-15
Vans	R-16
J. Number of Men	
2 men	R-18
3 men	R-17 & R-18
4 men	R-19
5 men	R-17 & R-19
6 men	R-18 & R-19
7 men	R-20
8 men	R-17 & R-20
Double Team	R-18 & R-20
K. Gear	
1. Hold	
Stevedore Wagon	R-21
Fork lift	R-22
Electric platform truck (jitney)	R-21 & R-22
Conveyor	R-23

	Code
Hand carry	R-21 & R-23
Hand truck	R-22 & R-23
Dolly	R-24
2. Apron	
Fork lift	R-25
Tractor-trailer	R-26
Electric platform truck (jitney)	R-25 & R-26
Stevedore Wagon	R-27
Railroad	R-25 & R-27
Barge	R-26 & R-27
3. Hook	Upper (1)
Pallet	1
Single unit (rope or wire)	2
Barrel sling	1 & 2
Chine hook	4
Reel ram	1 & 4
Net	2 & 4
Other	7
L. Winches	
1. Type	Upper (3)
Electric	1
Steam	2
2. Controls	
Single operator	4
Two operators	7
M. Type of ship	Upper (4)
C-1	1
C-2	2
C-3	1 & 2
C-4	4
Mariner	1 & 4
Liberty—EC	2 & 4
Victory—VC	7
Other	1 & 7
N. Hook	Hole to Right of Upper 1 (1)
Hatch	Hole to Left of Lower 1 (1)
O. Single team	2 notches below R-1
P & S	1 notch below R-1
Standard	no notch

