

An Analysis of Crewing Levels: Findings from the SIRC Global Labour Market Survey

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Executive Summary

The aim of this report is to consider crewing levels aboard ocean going cargo vessels and the effect of vessel size and flag on average numbers of officers, ratings, and total crew.

The report is based upon the SIRC Global Labour Market Survey and specifically upon data collected in the year 2003. It draws upon information contained in crew lists provided by 3,969 vessels calling at selected ports across the world in the month of March.

The analysis presented here is based upon the division of vessels into two main categories. Ships which can be termed 'tankers' are include in one category and ships that can be termed 'dry cargo' vessels constitute the second category. For each category vessels are then divided into smaller groups depending upon their size as indicated by their gross tonnage (gt). These groups are considered by flag type to determine the effect of flag, if any, on average crew levels. Flags are categorised as those which represent national, open, and second registers.

The statistically significant findings from this analysis indicate that once vessel size effects have been eliminated¹:

- There is an effect of flag upon crew size
- The effect is strongest for small to medium size vessels
- The effect of flag upon crew size is different for tankers and for dry cargo vessels.

¹ An effect of vessel age was checked for and found not to be present

Statistically significant findings relating to tankers

Average crew size

- Smaller tankers (1,000 to 9,999 gt) flagged with open registers carry larger average crews than vessels flagged with second registers.
- Tankers in the size group 5,000-9,999 gt flagged with open registers carry larger average crews than vessels in this size category flagged with national registers.
- Small tankers (1,000 to 4,999 gt) flagged with national registers carry larger average crews than vessels flagged with second registers.

Officer numbers

- Tankers flagged with national registers carry higher average numbers of officers in the size categories 1,000-2,999 gt and $\geq 100,000$ gt than vessels flagged with second registers.
- In the size category 5,000-9,999 gt tankers flagged with open registers carry higher numbers of officers than those flagged with national registers.
- In the size category $\geq 100,000$ gt tankers flagged with national registers carry higher numbers of officers than those flagged with open registers.

Average numbers of ratings

- Tankers, sized 1,000- 9,999 gt, flagged with open registers carry higher average numbers of ratings than those flagged with second registers.
- Tankers, sized 1,000-4,999 gt, flagged with national registers carry higher average numbers of ratings than those flagged with second registers.

Statistically significant findings relating to dry cargo vessels

Average crew size

- Dry cargo vessels sized 1000-9,999 gt and flagged with open registers have larger crews than those flagged with second registers.
- Dry cargo vessels sized 1000-19,999 gt and flagged with national registers have larger crews than those flagged with second registers.

- Dry cargo ships, in the categories 1,000-2,999, 3,000-4,999 gt and 10,000-19,999, flagged with national registers have larger crews than vessels flagged with open registers.

Officer numbers

- Dry cargo vessels sized 1,000-9,999 gt and flagged with national registers have larger average numbers of officers than those flagged with second registers.
- Dry cargo vessels in the categories 1,000-2,999 and 5,000-9,999 gt and flagged with open registers have larger average numbers of officers than those flagged with second registers.
- Dry cargo vessels sized 50,000-99,999 gt and flagged with second registers carry higher numbers of officers than vessels flagged with open or national registers .
- Dry cargo vessels, sized 1,000- 4,999 gt, and flagged with national registers have higher average numbers of officers than vessels flagged with open or second registers.
- In the single size category of 50,000-69,999 gt dry cargo vessels flagged with open registers carry higher numbers of officers on average than those flagged with national registers.
- Dry cargo ships sized 50,000-99,999 gt flagged with second registers carry higher numbers of officers than those flagged with national or open registers.

Average numbers of ratings

- Smaller dry cargo vessels sized 1,000-49,999 gt flagged with national registers carry more ratings than those flagged with second registers.
- Dry cargo vessels sized 1,000-4,999 and 20,000-49,999 flagged with open registers have larger numbers of ratings than those flagged with second registers.
- Dry cargo vessels in the categories 1,000-2,999, 5,000-9,999, 10,000-19,999 and 50,000-99,999 flagged with national registers carry more ratings than those with open registers.

- Dry cargo vessels sized 20,000-49,999 flagged with national registers carry more ratings than those with second registers.
- Dry cargo ships sized 1,000-4,999 gt flagged with open registers carry more ratings than those with second registers.
- Dry cargo vessels sized 20,000-49,999 gt flagged with open registers have higher numbers of ratings than those with national registers.
- Dry cargo vessels sized 50,000-69,999 gt flagged with national registers have higher numbers of ratings than those with open registers.

Conclusions

There are statistically significant differences in crew size found between vessels flagged with different flag types. Aboard tankers there is a tendency for vessels flagged with open registers in the lower size categories to carry larger crews than those with national and second registers. Aboard dry cargo ships there is a tendency for the opposite pattern to emerge: with vessels with national flags (particularly smaller ones) tending to carry bigger crews than those flagged with open or second registers.

The most noteworthy findings relate to vessels flagged with second registers which display a tendency to carry the smallest crews of the three flag groups where statistically significant results occur see Table A and B below.

Table A: The location of significant differences in crew size between tankers flagged with different registry types

TANKERS	Officers			Ratings			Crew		
	Open Second	Open National	National Second	Open Second	Open National	National Second	Open Second	Open National	National Second
1,000- 2,999									
3,000- 4,999									
5,000- 9,999									
10,000- 19,999									
20,000- 49,999									
50,000- 69,999									
70,000- 99,999									
>=100,000									

Table B: The location of significant differences in crew size between dry cargo vessels flagged with different registry types

DRY CARGO	Officers			Ratings			Crew		
	Open Second	Open National	National Second	Open Second	Open National	National Second	Open Second	Open National	National Second
1,000- 2,999									
3,000- 4,999									
5,000- 9,999									
10,000- 19,999									
20,000- 49,999									
50,000- 69,999									
70,000- 99,999									
>=100,000									

Key

- Blocks in **red** indicate that **open registers** carry larger average crews than the comparator.
- Blocks in **grey** indicate that **national registers** carry larger average crews than the comparator.
- Blocks in **blue** indicate that **second registers** carry larger average crews than the comparator.

Introduction

For several years a Global Labour Market study has been conducted by the Seafarers International Research Centre (SIRC). Data from the study have previously been used to consider the profile of the seafaring workforce for the global cargo fleet in terms of characteristics such as age, nationality, ship type, and rank. This report focuses upon an element of the data that has not previously been considered, and provides an analysis of crew-size by ship size and register type. The data presented here were collected in the final funded year of the SIRC research – 2003. The expertise to conduct a further data sweep for this study remains at SIRC, for the present, and the centre is currently attempting to raise funds to repeat the research in 2006/7².

Method

This paper is based upon the findings from an analysis of a dataset established at SIRC via the collation of data entered upon crew lists which were collected from a range of ports across the world. Specifically it reports on crew list data collected in 2003 and focuses upon the numbers of officers and ratings found upon vessels that have been categorised as either tankers or dry cargo ships (these categories have been adopted from Lloyds Register-Fairplay World Fleet Statistics³). The paper considers these levels by ship size and by category of ship register (open, national, and second).

In order to determine which results are statistically significant, in the first instance, a one-way analysis of variance (ANOVA) was used to test the null hypothesis that the mean level of crewing (officers, ratings, or total crew) did not differ with register type. These tests were carried out individually for each weight group in each vessel type; the null hypothesis was rejected if significance level was beneath 0.05.

² Should any individual, any organisation, or any consortium, be interested in sponsoring this research, the SIRC Director would be very pleased to hear from them. The research costs approximately £80,000 to carry out per year and multiple sponsorship would be considered by the centre.

