Employment and Mobility Characteristics of Australian Merchant Navy Personnel

Occasional Paper

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Employment and Mobility Characteristics of Australian Merchant Navy Personnel

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FOREWORD

One of the many important issues addressed by Sir John Crawford in his report on the 'Revitalisation of Australian Shipping' was the development of manpower policies. This study, which was initiated in the months following publication of the Crawford Report, was designed to assist those in both industry and government responsible for the development of manpower policies and in particular those responsible for the recruitment, training and career development of maritime industry personnel.

The specific aims of this work were to review the recent recruitment, promotion and wastage characteristics of personnel in the industry, to estimate the numbers of recruits required in future years to sustain balanced industry growth and to assess the mobility of labour within the industry.

Throughout the study, priority was given to discussing the issues with both industry and government officials. The Bureau gratefully acknowledges the value of these discussions and the time and effort given by the individuals concerned. Particular reference must be made to the assistance provided by the staff of Legislation and Crews Branch, Marine Operations Division, Department of Transport.

This work was undertaken by Dr H.B. Milloy and Dr E.M. Casling, with assistance from Mr S. Sullivan, Mr S. Wheatstone, Ms N. Shute, Ms P. Fiveash and Ms I. Chan.

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September 1983

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SUMMARY

This study was undertaken to assist in the development of manpower policies for the Australian merchant navy. More specifically the objectives were to review the recent recruitment, promotion and wastage characteristics of personnel in the industry, to estimate the numbers of recruits required in future years to sustain industry growth and to assess the mobility of labour within the industry.

The demand for manpower, which was defined in terms of the number of ship berths available for officers and ratings in the Australian merchant navy, was about 3900 from 1977-78 to 1981-82. Measured in terms of berths the two largest industry sectors were coastal bulk vessels and tankers; together these two sectors comprised about 50 per cent of total manpower demand. In the study period the overseas bulk sector recorded the highest average growth rate, followed by the offshore industry. The coastal bulk sector was the only one for which there was a net decline in the number of berths available.

Between 8000 and 9000 men were employed in the industry in the period 1976-77 to 1981-82, or approximately 2.2 men per berth. Officers represented about 35 per cent of the total workforce and the largest single employment category was deck ratings, which comprised 28 per cent of the workforce. Throughout the study period the proportion of men in each employment category remained essentially constant with the exception of shipwrights whose numbers fell by 29 per cent over the six-year period.

The age distributions of officers and ratings were found to be markedly different. The most probable age for an officer was between 30 and 35 years and between 50 and 55 years for a rating. The age distributions of officer and rating recruits were very similar. The most probable age of both officer and rating recruits was between 20 and 30 years and the average age of both groups of recruits was about 32 years. An analysis of recruitment sources revealed that stewards and cooks had the highest proportion of Australian recruits, with average values of 89 and 80 per cent respectively, whereas deck officers had the lowest with an average value of 52 per cent.

The average wastage rate for both officers and ratings in the period 1977 to 1982 was 7 per cent per annum.

A mathematical technique known as Markov chain analysis was used to estimate the number of recruits required in the future to sustain industry growth rates of +5, 0 and -5 per cent per year. Each of the main employment categories was examined with two recruitment strategies. In the first strategy future recruitment distributions were set at their previously stable historical values to assess the *status quo* option and to provide benchmark data for comparison with an alternative recruitment strategy. In this alternative strategy it was assumed that there will be more emphasis on recruiting younger officers and ratings. More specifically it was assumed that all officer recruits will be cadets under 21 years of age and rating recruits will be equally divided between the under 21 and the 21 to 30 age groups. In all calculations it was assumed that the rate at which personnel will leave the industry in the future will be the average rate observed in recent years.

It was found that, if historical recruitment and wastage patterns are continued in the future and industry growth is between plus and minus 5 per cent per annum, there are likely to be only small changes in the age distributions of officers and ratings in the next ten years. It was also found that any future reduction in the average age of recruits is

likely to result in a small, slow decrease in the average age of the workforce but is unlikely to have any major effect on the number of recruits required to sustain industry growth. The future growth rate of the industry will also effect the average age of the workforce. If recruitment and wastage patterns do not vary in the future then positive industry growth would result in a decrease in the average age of the workforce and negative growth would have the opposite effect.

The analysis of labour mobility in the industry between 1977 and 1981 revealed that a large fraction of both officers and ratings stayed on the same ship for extended periods. For example, 60 per cent of ratings and 52 per cent of officers changed ship less than once per year on average. However, the men who transferred frequently between ships caused crew turnover rates to be high; on average 50 per cent of a new crew of ratings transferred to another ship in the first two months. It was found that crew turnover depended strongly on industry sector, with the lowest turnover observed for tankers and the highest for overseas bulk vessels. Ratings showed 'loyalty' to the coastal bulk sector, but to no other industry sector. Thus it was concluded that the workforce did not consist of groups of men who worked on specific types of ships. Instead it appeared that a 'typical' man chose ship type on a random basis.

CHAPTER 1—INTRODUCTION

BACKGROUND

In July 1982 the Commonwealth Government announced a number of policy initiatives to encourage the development of an efficient, revitalised Australian shipping industry. These initiatives accorded with the recommendations made by Sir John Crawford in his 'Report on the Revitalisation of Australian Shipping' (Crawford 1982), which addressed a wide range of issues which affected the industry's ability to compete commercially with both land-based domestic transport and international shipowners. One of the more important of these issues, and the one which formed the background to this study, is the establishment of a new manpower policy for better and more flexible training of maritime personnel.

To assist in the development of manpower, and particularly training policies, in September 1982 the Bureau of Transport Economics (BTE) commenced this study of the employment and mobility characteristics of officers and ratings in the Australian merchant navy. The study was designed to provide a clearer understanding of the recruitment, promotion and wastage characteristics of personnel in the industry and so to estimate the number of recruits who would be required to sustain balanced industry growth. No attempt was made in this study to predict future growth patterns in the industry. Rather the approach has been to discuss the manpower implications for a range of growth rates and leave it to others to decide which growth rate will be the most likely.

Australia has a relatively small maritime industry. In July 1982 the total Australian trading fleet, that is, all vessels of 150 gross registered tonnes and over in both the coastal and overseas trades numbered 109 and had a deadweight of 3.4 million tonnes (DoT 1983): of these, 94 were registered in Australia. There were 28 vessels trading overseas and 17 of these were Australian-owned. In 1981-82, Australian-registered vessels carried approximately 4 per cent (in revenue tonnes) of Australia's overseas trade and Table 1.1 gives a breakdown of this trade by ship type and by imports and exports. One of the implicit objectives of the Government's revitalisation package is to enable the industry to transport larger fractions of Australia's exports and imports and hence to increase career opportunities for Australian seamen.

In recent years there have been between 8000 and 9000 personnel employed in the merchant navy, of whom about 2900 were officers. Almost all officers are permanent employees of ship operating companies and each company is responsible for the recruitment and career management of its officers.

Ratings, in contrast, can be considered as industry, rather than company, employees and an institutional framework has been developed to balance manpower supply and demand. On a day-to-day basis the balance is achieved by a formal engagement system (the Marine Cooks, Marine Stewards and Seamen's Engagement System). This system, which is administered by the Commonwealth with active co-operation from the shipping companies and the maritime unions, is designed to ensure an equitable allocation of berths among industry personnel and to decrease the costs of hiring labour incurred by both employees and employers.

In the longer term the supply-demand balance for ratings is maintained by trade union supervision of the number of recruits in each employment category. In the past it has been common practice to meet local shortfalls in manpower supply by recruitment of ratings and particularly officers from overseas. Recently this practice has been

TABLE 1.1—AUSTRALIAN FLAG CARRIAGE OF OVERSEAS CARGOES, 1981-82

Ship type	*Percentage of revenue tonnes carried in Australian flag ships*
General cargo	
Imports	7.7
Exports	5.5
Tankers	
Imports	2.7
Exports	0.9
Bulk carriers	
Imports	2.6
Exports	3.7
Other	
Imports	0.0
Exports	2.9
Total	
Imports	4.4
Exports	3.8

Source: B380 Shipping Statistics from ABS.

questioned and more emphasis is being given to recruiting and training local officer cadets and ratings. For example, the Australian Maritime College was established in Launceston in 1980 to train deck and engineer officers. In August 1982 it was announced that formal training for ratings will also be provided at Launceston. Accordingly, one of the objectives of this study was to provide those responsible for the design and management of maritime training facilities with a better understanding of the recruitment, promotion and wastage characteristics of personnel in the industry.

The mobility and motivation of personnel as they moved between ships and shipping sectors were also examined in the course of the study. As officers are usually company employees their mobility is determined largely by company policy. Ratings, on the other hand, are usually able to choose the time they stay on each ship. This work provides estimates of the frequency with which men changed ships and changed from one type of ship to another. The 'loyalty' of ratings to particular types of ships was also studied.

The data base for this study was the register of personnel records maintained by the Department of Transport in fulfillment of its responsibilities under the *Navigation Act* 1912 and Schedule 10 of the Maritime Industry Sea-going Award. Since 1975, annual reviews have been made of personnel in the industry but this is the first occasion a systematic analysis of manpower supply in the industry has been undertaken. No evidence has been obtained of a similar analysis of an overseas maritime industry. However, a British inquiry into shipping (Rochdale 1970) did address many of the broader issues affecting maritime manning policy.

EMPLOYMENT CATEGORIES

In theory it would have been desirable to describe the workforce characteristics of each of the approximately 50 employment classifications in the industry. In practice this was not possible due to lack of data and because the small numbers of personnel in some classifications resulted in unacceptably large statistical errors.

Grouping of the 50 employment classifications was found to be necessary and the composition of the 11 main employment categories used in this study is given in Table 1.2. For example the general term 'deck ratings' includes bosuns, bosuns' mates, able

seamen, ordinary seamen, deck boys and other deck ratings. Ten of the 11 employment categories listed in Table 1.2 can be treated independently as only rarely do personnel move between these broad categories. Crew attendants are the exception as they are usually recruited from deck ratings and engine-room ratings. In the future it may become more common for personnel to change from one category to another, particularly from deck ratings to deck officers and from engine-room ratings to engineer officers.

In addition to the 11 employment categories listed in Table 1.2 the terms officers and ratings are used frequently in this paper. The term 'officers' is used to describe deck and engineer officers, electrical and refrigeration engineers and radio officers. The term 'ratings' is used to describe the remaining categories in Table 1.2 including miscellaneous categories such as pursers and general purpose hands.

TABLE 1.2—EMPLOYMENT CATEGORIES IN THE AUSTRALIAN MERCHANT NAVY

Officers	
Deck officers	Masters 1st Mates 2nd Mates Deck officers (uncertificated) Deck cadets/apprentices
Engineer officers	Engineers Class 1 Engineers Class 2 Engineer officers (uncertificated) Engineer cadets/apprentices
Electrical and refrigeration engineers	Electrical engineers (uncertificated) Refrigeration engineers (uncertificated)
Radio officers	1st Class 2nd Class General
Ratings	
Deck ratings	Bosuns/bosuns' mates Able seamen Ordinary seamen Deck boys Other deck ratings
Engine-room ratings	Donkeymen and pumpmen Greasers Motormen Wipers
Stewards	Stewards Stewardesses
Cooks	Cooks Bakers Butchers
Crew attendants	Crew attendants
Shipwrights	Shipwrights
Miscellaneous	Miscellaneous

REPORT FORMAT

This report is, in effect, composed of two parts. The first, consisting of Chapters 2 to 5, describes the historical demand and supply characteristics of manpower in the industry and the numbers of recruits required to sustain a range of future industry growth rates. The effects on recruitment numbers brought about by changes to the age distribution of recruits are included in this analysis. The second part, comprising Chapter 6, describes the mobility of personnel in the industry.

CHAPTER 2—HISTORICAL DEMAND FOR MANPOWER

Although no attempt was made in this study to forecast the future demand for manpower in the merchant navy, an understanding of historical manpower demand was essential to the analysis of workforce mobility described in Chapter 6. The following analysis of total manpower demand and the breakdown of demand into industry sectors may also assist the continuing debate on industry revitalisation.

The demand for manpower is defined in this work in terms of the berths in the Australian merchant navy, which in turn is defined to be those ships covered by section 10 of the *Navigation Act* 1912.[1] This section of the Act applies to ships of which the majority of the crew are residents of Australia and which are operated by any of the following:

- a person who is a resident of, or has his principal place of business in, Australia;
- a firm that has its principal place of business in Australia; or
- a company that is incorporated, or has its principal place of business in Australia.

The demand for manpower was estimated from a knowledge of the ships in the industry at any time (DoT 1978-83) and the manning level of each ship. The total demand for manpower over the study period is shown in Figure 2.1. By considering the physical characteristics of each ship and the trade in which each ship was principally engaged, total demand was disaggregated into the following nine categories or industry sectors[2] (see Appendix I):

- coastal bulk
- tankers
- coastal roll-on/roll-off
- multi-purpose
- offshore[3] (resource exploration and exploitation)
- overseas bulk
- liner (Europe)
- liner (Asia)
- other.

The total number of berths available in the merchant navy from 1977-78 to 1981-82 and the number of berths in each industry sector are shown in Figure 2.1. It can be seen that the total number of berths remained relatively stable at about 3900.

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1. The demand for manpower could alternatively have been defined in terms of the labour requirements of employers registered under Schedule 10 of the Maritime Industry Sea-going Award. From 1977-78 to 1981-82 the number of berths available with registered employers was on average 3 per cent less than the berths on ships covered by section 10 of the *Navigation Act* 1912. This discrepancy, which is due to differences in the definitions of which ships were included in the industry, does not affect any of the conclusions reached in this study.

2. Section 10 of the *Navigation Act* 1912 does not provide a good coverage of harbour craft (tugs, dredgers etc) apart from Victoria (excluding Portland), South Australia, Western Australia and the Brisbane river. For this reason harbour craft are not included in this demand analysis.

3. A small number of vessels involved in the offshore industry were in practice not covered by section 10 of the *Navigation Act* 1912 and are therefore not included in this analysis.

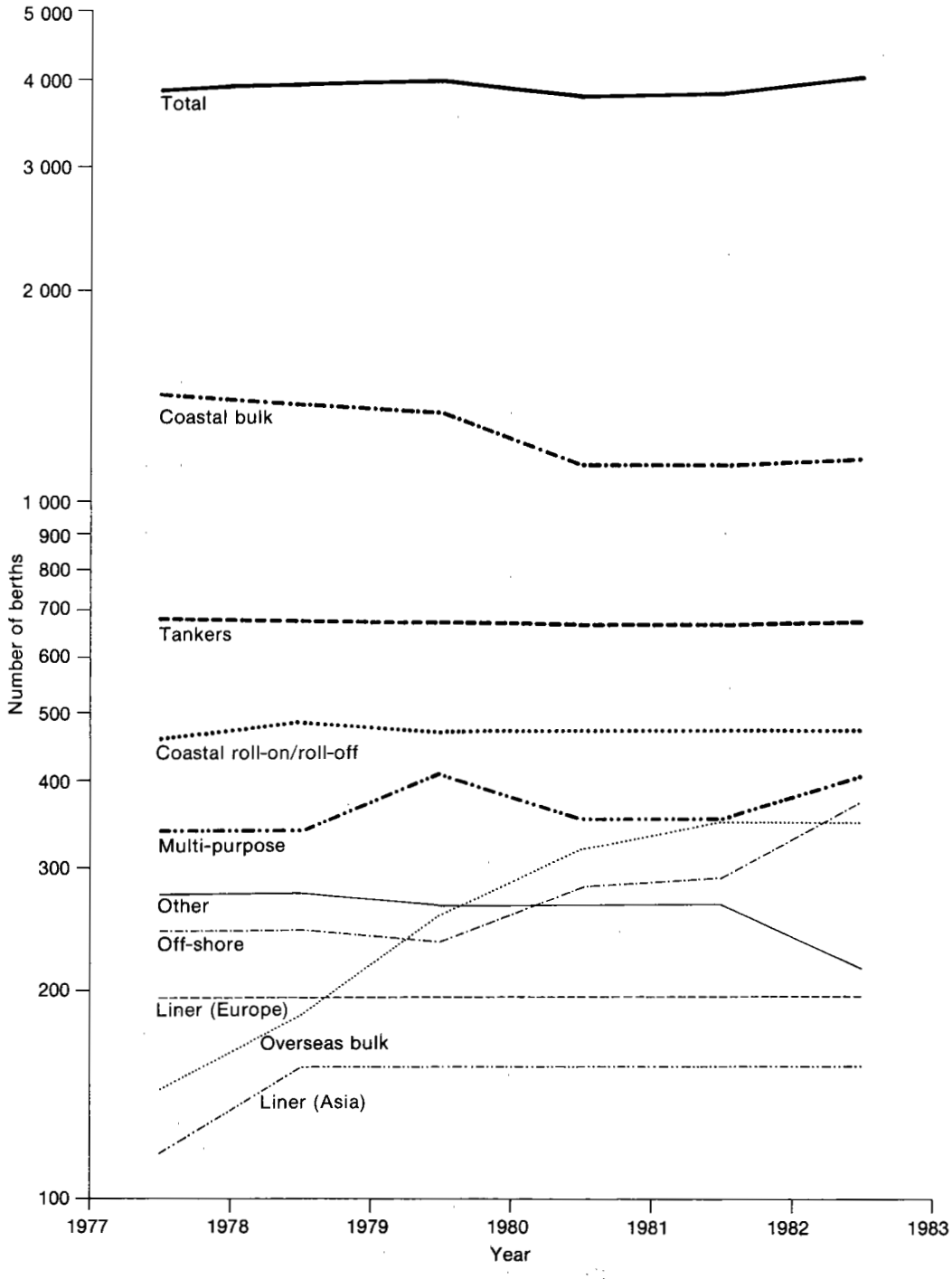

Figure 2.1— Historical demand for manpower in the Australian merchant navy

In terms of berths the two largest sectors were coastal bulk and tankers, which together constituted about 50 per cent of total manpower demand. In the period under study the overseas bulk sector recorded the highest average growth rate, followed by the offshore industry. The coastal bulk sector was the only one for which there was a decline in the number of berths available. These growth characteristics for the overseas and coastal bulk sectors are consistent with Sir John Crawford's observation (Crawford 1982) that ". . . the efforts to revitalise the Australian shipping industry . . . are likely to be seen principally in the overseas trade in bulk cargoes (rather) than in liner cargoes. I would not foresee great developments in the coastal trades except as a result of the improved efficiency resulting from combined coastal and overseas trading with bulk cargoes".

