AD NUMBER

AD473887

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

No public or foreign release.

AUTHORITY

DSWA ltr., 10 Apr 97

DIRECTOR OF SHIP MATERIAL

BUREAU OF MEDICINE AND SURGERY RESEARCH GROUP

REPORT

STATISTICAL ANALYSIS OF HEMATOLOGIC (RED BLOOD CELL COUNT) DATA ON PIGS TEST ABLE

APPENDIX NO. 5
TO THE FINAL REPORT

OPERATIONS CROSSROADS
JOINT TASK FORCE ONE

DIRECTOR OF SHIP MATERIAL

NAVAL MEDICAL RESEARCH SECTION

(11) 13 Oct[illegible]7, (12) 20 p.

(6) [illegible]

STATISTICAL ANALYSIS OF HEMATOLOGIC (RED BLOOD CELL COUNT) DATA ON PIGS TEST ABLE.

(21) ~~Report of Naval Medical Research Section, Joint Task~~ Report on Biological Aspects of Atomic Bomb Tests.
See also Appendix no. 3, AD-473[illegible]

(1) Appendix No. 5 To Final Report.

By

MEDICAL STATISTICS DIVISION
BUREAU OF MEDICINE AND SURGERY
NAVY DEPARTMENT

Approved:
R. H. DRAEGER
Captain, MC, U. S. Navy
Officer-in-Charge

(14) XRD - 166

INTRODUCTION

This is the second report on statistical analyses of data from a series of hematologic studies made on the animals aboard the target ships at Bikini.

For the purpose of this report several detailed data forms were developed, based upon the premise that they should be easy to fill in and complete, as well as be susceptible to large sample statistical tabulations. After the hematologic data were recorded, the forms were forwarded to the Medical Statistics Division for coding, tabulating, analyzing, and interpreting. Definitions, codes, and procedures were written and these were followed in the transcribing and card punching prior to making the actual machine tabulations. Every effort was made to eliminate human errors and it is believed that the data, as presented, are accurate and contain only such variations as are found in all tabulations of red cells.

In the first paper (1) the observed results on the white blood count of the pigs exposed to ionizing radiations were described. The data presented herein were obtained from the same group of pigs and because some of the red blood counts were compared with the counts of the white cells, it is appropriate to briefly list some of the findings as summarized in the previous paper:

1. There was a very high correlation between the lymphocyte count and the white blood count.
2. Of the 137 (pigs aboard the SAKAWA which sank are not included) experiemntal pigs placed aboard the target ships, 38 had died by 31 January 1947.
3. Twenty-six pigs had a reduced white blood count (13,000 or below-the normal mean count was 23,000) within eight days. Of these, 17 died and 9 lived.

4. All except one of the pigs with reduced counts were located aboard four ships (01,03,11,12). These same four ships also had the highest mortality rates.

5. There was a relationship between amount of white blood count reduction and survival time.

6. Many of the control, as well as the experimental pigs, had reduced counts from unexplained reasons during a period following the blast.

7. As far as white blood counts are concerned, the group that had reduced counts and yet lived had returned to normal limits by the end of the report period 31 January 1947.

RESULTS

Figure 1 (two RBCs, one of 3.0 and the other 8.9 not shown in Figure 1; and all red blood counts for pigs are shown in millions and parts of a million) is presented in the form of a histogram and shows the distribution of the number of pigs by the amount of the normal red blood count. These counts were the only ones available to be used in establishing the normal standards. For some of the pigs, two red blood cell counts had been done and for the remainder only a single count had been made. If a pig had more than one red blood count recorded for the period prior to A-Day, a single mean count was computed and used just as if there had been only one red blood cell count made.

It was pointed out in the discussion concerning white blood counts that there is a dearth of hematologic information available for use in comparing normal counts of different biological species. This fact makes it particularly difficult to differentiate between changes that may be caused by exposure to ionizing radiations and other determinants, such as physiological changes, diet, tropical exposure, etc.

It is rather interesting that the histogram, as shown, assumes a bi-modal type of distribution. This is usually caused by either working with heterogeneous material or a paucity of data. Since it is known that the red blood counts are homogeneous (the pigs were carefully selected as to age - approximately three months of age when brought aboard the USS BURLESON - ancestry, etc.) it is thought that a larger sample would assume a single point of major concentration; in fact the same result could be achieved with the data on hand by merely increasing the class interval.

The count distribution had a range of from 3.0 to 8.9. However, only two counts were outside the limits of 4.0 and 7.9. The mean was found to be 5.9 ($\bar{X} = 5.9$; $\sigma = 1.0$; $\sigma_{\bar{X}} = .09$).

When the white blood counts were examined it was shown that there was a dramatic drop in the total count for the pigs that received a heavy dose of radiation. This precipitous drop generally occurred within 72 hours following the test and either resulted in death, or a long convalescent period before the white blood count returned to normal limits.

Figure 2 depicts the average reaction of the pigs that had a reduced white blood count and also shows the trend of the red blood counts during the same period of time. There are two groups of pigs included: (1) those that lived; and (2) those that succumbed direct or indirect effects of the bomb. In general, there was a decline of the red blood count for the animals under consideration (those that had depressed white blood counts), although the reduction was not as sudden or as severe as is shown for the white blood counts during the first period (1 July 1946 - 5 July 1946). Because daily blood counts, subsequent to the test, were not obtained, it is impossible to compute the exact day of minimum readings. However, there was a lag in the suppression of the red blood count and the average

minimum counts did not appear until the fourth period (18 July 1946 - 23 July 1946).

It may be noted that, at the period of the minimum readings (the first and fourth), the average red blood count as well as the white blood count was higher for the group that lived. Data for the red blood counts are not available from the fifth to the tenth periods (24 July 1946 - 31 October 1946). During October the red blood counts had returned to normal, in fact they exceeded the pre-test counts during the remaining periods of the study. This picture did not hold true for the white blood counts as the average count for those that lived did not regain full pre-test status by the end of January 1947.

From Figure 3 (the average red blood counts shown in Figures 3 to 4 and 6 to 10 are based upon total counts from all pigs stationed aboard specific ships) one may obtain a comparison between the average red blood count for the first four ships (01 USS NEVADA, 03 USS INDEPENDENCE, 11 USS SALT LAKE CITY, and 12 USS FALLON), and the average for the remaining 11 ships. Since it is commonly accepted that the white blood count is a much more accurate index of the amount, or dose, of ionizing radiation received, it was felt that if the white blood count reduction was not detectable the red blood count would certainly not be reduced in significant amounts. Therefore, the two groups of ships shown in Figure 3 were determined by the fact that all of the pigs, with one exception, that had a reduced white blood count, were located on Ships 01, 03, 11 and 12.