³ Appendix A of this report reproduces the vessel types included within each category

Although the ANOVA procedure tells us that significant differences in means occur within these categories, it does not inform us where these differences lie. Hence, the post-hoc Least Significant Differences (LSD) test was performed in those categories where the null hypothesis were rejected⁴. The LSD test analyses each possible pairing of the independent variables (i.e. the types of register) to ascertain where significant differences exist. Once again the null hypothesis of no difference in means was rejected, i.e. that there is a statistically significant difference between the means, at the 0.05 level⁵.

Sample and sample distribution

Within the crew list data we have information on 1,054 tankers ranging from 1,000 gt to more than 150,000 gt. The dataset for dry cargo vessels is larger incorporating 2,915 cases. It is axiomatic that there is a relationship between the size of a vessel and the number of crew aboard it. Hence, a simple comparison of crew sizes across the whole of the sample would be likely to be misleading. ISF-BIMCO utilise a particular distribution of vessel sizes for the purpose of comparison, namely <500 gt, 500-1,600 gt, 1,600-10,000 gt, 10,000-150,000 gt and >150,000. Utilising these categories would have enabled us to report our data in a format compatible with the ISF-BIMCO report. However, there were a number of issues that prevented us from doing this. Firstly, the SIRC dataset is restricted to vessels of 1,000 gt and over⁶, resulting in an under representation of the smaller vessels more commonly found in the ISF-BIMCO sample. Secondly, for both dry cargo vessels and tankers there was, for the majority of the ISF-BIMCO size categories, a positive correlation between vessel size and crew size within the category. Thus results from a comparison of flag and crew size could prove to be spurious potentially deriving from sample distribution rather than from a genuine relationship between crewing level and register type. We have therefore adopted an alternate method of classifying vessel size.

⁴ Once the null hypothesis is rejected by the ANOVA test, the LSD post-hoc test is not performed.

⁵ A significance level of 0.05 is the standard acceptable level for statistical significance. For those wished to adopt an alternate level beneath the 0.05, Appendix D gives the raw significance scores for all the comparisons. In the course of this report statistically significant results refer to those that reject the null hypothesis at a significance level of 0.05 or below.

⁶ The raw data compilation includes vessels under the 1,000 gt level; these are excluded in the data cleaning process.

Our challenge in re-categorising our sample by vessel size was to produce categories within which there were no significant relationships between vessel size and crew size whilst nevertheless retaining groupings containing sufficient numbers of cases so that sensible comparisons could be made across different types of flags. Through a process of trial and error, refining, expanding, or reducing, categories it was possible to generate a classification of vessel size that produced a negligible impact of vessel size on crew size within categories and which, with the exception of very large vessels, contained sufficient numbers of cases. The size categories we eventually arrived at and the numbers of cases within each category are reproduced in Tables 1 and 2 below.

Table 1: Sample Distribution: Tankers (Number of Vessels)

Category (gt)	Total
1000 – 2999	154
3000 – 4999	171
5000 – 9999	128
10000 – 19999	151
20000 – 49999	246
50000 – 69999	109
70000 – 99999	45
>=100000	50
TOTAL	1054

Table 2: Sample Distribution: Dry Cargo Vessels (Number of Vessels)

Category (gt)	Total
1000 – 2999	607
3000 – 4999	284
5000 – 9999	409
10000 – 19999	532
20000 – 49999	765
50000 – 69999	211
70000 – 99999	92
>=100000	15
TOTAL	2915

Significant attention has been paid to the consequences of the rise of open registers and their effect on vessel operation (Alderton and Winchester, 2002 a,b,c; Barton, 1999; Carlisle, 1981; Johnson, 1996; Koch-Baumgarten, 2000, Metaxas, 1985, Winchester and Alderton, 2003). Most of these analyses have focussed either on regulatory context, vessel standards, contractual issues, working conditions or port state control. However, crew size, a factor that clearly underpins or is at least contributory to the outcomes of many of these prior studies, has previously received insufficient attention. In the main this is due to a general lack of systematic evidence facilitating such analyses. This report represents an attempt to correct this deficit via a detailed investigation of actual crew levels across different types of register⁷. Rather than adopting a simple dichotomous division between open and national registers, the recent and continuing development of second registers has led us to utilise a trichotomous categorisation of registers using definitions provided in Alderton *et al.* 2004: 28-34⁸. Tables 3 and 4 illustrate the relative distribution of the sample across these registers split by two vessel types (tankers and dry cargo).

Table 3. Sample Distribution: Tankers (Number of Vessels)

TANKERS Category (gt)	Register type			Total
	Open	National	Second	
1000 – 2999	40	78	36	154
3000 – 4999	92	48	31	171
5000 – 9999	70	39	19	128
10000 – 19999	79	32	40	151
20000 – 49999	128	75	43	246
50000 – 69999	65	30	14	109
70000 – 99999	19	18	8	45
>=100000	35	8	7	50
TOTAL	528	328	198	1054

⁷ Appendix B, gives a full details of the flags within the sample.

⁸ As Alderton *et al.* note the status of Hong Kong is problematic; in this analysis Hong Kong is classed as an open register.

Table 4. Sample Distribution: Dry Cargo Vessels (Number of Vessels)

DRY CARGO Category (gt)	Register type			Total
	Open	National	Second	
1000 – 2999	248	327	32	607
3000 – 4999	141	131	12	284
5000 – 9999	223	148	38	409
10000 – 19999	397	117	18	532
20000 – 49999	513	203	49	765
50000 – 69999	136	61	14	211
70000 – 99999	51	21	20	92
>=100000	9	1	5	15
TOTAL	1718	1009	188	2915

Findings

Tankers

The mean crew size based upon numbers of officers and ratings but excluding cadets, supernumeraries, and other cases,⁹ increases fairly sharply as vessel size increases up to the 10,000-19,999 gt group at which point the increase in crew numbers tends to level off. Other measures of central tendency, i.e. median (the middle value) and mode (the most common value) describe a similar pattern, with the levelling-off effect and the establishment of stable crewing levels aboard vessels above a particular size. It is interesting to note that within these groups the age of the vessel does not seem to have a significant effect.

⁹ Appendix C gives the list of included and excluded ranks.

Table 5. Tankers: Mean (standard deviation (SD), mode and median crew levels by size category

TANKERS	Measure		
Category (gt)	Mean (SD)	Median	Mode
1000 – 2999	11.7 (3.13)	11	10
3000 – 4999	15.5 (3.15)	16	15
5000 – 9999	17.7 (3.36)	18	19
10000 – 19999	22.7 (4.24)	22	22
20000 – 49999	23.6 (3.83)	23	23
50000 – 69999	24.0 (3.45)	23	22
70000 – 99999	24.4 (3.21)	23	23
>=100000	25.0 (3.38)	25	22

