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ANALYSIS OF STANDARD-PLATFORM WIND BIAS IN FALLOUT COLLECTION AT OPERATION REDWING

Research and Development Technical Report USNRDL-TR-363

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U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY

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ANALYSIS OF STANDARD-PLATFORM WIND BIAS IN FALLOUT COLLECTION AT OPERATION REDWING

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Effects of Atomic Weapons

Technical Objective
AW-7

Radiological Effects Branch
E. A. Schuert, Head

Chemical Technology Division
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ABSTRACT

At Operation REDWING, fallout sampling was conducted by arrays or groups of similar collecting instruments. Each array was located on the periphery of an elevated and circular wind-shielded platform designated as the standard platform. A correlation of the sampling variations in the amounts of fallout collected within the platforms was accomplished by the analysis of the collection data and the platform's air-flow characteristics. With a single-wind system the amount of fallout collected in the upwind part of the platform was lower than that collected in the downwind section and the collections around the platform varied symmetrically with respect to the wind direction. With a multi-wind system, similar characteristics were exhibited about a reference direction which was correlated to the variability of wind directions and associated fallout amounts by a vector summation. The extent of sampling variation or collection bias in both systems can be defined by certain parameters. For each platform the values of these parameters were obtained from the properties of a collection curve describing the variation around the platform. Collection curves of both systems were completed by interpolation and their notable aspect is that they resemble sine curves. At the only land station the sampling data between the platform collection and the associated collection on the ground was too limited for extrapolation to other systems. Sampling relationships between platform collection and associated ground collection are described for the single-wind system but not for the multi-wind system. At the ship stations the equivalent ground value of the platform collections i.e., the value that would be collected by the earth's surface, could not be determined; however, the weighted mean values of some of these platform collections are presented.

SUMMARY

The Problem

Fallout sampling by Project 2.63 at Operation REDWING was conducted by groups of similar instruments and each group was located on the periphery of a special wind-shielded platform designated as the standard platform. The amount of fallout collected by the instruments within each platform showed considerable variation and it is likely that these variations were caused by the effects of wind flow about the platform. Therefore it is necessary to correlate the sampling variations with the air-flow characteristics above the platform and with the properties of the prevailing winds. Another objective of this study is the determination of the equivalent ground value of the collections from platforms mounted on ships i.e., the value that would be collected by the earth's surface at the same location. To attain this objective the relationship between platform and ground sampling was needed.

Findings

Studies of the fallout collection data and the platform's air-flow characteristics showed that the amounts of fallout collected around a platform vary symmetrically with respect to the wind direction in a single-wind system or to a correlated reference wind direction in a multi-wind system. For both wind systems the amount of fallout collected in the upwind part of the platform was lower than that of the downwind section. The sampling variation within each platform can be defined by the use of certain parameters. The value of these parameters were determined from the properties of the collection curve describing the sampling variation around a given platform. Only the sampling relationships between platform collection and ground collection of the single-wind system could be described. It was not possible to determine the equivalent ground values of shipboard collections because of the lack of fundamental data or platform-ground sampling relationships.

ADMINISTRATIVE INFORMATION

The work reported was done under Bureau of Ships Project Number NS-081-001 (Technical Objective AW-7), as part of Subtask 1, Problem 2. The Problem described as Problem 3, Program 1, in this Laboratory's _Preliminary Presentation of USNRDL Technical Program for FY 1957_, February 1956. The work was continued under Bureau of Ships Project Number 088-001 (Technical Objective SR-2), Subtask 1, Problem 1, described in _USNRDL Technical Program Proposed for Fiscal Year 1958_, May 1957, as Problem 3, Program 2.

ACKNOWLEDGEMENTS

Appreciation is expressed to Messrs. P.D. LaRiviere and W.L. Galliher for their assistance to this study.