The average red blood counts of both groups showed a downward trend following irradiation although the counts for the pigs aboard the first four ships dropped the more rapidly. The minimum average count for this group was reached during the fourth period; however, there was not a

significant difference in the mean during this period. In fact the trends of the counts of the two groups are very similar and it is impossible to state that any of the observed differences could definitely be related to the effects of exposure to ionizing radiations. Since many of the animals located in the first group were having repeated mediastinal hemorrhages, it is quite possible that this factor partially accounted for the slight progressive anemia. However, there is no doubt, as evidenced by the blood smears, that there was some degree of disturbed erythropoiesis from radiation or other factors. The depression of the red blood count for either group is difficult to evaluate, especially for the first four ships. There are four control count readings shown on the chart for the sixth, tenth, eleventh, and thirteenth periods. It is apparent that control counts follow about the same trend as the other two groups from the sixth period on. From this comparison it would seem that other factors, perhaps tropical anemia, effect of sodium fluoride used as a vermifuge, nutritional deficiency due to minimum weight requirements, or increasing maturity influenced the red blood counts as much as the radiation exposure.

Figure 4 might be considered as a supplement to Figure 3. In the former figure the charting was made on the absolute red blood counts only. The averages as shown in Figure 4 have been converted from absolute counts to percents of the normal or pre-test readings. This allows a direct comparison to be made between any period and the normal count. The average white blood counts for the two groups are also shown in order to allow the trend comparisons of the two counts to be made. One is immediately impressed with the precipitous white blood count drop experienced by the first four ships and it is apparent that the counts of the animals that lived did not coincide with the trend until the tenth

period (1 October 1946 - 31 October 1946). Furthermore, at the end of the period under consideration (31 January 1947) the white blood counts were only about 90% of their pre-test average. While the average white blood count for the first four ships had dropped to 43% of the normal count during the first period, the red blood count for the same group had decreased only to the 85% level. It is quite noticeable, as was previously mentioned, that the average red blood counts for both groups were considerably above the normal count which had been taken about seven months earlier.

The data for the animals included in Figure 5 might be considered a refinement over those shown in some of the previous charts. While, as was noted, all of the animals that had a reduction (with one exception: Pig 376, Ship #31) were located on Ships 01, 03, 11 or 12, it was also true that not all of the pigs on those four vessels did have a depressed white blood count. The other pigs that are included in Figures 3 and 4 might be considered dilutions. Therefore, Figure 5 includes only those animals that had a reduction in white blood count. The same sudden decline is still there in the white blood count trends; in fact the drop, as might be expected, is even more drastic than is shown in the previous chart. It appears probable that the red blood count trend portrays the best possible picture of the red blood count reduction following the test; however, as has been pointed out, caution should be followed in attributing all or any certain proportion of the suppression to disturbed erythropoiesis from radiation.

DISCUSSION AND SUMMARY

The red blood counts were tabulated for the experimental pigs prior to A-Day, and these counts were considered as normal readings.

However, it should be pointed out that the pigs, at the time they were received, were approximately three months of age and by the termination of the study period (31 January 1947), were about ten months old. For some of the pigs two normals were available and for the remainder only a single count had been made. If a pig had more than one red count recorded for the period prior to the test, a mean count was computed and this was used just as if there had been only a single count taken. The mean normal red blood count was found to be 5.9. $\sigma = 1.0$; $\sigma_{\bar{X}} = 0.09$; $N = 118$

Approximately seven months later during January, the mean count for the pigs alive at that time was 6.6.

$\sigma = 1.0$; $\sigma_{\bar{X}} = 0.15$; $N = 47$

The frequency distribution of the pre-test normal counts, formed a bi-modal pattern; however, it is believed that this would have been eliminated if more data had been available.

There was a decline in the red blood counts subsequent to A-Day; however, the depression was not as drastic nor as sudden as was observed for the white blood counts. There were 26 animals that experienced white blood count reductions and of these, 17 died and 9 lived. It was found that there was a significant difference in the average white blood counts during the first period (1 July 1946 - 5 July 1946) between those living (9) and those dying (16). When the red blood counts were tabulated, it was observed that these pigs that died also had lower minimum red blood counts (3.4) than those that lived (3.8). However, one very important point should be emphasized that while the minimum white counts occurred within 96 hours, the lowest red blood counts did not appear until from 16 to 22 days following the explosion.

There was a depression in the average blood counts following the test, both for the pigs aboard the first four ships (this grouping was made because all of the pigs that had depressed white blood counts were aboard these ships) 01, 03, 11, 12 and those on the remaining 11 which had not received enough ionizing radiation to make discernible differences in the white blood counts. Possibly the lower average red blood counts experienced by the animals on the first four ships during the fourth period could be ascribed to the effects of the irradiation.

When comparisons were made collectively, between red and white blood count trends, for all pigs with (white count) reductions, some interesting facts were available. During the first period for these animals, the average white blood count had dropped to 26% of normal while the average red blood count had only been reduced to 88% of normal. The average white count changed very little between the first two periods; however, the fed counts continued to decline and reached the 81% level during the second period. From this period through the fourth, the white counts increased and during the second period were approximately 50% normal while the declining red counts had dropped to 65% of their pre-test levels. From the fourth through the tenth periods (17 July 1946 - 31 October 1946) the white counts showed a very slow recovery while by the tenth period the red counts had reached the 95% mark and continued to increase until, during the last two months (December 1946 and January 1947), of the study, they were above the normal counts. Meanwhile the recovery of the white counts had reached 75% of normal during January 1947.

In making direct comparisons between the recovery rates, it should be emphasized that there are missing data on the red cells between the fifth and tenth periods. Also, the trends of the counts

subsequent to the test cannot necessarily be entirely attributed to ionising radiation.

BIBLIOGRAPHY

(1) Report of the Naval Medical Research Section, Joint Task Force ONE on Biological Aspects of Atomic Bomb Tests, Appendix No. 4., Statistical Analysis of Hematological Data on Pigs, White Blood Cell Counts.