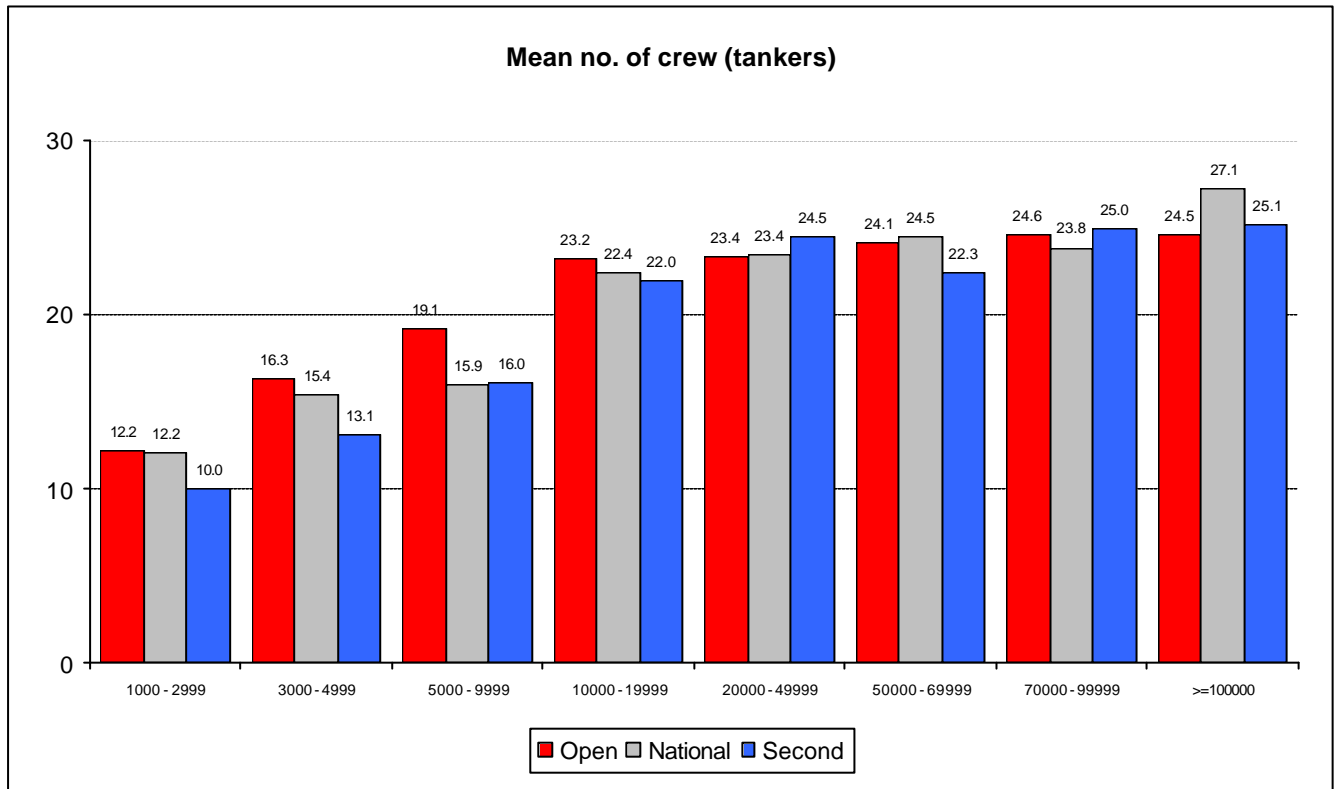
Having controlled for the effect of distribution of vessel size within each category (see earlier explanation) and noting the negligible effect of vessel age on crew size, it becomes possible to compare crewing levels for vessels flying different types of flag. Any sampling procedure carries with it the possibility of creating erroneous results, however we consider the measures adopted here to be reasonably robust.

Tankers: Flag and Crew size

For all register types there is a positive correlation between crew and vessel size up until the size category 10,000-19,999 gt. Vessels larger than this demonstrate a general levelling off of crew size.

The most distinct differences between flags, when considering crew size, occur in the lowest three gross tonnage bands. Here we can identify lower crewing levels aboard vessels flagged with second registers as compared with those flagged with open registers (in all of three lower gt bands these differences are statistically significant). There are also statistically significant differences between national and second registers in the size categories 1,000-2,999 and 3,000-4,999 with crew levels higher on national flagged ships. Turning to open and national registers, with the exception of a statistically significant higher level of crew on open registers in the category 5,000-9,999 gt all other comparisons between open and national registers are not statistically significant. Therefore a limited claim can be made that for smaller

vessels there is a significant and meaningful difference between vessel registration and crew level. Ships flagged with second registers carry significantly smaller crews than those ships flagged with open registers. However, this relationship tends to break down when considering vessels of 10,000 gt and more.

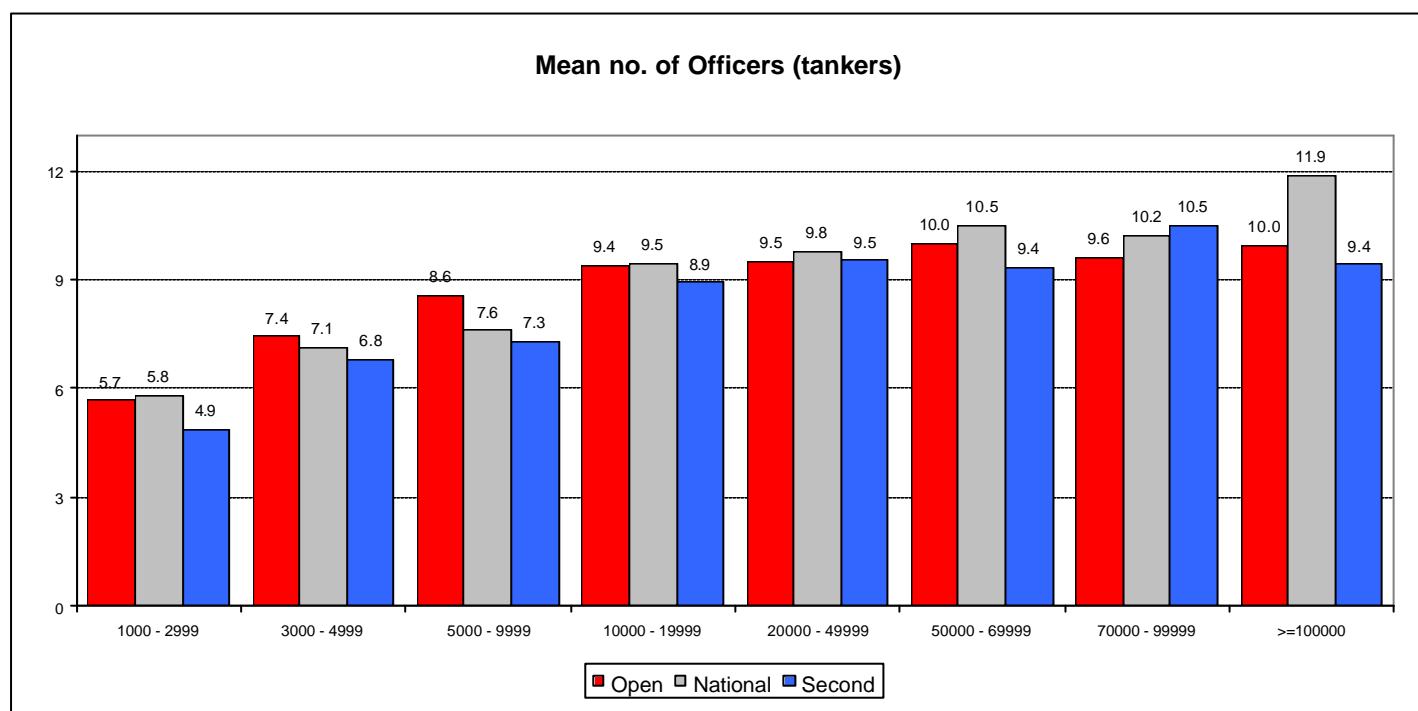


In only one size category (the highest gross tonnage division whose classification has the lowest sample number and is therefore the least reliable) do open registers show the single lowest absolute crew levels. Indeed in the first four smallest categories of tanker open registered vessels have the highest absolute levels of crewing. Thus it seems that whilst tanker owner/operators may choose open registers to restrict or reduce operating costs their decision is not accompanied by a reduction in crewing levels. It may be the case that drawing on cheaper labour supplies allows operators to raise their total crew complement. Of further interest, and particular note, is the status of second registers. In the smaller vessel categories the comparison between second registers and national registers (noting that this is not a direct comparison between a particular second register and its national 'parent' register but of aggregate

figures) shows a noticeable difference in average crew numbers with second registered tankers carrying fewer crew.