CHAPTER 3—HISTORICAL WORKFORCE CHARACTERISTICS

EMPLOYMENT LEVELS

The total number of men employed in the merchant navy between 1976-77 and 1981-82 is shown in Figure 3.1, together with the numbers of officers and ratings employed in the same period. These estimates of the size of the workforce include the men who were occupying berths, the men on leave and the relatively small number of men waiting to be offered berths at any one time. It can be seen from Figure 3.1 that total employment in the industry varied between 8000 and 9000 in the six-year period. Officers and ratings represented about 35 and 65 per cent of the workforce respectively.

It follows from the data in Figures 2.1 and 3.1 that about 2.2 men were employed for each available berth. This ratio reflects the fact that men were granted about one day's recreational leave for one day's work and the general need to employ a small number of additional men to allow for non-recreational leave such as sick leave. The slight increase in employment observed for ratings in 1981-82 is not reflected in the demand data in Figure 2.1 and was due to an increase in leave allowances and the subsequent need to employ more ratings.

The number of men in each employment category is listed in Table 3.1. It follows from this table that not only did employment levels remain relatively stable but also that the relative numbers in all employment categories except shipwrights remained stable. In the six-year period the proportion of shipwrights in the industry fell from 2.8 to 2.0 per cent of the workforce, a fractional decrease of 29 per cent.

Figure 3.2 is a schematic breakdown of the workforce by employment category. The data in Figure 3.2, which are averages over the six-year period, show that deck ratings were by far the largest category. It is interesting to note that about two deck ratings were employed for each deck officer but, in contrast, there were 50 per cent more engineer officers than engine-room ratings.

AGE DISTRIBUTION OF EACH EMPLOYMENT CATEGORY

Data were available on the age distribution of men in each employment category from 1977-78 to 1981-82. The data were recorded in five-year age intervals. In the five-year period there was no evidence of statistically significant changes to the age distribution of any employment category and scatter in the distributions could therefore be reduced by averaging over time. The time-averaged age distributions for the six largest employment categories are shown in Figure 3.3, and the aggregated data for officers and ratings are shown in Figure 3.4. It can be seen that the forms of the distributions for officers and ratings were quite different: the most probable age of an officer was in the range 30 and 35 years whereas the most probable age of a rating was between 50 and 55 years. The average ages of officers and ratings were 39 and 42 years respectively.

RECRUITMENT

The number and age distribution of recruits in each employment category were available for the period 1977-78 to 1981-82. As no significant changes with time were observed for any employment category the data for each category were averaged. The time-averaged recruitment distributions for the six largest employment categories are shown in Figure 3.5. The aggregated data for officers and ratings, which are shown in

Figure 3.6, indicate that the average age for officer recruitment was 32 years which was about the same as that for ratings (33 years). The most probable age of both officer and rating recruits was between 20 and 30 years.

Sources of recruits

Personnel were recruited to the Australian merchant navy from various sources, including Australia, the United Kingdom, New Zealand and other foreign countries. Tables 3.2 to 3.9 give the numbers and relative proportions of recruits from these sources for the years 1977 to 1979, 1980-81 and 1981-82 and for the employment categories under detailed consideration in this paper. A change in the data collection procedures in 1980 was responsible for the change from calendar to fiscal years.

Between 1977 and 1980-81 the percentage of Australian recruits in the industry increased from 55 to 77 per cent, while that for United Kingdom/New Zealand recruits rose from 3 to 15 per cent. Between 1980-81 and 1981-82, however, there was a slight drop to 72 per cent in the fraction of Australian recruits, together with an increase from 8 to 12 per cent in the proportion of other/ foreign recruits. These changes coincided with the increase in the total number of recruits caused by changes to the leave provisions in 1981.

Similar trends were also observed for individual employment categories. Over the five-year period stewards and cooks had the highest proportion of Australian recruits, with average values of 89 and 80 per cent respectively, whereas deck officers had the lowest, with an average value of 52 per cent.

TABLE 3.1—EMPLOYMENT LEVELS BY CATEGORY; 1976-77 TO 1981-82

Employment category	*Financial year*					
	76-77	*77-78*	*78-79*	*79-80*	*80-81*	*81-82*
Officers						
Deck officers	1199	1234	1192	1139	1223	1235
Engineer officers	1457	1389	1367	1262	1278	1362
Electrical and refrigeration engineers	195	183	191	192	194	198
Radio officers	206	197	196	193	181	199
Total	3057	3003	2946	2786	2876	2994
Ratings						
Deck ratings	2485	2437	2426	2327	2248	2566
Engine-room ratings	885	840	868	832	815	939
Stewards	1020	977	1001	988	1008	1072
Cooks	560	536	569	528	539	601
Crew attendants	428	424	422	411	356	368
Shipwrights	247	235	217	172	174	177
Miscellaneous	124	104	39	49	142	266
Total	5749	5553	5542	5307	5282	5989
Total	8806	8556	8488	8093	8158	8983

Source: General register of seamen: masters and seamen employed during the financial year, DoT.

Figure 3.1— Employment levels; 1976-77 to 1981-82

TABLE 3.2—SOURCE OF RECRUITS; DECK OFFICERS

Year	Australia	United Kingdom & New Zealand	Other/ foreign	Total
1977	35	3	50	88
	(0.40)	(0.03)	(0.57)	
1978	25	4	42	71
	(0.35)	(0.06)	(0.59)	
1979	68	24	10	102
	(0.67)	(0.24)	(0.10)	
1980-81	64	28	22	114
	(0.56)	(0.25)	(0.19)	
1981-82	111	29	37	177
	(0.63)	(0.16)	(0.21)	

NOTE: Parentheses indicate proportion of total.
Fractions may not add to 1.00 due to rounding.

Source: General register of seamen: number of new entrants to the Australian maritime industry, DoT.

TABLE 3.3—SOURCE OF RECRUITS; ENGINEER OFFICERS

Year	Australia	United Kingdom & New Zealand	Other/ foreign	Total
1977	40	1	35	76
	(0.53)	(0.01)	(0.46)	
1978	35	3	36	74
	(0.47)	(0.04)	(0.49)	
1979	59	11	13	83
	(0.71)	(0.13)	(0.16)	
1980-81	93	14	6	113
	(0.82)	(0.12)	(0.05)	
1981-82	122	32	41	195
	(0.63)	(0.16)	(0.21)	

NOTE: Parentheses indicate proportion of total.
Fractions may not add to 1.00 due to rounding.

Source: General register of seamen: number of new entrants to the Australian maritime industry, DoT.

TABLE 3.4—SOURCE OF RECRUITS; DECK RATINGS

Year	*Australia*	*United Kingdom & New Zealand*	*Other/ foreign*	*Total*
1977	42	3	34	79
	(0.53)	(0.04)	(0.43)	
1978	50	1	8	59
	(0.85)	(0.02)	(0.14)	
1979	88	23	4	115
	(0.77)	(0.20)	(0.03)	
1980-81	95	30	4	129
	(0.74)	(0.23)	(0.03)	
1981-82	274	93	29	396
	(0.69)	(0.23)	(0.07)	

NOTE: Parentheses indicate proportion of total.
Fractions may not add to 1.00 due to rounding.

Source: General register of seamen: number of new entrants to the Australian maritime industry, DoT.

TABLE 3.5—SOURCE OF RECRUITS; ENGINE-ROOM RATINGS

Year	*Australia*	*United Kingdom & New Zealand*	*Other/ foreign*	*Total*
1977	13	3	10	26
	(0.50)	(0.12)	(0.38)	
1978	15	1	4	20
	(0.75)	(0.05)	(0.20)	
1979	65	11	4	80
	(0.81)	(0.14)	(0.05)	
1980-81	50	8	8	66
	(0.76)	(0.12)	(0.12)	
1981-82	113	26	32	171
	(0.66)	(0.15)	(0.19)	

NOTE: Parentheses indicate proportion of total.
Fractions may not add to 1.00 due to rounding.

Source: General register of seamen: number of new entrants to the Australian maritime industry, DoT.

TABLE 3.6—SOURCE OF RECRUITS; STEWARDS

Year	*Australia*	*United Kingdom & New Zealand*	*Other/ foreign*	*Total*
1977	19	—	5	24
	(0.79)	—	(0.21)	
1978	32	1	5	38
	(0.84)	(0.03)	(0.13)	
1979	91	9	—	100
	(0.91)	(0.09)	—	
1980-81	73	3	1	77
	(0.95)	(0.04)	(0.01)	
1981-82	157	6	1	164
	(0.96)	(0.04)	(0.01)	

— Nil or rounded to zero

NOTE: Parentheses indicate proportion of total.
Fractions may not add to 1.00 due to rounding.

Source: General register of seamen: number of new entrants to the Australian maritime industry, DoT.

TABLE 3.7—SOURCE OF RECRUITS; COOKS

Year	*Australia*	*United Kingdom & New Zealand*	*Other/ foreign*	*Total*
1977	25	—	10	35
	(0.71)	—	(0.29)	
1978	12	1	3	16
	(0.75)	(0.06)	(0.19)	
1979	33	11	2	46
	(0.72)	(0.24)	(0.04)	
1980-81	52	2	1	55
	(0.95)	(0.04)	(0.02)	
1981-82	92	12	3	107
	(0.86)	(0.11)	(0.03)	

— Nil or rounded to zero

NOTE: Parentheses indicate proportion of total.
Fractions may not add to 1.00 due to rounding.

Source: General register of seamen: number of new entrants to the Australian maritime industry, DoT.

TABLE 3.8—SOURCE OF RECRUITS; OFFICERS

Year	Australia	United Kingdom & New Zealand	Other/ foreign	Total
1977	79	4	89	172
	(0.46)	(0.02)	(0.52)	
1978	64	11	84	159
	(0.40)	(0.07)	(0.53)	
1979	147	43	28	218
	(0.67)	(0.20)	(0.13)	
1980-81	172	47	31	250
	(0.69)	(0.19)	(0.12)	
1981-82	250	67	89	406
	(0.62)	(0.17)	(0.22)	

NOTE: Parentheses indicate proportion of total.
Fractions may not add to 1.00 due to rounding.

Source: General register of seamen: number of new entrants to the Australian maritime industry, DoT.

TABLE 3.9—SOURCE OF RECRUITS; RATINGS

Year	Australia	United Kingdom & New Zealand	Other/ foreign	Total
1977	130	6	72	208
	(0.63)	(0.03)	(0.35)	
1978	115	4	32	151
	(0.76)	(0.03)	(0.21)	
1979	299	56	10	365
	(0.82)	(0.15)	(0.03)	
1980-81	281	43	14	338
	(0.83)	(0.13)	(0.04)	
1981-82	671	137	65	873
	(0.77)	(0.16)	(0.04)	

NOTE: Parentheses indicate proportion of total.
Fractions may not add to 1.00 due to rounding.

Source: General register of seamen: number of new entrants to the Australian maritime industry, DoT.