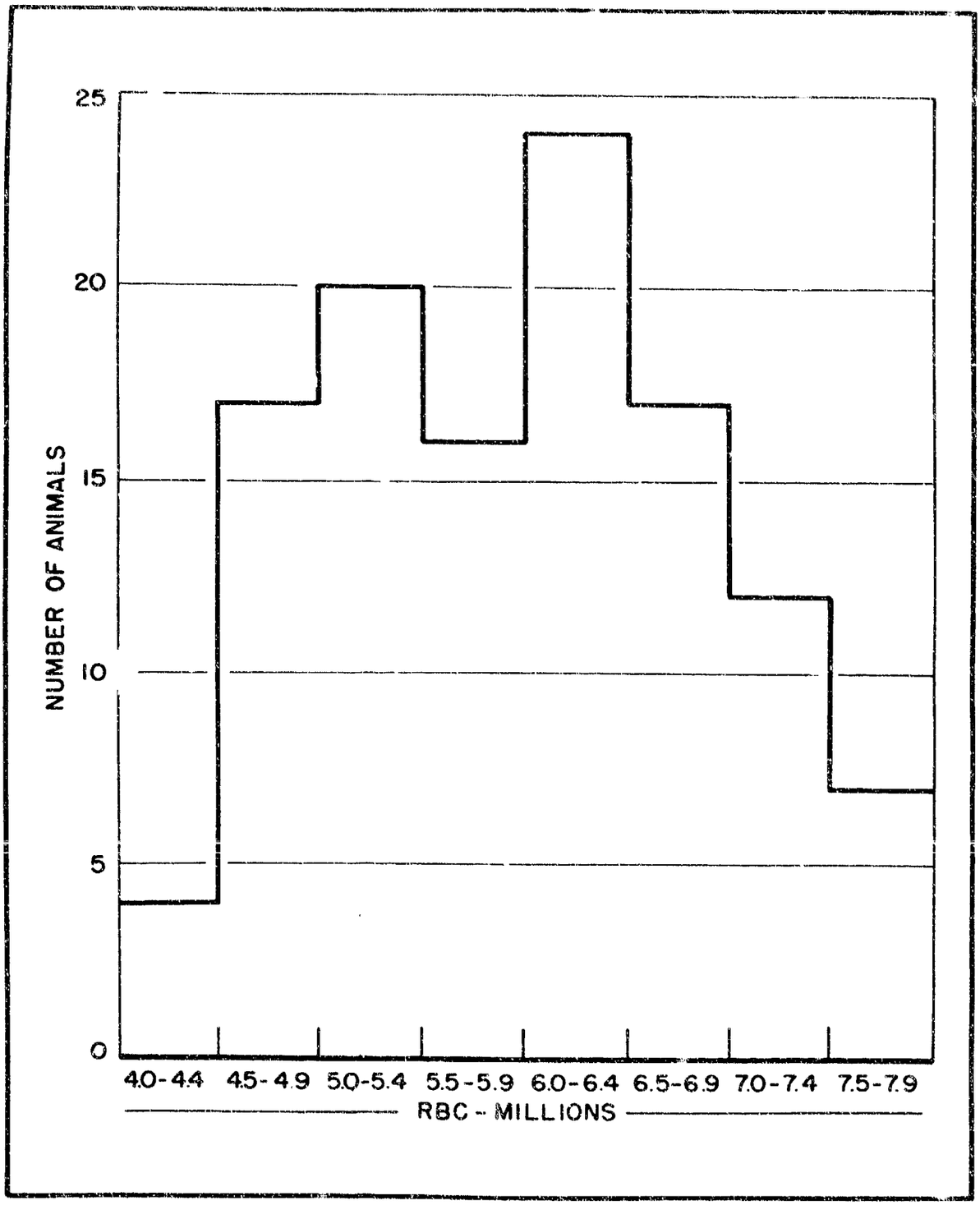

Fig. 1. Distribution of normal RBC's. 116 experimental pigs.

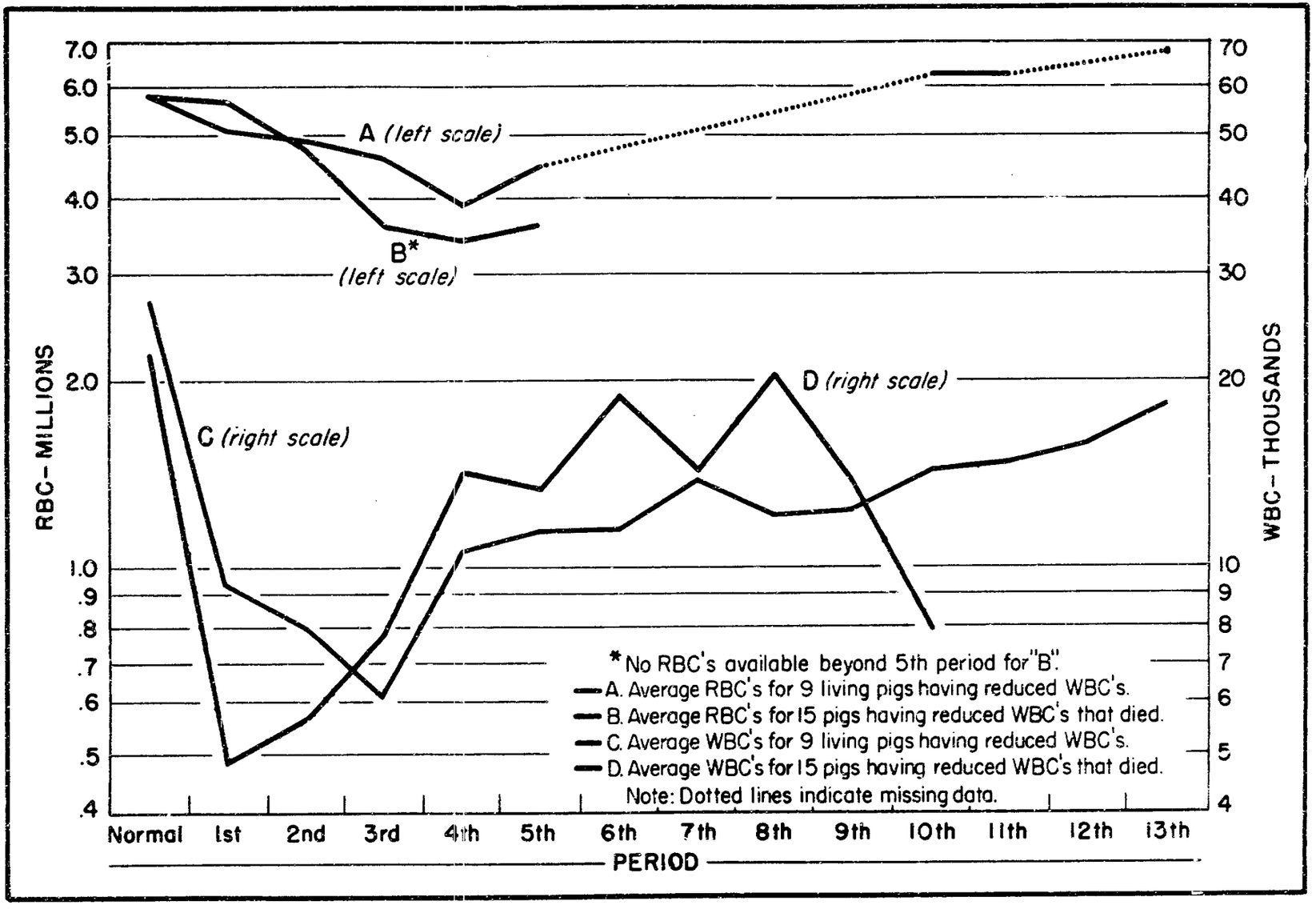

Fig. 2. Comparison of RBC's and WBC's for pigs having a reduced WBC.