INTRODUCTION

Data documenting the quantity of fallout reaching the earth's surface is derived, in part, from measurements of samples collected passively at specific locations. Knowledge of the sampling accuracy is necessary to provide reliable values of fallout per unit area. Wind effects constitute the major consideration in representative sampling since particle collection depends critically on the characteristics of the airstream above the instruments. Winds are generally streamline in nature but when they encounter the physical obstruction of the collecting instruments, varying degrees of turbulence and other flow disturbances are produced. Under the influence of these flow conditions above the instruments the trajectories of falling particles become distorted and displaced. These effects will depend on the intensity of the flow disturbances and the physical nature of the particles involved. The net result is that the quantity of particles falling into the collector will differ significantly from the quantity which would have fallen through the area occupied by the instrument. As a consequence, a biased or non-representative sample is collected.

In studies of precipitation collection, an analogous situation, the problem of biased collection due to wind effects has long been recognized. It has been found that the amount of rainfall collected varies inversely with the height at which the collectors are positioned due to increasing wind effects.[1] Horizontal windshields have been attached to experimental collectors in attempts to minimize air flow disturbances.

Studies have shown that when many identical instruments are arrayed adjacent to each other, their fallout collections vary with respect to their positions relative to the wind direction.[2] Fallout sampling in Project 2.63 at Operation REDWING[3] was conducted by more openly and systematically spaced arrays or groups of similar collecting instruments. Each array was accommodated in an elevated and circular wind-shielded platform designated as the standard platform. These standard platforms were located at a land station as well as on several ships and anchored barges. The purpose of the windshield was to standardize the air flow pattern over the standard platforms and to minimize wind bias effects. The results of the fallout sampling indicated that for a single platform array the quantities of fallout collected around the platform showed considerable variation. However, it was noted that in certain cases this variation followed a geometry which was oriented to the wind direction. This variation of collection or sampling bias was caused by the particular air flow pattern induced by the wind impinging on the wind-shielded platform. This paper presents the results of a study to define and to correlate the sampling bias with certain air flow characteristics above the platform. From the analyses of the air flow pattern above the standard platform and the REDWING sampling data it was possible to define the collection bias within a platform by certain parameters. The values of these parameters were determined from the properties of a collection curve describing the variation. Where more than one wind is involved the observed sampling bias within the platforms was further correlated to the properties of the prevailing winds. In certain cases the effects of particle size and density were noted. It is also the objective of the study to determine the equivalent ground value associated with each shipboard platform of collections, i.e. the value that would be collected by the earth's surface (at the same location).

FALLOUT COLLECTION

Fallout was collected from four events and for this study they are designated as Shots A, B, C and D. The relative quantity of fallout particles collected by the receiving tray of each instrument was determined by measuring their total activity in a gamma crystal counter known colloquially as the doghouse counter. All activity units are in terms of net doghouse counts per min at H + 100 per tray.

Standard Platform

The standard platforms, comprising Project 2.63 major collecting stations, were located on HOW Island and on the following vessels: YAG-40, YAG-39, LST-611, YFNB-13, YFNB-29 (2 platforms). To specify the platform and event under discussion, designating terms such as YAG-40-A are used. Platform dimensions, geometry, and pertinent instrumentation are depicted in Fig. 1 for the shipboard stations and Fig. 2 for the barge (YFNB) and land stations. With the exception of the differences in size and some additional instruments on the larger platform, the two platforms are geometrically similar and can be considered identical with respect to sampling and bias characteristics. On the YAG's the platform was mounted on the forward kingpost approximately 60 ft above the water line. The LST platform, placed on a tower above the ship's bow, was 35 ft above the water line. The platforms on the two anchored YFNB's were also 35 ft above the water line, being situated on towers located on the vessel bows as well as on the YFNB-29 stern. The HOW platform, mounted on a tower similar to those used on the barges, was 27 ft above ground and associated with this particular platform was an array of ground collectors. This arrangement of platform and surrounding ground collectors provided the only comparison between platform collections and ground collections. The location and geometry of the ground array are depicted in Ref. 3.