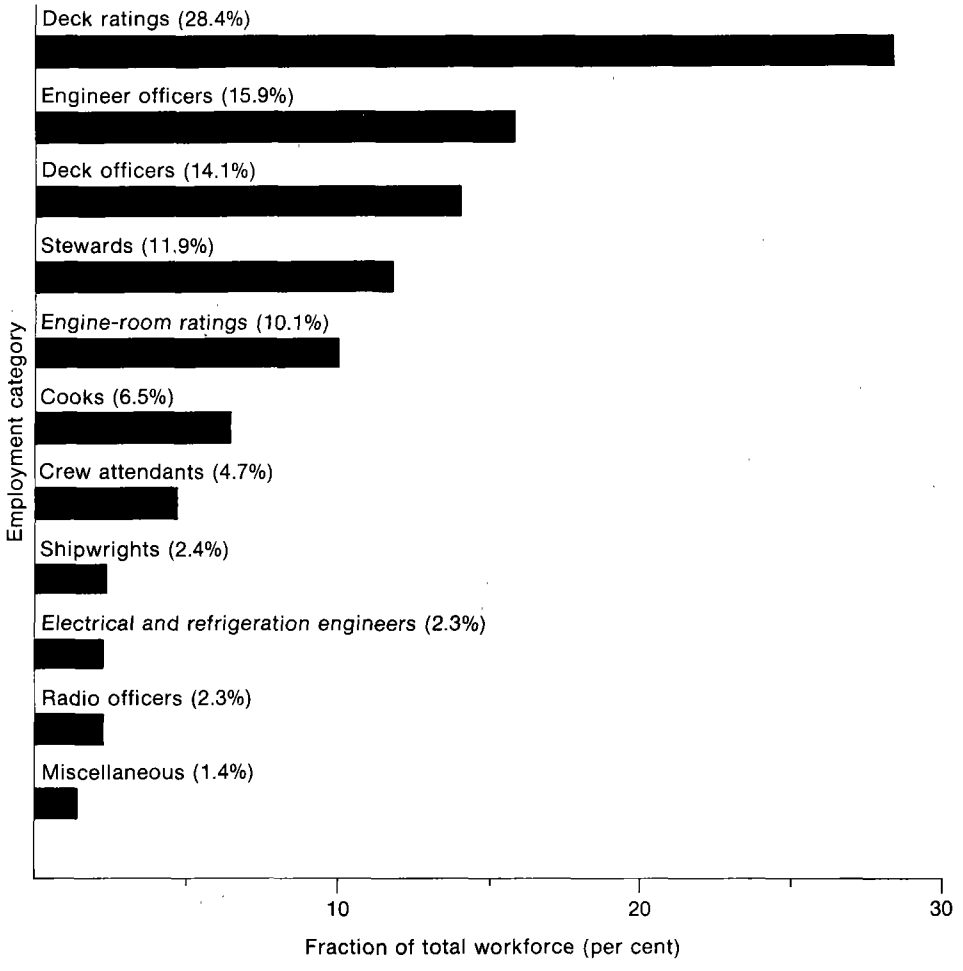

Figure 3.2— *Composition of the workforce by employment category*

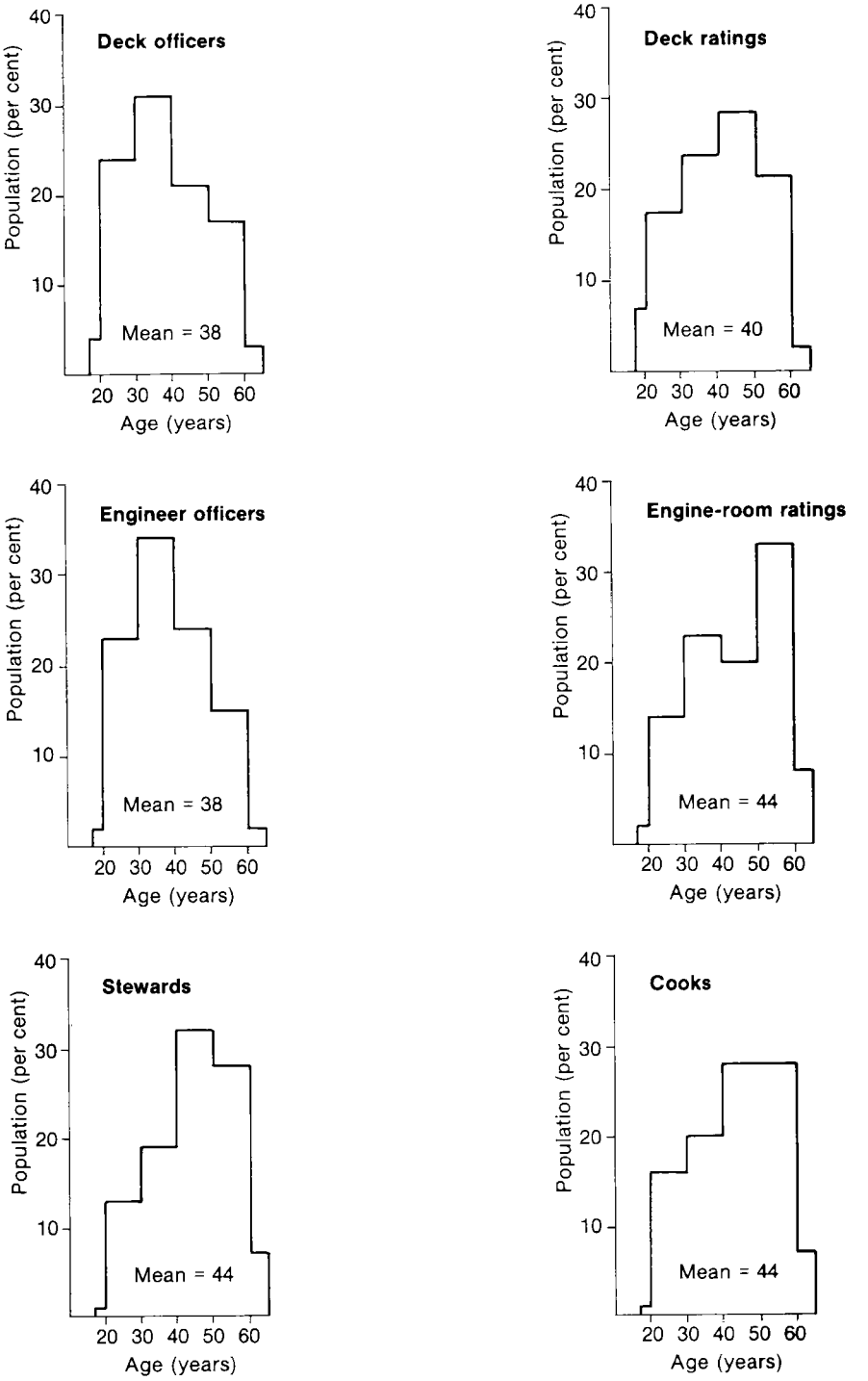

Figure 3.3—Age distributions for individual employment categories

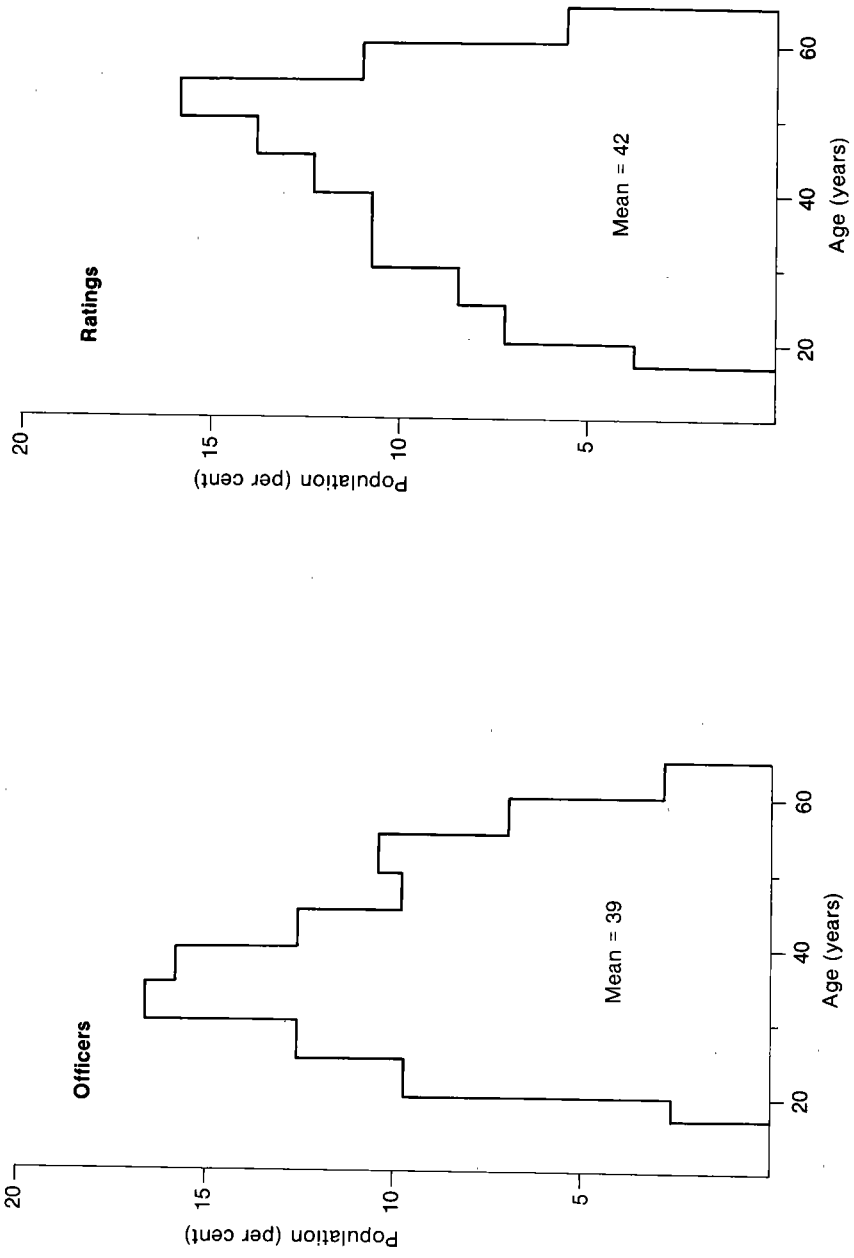

Figure 3.4— Age distributions for officers and ratings

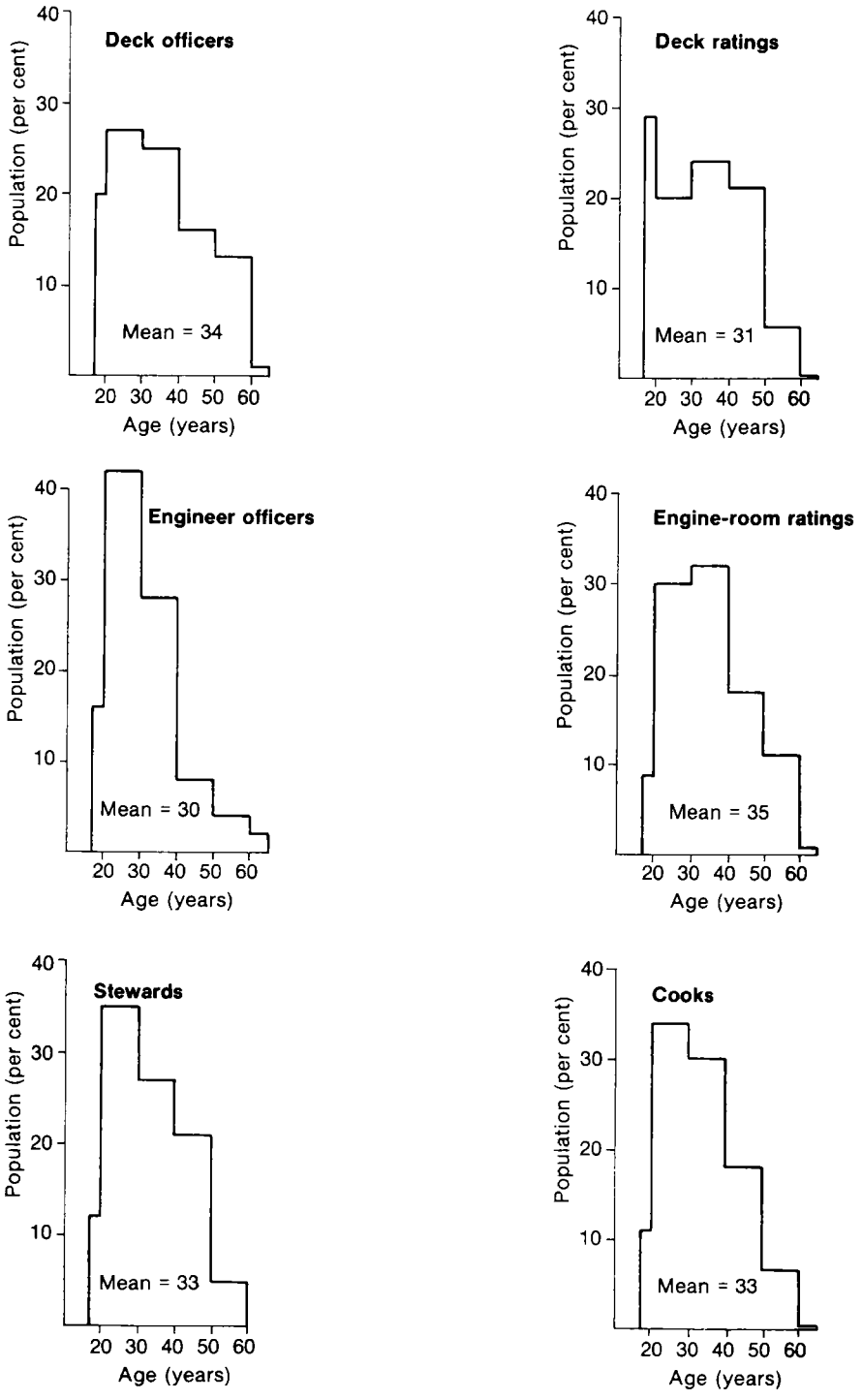

Figure 3.5—Age distributions of recruits to individual employment categories

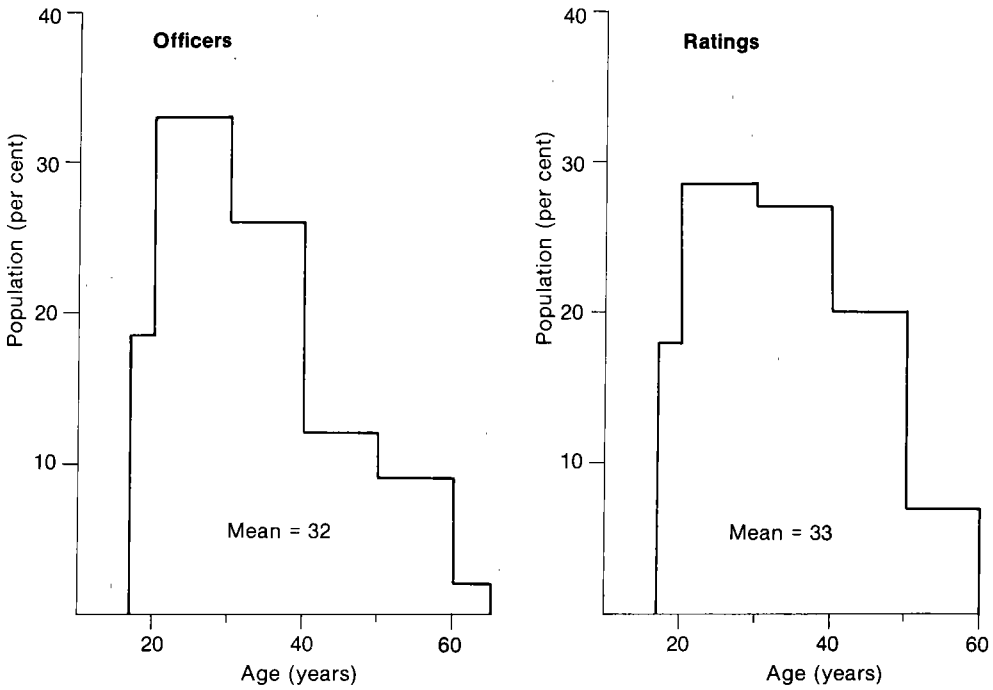

Figure 3.6—Age Distributions of officer and rating recruits

WASTAGE

In the merchant navy, as in any other industry, there is a continuous movement of personnel into and out of the workforce. One of the aims of this study was to analyse the numbers and age distribution of the men in each employment category who left the industry in recent years. In manpower planning studies the movement of personnel from an industry is often described as 'wastage' and 'wastage probabilities' are defined in terms of the probability that an individual of a particular age will leave the industry in a given year. The main causes of wastage are career change, retirement, invalidity and death.

Details of manpower wastage in the maritime industry were not available from industry sources and it was necessary to derive wastage data from the general relationship,

$$\text{change in employment numbers} = \text{recruitment} - \text{wastage} \qquad (3.1)$$

Equation (3.1) was used to determine, for each employment category, the wastage probabilities of men in the age intervals <21, 21-30, 31-40, 41-50, 51-60, >60. Account was taken of aging and a description of how aging was included in the analysis is given in Chapter 4 (refer equation (4.5)).

It was found that the wastage probabilities calculated using equation (3.1) varied markedly from year to year. While large annual variations in wastage probabilities may have been an inherent feature of the industry, it seemed likely that at least some of the scatter in the results was due to small errors in the employment data. This source of error was reduced by averaging the wastage probabilities over a number of years as any error in the employment data for one year affected the wastage probabilities for future

and past years in opposite ways. Nevertheless it was only possible to derive reliable wastage data by averaging over employment categories or age groupings.

The wastage probabilities for officers and ratings are shown in Figure 3.7. The high probability of wastage for both officers and ratings over 60 years of age corresponded to retirement. It is interesting to note that the wastage data for either officers or ratings did not show the pronounced maximum at low ages often observed in manpower planning studies and caused by young people changing careers more frequently than their older colleagues.

From the wastage probability data and the age distribution data (refer Figures 3.3 and 3.4) estimates were made of the annual wastage of men from individual employment categories. These annual wastage rates, which are listed in Table 3.10, represent averages over the period 1977-78 to 1981-82. There was, for example, an average annual wastage of deck officers of 6 per cent. No significant differences between the wastage rates for any employment category were observed and in general the rates were consistent with the rates experienced in many shore-based industries (ABS 1982).

TABLE 3.10—ANNUAL WASTAGE RATE FOR EACH EMPLOYMENT CATEGORY

Employment category	*Wastage rate*
Officers	
Deck officers	0.06
Engineer officers	0.08
Average	0.07
Ratings	
Deck ratings	0.07
Engine-room ratings	0.08
Stewards	0.07
Cooks	0.08
Average	0.07

PROMOTION

When discussing the promotion of men within career structures in the maritime industry it is necessary to stress the distinction between manpower supply and demand. The supply of manpower at each career level is measured in terms of the number of men who have the appropriate formal qualifications. Promotion, in the supply sense, thus corresponds to the admission to a higher qualification and may not necessarily involve greater responsibility or remuneration. In contrast the demand for manpower is measured in terms of the number of berths for men with the qualifications required to fill the position. Thus promotion in the demand sense need not necessarily involve a change in qualification. In fact many promotions are temporary as an individual with, for example, Masters qualifications may serve on one ship as a Master and on the next ship as a 1st Mate or even a 2nd Mate. In this study the emphasis was on manpower supply and therefore an individual was said to be promoted when he obtained higher formal qualifications.