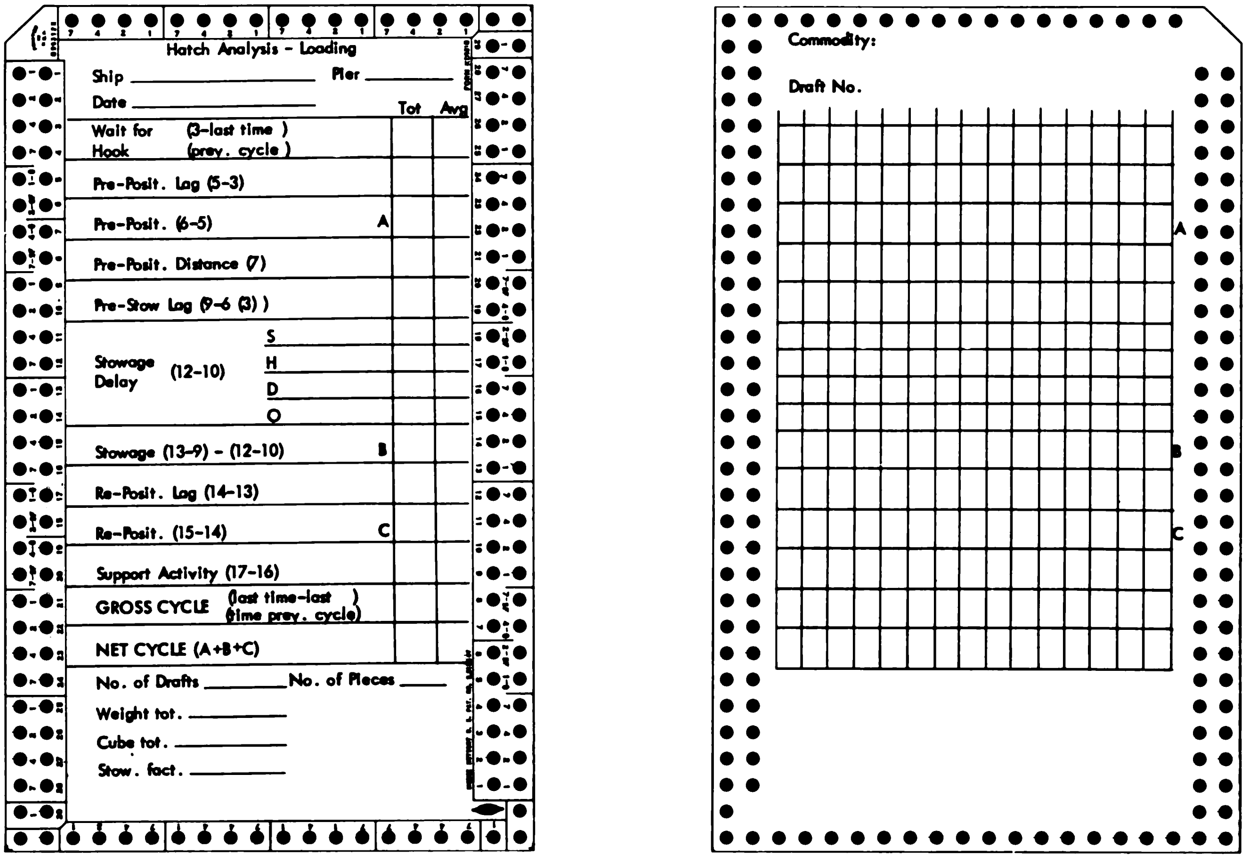


Figure C-6. Keysort card for analysis of hold gang activities while loading cargo.

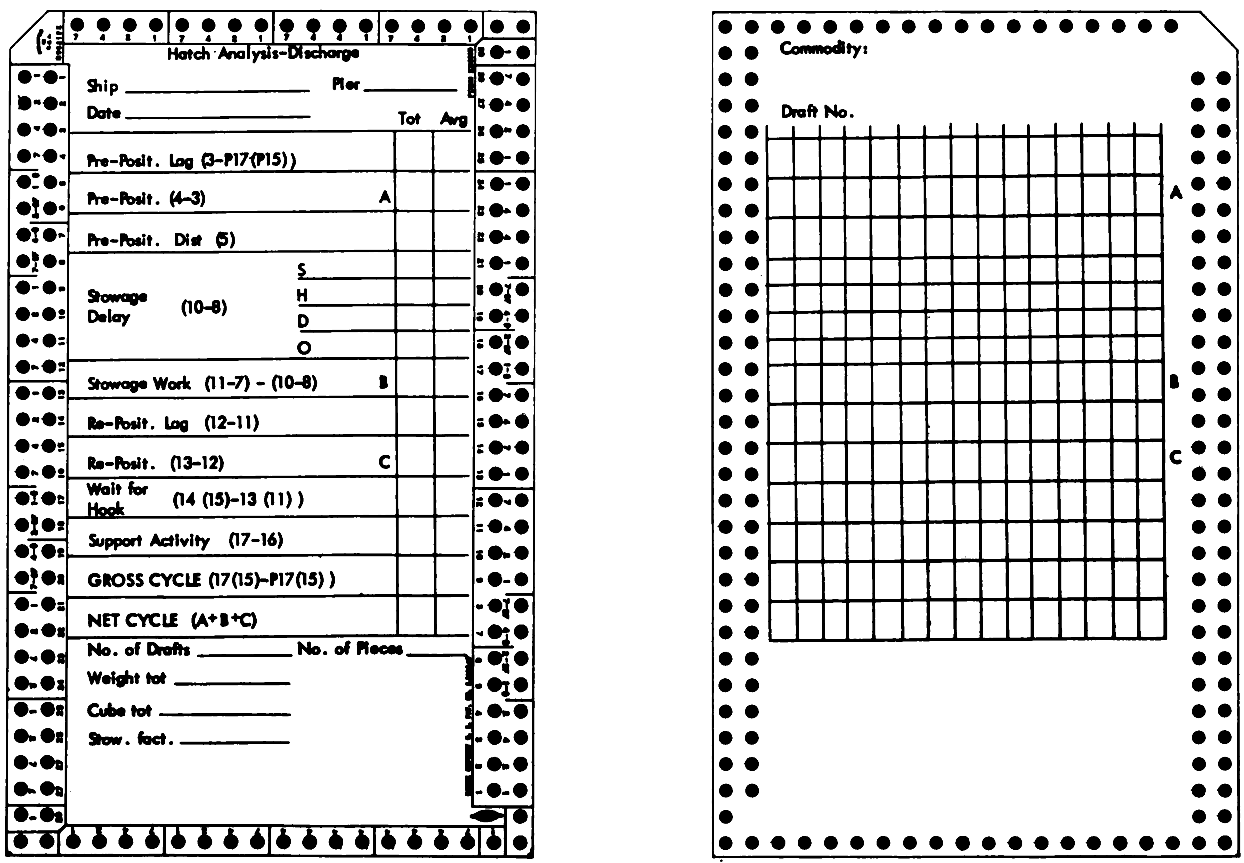


Figure C-7. Keysort card for analysis of hold gang activities while discharging cargo.