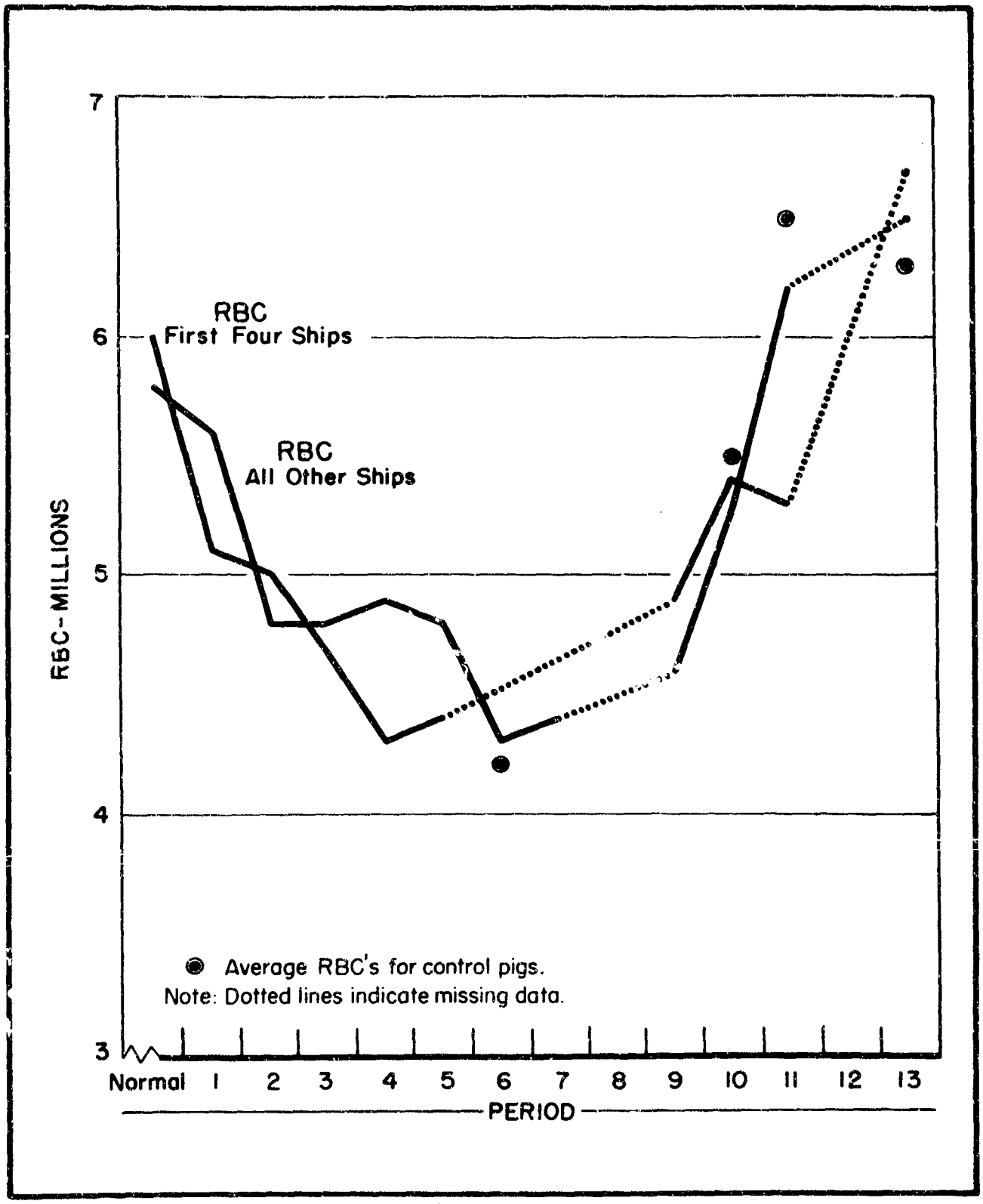

Fig. 3. Comparison of average RBC's for first four ships (01,03,11,12) and all others.