No attempt was made in this work to model the fine details of the numerous possible career paths of deck and engineer officers. An important factor in this decision was that the necessary historical data would have been very costly to collect. Thus the model of the future supply of officers was limited to a broad description of career structures. The

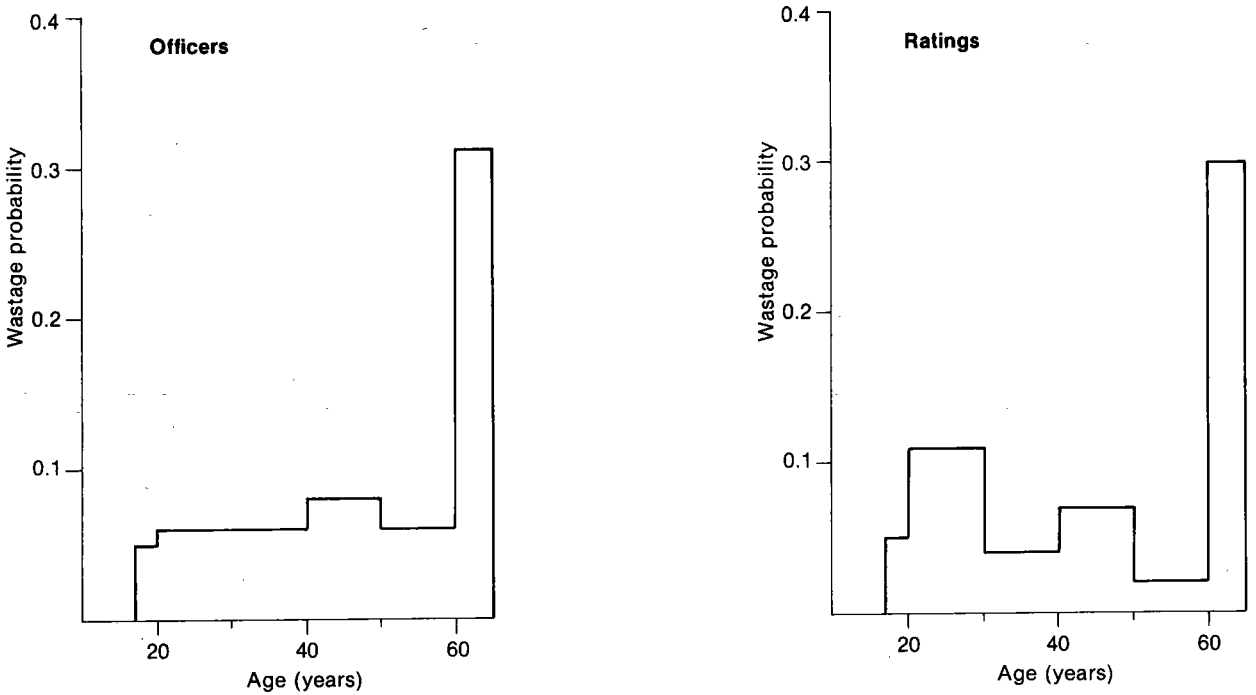

Figure 3.7—Wastage probabilities for officers and ratings

career path for deck officers was taken to be Cadet-2nd Mate-1st Mate-Master and the career path for engineer officers was taken to be Cadet-Engineer Class 2-Engineer Class 1.

The promotion probabilities were obtained by dividing the number of men in each age interval who obtained the relevant qualifications in a given year by the total number of men in the same age group who were eligible to apply for promotion in that year. It was assumed that the promotion probabilities were time-invariant over the period 1978 to 1982 and the results were averaged. The results are shown for deck and engineer officers in Table 3.11; for example there was a probability of 0.2 that a 1st Mate aged between 31 and 40 would be promoted to Master in the next year.

TABLE 3.11—PROMOTION PROBABILITIES FOR DECK AND ENGINEER OFFICERS

Promotion Path		*Officer age group*				
From	*To*	*21-30*	*31-40*	*41-50*	*51-60*	*>60*
1st Mate	Master	0.14	0.20	0.09	0.05	0.00
2nd Mate	1st Mate	0.27	0.09	0.00	0.00	0.00
Cadet	2nd Mate	0.68	0.00	0.00	0.00	0.00
Engineer Class 2	Engineer Class 1	0.35	0.32	0.17	0.10	0.00
Cadet	Engineer Class 2	0.22	0.25	0.21	0.06	0.00

CHAPTER 4—THEORETICAL BASIS OF MANPOWER PLANNING MODEL

This chapter presents a theoretical approach to manpower planning and outlines the decision to model the supply of sea-going manpower with Markov chain techniques. A detailed understanding of this theoretical chapter is not required to interpret the results in Chapter 5.

A common basis for an analysis of this type is to describe the organisation as a dynamic system of stocks and flows (Bartholomew and Forbes 1979). All members of the organisation are subdivided into groups on the basis of attributes such as age and rank and it is assumed that all individuals in the same group have the same aging, promotion and wastage probabilities. If the time interval from T to T+1 is considered and the flow of men from group i to group j in this period is denoted by $m_{ij}(T)$, it follows that the stock in group j at time T+1 can be written:

$$n_j(T+1) = \sum_{i=1}^{k} m_{ij}(T) + R(T+1)r_j \qquad (j = 1, \ldots, k) \qquad (4.1)$$

where R(T+1) = total recruitment in the time interval (T,T+1);
r_j = fraction of recruits entering group j; and
k = total number of groups.

To incorporate the basic stock-flow equation (4.1) into a model of a manpower system it is necessary to consider the organisation constraints, that is, to identify which stocks and flows are predetermined and which are not. In some organisations (a public service department is a good example) the number of jobs in each grade is fixed and promotions and recruitment can only take place to fill vacancies as they occur. The models which describe this type of organisation are known as renewal or top-down models as wastage from the higher levels of the organisation 'drives' the system by creating vacancies to be filled by promotion and recruitment.

In a manpower system such as the Australian merchant navy the supply of men in each grade is variable. There are, for example, many more officers with Masters qualifications than there are berths for Masters and it is common for 1st Mates to have Masters' qualifications. In addition, the number of men who qualify as Masters each year is not directly related to the number of berths for Masters as there are incentives (such as study leave) for each individual to gain further qualifications. In these circumstances the model must be 'driven' from the bottom by the process of recruitment. Markov chain theory can be used as the basis for models of this type if it can be validly assumed that the flow from one group to another is proportional to the stock in the first group, that is:

$$m_{ij}(T) = n_i(T)p_{ij} \qquad (4.2)$$

where p_{ij} = probability that an individual in group i at time T-1 is in group j at time T.

Equation (4.1) can now be written in matrix notation:

$$\underline{n}(T+1) = \underline{n}(T)\underline{P} + R(T+1)\underline{r} \qquad (4.3)$$

where $\underline{P}$ = transition matrix with elements p_{ij}.

Equation (4.3) is the basis of a Markov chain analysis of a manpower organisation. Note that the wastage of men from the organisation is not explicitly included in equation (4.3) but is included implicitly as the probability of wastage from group i, w_i, is related to the row elements of the transition matrix $\underline{P}$ by:

$$\sum_j p_{ij} + w_i = 1 \qquad \text{for all } i \tag{4.4}$$

Under some circumstances it is convenient to combine equations (4.3) and (4.4) and derive an expression for the probability of wastage. For example, for an employment category without a career structure the probability of wastage from each age group can be determined from the expression:

$$w_i n_i(T) = R(T+1)r_i - [n_i(T+1) - n_{i-1}(T)p_{i-1,i} - n_i(T)(1-p_{i,i+1})] \tag{4.5}$$

In the present application the growth rate of an employment category was held constant and the model used to calculate the number of recruits required each year to sustain the fixed growth rate. In this situation a more convenient form of equation (4.3) can be derived by expressing the number of recruits as a random variable composed of two parts. The first describes the recruits required to fill new vacancies arising from growth in the organisation and the second those who replace leavers. The value of R(T+1) can then be expressed:

$$R(T+1) = N(T+1) - N(T) + \sum_{i=1}^{k} n_i(T)w_i \tag{4.6}$$

where $N(T)$ = size of the organisation at time T

$$= \sum_{i=1}^{k} n_i(T)$$

There is nothing to prevent N(T+1) - N(T) being negative. If R(T+1) is also negative it means that the fixed size can only be achieved by having redundancies (negative recruitment).

Substituting equation (4.6) into equation (4.3) gives:

$$\underline{n}(T+1) = \underline{n}(T)\ (\underline{P}+\underline{w}'\underline{r}) + M(T+1)\underline{r} \tag{4.7}$$

where $M(T+1) = N(T+1) - N(T)$

and $\underline{w}'$ = transpose of $\underline{w}$

Each term in equation (4.7) can be identified in the following way:

$\underline{n}(T)\underline{P}$ = normal internal movements;
$\underline{n}(T)\underline{w}'\underline{r}$ = recruits who replace leavers; and
$M(T+1)\underline{r}$ = recruits who fill new vacancies.

If we write $\underline{Q}=\underline{P}+\underline{w}'\underline{r}$ it can be seen that equation (4.7) has the same form as equation (4.3).

The first steps required to implement the theory embodied in equations (4.3) and (4.7) are to define each of the groups and to determine the elements in the transition and recruitment matrices. In practice these steps are carried out iteratively because the choice of groups depends on data availability.

In this analysis the groups were generally defined on the basis of employment

categories and age intervals. For the employment categories which do not have rank structures based on academic qualifications (for example ratings) it was only necessary to classify personnel by age as only rarely do ratings move from one employment category to another. For officers, however, it was necessary to include career structures in the model and each age group was therefore divided into sub-groups to allow for the career hierarchy.

The data requirements can therefore be summarised in the following terms. For each employment category (including officer) the age distribution of manpower supply, recruitment and wastage is required. For officer categories data are also required on the promotion probabilities as a function of age.

CHAPTER 5—SUPPLY OF RECRUITS REQUIRED TO SUSTAIN INDUSTRY GROWTH

It was shown in Chapter 3 that over the six-year period 1976-77 to 1981-82 the workforce characteristics of the industry remained essentially stable. Given the changes which are presently occurring in the industry it can be argued that this stability will not continue and this chapter discusses the effects of changes to some previously stable characteristics of the maritime workforce. Particular attention is paid to the implications of industry growth on recruitment numbers and the effects of changing the age distribution of recruits. The analytic techniques used in this chapter have been described in Chapter 4.

EXAMPLE USING UNIFORM DISTRIBUTIONS

To introduce the approach used in this chapter and to aid understanding of the relationship between recruitment, wastage and industry growth, it is first assumed that all distributions are uniform, that is, the recruitment and wastage distributions are age independent, all age intervals are the same size and there are the same number of men in each age interval.

The results from this example are shown in Figure 5.1, where the number of recruits required per annum to sustain various industry growth rates are plotted as a function of time. The industry growth rates considered range from +10 to -20 per cent per annum, this range being chosen purely to illustrate how the results change with growth rate.

Two sets of curves are shown in Figure 5.1. The upper set (continuous curves) corresponds to an annual wastage rate of 0.2, that is, an annual turnover of 20 per cent. The lower set (broken curves) corresponds to an annual wastage rate of 0.1. These sets of curves show clearly that if wastage is increased more recruits are required to sustain a given industry growth rate. Figure 5.1 illustrates the point that if the industry is required to expand after a period of historically low wastage, then the proportionate increase in recruitment will be high. Conversely if wastage has been high then the proportionate increase to the recruitment and training system in a period of expansion could be relatively small as the industry would be geared to high recruitment intakes.

Figure 5.1 also shows that redundancies (negative recruitment) are required to sustain negative industry growth rates which exceed wastage rates. For all negative growth rates recruitment always approaches zero (from either positive or negative values) as the absolute size of the industry decreases with time.

RESULTS FOR OFFICERS AND RATINGS

This section describes the implications for recruitment of different industry growth rates and recruitment practices. In all the calculations it has been assumed that wastage probabilities will be maintained at their historical levels (refer Chapter 3).

Each employment category was examined with two recruitment strategies. In the first, recruitment age distributions were set at their historical levels (see Chapter 3) and, in the second, recruits entered only in the lower age categories. Specifically in the second strategy, all officer recruitment was assumed to occur in the 20 and under age group in the least-skilled employment category and, for ratings, recruitment was assumed to be equally split between the 20 and under and the 21 to 30 age groups.

The industry growth patterns considered were zero growth, a 5 per cent per annum increase and a 5 per cent per annum decrease for both officers and ratings. The

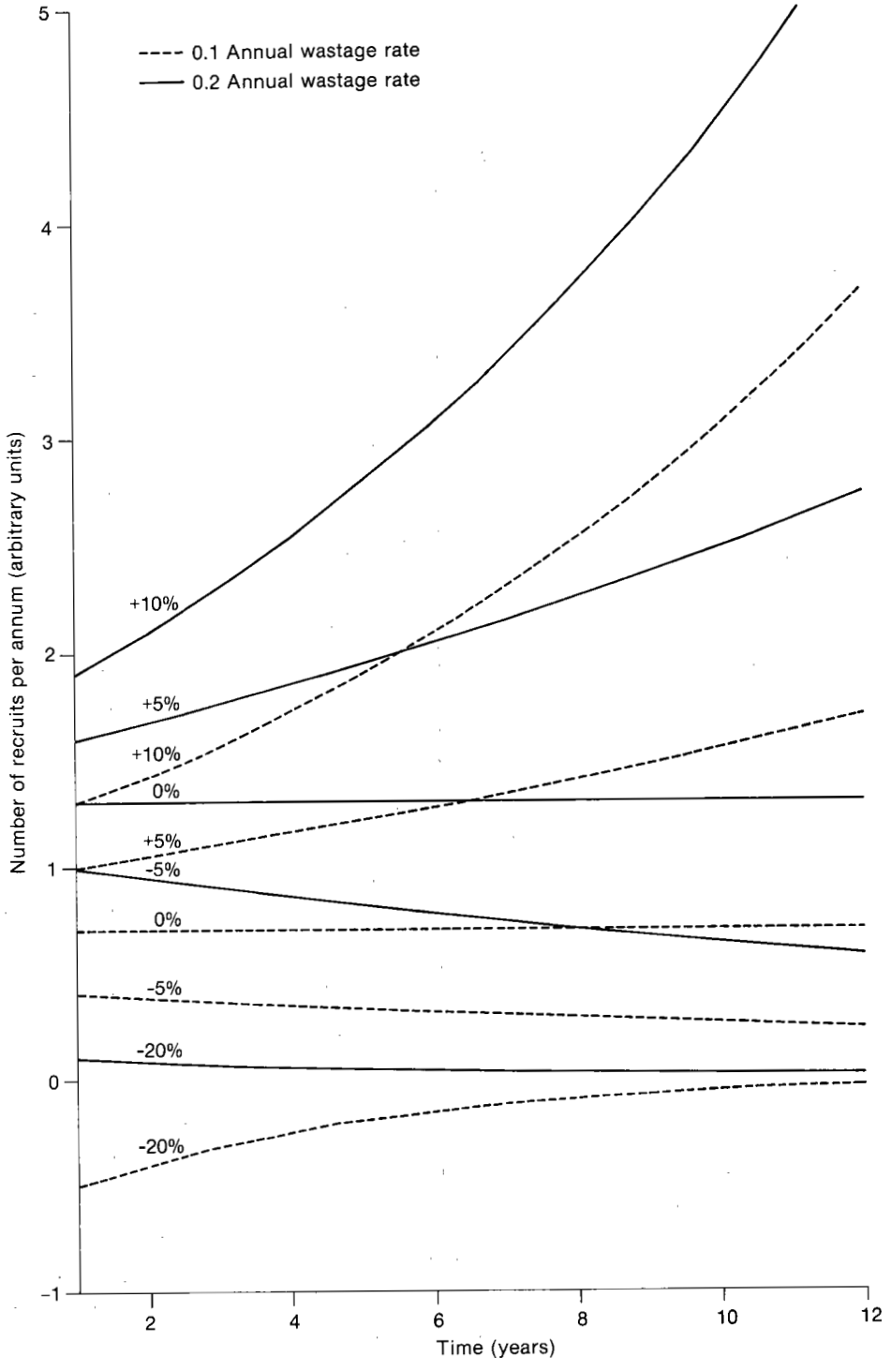

Figure 5.1—Recruitment required to sustain industry growth; example with uniform age distributions

numbers of recruits required to sustain these growth rates are shown in Figures 5.2 to 5.8 for deck ratings, engine-room ratings, stewards, cooks, ratings, deck and engineer officers respectively. In each of these figures, the continuous and broken curves show the results for the historical and alternative recruitment distributions respectively.

The results for different categories of ratings (see Figures 5.2 to 5.6) all show a similar pattern. For zero growth, the number recruited increases at first, then levels off at a value above the initial number, with the alternative recruitment distribution curve rising to a higher value before stabilising. In the 5 per cent decrease case, the initial number recruited is less than a third that for zero growth. The results for both recruitment distributions initially increase, with the alternative recruitment distribution curve again rising higher; both curves then decrease gradually over time towards zero. Initial recruitment in the 5 per cent growth rate case is just under twice that for zero growth. Both curves have an exponential shape, with the alternative recruitment pattern producing a faster rate of increase.

Similarly, the results for deck and engineer officers have a common pattern (see Figures 5.7 and 5.8). For zero growth, the required number of deck and engineer officer recruits per annum was found to be almost constant with time for both the historical and alternative recruitment age distributions. In the case of a 5 per cent decrease per annum the initial number of recruits required was calculated to be only about a third of those required for zero growth. Also the number of recruits required for each officer category was almost independent of the recruitment age distribution. For positive growth of 5 per cent per annum slightly smaller numbers of recruits were required in the case of the alternative recruitment age distribution.

The effects that changes to the recruitment age distributions would have on the age distribution of the workforce can be deduced from Table 5.1. This table gives a comparison for deck officers, engineer officers and ratings, between the mode (most probable) and the mean (average) of the current age distributions and the age distributions in ten years time if historical or alternative recruitment patterns prevail.