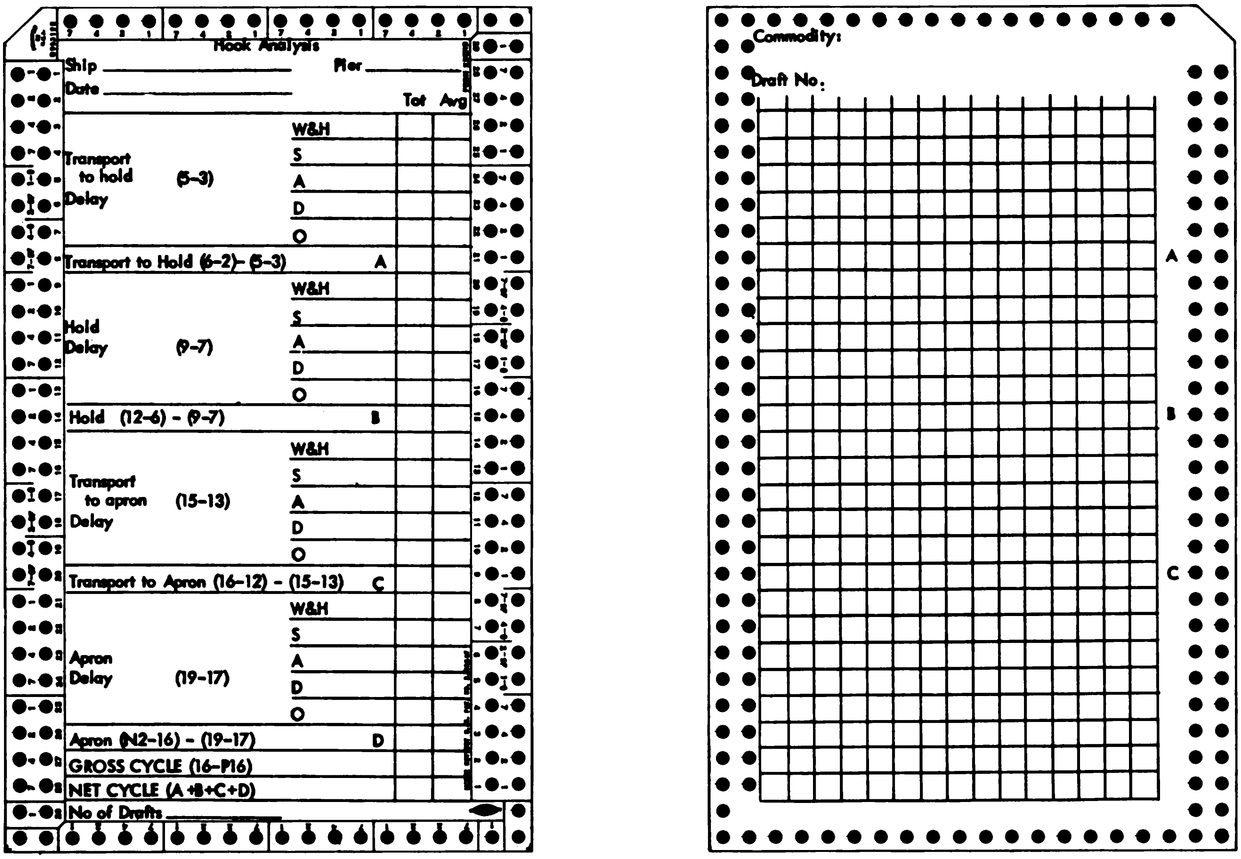


Figure C-8. Keysort card for analysis of cargo hook activities.

counting sheets were used for working forms and adapted to the specific task.

Most of the cargo handling was done by a split gang, with one group working the port and the other the starboard side of the hatch. However, only one side was observed. It was, therefore, necessary to multiply the number of drafts, and the weight and cube by two to get the total cargo loaded by the entire gang. When the gang worked as a single team, as they did when working in the square, the data could be used as observed.

Appendix D

PRECISION OF DATA AND MEASURES OF VARIANCE

It was not possible to control or segregate all of the large number of factors which might have affected the data presented in this report. Since exact duplication of all significant conditions which prevailed during the collection of data is impossible, the reproducibility of this data is limited. However, an effort was made to minimize possible bias by collecting data under a wide variety of conditions in the expectation that many of the unmeasured factors would cancel out.