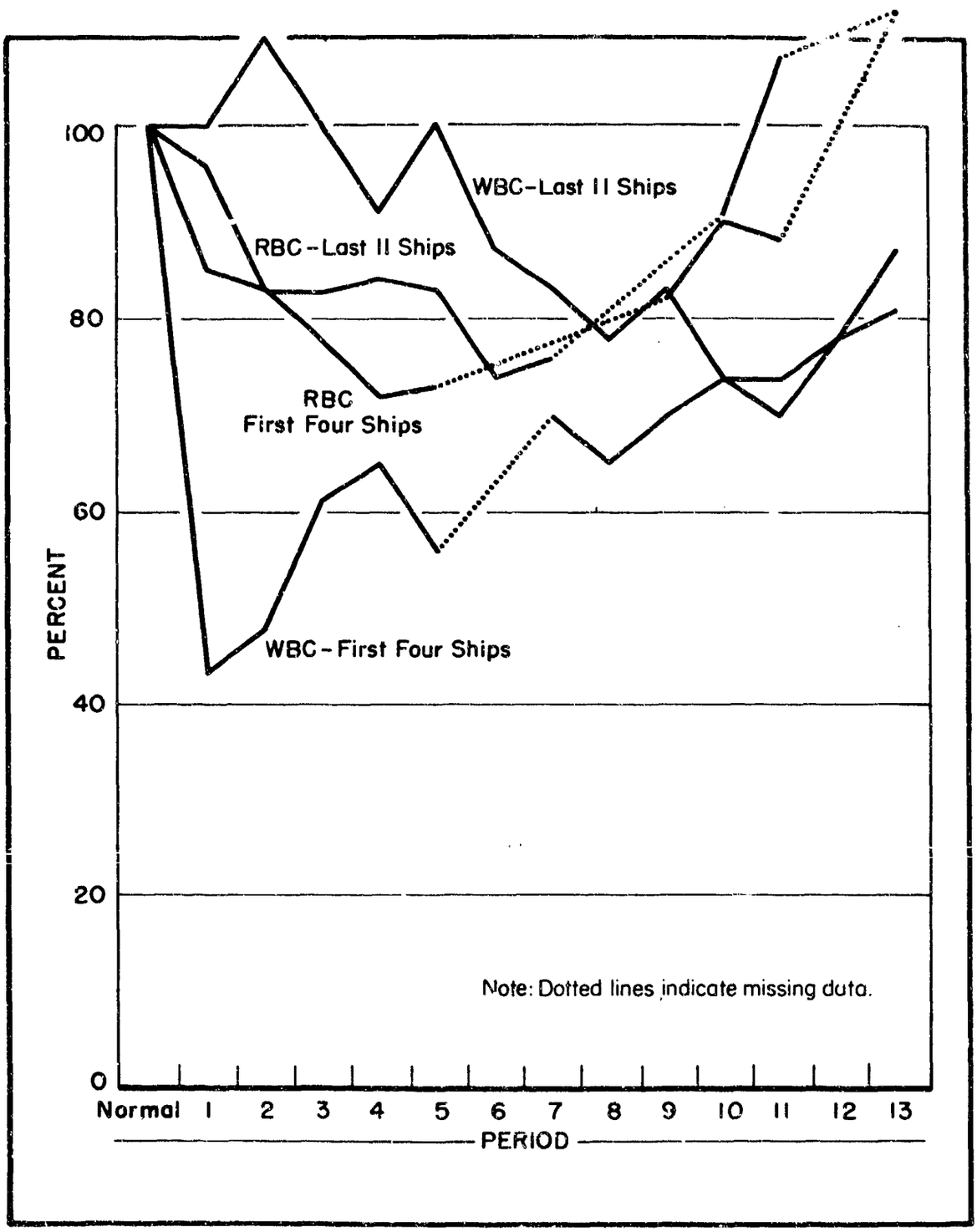

Fig. 4. Comparison of percent of RBC and WBC reduction. First four ships(01,03,11,12) and all others.

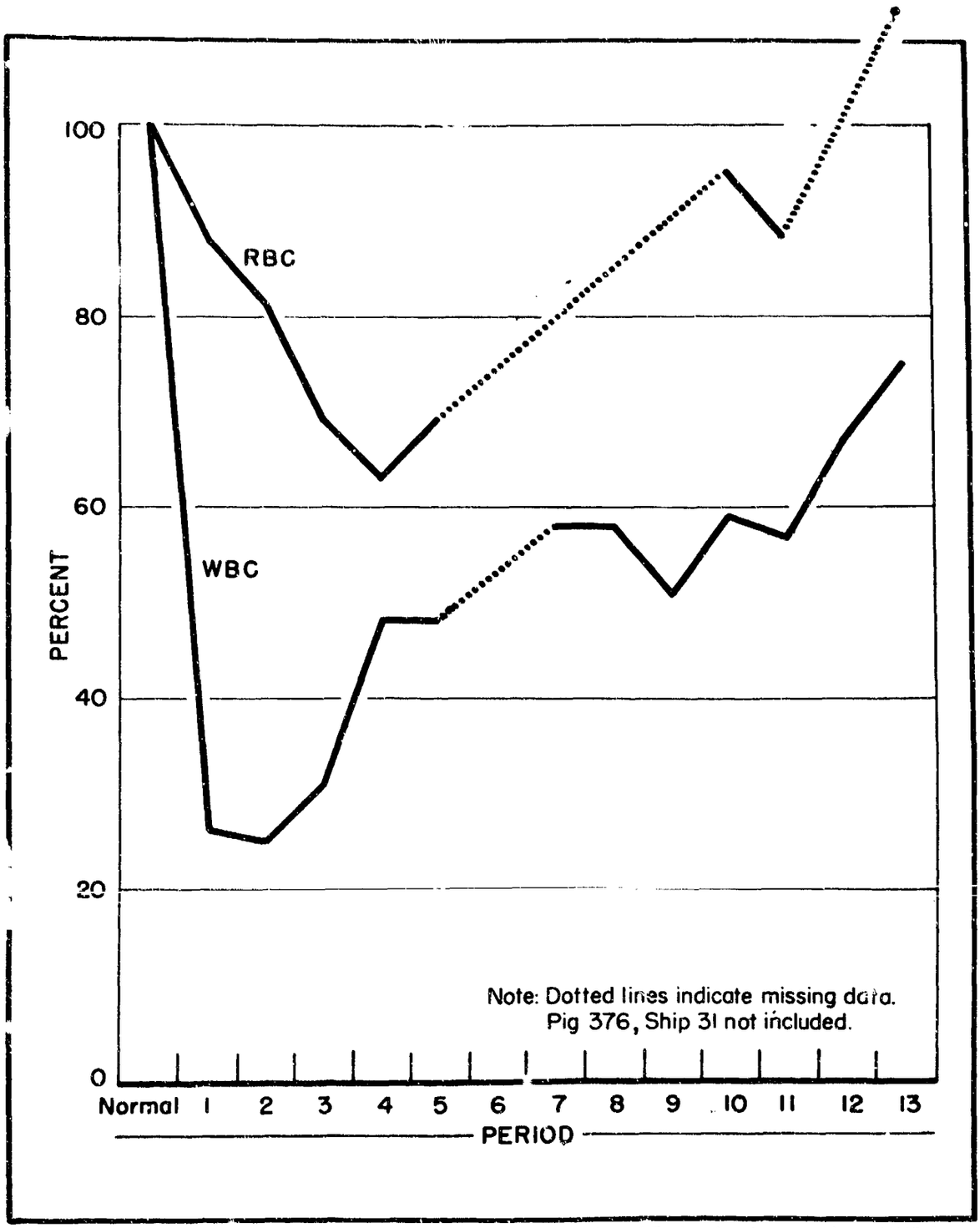

Fig.5. Comparison of percent of RBC and WBC reduction 25 pigs having a reduced WBC.