Details of aggregate crew size tell us little of the relative distribution of crew complements across the key designators of rank, i.e. the categories of ratings and officers. It is useful to consider these further.

Distribution of officers aboard tankers by flag

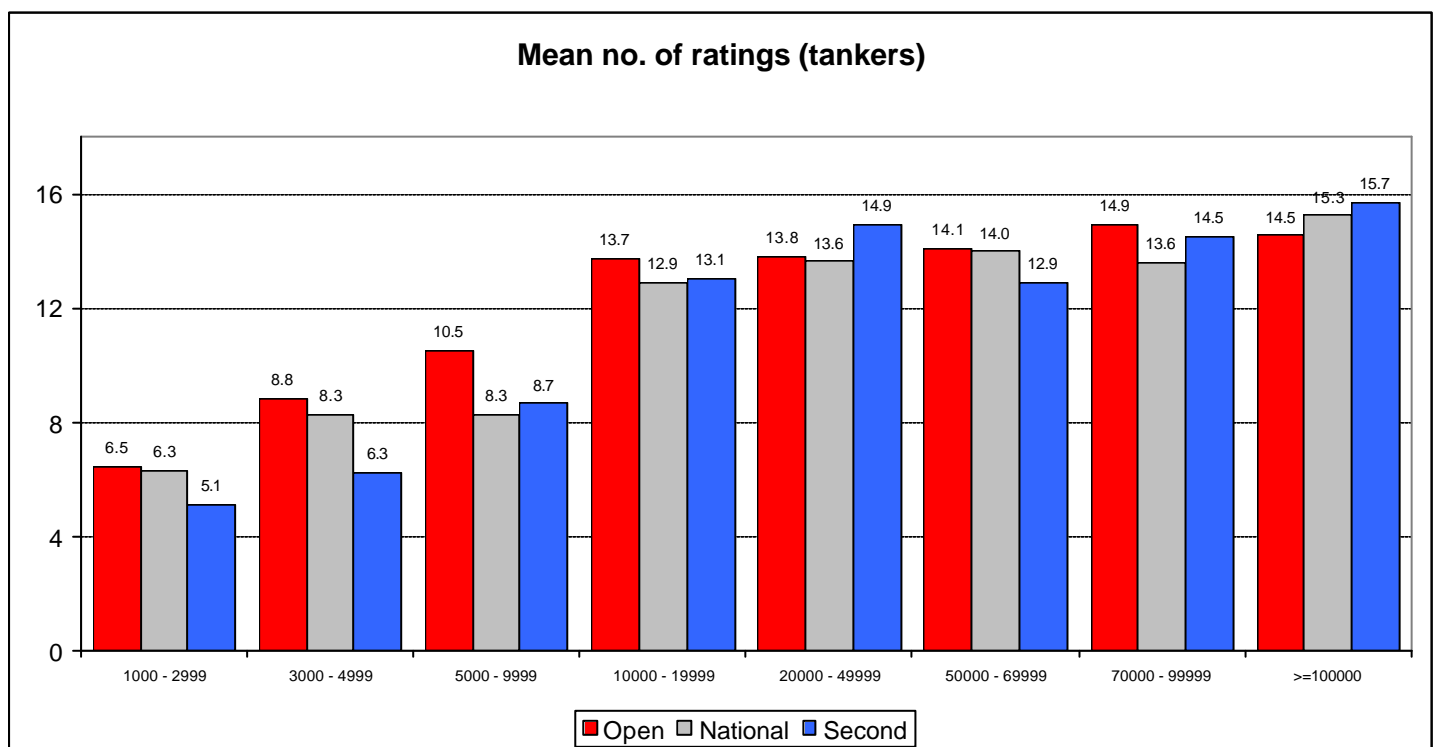


When we consider officer distribution we find a similar pattern to that found with aggregate figures. Of particular note is the finding that in seven of the eight vessel size categories second registered vessels have the lowest average numbers of officers on board. In the categories 1,000-2,999, and 5,000-9,999, the higher levels of officers found on vessels registered with open, as opposed to second registers, are statistically significant. Second registered vessels have fewer officers than national registered ships in all but one size category; the difference between mean number of officers aboard vessels flagged with national and second registers are statistically significant in the 1,000-2,999 and >=100,000 size categories. Mean officer levels for open and national registers, for the most part show little difference. However, the apparent differences in the 5,000-9,999 and >100,000 size categories are statistically

significant. In the smaller size group open register vessels have a higher mean number of officers than national register ships while the reverse pattern is seen in the >100,000 gt category.

Thus, as with total crew size, the most apparent differences are found between vessels flagged with second registers and vessels flagged with either national or open registers. This finding and the associated hypothesis that second registers are facilitating a reduction in crew levels, to an extent that many had not previously anticipated, suggests that this is an area that is worthy of further research.

Ratings



The pattern for ratings shows some similarities with that for officers and total crew complement. Again we find that statistically significant results cluster around the smaller gross tonnage size categories and that these highlight differences between open and second registers (categories 1,000-2,999, 3,000-4,999 and 5,000-9,999 level) and between national and second registers (1,000-2,999, 3,000-4,999) with open and national registered ships carrying higher numbers of ratings than second

register vessels. The only other statistically significant result occurs between open and national registers in the group 5,000-9,999; in this case open register vessels carry more ratings than national register vessels.

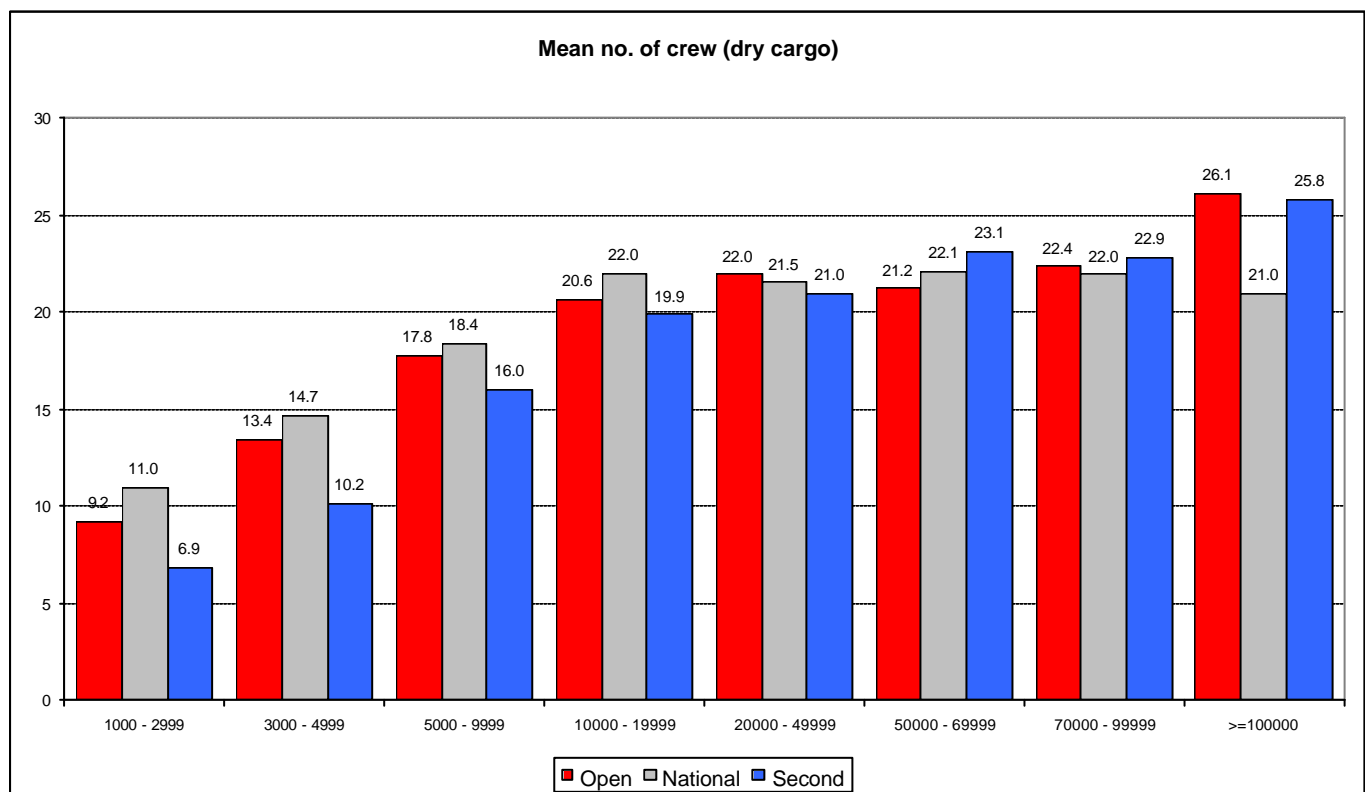
In contrast with the picture for officers, where second register vessels carried the lowest mean numbers of officers (in seven out of eight size categories) second register vessels carry the lowest mean numbers of ratings in only three of the eight size categories; indeed in two categories second register vessels carry the highest average numbers of ratings. This could lead to a tentative claim concerning operators choosing to flag with second registers, that in reducing crew sizes they are focusing on cutting officer numbers. In the small to medium size categories - up to 10,000-19,999gt - open register vessels carry the highest average levels of ratings, above this size category there is no discernable pattern across different forms of vessel registers.