TABLE 5.1—COMPARISON OF THE AGE DISTRIBUTIONS OF OFFICERS AND RATINGS UNDER DIFFERENT RECRUITMENT STRATEGIES AND ANNUAL GROWTH RATES

Employment category	*Years*					
	-5% growth		*0% growth*		*5% growth*	
	Mode	*Mean*	*Mode*	*Mean*	*Mode*	*Mean*
Deck officers						
Current distribution	31-40	38	31-40	38	31-40	38
Distribution in year 10						
Historical recruitment	31-40	43	31-40	40	31-40	40
Alternative recruitment	31-40	40	21-30	33	21-30	32
Engineer officers						
Current distribution	31-40	38	31-40	38	31-40	38
Distribution in year 10						
Historical recruitment	31-40	41	31-40	39	31-40	37
Alternative recruitment	31-40	41	31-40	34	21-30	32
Ratings, total						
Current distribution	51-60	43	51-60	43	51-60	43
Distribution in year 10						
Historical recruitment	51-60	46	31-60	43	31-40	40
Alternative recruitment	51-60	43	21-30	37	21-30	33

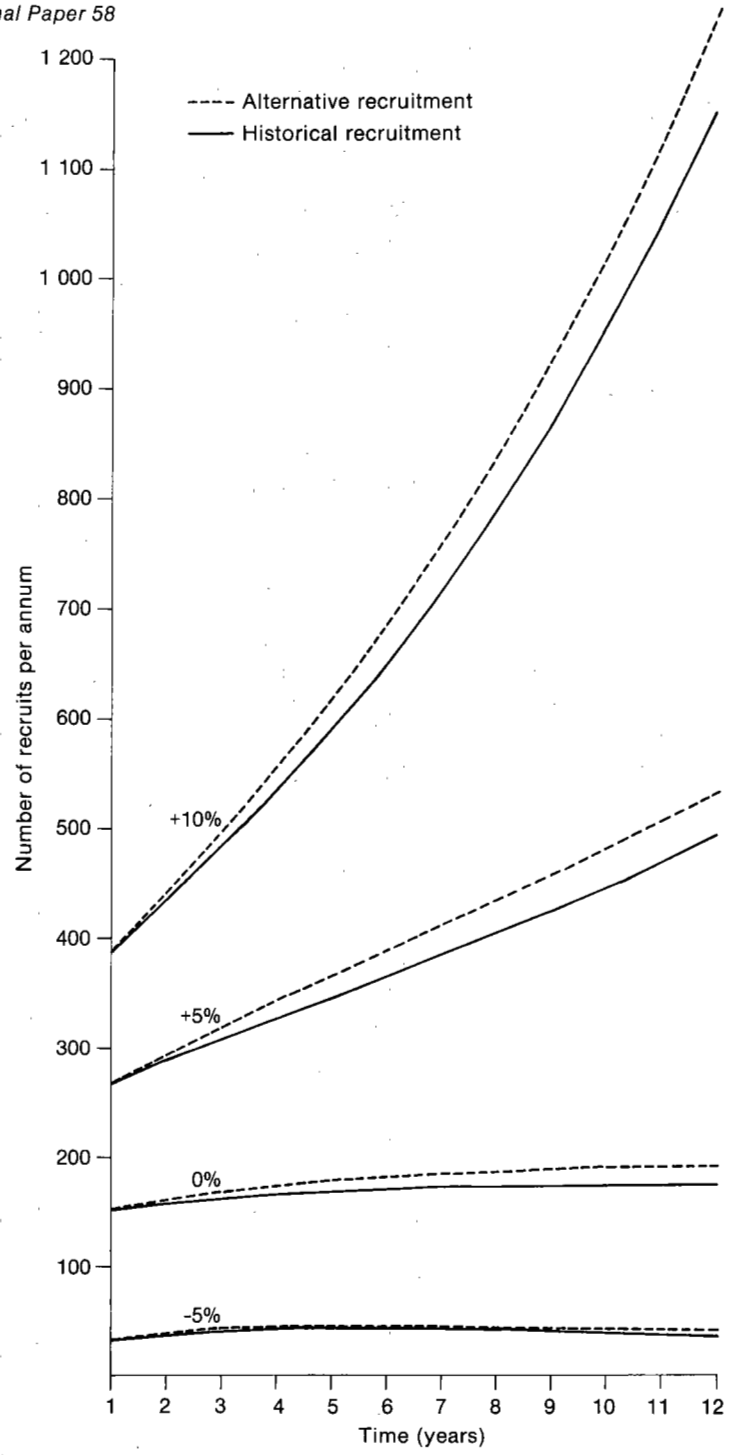

Figure 5.2—Recruitment required to sustain industry growth; deck ratings

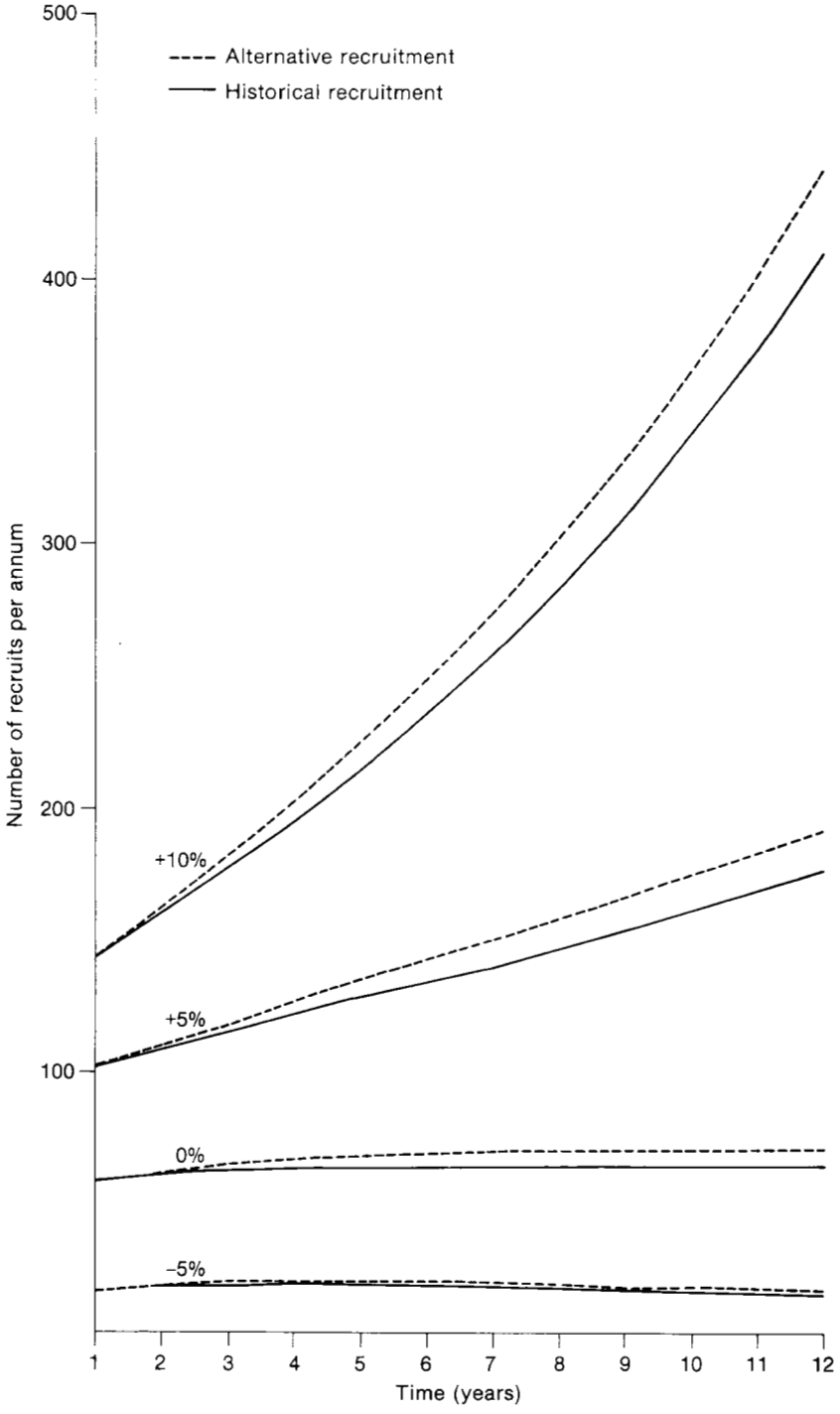

Figure 5.3—Recruitment required to sustain industry growth; engine-room ratings

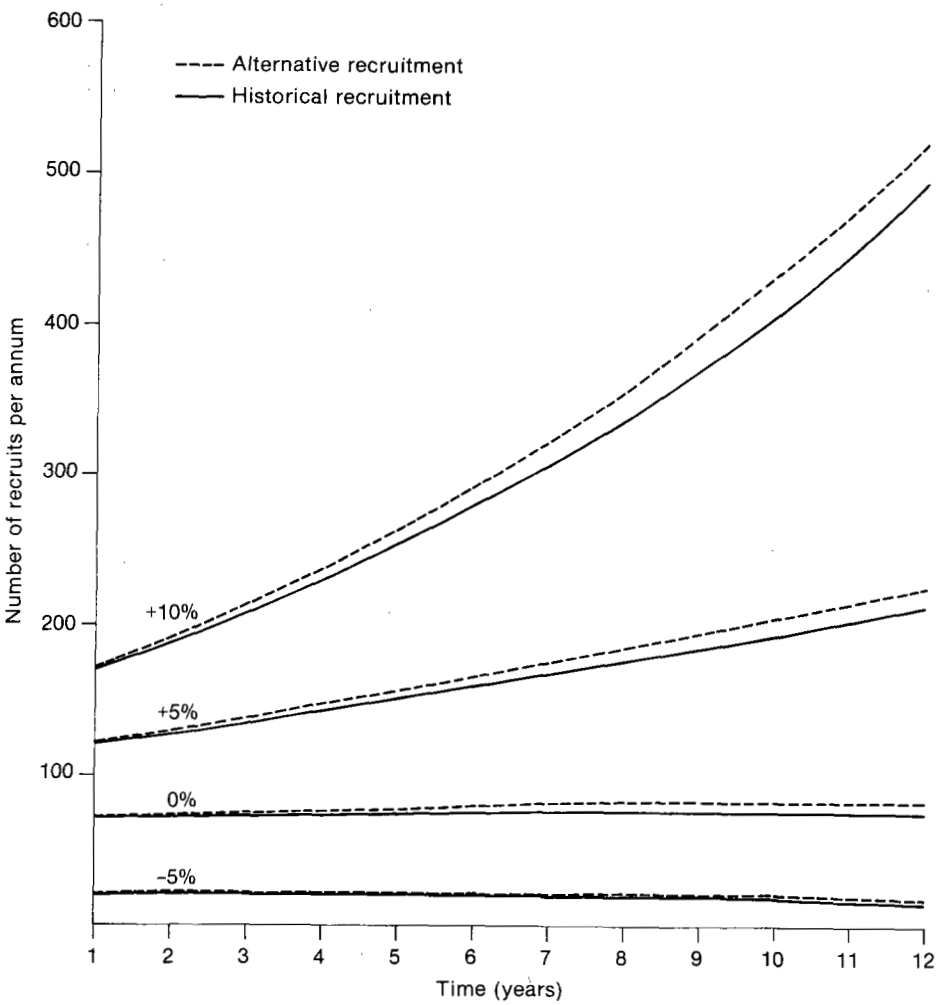

Figure 5.4— Recruitment required to sustain industry growth; stewards

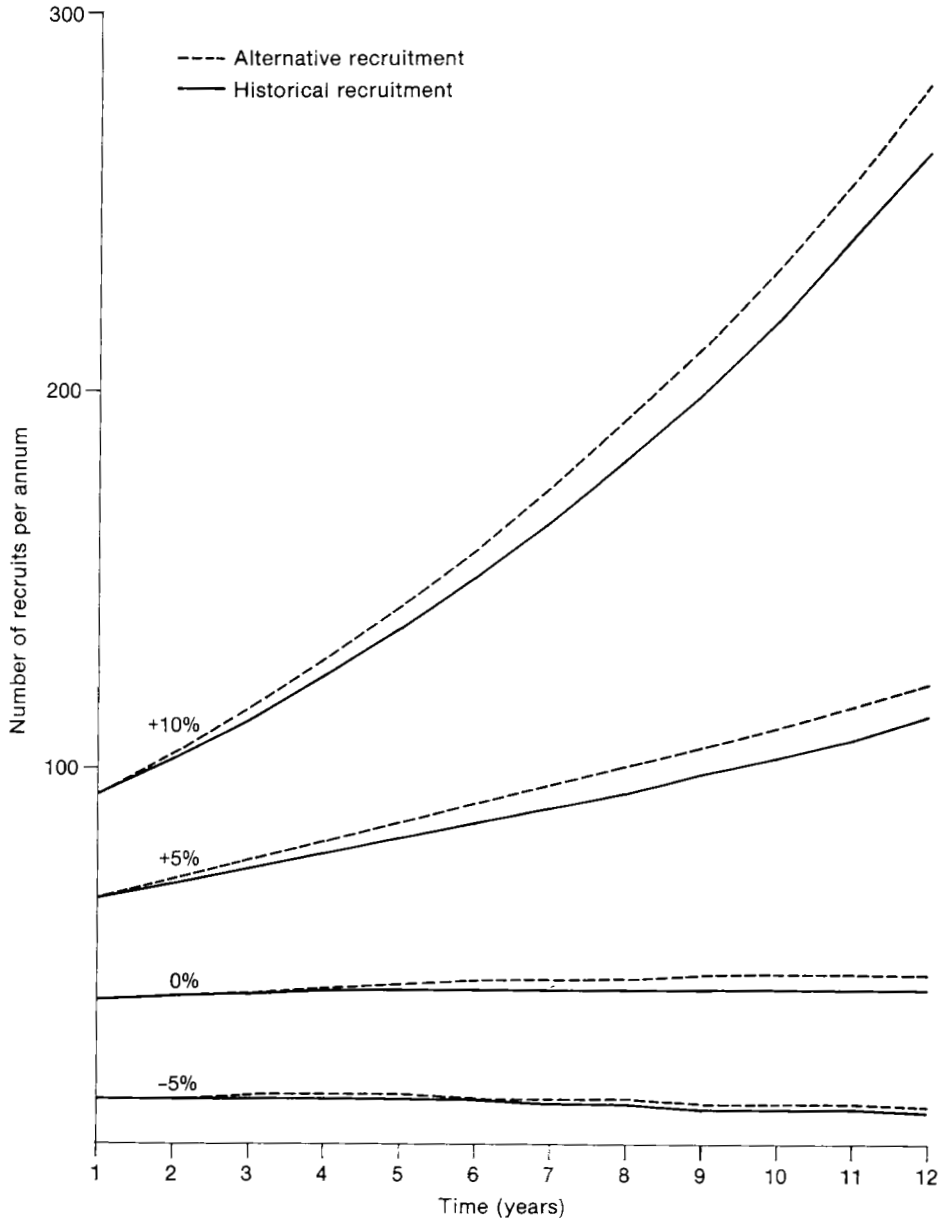

Figure 5.5—Recruitment required to sustain industry growth; cooks

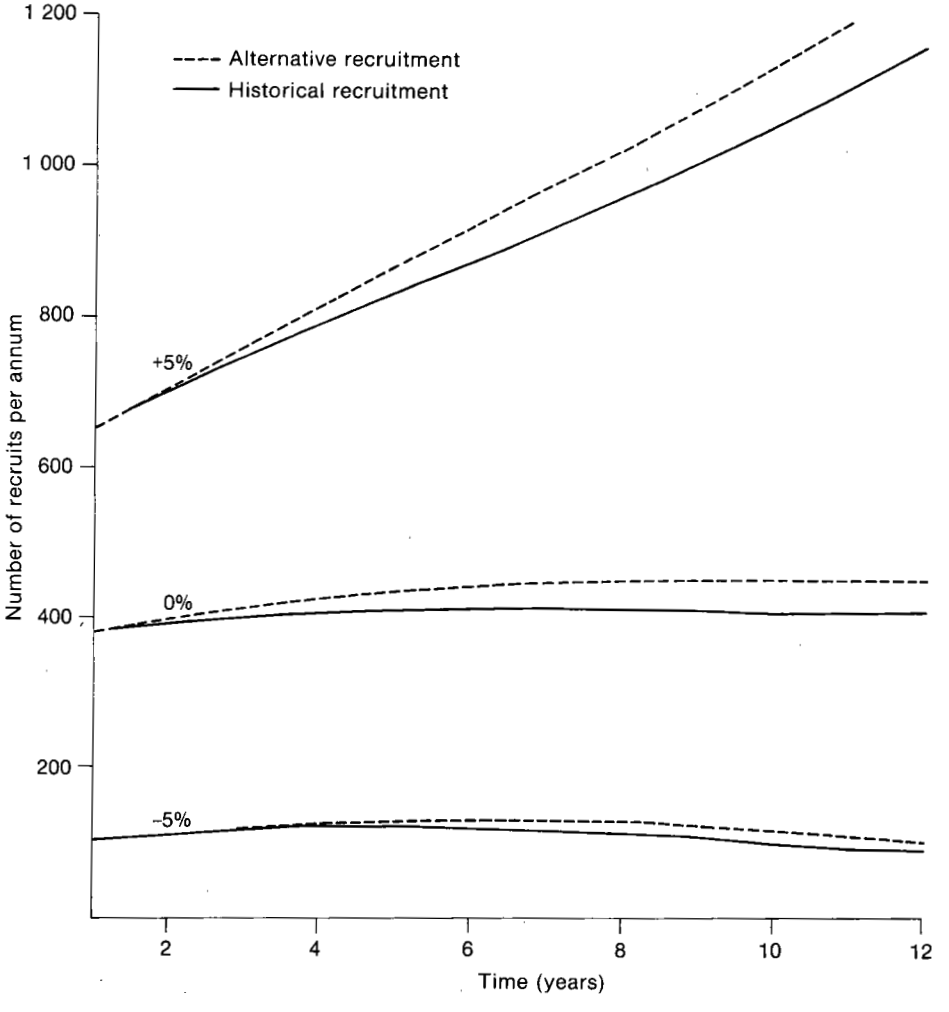

Figure 5.6—Recruitment required to sustain industry growth; ratings

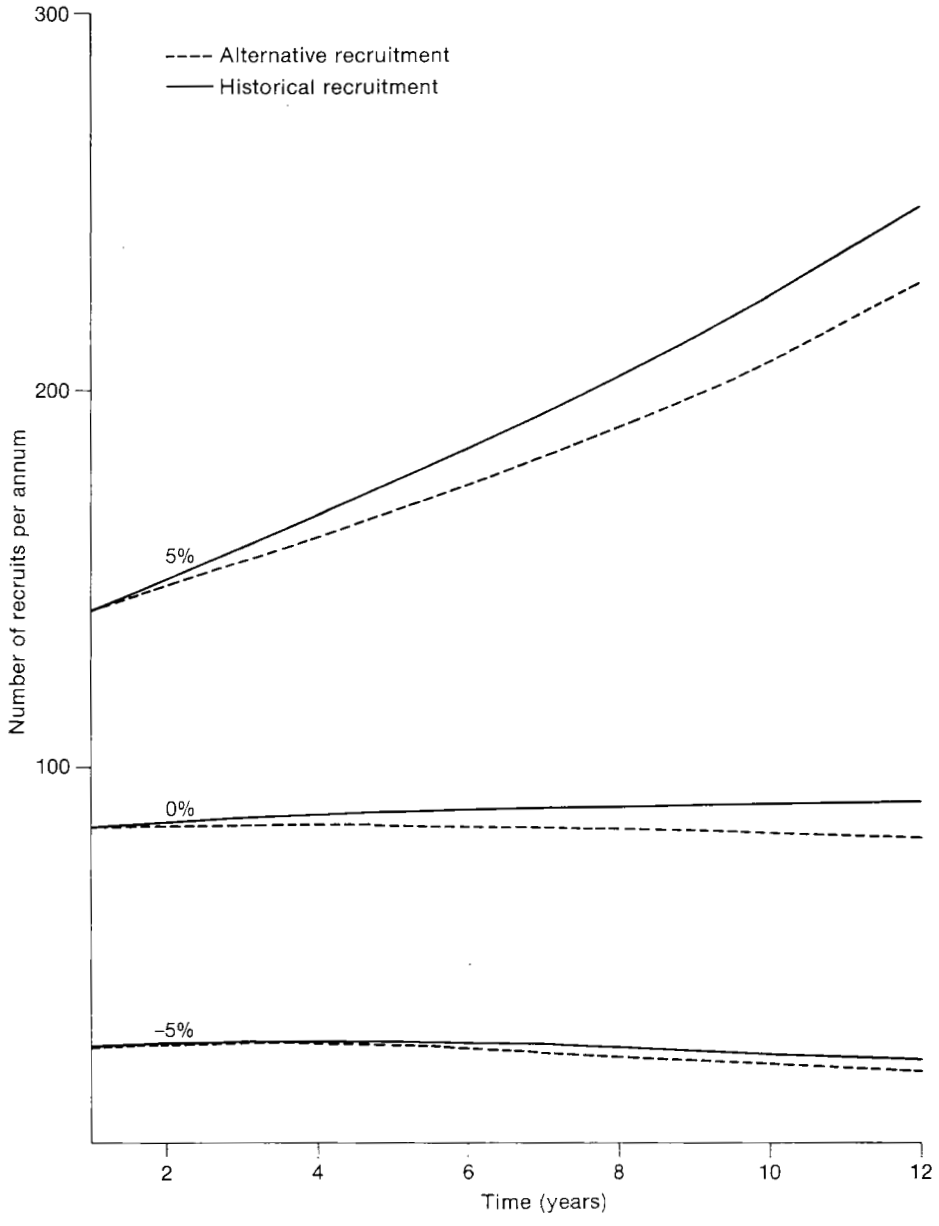

Figure 5.7—Recruitment required to sustain industry growth; deck officers

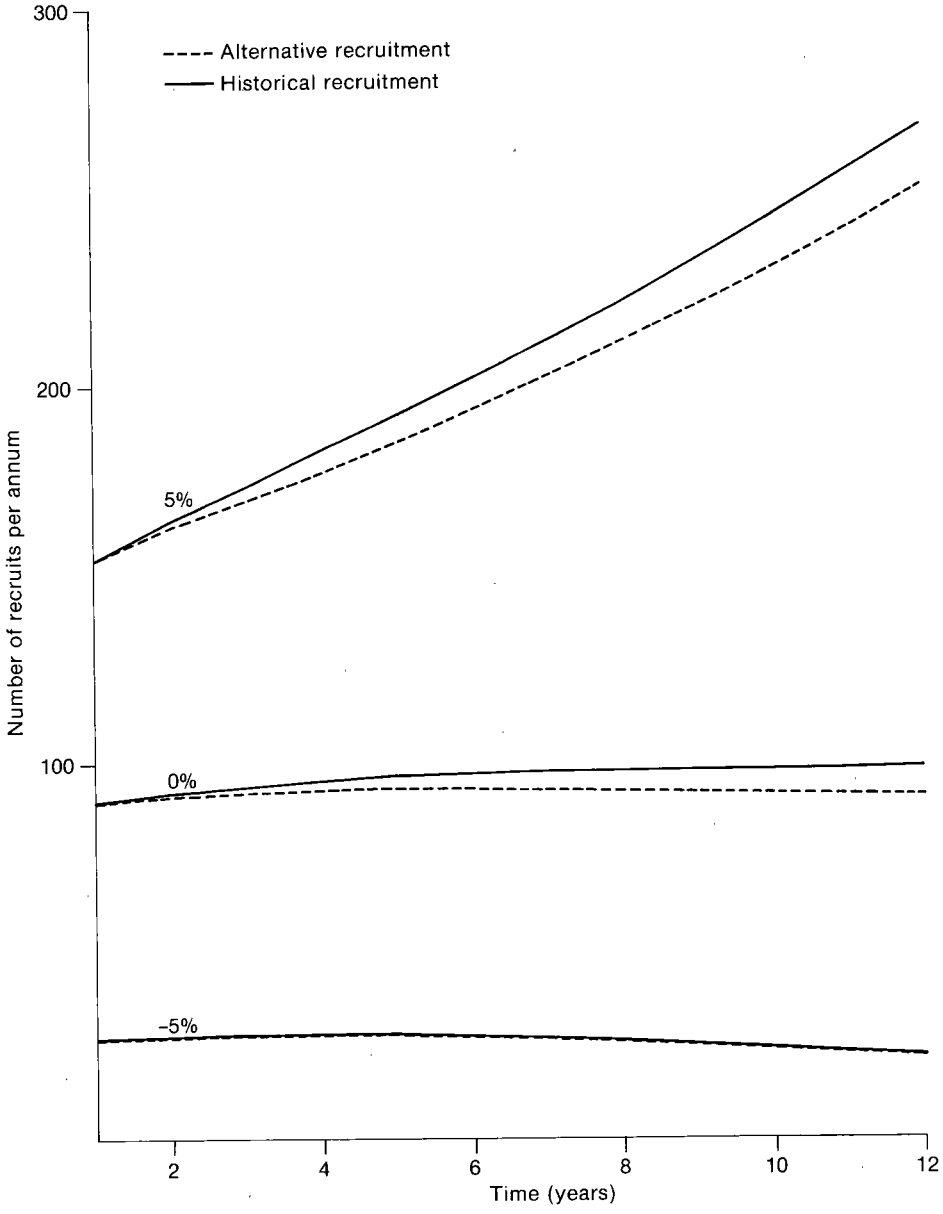

Figure 5.8—Recruitment required to sustain industry growth; engineer officers

The results in Table 5.1 indicate that if historical recruitment and wastage patterns are continued in the future, and the industry growth rate varies between plus and minus 5 per cent per annum, there are likely to be only relatively small changes in the age distributions of officers and ratings in the next ten years. For example, if a zero growth rate is experienced over the next ten years, the average ages of deck officers, engineer officers and ratings appear likely to change by less than two years. Slightly larger changes are likely if positive or negative growth rates are experienced in the industry. Negative growth rates by themselves would increase the average age of the workforce and positive growth rates would have the opposite effect.

Table 5.1 also shows that a reduction in the average age of recruits (alternative recruitment strategies) would result in small reductions in the average ages of deck officers, engineer officers and ratings. This effect can be seen by comparing the results for the alternative and historical recruitment strategies after ten years.

In summary, the results of this chapter indicate that any future reduction in the average age of recruits is likely to slowly reduce the average age of the workforce but is unlikely to significantly affect the number of recruits required to sustain industry growth of less than 5 per cent per annum. The future growth rate of the industry will also affect the average age of the workforce. For example, positive industry growth would probably result in a decrease in the average age of the personnel in each employment category.

CHAPTER 6—LABOUR MOBILITY IN THE MERCHANT NAVY

BACKGROUND

The aim of this chapter is to describe the historical movement of men from ship to ship and from one type of ship to another in the five-year period 1977 to 1981. The emphasis is mainly on ratings as they were usually employed on a casual basis and thus were able to largely control their own mobility. In contrast, officers were usually company employees and their mobility was largely determined by company policy.

The technique used to describe workforce mobility is introduced with the aid of Figure 6.1, which illustrates an individual's work history. In Figure 6.1, b_x represents the time between first joining ship x and leaving ship x for another ship. The time b_x, or ship survival time, includes periods of leave taken between voyages on ship x. The time l_x represents the period of leave between service on ships x and x+1. The calendar time at which the individual joined ship x is denoted by t_x. The time s_x is the sector survival time, that is, the continous period of time the individual is employed on ships of the same type. Sector survival times include periods of leave taken between voyages on the same ship and between voyages on ships of the same type. In Figure 6.1 it is assumed that ships 2 and 3 are the same type and different from ship 1 and ship 4.