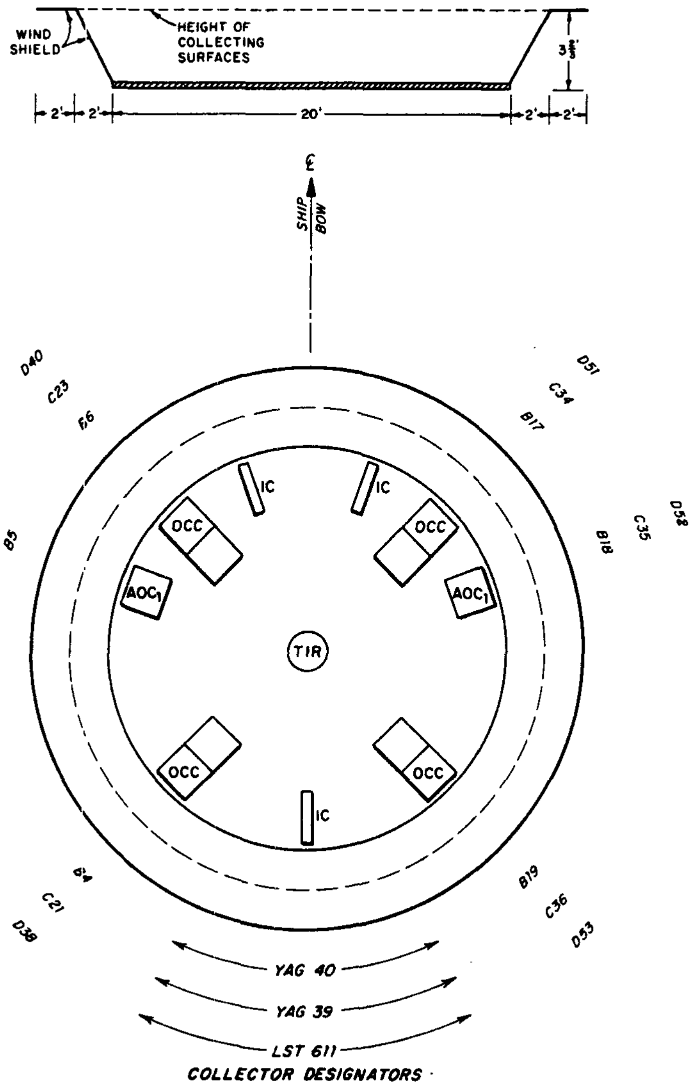

Fig. 1 Dimensions and Instrumentation, YAG and LST Platforms

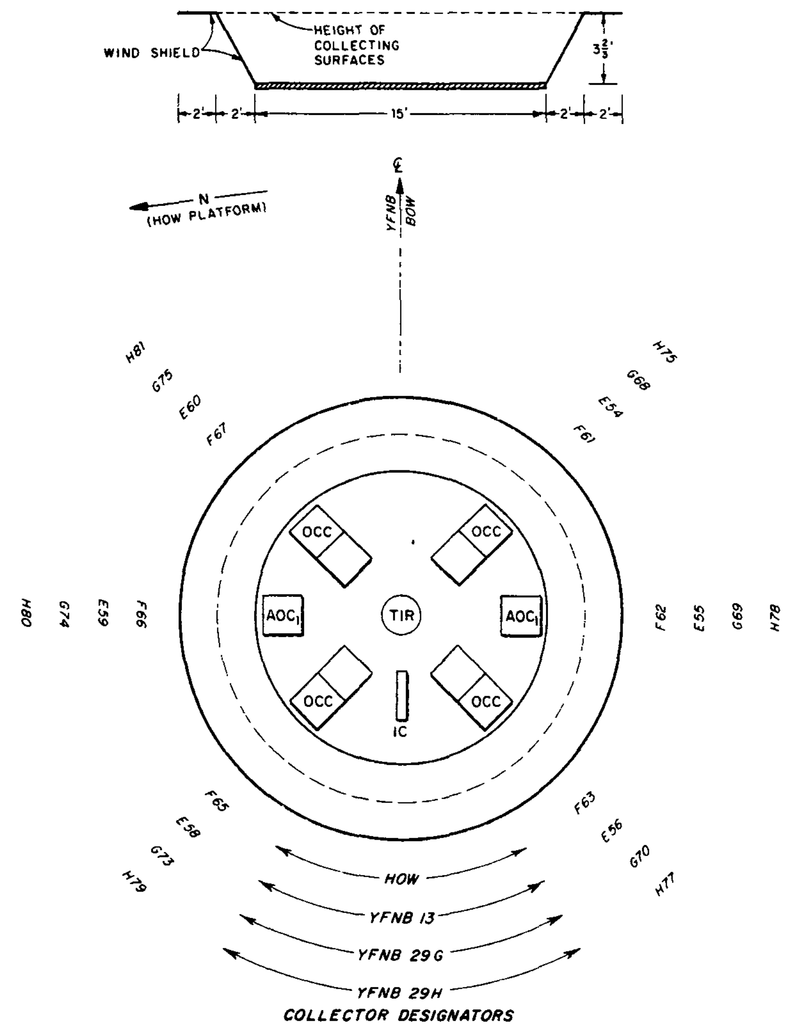

Fig. 2 Dimensions and Instrumentation, HOW and YFNB Platforms

Instrumentation

The principal collecting instruments of each platform were four Open-close Collectors (OCC) and two Always-Open Collectors (AOC_1) located in the periphery area. These two types of instruments have similar collecting characteristics since they both expose identical hexcell-containing collecting trays of 2.6 sq ft sampling area. Other pertinent instruments were one Gamma Time Intensity Recorder (TIR) and one to three Incremental Collectors (IC). The TIR, located at the platform center, detected and recorded gamma radiation intensity versus time. The IC's sampled fallout incrementally with time to provide information regarding times of arrival and cessation, rates of arrival, and particle sizes. Collecting surfaces of the instruments were level with the windshield rim.

On each platform, except for those of the YFNB 13 and YFNB 29 H (stern), relative wind velocities were documented with time by a recording anemometer (RA) which was located 10 ft above the after part of each platform. Wind speed data were adjusted, where necessary, to accommodate for this height difference from information extrapolated from Ref. 4. Wind directions were measured clockwise in degrees from the bow of the vessel except in the case of the HOW platform where they were measured from true north. Locations of instruments are also given by their angular displacement from the reference direction. The array of ground collectors consisted of 12 AOC_1 trays filled with environmental soil and buried flush with the ground. Detailed descriptions of all instruments are found in Ref. 3.