Dry Cargo Vessels

In the case of dry cargo vessels, both the mean and median crew levels exhibit a similar tendency, i.e. a fairly steady increase up to the 10,000-19,999 gt size category with a subsequent levelling off (until the highest gross tonnage category is arrived at). In contrast, the most common value for the number of crew, the mode, displays a somewhat different pattern at the lower size levels. Up until the 5,000-9,999 size category, the mode value almost doubles per change in category. In the case of the first two size categories the mode is at a level noticeably lower than other measures of central tendency (see Table 6). After the first three categories the mode levels out somewhat with a small upwards trend detectable.

Table 6. Dry Cargo: Mean (standard deviation (SD), median, and mode crew numbers by vessel size

DRY CARGO	Measure		
	Mean (SD)	Median	Mode
1000 - 2999	10.0 (4.01)	10	6
3000 - 4999	13.9 (3.87)	13	11
5000 - 9999	17.9 (4.60)	18	20
10000 - 19999	20.9 (3.72)	21	20
20000 - 49999	21.8 (3.25)	21	21
50000 - 69999	21.6 (3.62)	22	22
70000 - 99999	22.4 (3.51)	22	22
>=100000	25.7 (3.42)	25	25



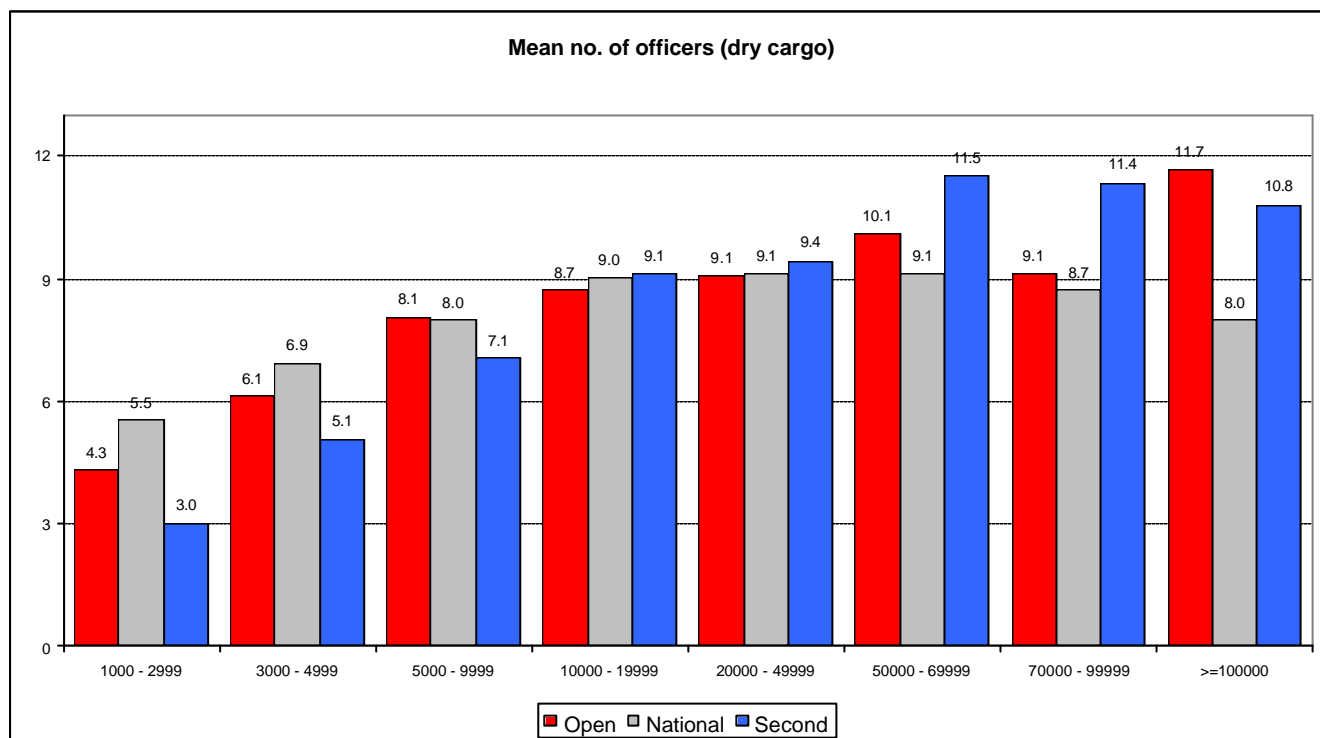
Vessels flagged with all types of register in the size categories up to 10,000-19,999 gt show a positive correlation in terms of vessel size and mean crew number. In these size categories, vessels flagged with national registers have the highest average crew levels, followed by open register flagged ships.

Vessels registered with second registers display the lowest mean crew size in five of the eight size categories but most notably in the first three gross tonnage categories. In the first four weight divisions (up to 19,999 gt) the higher mean numbers of crew aboard vessels flagged with national as opposed to second registers are statistically significant. In the first three categories (up to 9,999gt) the higher mean numbers of crew aboard open as compared to second registers are statistically significant. In terms of a comparison between vessels flagged with national and open registers, the lower mean crewing numbers found on vessels flagged with open registers in the categories, 1,000-2999, 3,000-4,999 and 10,000-19,999 are statistically significant. Thus, as with tankers, smaller cargo vessels flagged with second registers carry significantly lower average numbers of crew aboard, than smaller vessels flagged with open/national registers.

However in these size categories there is also a difference between tankers and cargo vessels. Cargo vessels in the lower size categories that are flagged with national registers tend to carry bigger crews than those flagged with open registers. This is the reverse of the pattern identified for tankers where smaller ships flagged with open registers tended to carry bigger crews than those flagged with national registers. None of the differences in crew size in the categories 20,000-49,999 upwards were of statistical significance.

In contrast to the results for tankers there appears to be a difference apparent when comparing national and open registers, at least in the low to moderate gross tonnage categories. In three out of the four smallest size categories vessels flagged with open registers carried significantly lower average numbers of crew than those which were nationally registered. However, in congruence with the findings for tankers, the most noticeable effect of flag is the difference found between second register ships and open/national register vessels. It is not easy to square this result with the current, albeit limited, analyses of second registers. However this result, reproduced as it is with both tankers and dry cargo vessels, merits further investigation.