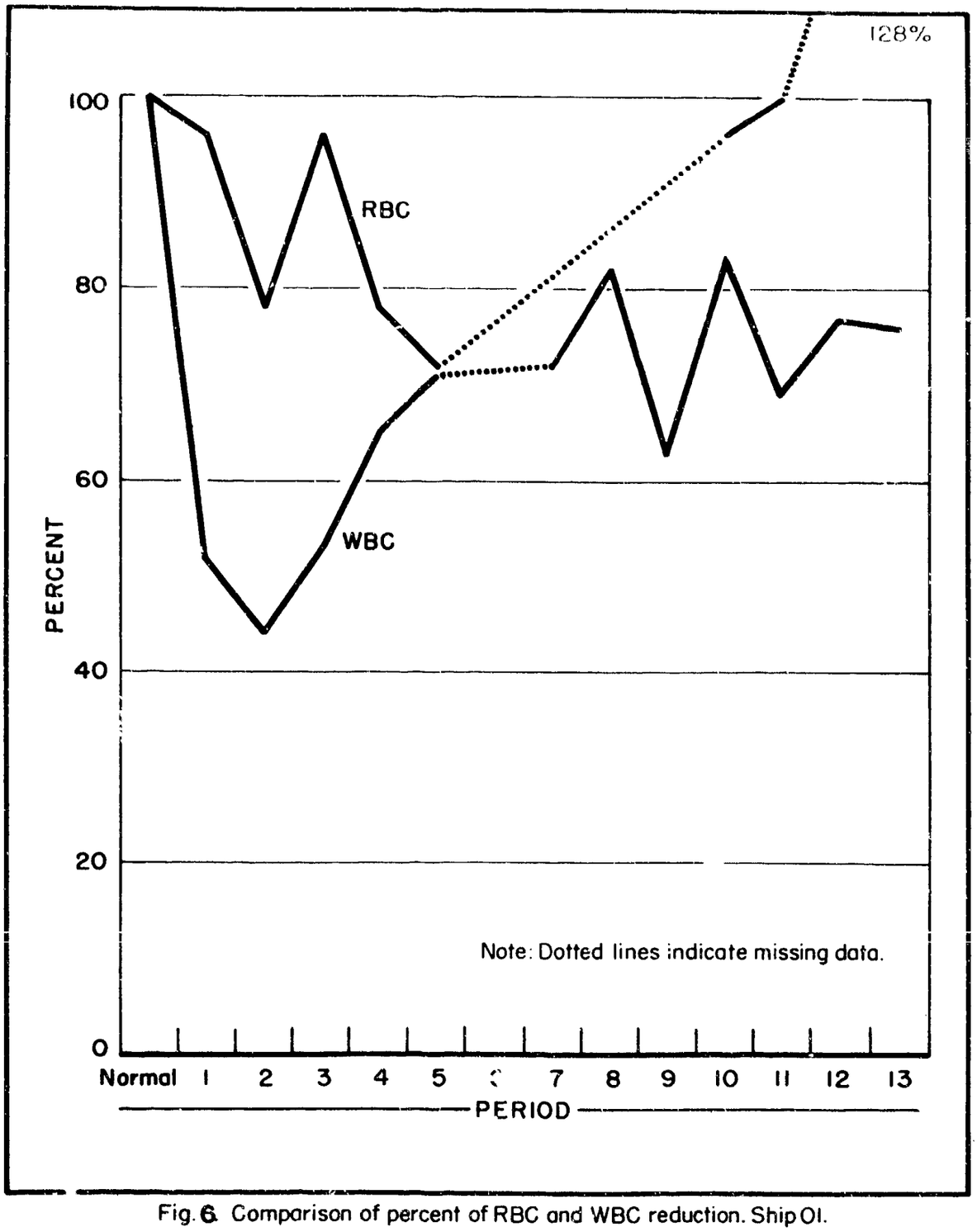

Fig. 6. Comparison of percent of RBC and WBC reduction. Ship OI.

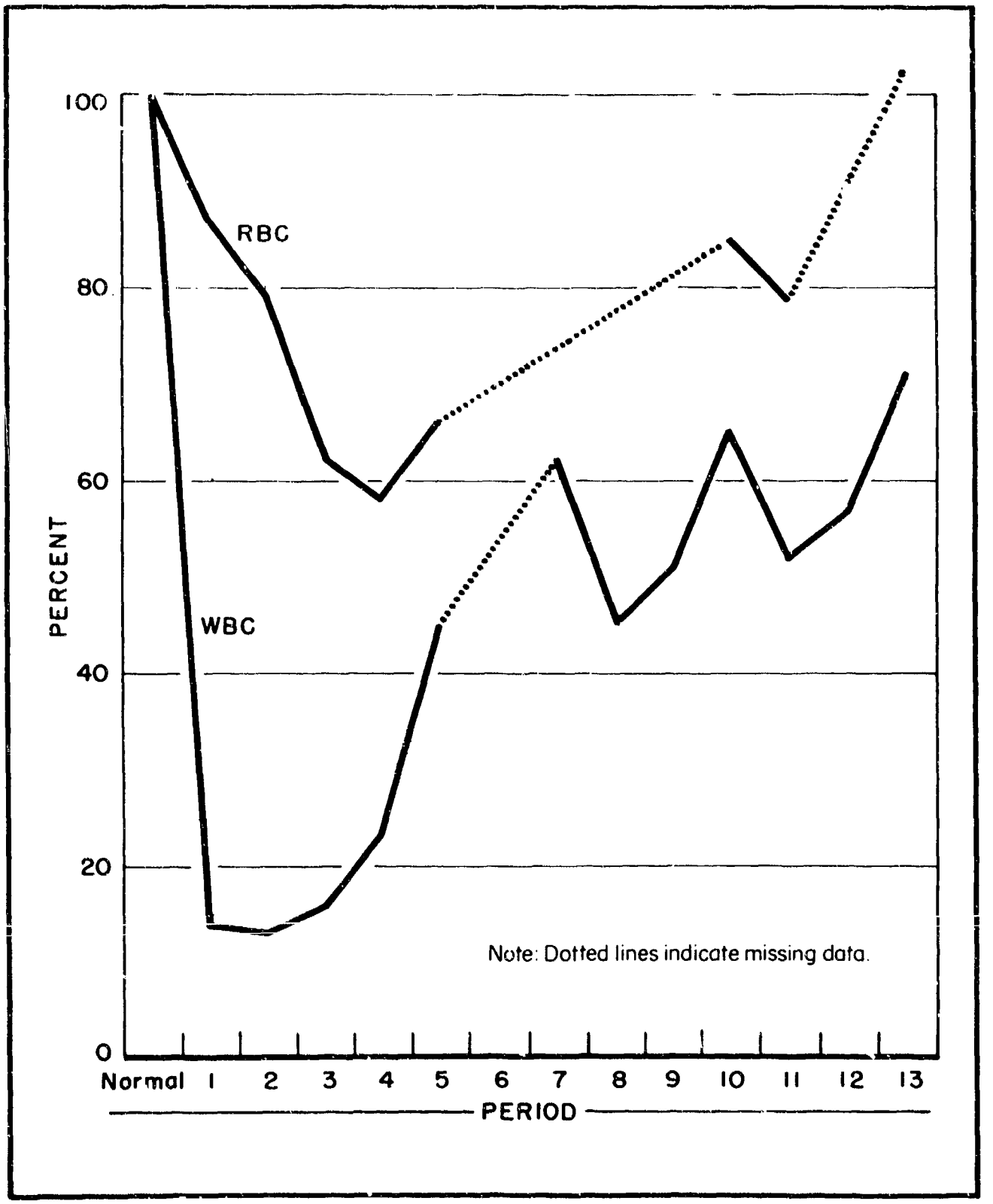

Fig. 7. Comparison of percent of RBC and WBC reduction. Ship 03.