PROBLEMS OF STANDARD PLATFORM WIND BIAS

Collection bias is generally defined as the variation of collection with respect to some ideal value. In the case of the wind bias of the standard platform to fallout collection, there are two problems to consider: the variation of collection within the platform (relative bias) and the relationship of some mean platform value to the ground value (ground bias).

Fallout collection at Operation REDWING occurred under the influence of two wind systems and the present study is separated under these systems. They are designated as a single-wind (s.w.) system when a single relative wind velocity predominates or a multi-wind (m.w.) system when more than one wind velocity is involved.*

*Due principally to ship maneuvers or "swing" of the anchored barges at the test site.

Relative Bias

For either wind system, relative bias may be defined by two bias parameters, bias direction and bias ratio. Bias direction describes the orientation of the collection geometry and is the angle measured clockwise from the reference direction (bow or true north) to the minimum-maximum axis of the collection geometry or pattern. Bias ratio is a measure of the magnitude of relative bias and is defined as the ratio of the maximum to the minimum value of the collection curve which represent the variation of collection around the platform. The bias direction of a s.w. system is merely the wind direction and this fact serves as a criterion in the orientation of s.w. collection pattern or curve. For this system the bias ratio increases with increasing wind speed and decreases with increasing particle size and density. In the m.w. system, wind velocities and the relative amount of fallout associated with each wind velocity must also be taken into account in the variation of bias direction and bias ratio.