Officers



In terms of officer numbers, the mean values do not closely follow the pattern seen for total crew size. All three types of register show an upwards trend in mean officer numbers for vessels of increasing size in the first four gross tonnage categories. Thereafter, however, the patterns differ. With national registers the trend tends towards stasis for medium sized vessels with a decline in average officer numbers on the largest ships. Second registers show a steady increase in average officer numbers up to the 50,000-69,999 gt category but decrease thereafter. By contrast, the mean number of officers aboard vessels flagged with open registers steadily increases with ship size with the single exception of 70,000-99,999 gt group.

There is a marked inconsistency aboard dry cargo vessels in terms of the registration of vessels with the highest average numbers of officers. In the first three weight categories (where 45% of the sample lie) the mean numbers of officers aboard vessels flagged with second registers are noticeably lower than the numbers aboard those flagged with national or open registers; with the exception of the comparison between open and second registers in the 3,000-4,999 gt group these differences are

statistically significant. However in the higher gross tonnage groups (50,000 gt and above), second registers display the highest average numbers of officers (with the exception of the very highest tonnage category which contains a relatively small number of cases). In the groups 50,000-69,999 and 70,000-99,999 gt, the higher mean number of officers on vessels flagged with second registers as opposed to those flagged with both open and national registers are statistically significant.

National register vessels carry the highest mean numbers of officers within the lowest two gross tonnage groups (statistically significantly higher numbers than those found on both open and second register vessels).

In the three tonnage groups 5,000-9,999, 10,000-19,999 and 20,000-49,999 gt the mean number of officers aboard vessels flagged with national registers falls between the mean numbers found aboard vessels flagged with second and open registers. However, the differences in these size categories are not statistically significant except in the 5,000-9,999 gt group where national registers have a higher officer average than second registers.

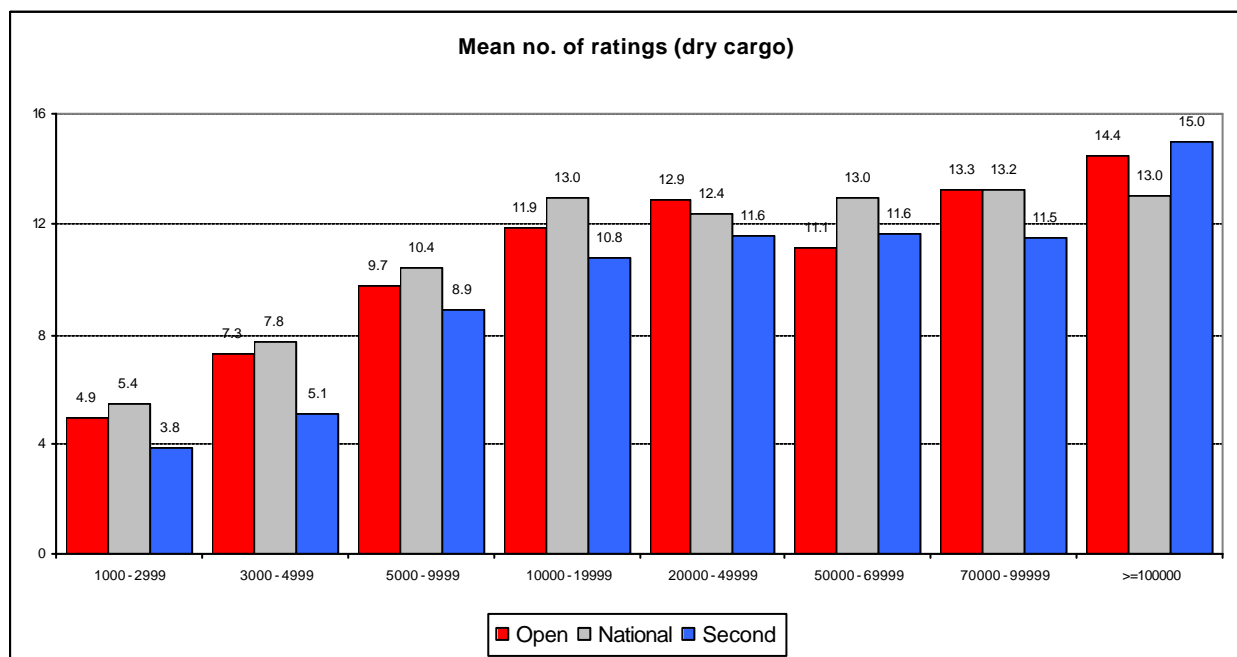
In the three highest gross tonnage divisions vessels flagged with national registers carry the lowest mean numbers of officers. Statistically significant differences occur between open and national registered vessels in the 50,000-69,999 group where open registered vessels carry a higher average number of officers than national register ships and between national and second registers in the 50,000-69,999 and 70,000-99,999 bands where second register vessels carry a higher average number of officers than national register ships.

Open registers fail to display any distinct pattern vis-à-vis other registers. Vessels flagged with open registers carry the highest average numbers of officers in two size categories, the lowest average number of officers in two other size categories, and they lie between the other register types for the remaining size groups. In terms of statistically significant differences, these occur between open and second register vessels in the 1,000-2,999 and 5,000-9,999 categories, where the mean officer number is *higher* for open than second register ships; in the 50,000-69,999 and 70,000-99,999 categories where the mean officer numbers on open register vessels is *lower* than on

second register ships. The differences between average officer numbers on open and national register ships is statistically significant for the 1,000-2,999 and 3,000-4,999 divisions with *lower* mean officer numbers on open registered vessels than national registered ships and for the 50,000-69,999 group where the average officer complement on open registered vessels is *higher* than on national flagged vessels.

Arriving at a clear and concise conclusion given the complexity of the observed effect of vessel registration on officer complement is problematic. The pattern of difference observed for register types at the lower end of the vessel size scale seems to be reversed at the higher end (it should be noted that the sample sizes in these higher weight divisions are noticeably smaller and hence are, to a degree, not as reliable as those figures in the lower weight categories). It could be possible that the presence of certain types of vessel within the dry cargo category could affect the results here. However, upon checking the distribution of vessel types within these registration categories, it seems that they are not so divergent as to be likely to skew the results. Sampling procedures could also produce spurious results but the fact that a large number of the results are statistically significant at both the higher and lower ends of the gross tonnage classification would suggest otherwise.

Ratings



In terms of average numbers of ratings, the first four gross tonnage divisions display a definite pattern. A consistent increase in mean numbers of ratings occurs in all types of registers, with national register vessels exhibiting the highest mean numbers of ratings, and second register vessels the lowest, for all these categories. After this point there is a divergence in the trendlines with numbers of ratings aboard national and second register vessels, tending to stabilise. Vessels registered with open registers display a steady increase in numbers of ratings up to the 20,000-49,999 tonnage category, a subsequent drop in the next gross tonnage division, followed by a further steady increase.

Second register vessels carry the lowest average numbers of ratings in six out of the eight weight categories, including the four smallest vessel categories. The lower mean numbers of ratings carried by vessels flagged with second registers compared with those flagged with national registers are statistically significant in the groups 1,000-2,999, 3,000-4,999, 5,000-9,999, 10,000-19,999 and 20,000-49,999.

Vessels flagged with second registers also carry lower numbers of ratings than open register vessels in some weight categories. Statistically significant differences are found in the groups 1,000-2,999, 3,000-4,999 and 20,000-49,999. In contrast to the figures for officers, vessels flagged with second registers carry the highest average numbers of ratings in only one case; and because of the small number of vessels found in this weight category this is the least reliable figure cited.