Using these definitions a ship transfer rate equal to $(M-1)/(t_M-t_1)$ could be determined for each individual. A distribution of ship transfer rates could then be determined for a class of men and used, for example, to estimate the fraction of men who changed ships on average less than once per year. The probability that a crew member stayed on a ship for say three months, or equivalently the fraction of a new crew which were still on a ship after three months, is given by the distribution of ship survival times (b_x in Figure 6.1). A comparison between the distributions of ship and sector survival times provided information on the 'loyalty' of individuals to ships of one type.

DATA COLLECTION

The source of data for the analysis of workforce mobility in the industry was the register of personnel records maintained by the Department of Transport. This register, which was started in 1922, contains the details of the work history of all individuals who have been or still are employed in the industry. The sampling technique for each employment category was to choose a section of the register at random and then to record, in the manner illustrated in Figure 6.1, the berths occupied by all men employed between 1977 and 1981 inclusive. Thus the recorded work histories varied from a few months to about five years.

Typically the records of 50 men (about 200 ship transfers) were identified and recorded on a micro-computer in a three-hour period by a team of three. In the next three-hour session a different section of the register was searched and this procedure was repeated until enough data had been collected for a specific employment category. The number of work histories recorded for each employment category was varied according to the relative sizes of the categories. In all, about 25 man days were required to record the work histories of about 1000 men. At regular intervals the micro-computer was transported across the city and the data transferred to a mini-computer for analysis.

INTER-SHIP MOBILITY

The ship transfer rate distributions for ratings and officers are shown in Figure 6.2. It must be remembered when comparing these distributions, which represent averages

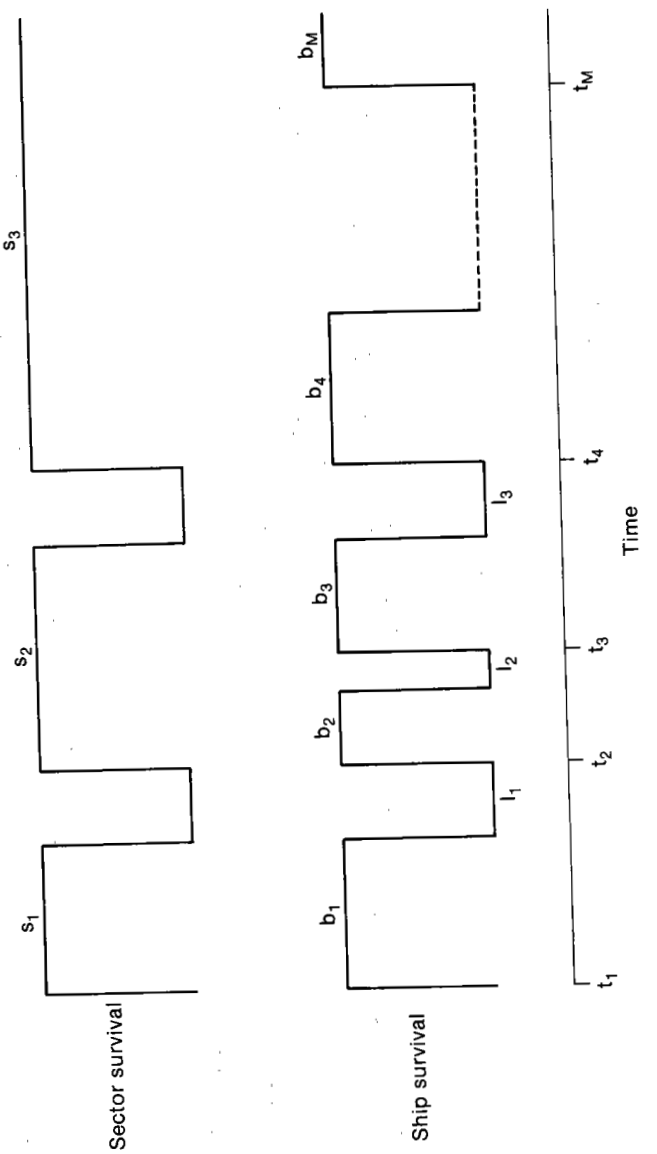

Figure 6.1—Representation of an individual's work history

over the five-year period 1977 to 1981, that officer mobility was determined largely by company policy and the mobility of ratings was determined by individual motivation. It can be seen that 60 per cent of ratings and 52 per cent of officers changed ship on average less than once per year. The difference between the distributions is larger at higher ship transfer rates. For example 15 per cent of ratings and 4 per cent of officers changed ship more than three times per year on average.

Figure 6.3 shows that the fraction of ratings who were 'stable' (that is, changed ship less than once per year on average) increased with increasing age.

The probability that a rating changed ship in a specific month-long interval is shown by the solid curve in Figure 6.4. There was a probability of about 0.30 that a rating changed ship after one month but before two months, and a probability of about 0.21 that he changed ship after 12 months. The major difference between this curve for ratings and the equivalent curve for officers (broken curve in Figure 6.4) is in the probability of changing ship within the first two months. After two months 50 per cent of a new intake of ratings changed ship but only 25 per cent of a new intake of officers changed ship.

The probability that an individual remained on a ship for at least a specified time is the complement of the integral of the probability distribution in Figure 6.4. The ship survival functions for officers and ratings, which are shown in Figure 6.5, represent averages over all ships in the industry over the study period.

Table 6.1 summarises the ship survival functions for ships in each sector. For example there was a probability of 0.32 that a rating employed on a tanker stayed on the same ship for at least 24 months. Similarly there was a probability of 0.25 that a rating employed on a ship in the overseas bulk trade stayed on the same ship for at least six months. The data in Table 6.1 give estimates of the relative popularity of ships in the different industry sectors. The reason why tankers appear to have been the most popular type of ship may have been partly due to the relatively high rates of pay awarded to tanker crews. However, rates of pay cannot have been the only reason as the crews of offshore industry vessels were also paid at above average rates.