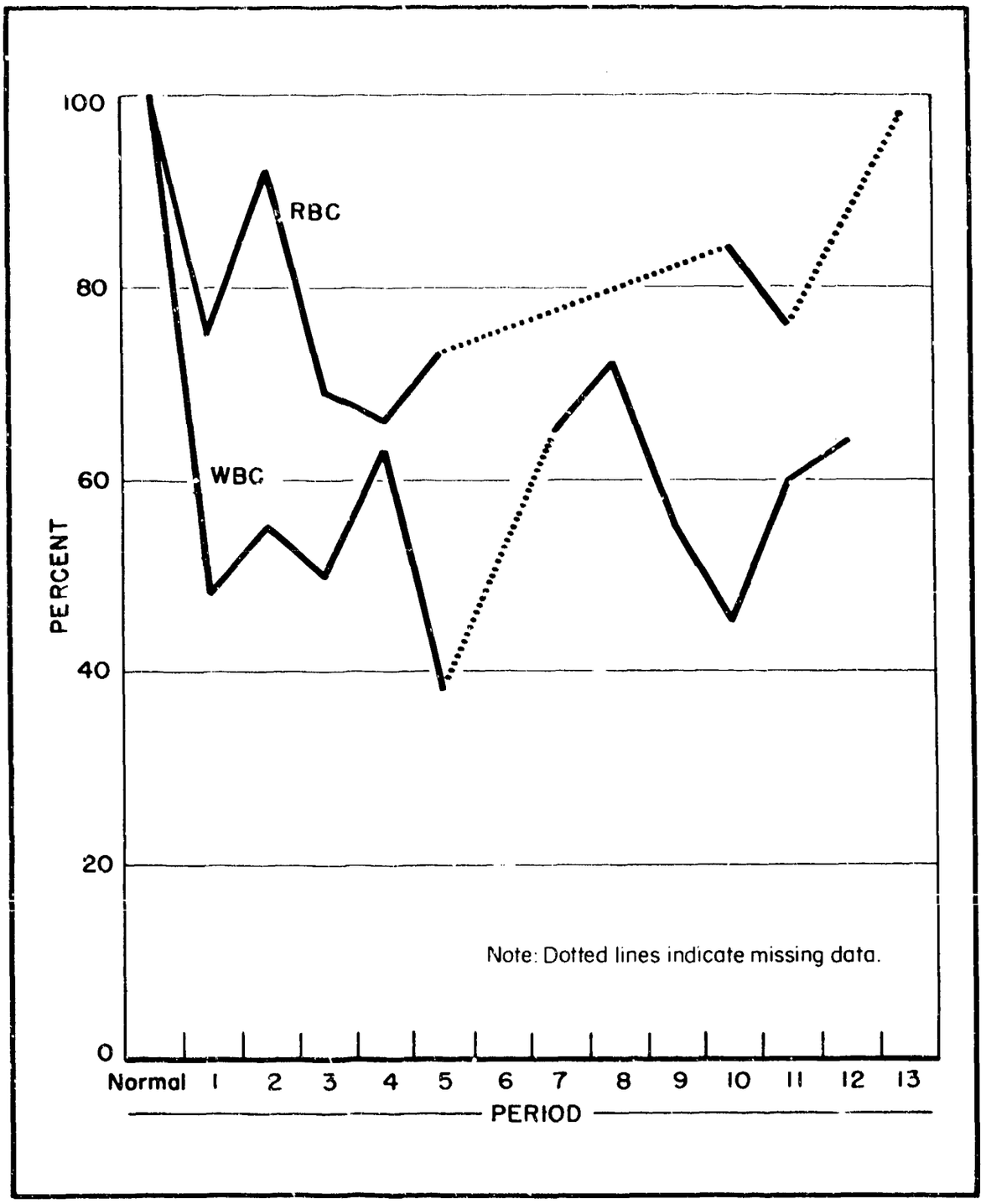

Fig. 8 . Comparison of percent of RBC and WBC reduction. Ship

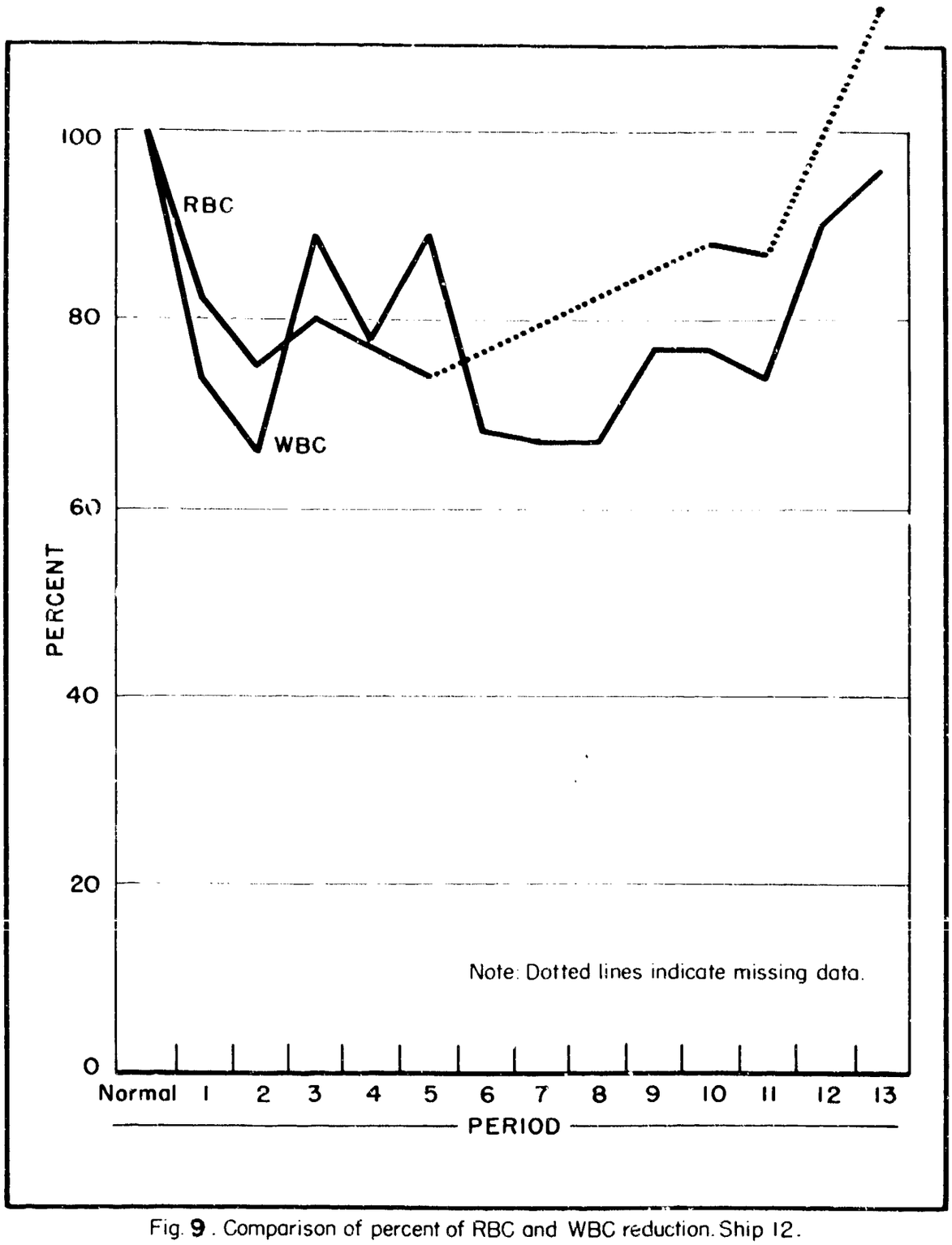

Fig. 9. Comparison of percent of RBC and WBC reduction. Ship 12.

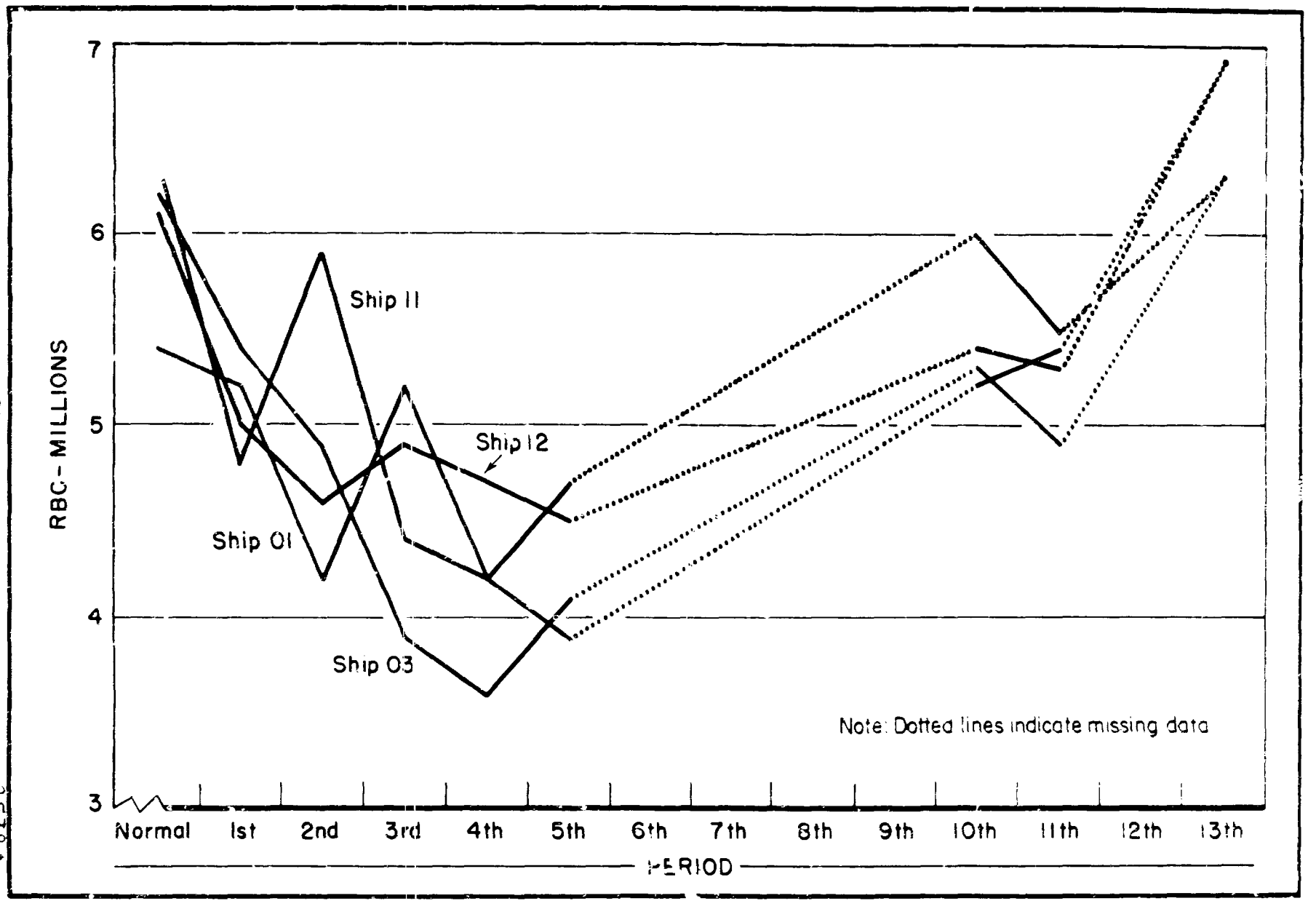

Fig. 10. Average RBC's by period for ships 01, 03, 11 and 12.

Defense Special Weapons Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398

TRC

10 April 1997

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTENTION: OMI/Mr. William Bush

SUBJECT: Declassification of Reports

The Defense Special Weapons Agency (formerly Defense Nuclear Agency) Security Office has reviewed and declassified the following reports:

AD-366718	XRD-32-Volume 3
AD-366726	XRD-12-Volume 2
AD-366703	XRD-16-Volume 1
AD-366702	XRD-14-Volume 2
AD-376819L	XRD-17-Volume 2
AD-366704	XRD-18
AD-367451	XRD-19-Volume 1
AD-366705	XRD-20-Volume 2
AD-376028L	XRD-4
AD-366694	XRD-1
AD-473912	XRD-193
AD-473891	XRD-171
AD-473899	XRD-163
AD-473887	XRD-166
AD-473888	XRD-167
AD-473889	XRD-168

AD-366705

ST-A 28 JAN 80 made target

TRC 10 April 1997

SUBJECT: Declassification of Reports

AD-B197749	XRD-174
AD-473905	XRD-182
AD-366719	XRD-33 Volume 4
AD-366700	XRD-10
AD-366712	XRD-25 Volume 1
AD-376827L	XRD-75
AD-366756	XRD-73
AD-366757	XRD-74
AD-366755	XRD-72
AD-366754	XRD-71
AD-366710	XRD-23 Volume 1
AD-366711	XRD-24 Volume 2
AD-366753	XRD-70
AD-366749	XRD-66
AD-366701	XRD-11
AD-366745	XRD-62.

All of the cited reports are now **approved for public release; distribution statement "A" applies.**

Ardith Jarrett

ARDITH JARRETT
Chief, Technical Resource Center

copy furn: FC/DSWA (DASIAC)
KSC

Completed

E.W