Vessels flagged with national registers carry the highest mean numbers of ratings in the four smallest gross tonnage categories. In the first five tonnage categories, statistically significant higher mean numbers of ratings are found aboard vessels flagged with national registers as compared to vessels flagged with second registers.

When we compare national and open register vessels we find higher mean numbers of ratings on vessels flagged with national registers. These differences are statistically significant in the 1,000-2,999, 5,000-9,999 and 10,000-19,999 and 50,000-99,999 weight groups.

In the weight category 20,000-49,999 gt we find a statistically significant difference in the opposite direction. In this weight category vessels flagged with open registers carry higher average numbers of ratings than vessels flagged with national registers. As with national and second registers, open registers display a clear pattern in the initial four weight categories.

When we compare vessels flagged with open and national registers we find statistically significant results in the 1,000-2,999, 5,000-9,999 and 10,000-19,999 weight groups, with open register vessels carrying lower average numbers of ratings than national vessels in these three categories.

When open and second registers are compared statistically significant results are found in two weight groups (1,000-2,999 and 3,000-4,999 gt) where open register vessels carry higher average numbers of ratings than second register ships.

In the higher weight groupings significant differences occur between open and national register vessels in the groups 20,000-49,999 (with open register vessels carrying a *higher* mean number of ratings than national register vessels) and 50,000-69,999 (with open register vessels carrying a *lower* mean number than national register vessels). Significant differences also occur between open and second register vessels in the weight group: 20,000-49,999 gt, where open register vessels carry a *higher* mean number of ratings than second register vessels.

These results are somewhat easier to interpret than those found for officer numbers. In the lowest four weight categories ships with national flags tend to carry higher average numbers of ratings than those vessels flagged with open registers. However, a further marked difference is apparent within these four categories which relates to the low numbers of ratings on second registered vessels. Indeed, across all size categories, second registers vessels, in general, carry relatively low average numbers of ratings - frequently the *lowest* level.

Summary

Whilst the picture for crewing and the effect of register type is complex it is clear that flag does impact upon the total numbers of seafarers, the numbers of officers, and the numbers of ratings aboard tankers and dry cargo ships.

Where there is an effect of flag upon crew size, this occurs most strongly aboard smaller/medium sized vessels (the first four divisions of gross tonnage). In the first four weight groups, where these relationships between flag and crew size exist, the relationship changes according to vessel type (tankers versus cargo). Aboard tankers our data demonstrate that the highest numbers of seafarers are found on vessels flagged with open registers (with this result replicated for both ratings and officers when considered separately). In terms of dry cargo vessels however the highest average crew sizes are found aboard vessels flagged with national registers.

One possible explanation for this pattern is that tanker operators are choosing to carry relatively large crews aboard their vessels for operational reasons (such as a high requirement for safety) whilst concurrently maximizing the benefits which accrue from flagging with open registers (in terms of per capita employment costs for example). In the dry cargo sector by contrast, where there is less emphasis on safety (from charterers, regulators etc), we might conclude that operators are not only taking advantage of the general benefits of 'flagging out' but are also taking the opportunity to cut total crew sizes aboard.

In the low to medium size vessel categories, (where significant differences occur) second register vessels carry the lowest total crew complements, and the lowest average numbers of officers and ratings in both vessel (cargo and tanker) categories. Whilst the impact of second registers has so far attracted limited academic attention, a tentative hypothesis to explain this pattern could be that flagging to second registers - which tend to have reduced regulatory requirement vis-à-vis national registers, but tend to be more stringent than open registers (Winchester and Alderton, 2003) - has resulted not in simple labour substitution to reduce crewing costs (i.e. without any effect on total crew size), but in an absolute reduction in crew size. Clearly this result

is cause for concern in terms of levels of work and their concomitant effects on seafarer fatigue. This issue, it would seem, requires urgent further attention.

Outside the low to medium size vessel categories, patterns do not emerge quite so clearly. Whilst interpretation of data relating to the largest vessels in the sample needs to be tempered by an awareness of the potential effects of sample size, the remaining size categories do not suffer from this sampling problem and it is difficult to arrive at clear cut conclusions in relation to larger vessels.

The issue of crew size aboard modern cargo vessels is clearly linked to emergent issues relating to seafarer workload and potential fatigue. Fewer people on board generally mean that there is more work to be done by each individual, although vessel size also has to be factored into the equation. Recent research at SIRC, carried out by the Lloyds Register funded research unit (LRRU), suggests that seafarers are beginning to feel that crewing levels have dropped below that which is sustainable in terms of managing both workloads and levels of fatigue (Ellis, 2005).

Despite the inadequacy of data available on the mortality and morbidity rates for seafarers, seafaring is nevertheless demonstrably an occupation which carries with it a comparatively high risk of personal injury. Research in Denmark suggests that Danish seafarers suffer an occupational mortality rate eleven times greater than workers in equivalent land-based industries (Hansen, 1996). Data collected in the UK suggest that UK seafarers are 26 times more likely to suffer a fatal injury at work than land-based UK workers (Roberts, 2002) and the UK P&I club's 10 year analysis suggests that there is a trend of rising repatriation and illness claims in the period 1987-97 (UK P&I club, 1999). Amongst the factors contributing to risk aboard ship may be noise, vibration, exposure to hazardous substances and weather-related dangers. However, awareness of the risk posed by fatigue to seafarers and the safe navigation of ships has increased across the sector. An ongoing Cardiff study of seafarers employed on vessels engaged in short-sea trades indicates that high fatigue scores are associated with mental health problems suggesting that stress may compound fatigue-related risks, and in a 1996 analysis of 179 US Coastguard reports fatigue was identified as a contributory factor in 16% of critical vessel casualties and 33% of personal injuries (McCallum *et al.*, 1996). Fatigue is thus an issue that has to

be taken seriously and it is an issue that now needs to be considered in the contemporary context of reduced crewing levels, particularly aboard some vessel types and aboard ships flagged with particular types of registry.

In summing up it is possible to state that there is evidence of a relationship between vessel registration and crewing. However, the nature of this relationship varies with size of vessel (low-medium sized vessels display the clearest relationship) and the type of vessel (relative hierarchy amongst registers is affected by the vessel type). Further research is required to establish what causal explanations account for the identified relationships. Choice of flag is never a neutral affair for a vessel operator and where it is made with a view to reducing the size or quality (often related to cost) of a crew it impacts on the safety of shipping and on the occupational health and safety of seafarers. The intentions underpinning decisions relating to flagging and overall crewing levels thus require further, and urgent, attention.

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APPENDIX A: Classification of Vessels

SHIPTYPES	BASIC GROUPINGS												
LNG TANKER LPG TANKER	LIQUEFIED GAS	BULK LIQUID CARGO	TANKERS										
CHEMICAL / OIL PRODUCTS TANKER CHEMICAL TANKER	CHEMICAL												
CRUDE OIL TANKER OIL PRODUCTS TANKER	OIL												
BEER TANKER BITUMEN TANKER CARBON DIOXIDE TANKER COAL / OIL MIXTURE TANKER EDIBLE OIL TANKER FISH OIL TANKER FRUIT JUICE TANKER LATEX TANKER MOLASSES TANKER OIL-SLUDGE TANKER VEGETABLE OIL TANKER WATER TANKER WINE TANKER	OTHER LIQUIDS												
BULK CARRIER ORE CARRIER	BULK DRY					BULK DRY CARGO							
BULK / OIL CARRIER ORE / OIL CARRIER	BULK DRY / OIL												
SELF-DISCHARGING BULK CARRIER	SELF-DISCHARGING BULK DRY												
AGGREGATES CARRIER ALUMINA CARRIER CEMENT CARRIER LIMESTONE CARRIER MUD CARRIER POWDER CARRIER REFINED SUGAR CARRIER UREA CARRIER WOOD CHIPS CARRIER	OTHER BULK DRY												
DECK CARGO SHIP GENERAL CARGO SHIP PALLETISED CARGO SHIP	GENERAL CARGO									ALL OTHER DRY CARGO	DRY CARGO		
PASSENGER / GENERAL CARGO SHIP	PASSENGER / GENERAL CARGO												
CONTAINER SHIP PASSENGER / CONTAINER SHIP	CONTAINER												
REFRIGERATED CARGO SHIP	REFRIGERATED CARGO												
CONTAINER / RO-RO CARGO SHIP LANDING CRAFT RO-RO CARGO SHIP VEHICLES CARRIER	RO-RO CARGO												
BARGE CARRIER HEAVY LOAD CARRIER LIVESTOCK CARRIER LOG-TIPPING SHIP NUCLEAR FUEL CARRIER PEARL SHELLS CARRIER PULP CARRIER STONE CARRIER	OTHER DRY CARGO												