The internal consistency, or precision, of the data samples can be determined in terms of standard errors of the mean, which are presented throughout this report. Whenever practical, an attempt was made to insure a degree of precision of the sample means of at least ± 10 per cent at the 90 per cent level of confidence. Errors in measuring time intervals, cargo weight, and cargo volume were negligible.

Data were collected on a draft-by-draft basis. In the analysis process, time and cargo information for each draft was accumulated on Keysort cards. Examples of these cards are presented in Appendix C. The cards had space to record information on 15 drafts. When there was a change in any of the variables such as commodity, stowage location, or number of men, a new card was employed. Because of these changes, cards may have as few as one or two drafts recorded on them. For each card a computation was made of the average amount of cargo handled per minute of gang activity. This observed cargo handling rate was treated as a subsample whose statistical weight was determined by the length of the observation expressed in minutes. Those cards or subsamples having the same characteristics with regard to recorded conditions such as ship type, commodity, stowage area, etc., were grouped together into samples. Any sample containing less than two observation cards or twenty drafts was considered too small to be significant for correlation or comparison purposes. The variance was computed for each sample using the standard variance formula [1] weighted according to subsample time duration and simplified for computation ease.

Non-quantitative variables, such as ship type or night and day operations, were evaluated by comparing mean productivity rates of the samples. These comparisons were made only within commodity groups. The significance of the difference between two samples was determined by use of the standard "t" test at the 95 per cent confidence level. A cross check of component distributions indicated that they approximated the normal curve closely enough for this purpose. Productivity differences between non-quantitative variables were concluded to be significant only when results for all commodities tested showed a consistent trend.

Where a quantitative variable, such as draft size or cargo density, was analyzed, simple regression analysis techniques were used. Correlation was considered significant when the square of the correlation coefficient exceeded 0.5.

---

[1] Weighted Standard Variance Formula

$$S^2 = \frac{\sum_{i=1}^{N} \frac{C_i^2}{t_i} - \sum_{i=1}^{N} C_i\bar{p}}{N-1}$$

and

$$S_{\bar{p}}^2 = \frac{S^2}{\sum_{i=1}^{N} t_i}$$

Where:

S^2 = unbiased estimator of sample variance

C_i = amount of cargo handled in i^{th} subsample (cubic feet or pounds)

t_i = time duration of i^{th} subsample

$\bar{p}$ = average amount of cargo handled per minute during sample

$$= \frac{\sum_{i=1}^{N} C_i}{\sum_{i=1}^{N} t_i}$$

N = number of subsamples

$S_{\bar{p}}^2$ = estimated variance of the mean $\bar{p}$

14[f]		15		16[f]		17		18[g]	
$\frac{M}{14}$	$\left(\frac{M}{12}\right)$	$\frac{M'}{g}$		$\frac{14}{M}$	$\left(\frac{12}{M}\right)$	$\frac{g}{M'}$		$\frac{15}{M'}$	$\left(\frac{13}{M'}\right)$
Observed Productivity Per Man Hour		Hand Stow Simulated Tons per Man Hour		Observed Man Hours Per Ton		Hand Stow Simulated Man Hours per Ton		Mach. Stow Simulated Man Hours per Ton	
MT/MH	ST/MH	MT/MH	ST/MH	MH/MT	MH/ST	MH/MT	MH/ST	MH/MT	MH/ST
1.63	1.51	3.03	2.79	.625	.664	.330	.359	.292	.316
1.79	1.34	3.90	2.91	.559	.746	.257	.344	.183	.244
1.58	1.30	3.51	2.89	.633	.769	.285	.346	.186	.226
1.42	.69	3.10	1.51	.705	1.450	.323	.662	.211	.432
1.59	.72	3.39	1.54	.629	1.390	.295	.650	.234	.512
2.46	1.75	5.09	3.61	.407	.572	.197	.277	.174	.245
1.49	.89	3.26	1.96	.670	1.130	.307	.510	.219	.363
1.59	1.06	3.33	2.21	.629	.945	.300	.452	.196	.295
$\frac{M}{12}$				$\frac{12}{M}$				$\frac{13}{M'}$	
1.98	.95	2.92	1.40	.505	1.052	.343	.714	.234	.489
1.82	1.39	4.24	3.24	.550	.720	.236	.309	.146	.191
2.07	1.87	2.91	2.64	.483	.536	.344	.379	.298	.329

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