TABLE 6.1—SHIP SURVIVAL PROBABILITIES FOR RATINGS IN EACH INDUSTRY SECTOR

Sector	*Probability of survival*			
	At least 3 months	*At least 6 months*	*At least 12 months*	*At least 24 months*
Tankers	.46	.41	.38	.32
Other	.41	.34	.22	.15
Liner (Europe)	.69	.29	.20	.14
Liner (Asia)	.41	.28	.20	.13
Coastal roll-on/roll-off	.34	.26	.18	.13
Offshore	.48	.35	.23	.12
Coastal bulk	.37	.21	.15	.11
Multi-purpose	.37	.24	.14	.10
Overseas bulk	.41	.25	.18	.09

A specific statistical technique known as the Kolmogorov-Smirnov test was used to test for statistically-significant differences between the survival functions for ships in each sector. It was found that, at the 10 per cent level, only two functions were different from the others. The survival function for tankers was different because survival is high on these ships (due at least partly to higher rates of pay). The survival curve for liners travelling to Europe was different because of the high probability of survival on the same ship for at least three months (as would be expected for the relatively long voyage to Europe).

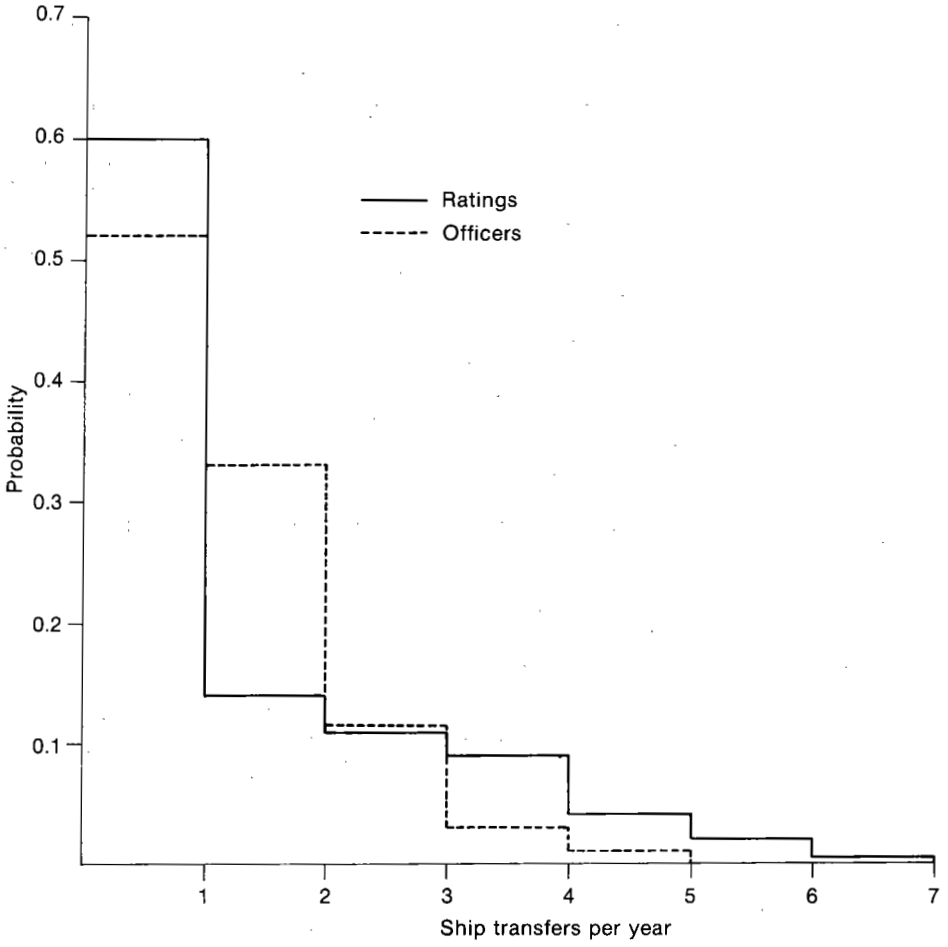

Figure 6.2—Ship transfer rate distributions for officers and ratings

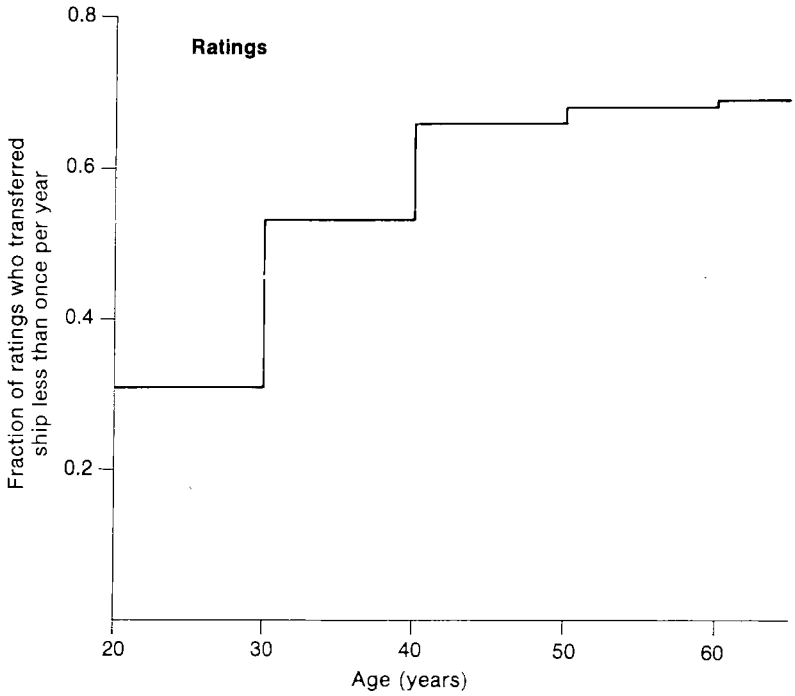

Figure 6.3— Age distribution for ratings who changed ship, on average, less than once per year

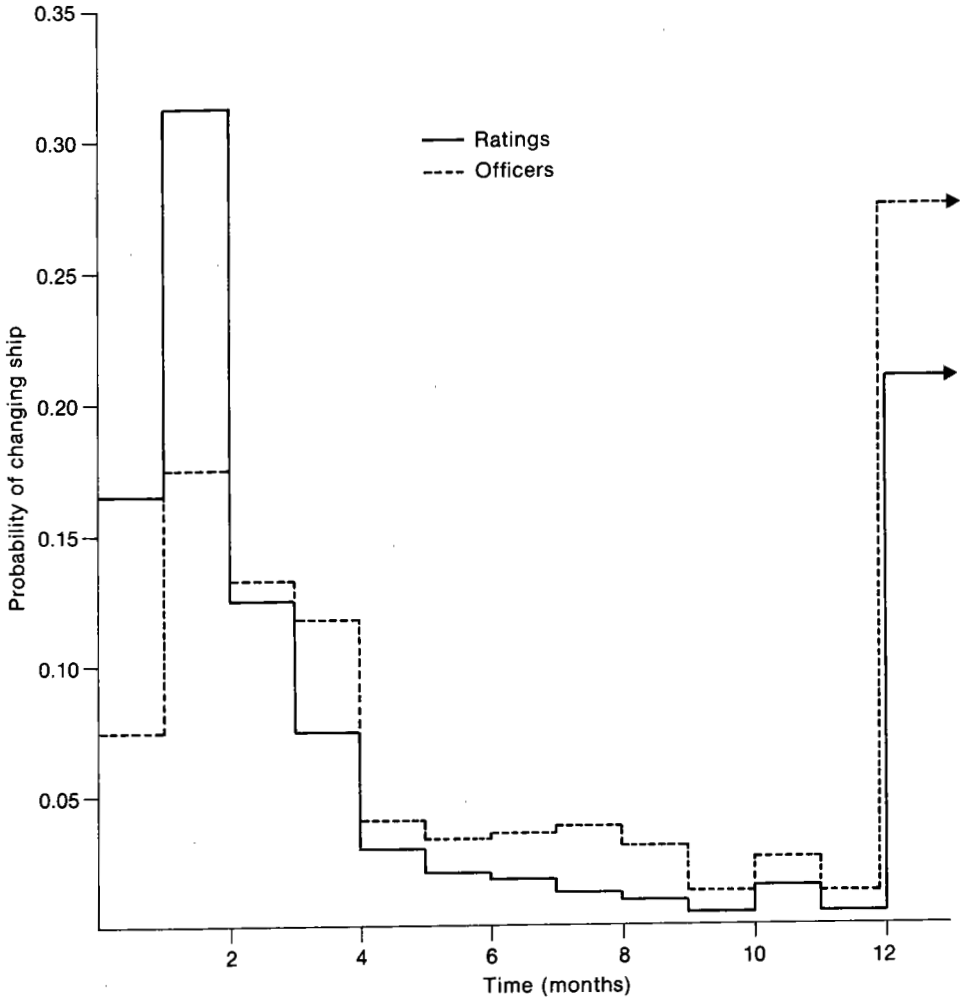

Figure 6.4—Ship change probability distributions for officers and ratings

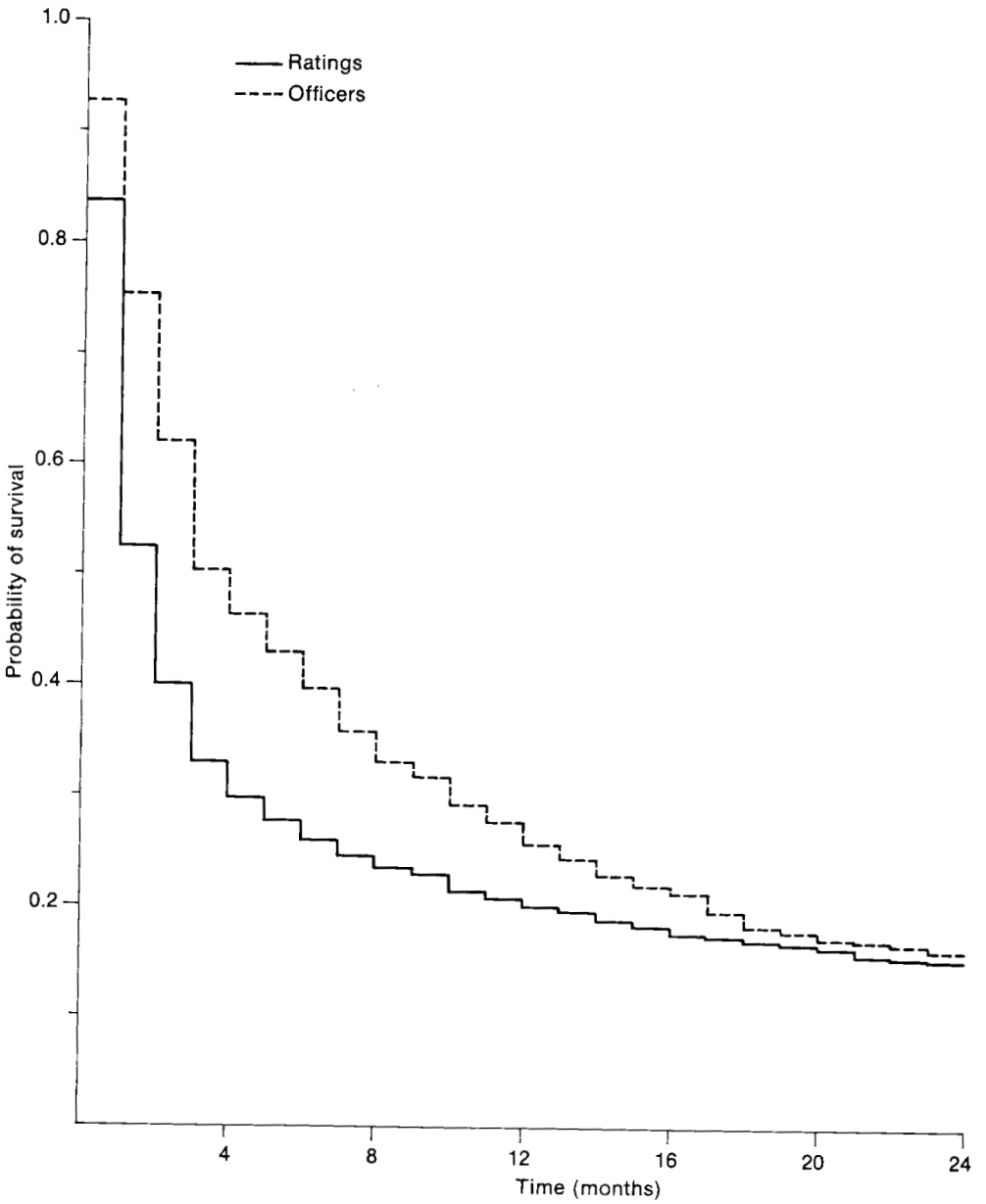

Figure 6.5—Average ship survival functions for officers and ratings

INTER-SECTOR MOBILITY

So far the results reported in this chapter have referred only to inter-ship transfers. The discussion is now extended to inter-sector transfers. If a rating always changed sector when he changed ship then the sector survival function would coincide with the ship survival function for that sector. Under no circumstances could a sector survival function fall below the ship survival function of that sector because sector cannot be changed before ship. If, however, choice of sector was a random process then the sector survival function would lie above the ship survival function as there is a finite probability that an individual would serve consecutively on two or more ships in the same sector. The sector survival function based on the assumption of random ship choice is derived in Appendix II. If the observed sector survival function lies significantly above the 'random' sector survival curve then sectoral loyalty would exist for that sector.

Figures 6.6 to 6.8 enable a comparison to be made between the ship, 'random' sector and observed sector survival functions for the tanker, coastal bulk and offshore sectors. For these and the other sectors the Kolmogorov-Smirnov test was used to examine the hypothesis that the observed sector and random sector functions were equal. In all cases except one the hypothesis was not rejected at the 20 per cent level and it was therefore concluded that ratings did not show loyalty to any of these sectors. In the case of the coastal bulk sector the hypothesis was rejected at the 2 per cent level and it was concluded that ratings exhibited loyalty to this sector.

No explanation is offered for the fact that loyalty was observed only in the coastal bulk sector. It should be noted, however, that the relative sizes of the industry sectors were taken into account in this analysis and therefore the existence of loyalty in only the largest sector was purely coincidental.

The general lack of loyalty was interpreted to mean that a typical seaman chose ship type on a random basis. The workforce therefore did not consist of groups of men who worked on specific types of ship, except for one group who worked on coastal bulk vessels.

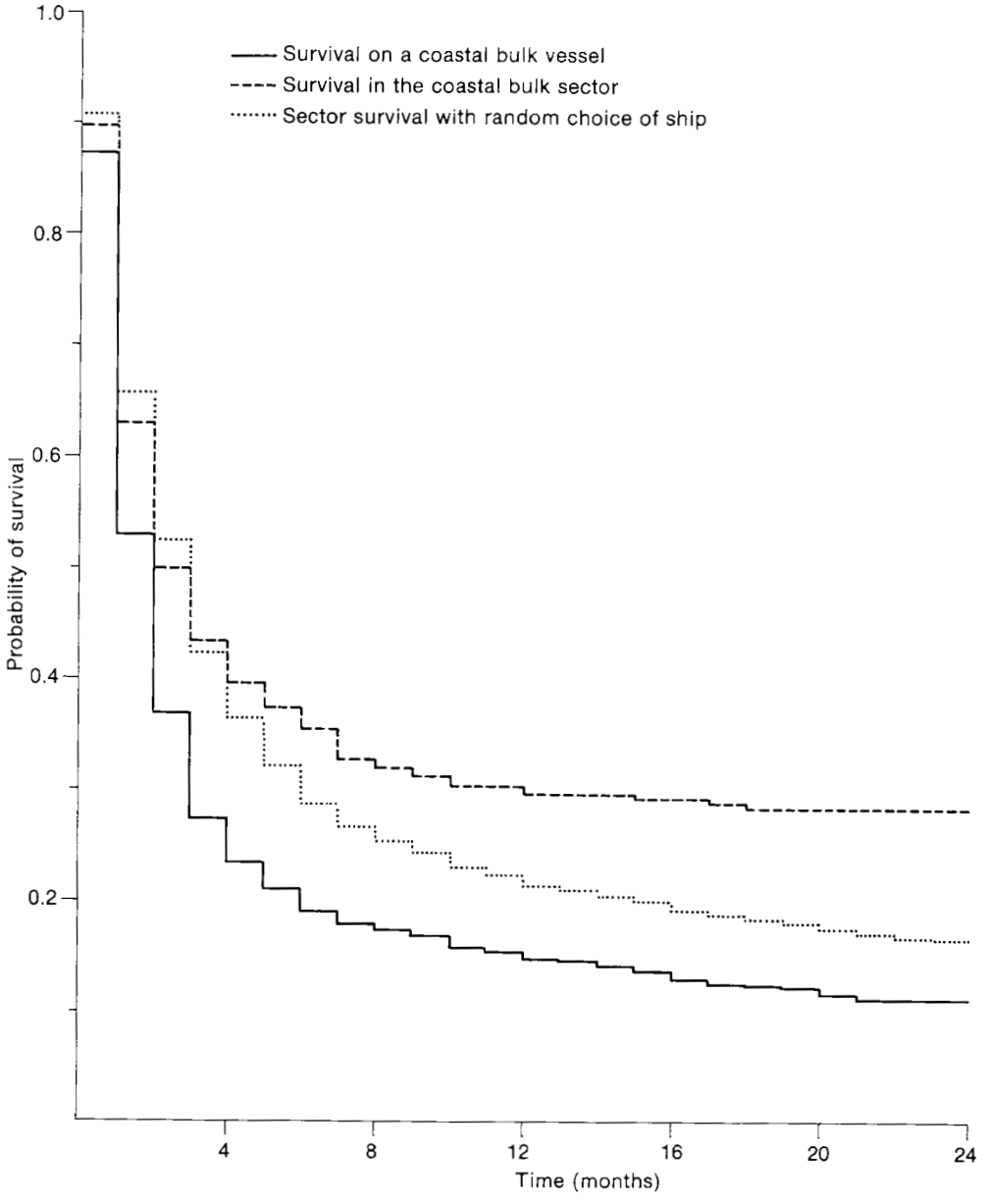

Figure 6.6— Ship and sector survival functions for ratings in the coastal bulk sector