Source: Lloyd's Register-Fairplay, World Fleet Statistics

APPENDIX B: Flags in the sample

Open Registers

FLAG	TANKER	DRY CARGO	TOTAL
Antigua and Barbuda	7	170	177
Bahamas	42	125	167
Barbados	0	8	8
Belize	1	5	6
Cambodia	1	71	72
Comoros	0	4	4
Cyprus	40	153	193
Equatorial Guinea	0	1	1
Honduras	0	6	6
Hong Kong	21	85	106
Jamaica	0	1	1
Lebanon	0	3	3
Liberia	94	208	302
Malta	93	213	306
Marshall Islands	18	45	63
Panama	175	489	664
Saint Vincent	5	67	72
Sao Tome and Principe	0	1	1
Singapore	30	47	77
Tonga	1	8	9
Tuvalu	0	2	2
Vanuatu	0	6	6
TOTAL	528	1718	2246

Second Registers

FLAG	TANKER	DRY CARGO	TOTAL
Bermuda	0	5	5
Cayman Islands	27	16	43
Faeroe Islands	1	0	1
Gibraltar	9	10	19
Isle of Man	32	24	56
Netherlands Antilles	2	25	27
Denmark (Dis)	22	48	70
French Southern (Antarctic) Territory	7	7	14
Madeira (Portugal)	8	0	8
Norway (Nis)	89	49	138
Spain (Csr)	1	4	5
TOTAL	198	188	386

National Registers

FLAG	TANKER	DRY CARGO	TOTAL
Azerbaijan	0	5	5
Bahrain	0	1	1
Bangladesh	0	1	1
Bolivia	0	2	2
Brazil	1	3	4
Bulgaria	2	18	20
Chile	0	1	1
China	7	46	53
Colombia	1	1	2
Croatia	1	5	6
Korea, North	0	9	9
Ecuador	2	0	2
Egypt	0	4	4
Estonia	0	3	3
Ethiopia	0	2	2
Finland	3	3	6
France	1	0	1
Georgia	0	22	22
Germany	2	92	94
Greece	62	64	126
India	4	9	13
Indonesia	1	19	20
Iran	2	6	8
Ireland	0	5	5
Israel	0	6	6
Italy	34	13	47
Japan	4	14	18
Kuwait	3	0	3
Lithuania	0	2	2
Luxembourg	10	4	14
Malaysia	29	53	82
Maldives	1	0	1
Mexico	1	0	1
Morocco	1	3	4
Myanmar	0	7	7
Netherlands	40	128	168
Norway	8	1	9
Pakistan	0	1	1
Philippines	3	21	24
Poland	0	2	2
Portugal	2	1	3
Qatar	0	3	3
South Korea	5	14	19
Reunion	1		1
Romania	1	6	7
Russian	16	129	145
Saudi Arabia	3	3	6
Seychelles	0	1	1
Slovakia	0	1	1

Spain	0	1	1
Sri Lanka	0	1	1
Sweden	18	13	31
Switzerland	0	2	2
Syrian	0	42	42
Thailand	7	23	30
Turkey	25	81	106
Ukraine	4	44	48
United Arab Emirates	0	2	2
United Kingdom	12	42	54
United States	8	15	23
Venezuela	1	0	1
Viet Nam	2	9	11
TOTAL	328	1009	1337

APPENDIX C: Ranks

RANK	JOB ID	JOB TITLE
OFFICER	1	CAPTAIN
OFFICER	2	CHIEF ENGINEER
OFFICER	3	CHIEF OFFICER
OFFICER	4	2ND ENGINEER
OFFICER	5	PURSER
OFFICER	6	DOCTOR
OFFICER	7	POLITICAL COMMISSAR
OFFICER	8	2ND OFFICER
OFFICER	9	3RD OFFICER
OFFICER	10	RADIO OFFICER
OFFICER	11	JUNIOR OFFICER
OFFICER	12	ELECTRICIAN
OFFICER	13	CHIEF STEWARD
OFFICER	14	3RD ENGINEER
OFFICER	15	4TH ENGINEER
OFFICER	16	ENGINEER
EXCLUDED	17	CADET
RATINGS	18	DECK PETTY OFFICERS
RATINGS	19	ENGINE PETTY OFFICERS
RATINGS	20	PAINTER
RATINGS	21	QUARtermaster/HELMSMAN
RATINGS	22	TECHNICIAN
RATINGS	23	TURNER
RATINGS	24	PUMPMAN
RATINGS	25	WELDER
RATINGS	26	FITTER
RATINGS	27	COOK
RATINGS	28	AB
RATINGS	29	FIREMAN
RATINGS	30	GREASER
RATINGS	31	MECHANIC
RATINGS	32	MOTORMAN
RATINGS	33	OILER
RATINGS	34	WIPER
RATINGS	35	GP
RATINGS	36	OS
RATINGS	37	MESSMAN
RATINGS	38	STEWARD
RATINGS	39	GENERAL BOY
EXCLUDED	55	SUPERNUMERARY
EXCLUDED	99	UNKNOWN

APPENDIX D: RAW SIGNIFICANCE LEVELS¹⁰

TANKERS

ANOVA F-test of significant differences in means

Crew Category	Officers	Ratings	Total Crew
1,000- 2,999	0.015	0.020	0.001
3,000- 4,999	0.141	0.000	0.000
5,000- 9,999	0.000	0.000	0.000
10,000- 19,999	0.135	0.392	0.326
20,000- 49,999	0.348	0.077	0.242
50,000- 69,999	0.084	0.415	0.128
70,000- 99,999	0.472	0.341	0.65
>= 100000	0.015	0.538	0.142

Least Significant Difference (LSD) post-hoc test

Crew Category	Officers			Ratings			Total Crew		
	Open-Second	Open-National	National-Second	Open-Second	Open-National	National-Second	Open-Second	Open-National	National-Second
1,000- 2,999	0.036	0.615	0.004	0.012	0.692	0.013	0.002	0.971	0.001
3,000- 4,999	x	x	x	0	0.105	0.000	0.000	0.108	0.001
5,000- 9,999	0.000	0.001	0.422	0.002	0.000	0.529	0.000	0.000	0.903
10,000- 19,999	x	x	x	x	x	x	x	x	x
20,000- 49,999	x	x	x	x	x	x	x	x	x
50,000- 69,999	x	x	x	x	x	x	x	x	x
70,000- 99,999	x	x	x	x	x	x	x	x	x
>= 100000	0.467	0.008	0.01	x	x	x	x	x	x

¹⁰ Figures in green indicate those results that are significant at the 0.05. An 'x' indicates that no test was performed (the LSD test is only appropriate when the null hypothesis has been rejected by the ANOVA test).