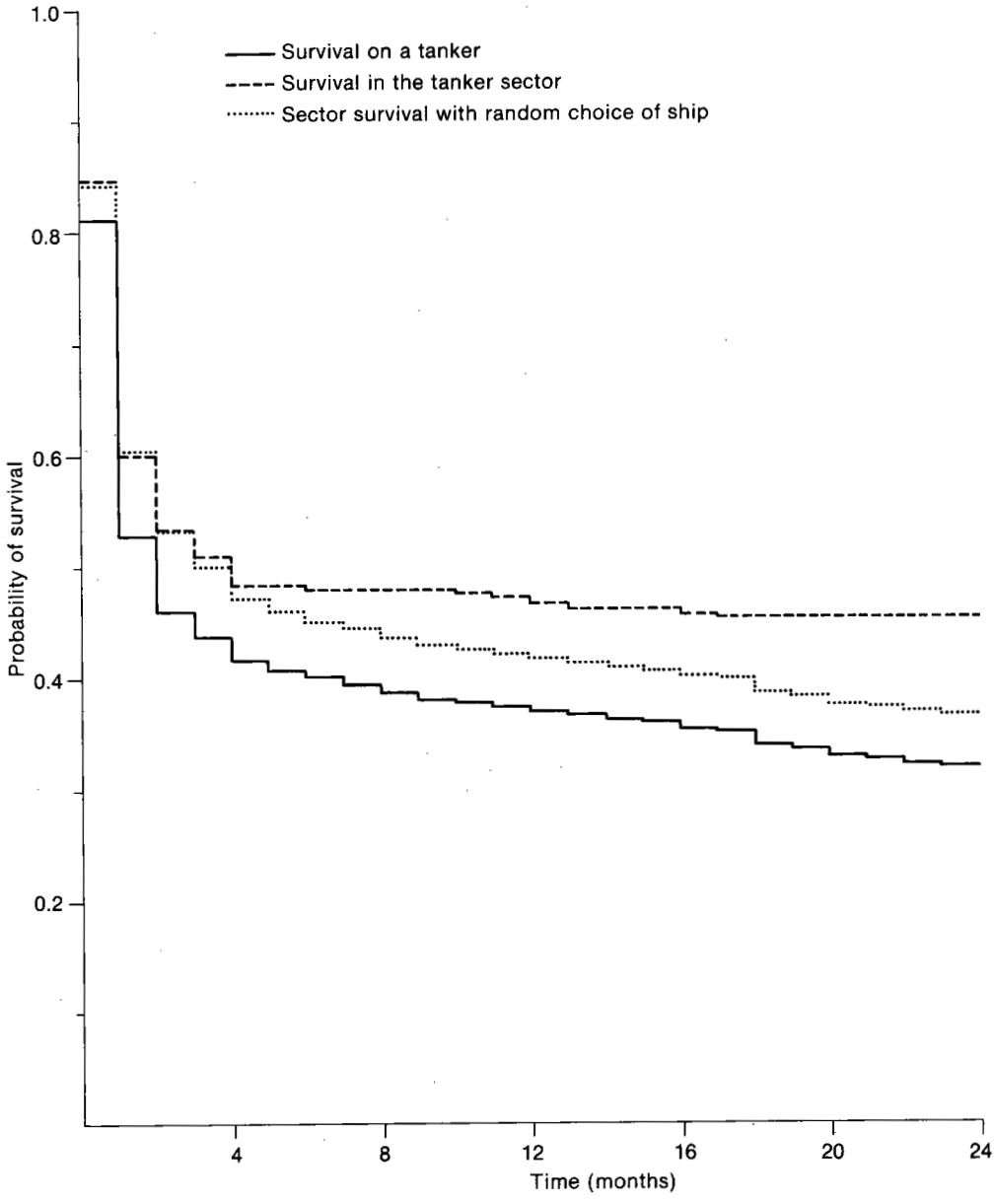

Figure 6.7—Ship and sector survival functions for ratings on tankers

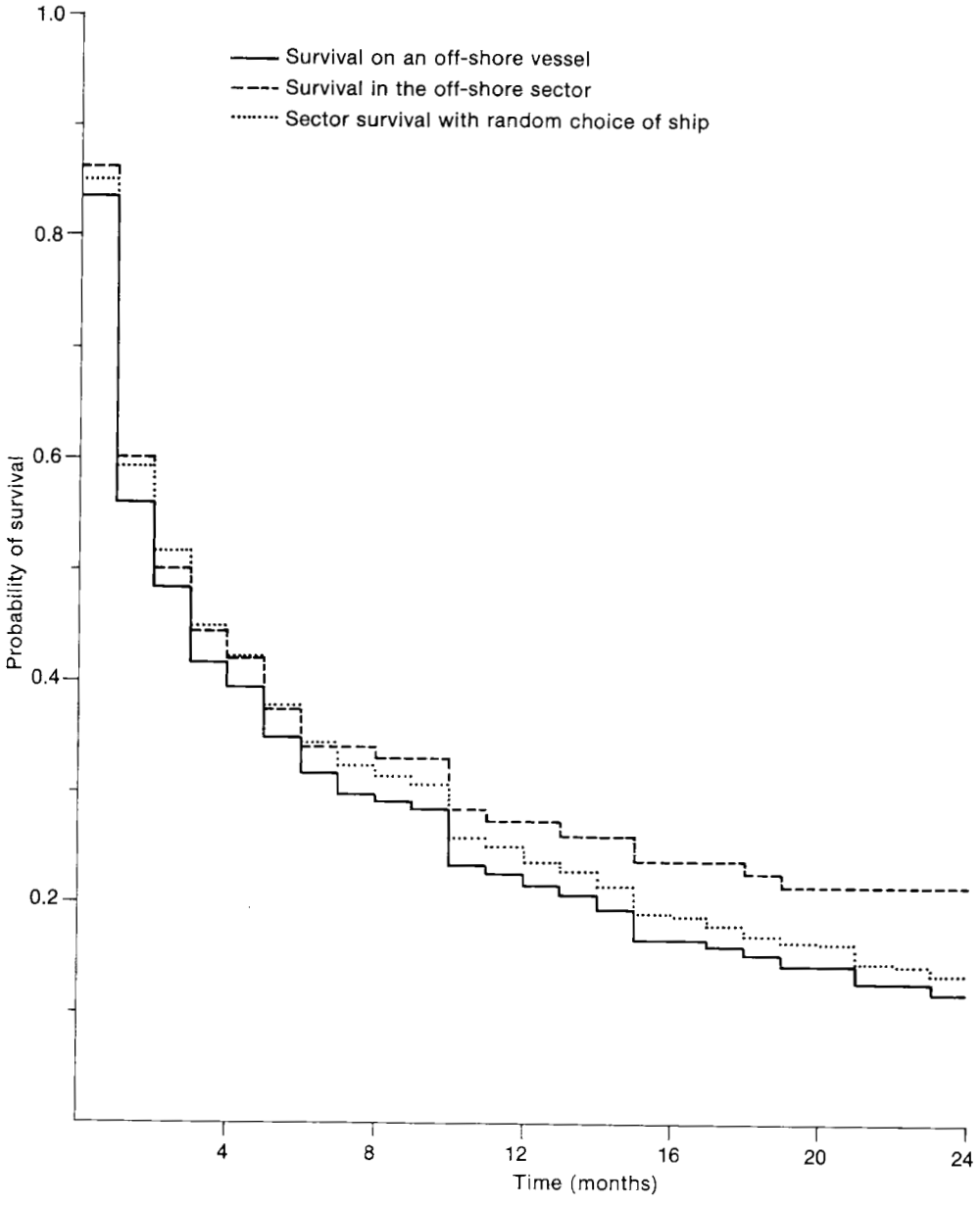

Figure 6.8—Ship and sector survival functions for ratings in the off-shore industry

CHAPTER 7—CONCLUDING REMARKS

In the period 1977 to 1982 the total number of berths available for men in the Australian merchant navy remained almost constant, although there was a significant reduction in the number of berths in the coastal bulk sector and significant increases in the number of berths in the overseas bulk and offshore sectors. In this period there was no evidence of change in the age distribution of men in the industry or in the age distributions of recruitment or wastage. Thus if historical employment patterns remain unchanged in the future there will only be very small changes in the industry's workforce characteristics.

Any future reduction in the average age of recruits is likely to result in a small, slow decrease in the average age of the workforce but is unlikely to have any major effect on the number of recruits required to sustain industry growth. The future growth rate of the industry will also affect the average age of the workforce. If recruitment and wastage patterns do not vary in the future then positive industry growth would result in a decrease in the average age of the workforce and negative growth would have the opposite effect.

The average wastage rate for both officers and ratings in the period 1977 to 1982 was 7 per cent per annum.

It has been shown that a large fraction of both officers and ratings stayed on the same ship for extended periods; 60 per cent of ratings and 52 per cent of officers changed ship less than once per year on average. However the men who transferred frequently between ships caused crew turnover rates to be high; on average 50 per cent of a new crew of ratings transferred to another ship in the first two months. Ship transfer rates decreased with increasing rating age.

It was found that crew turnover depended strongly on industry sector, with the lowest turnover observed for tankers and the highest for overseas bulk vessels. Ratings exhibited 'loyalty' only to coastal bulk vessels and it was concluded that in general the workforce did not consist of groups of men who worked on specific types of ships.

APPENDIX I—BREAKDOWN OF THE VESSELS IN THE MERCHANT NAVY INTO DISCRETE SECTORS

The purpose of this appendix is to list the ships in each of the sectors listed in Chapter 2. Ships were classified into sectors on the basis of type and trade patterns.

COASTAL BULK

Accolade
Alnwick Castle
Bulknes
Camira
Cobargo
Conara
Curtis Capricorn
Curtis Oceanic
Cycle
Darling River
Gerrigong
Goliath
Hexham Bank
Iranda
Iron Baron
Iron Bogong
Iron Capricorn
Iron Carpentaria
Iron Cavalier
Iron Cumberland
Iron Curtis
Iron Endeavour
Iron Flinders
Iron Hunter
Iron Hyarra
Iron Shortland
Iron Sirius
Iron Somersby
Iron Spencer
Iron Whyalla (1)
Iron Whyalla (2)
Jeparit
Lake Barrine
Lake Boga
Lake Colac
Lake Eildon
Lake Eyre
Lake Hume
Lake Macquarie
Lake Sorell
Lake Torrens
Lisa Miller
Macedon
Merringa
Mount Newman
North Esk
Ormiston
Poolta
Stephen Brown
Stirling Range
Tambo River
Tolga
Yarra River

TANKERS

Amanda Miller
Ampol Sarel
Arthur Phillip
BP Endeavour
BP Enterprise
Cellana
Esso Gippsland
Express
Howard Smith
John Hunter
Mobil Australis
Nancy Heath
PJ Adams
Robert Miller
Silverharrier
Silverhawk
William Dampier
WM Leonard

COASTAL ROLL-ON/ROLL-OFF

Bass Trader
Brisbane Trader
Dundas
Iron Duke
Iron Monarch
John Burke
Lysaght Endeavour
Mary Holyman
Melbourne Trader
Pera
Seaway Prince
Seaway Princess
Seaway Queen
Sid McGrath
Straitsman
Sydney Trader
Townsville Trader
Troubridge

MULTI-PURPOSE

Beroona
Darwin Trader
Iron Arnhem
Iron Kerry
Iron Kestrel
Iron Mittagong
Iron Sturt
Iron York
Kimberley
Loorana
Wambiri
Wongala
Zincmaster

OFF-SHORE

Austral Tide
Bass Tide
Chantik
Eastern Tide
Eugene McDermott II
Flinders Tide
Karunda
Lady Ann
Lady Cynthia
Lady Diana
Lady Florence
Lady Gay
Lady Jane
Lady Joyce
Lady Rachel
Lady Vera
Lady Vilma
Marchant 3
Miss Rankin
Northern Tide
Ocean Endeavour
OSA 485 Leinetor
OSA 607 Sandtor
OSA 605 Steintor
OSA 482 Winsertor
OSA Tiger
Regional Endeavour
San Pedro Bay
San Pedro Sound
Sea Emerald
Sedco 445
Sedco 472
Sedco/BP 471
Southern Tide
Tasman Tide
Victoria Tide
Western Endeavour
Western Odyssey
Western Pacific
Western Tide

OVERSEAS BULK

Australian Pioneer
Australian Progress
Australian Prospector
Australian Purpose
Baron Murray
Cape Hawke
Cape Otway
Flinders Range
Howard Smith
Selwyn Range

LINER (EUROPE)

Allunga
Australian Endeavour
Australian Enterprise
Australian Exporter
Australian Venture

LINER (ASIA)

ANRO Australia
Australian Emblem
Australian Escort
Australian Explorer

OTHER

Albany
Boogalla
Empress of Australia
Falie
Flinders Trader
Fourcroy
Glenda Lee
Joseph Banks
Lady Basten
Lady Jillian
Nelcebee
Nyanda
Rah
Roger Rougier
Warrender
Wyunander

APPENDIX II—SECTOR SURVIVAL FUNCTION WITH RANDOM CHOICE OF SHIP

One of the aims of Chapter 6 is to answer the question: is there a greater than random probability that when a seamen transfers between ships, he will transfer between ships in the same sector? In other words, does sectoral loyalty exist, and if so, for what sectors? These questions were addressed by first measuring the survival function of men in a sector and then comparing the result with the survival function which would have been observed if men chose ships on a random basis. The purpose of this appendix is to derive an expression for the probability that an individual will transfer between industry sectors in a given time interval, given that ships are chosen randomly. This probability function can then be used in a straightforward way to derive the required survival function.

Let the probability that a seaman changes ship in the time interval (t-1,t) be denoted by f_t and the probability that a seaman changes sector in (t-1,t) be denoted by s_t. The probability of changing sector in the first time interval (0,1) can then be written:

$$s_1 = f_1 p \qquad \text{II.1}$$

where p = probability of changing sector when changing ship.

To determine the probability of changing sector in the second time interval (1,2) it is necessary to consider not only the seamen who stayed on the same ship until the second time interval and then changed ship and sector, but also those who changed ship but not sector in (0,1) and then in (1,2) changed ship and sector. It follows that:

$$s_2 = [f_2 + f_1^2 q]p \qquad \text{II.2}$$

where $q = 1 - p$.

The expression for s_3 must take account of the seamen who have changed ship without sector one or two times before they changed ship and sector. It follows that:

$$s_3 = [f_3 + 2f_1 f_2 q + f_1^3 q^2]p \qquad \text{II.3}$$

In a similar way it follows that:

$$s_4 = [f_4 + (2f_1 f_3 + f_2^2)q + 3f_1^2 f_2 q^2 + f_1^4 q^3]p \qquad \text{II.4}$$

$$s_5 = [f_5 + (2f_1 f_4 + 2f_2 f_3)q + (3f_1^2 f_3 + 3f_1 f_2^2)q^2 + 4f_1^3 f_2 q^3 + f_1^5 q^4]p \qquad \text{II.5}$$

$$\text{and } s_6 = [f_6 + (2f_1 f_5 + 2f_2 f_4 + f_3^2)q + (3f_1^2 f_4 + 6f_1 f_2 f_3 + f_2^3)q^2 + (4f_1^3 f_3 + 6f_1^2 f_2^2)q^3 + 5f_1^4 f_2 q^4 + f_1^6 q^5]p \qquad \text{II.6}$$

The general expression for s_t consists of 2^{t-1} terms of varying orders of q. As each term in q^n involves the multiplication of n+1 values, it was impractical to numerically evaluate the general expression. In order to maintain the manageability of the computations and reasonable accuracy, s_t was approximated to the third order in q.

The sector survival function based on the assumption of random choice of ship is the complement of the cumulative distribution of s_t. It is estimated that the maximum accumulated error in any calculated survival function was less than 0.025.

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