It is recognized that particle shape is another variable to be considered not only because of the aerodynamic effects but it also may be an indication of different particle types with intrinsic differences in the concentrations of radionuclides in the particles.[5] However to maintain simplicity in discussion of certain basic bias relationships, this variable is not included in this study.

The objective of relative bias analysis is the determination of the collection curve* from which the describing bias parameters and a significant mean platform value may then be derived. As will be shown, the number of sample values per platform were insufficient to adequately describe the collection curve; hence, interpolation has been used extensively. To aid in this interpolation, the results of an air flow study have been used in conjunction with the actual collection data to establish the important characteristics of relative bias.

Air Flow Studies

To investigate the air flow characteristics above the standard platform in a given wind, wind tunnel model studies, as well as smoke and wool tuft

*It is to be noted that the intrinsic efficiencies of the collectors are not known and therefore sample values may not represent absolute amounts deposited; nevertheless the values do indicate relative bias since collectors of identical efficiencies were employed.

studies with an instrumented platform, were performed.[6] Results indicated that the flow disturbances and turbulences that existed above the platform followed a particular geometry. In the peripheral area where the collectors were located, smoke studies indicated the occurrence of an ill-defined but orderly recirculatory flow system, moving upward in the windward section and downward in the leeward section. Since the vertical component of the recirculatory flow is greatest at the extreme upwind and downwind peripheral positions, minimum and maximum collections might be expected at these positions, respectively. Due to the circular platform geometry, it was also expected that the variation of collection would be symmetrical about the minimum-maximum collection axis.

Ground Bias

At present the relationship between the mean platform value and the equivalent ground value is empirical. It is assumed that for each bias ratio, with or without qualifications, there is a factor which empirically relates the mean platform value to the ground value. This ground factor, g, is defined as follows:

$$\text{equivalent ground value} = g \times \text{mean platform value}$$

The relationship automatically takes into account the intrinsic efficiency of the platform collectors which, in this study, are limited to periphery-located OCC's and AOC_1's.

SINGLE-WIND SYSTEM

The most important bias characteristic of a s.w. system is the bias ratio because it not only describes the extent of relative bias but also determines the ground factor (assuming the information is available). With the ground factor known, the ultimate objective of most bias studies is met, i.e., the computation of the equivalent ground value. Thus there exists a need for fundamental experimental data to describe the variation of ground factor with bias ratio. Also needed is data to study the variation of the bias ratio with wind speed, particle size and density. In this system an unqualified and particular ground factor is associated with each bias ratio since the ratio is a specific measure of the resultant bias effects. In the case of uniform collection (bias ratio of unity) the values are ground values if collecting efficiency is 100 %. For practical reasons, a system with winds of approximately equal speeds and of directions varying within a 30° sector are considered to be a s.w. system.

Analysis of REDWING Single-Wind Bias Data

The HOW platform collections which experienced s.w. bias on Shots A, B, and D (little fallout on Shot B) are illustrated in Figs. 3, 5 and 7. Wind directions and observed bias directions are depicted for comparison and are discussed below. As the six sample values for a platform were insufficient to approximate the collection curve, the curves that are shown in Figs. 4, 6 and 8 were completed through interpolation based on the requirement of symmetrical variation about a minimum-maximum axis as derived from the air-flow studies. Curve fitting was done by trial and error methods in which the locations of the maximum and minimum collections (180° separation) were first assumed. With this assumption the locus of maximum and minimum values each form a line perpendicular to the abscissa. From a probable point on the maximum value locus and symmetric about this locus, two diverging lines of best fit were extended through the data points until they intersected the minimum value locus. Near this intersection and the forementioned originating point the two lines were further fitted for continuity (curved portions) as consistent with platform geometry.

Admittedly there is a certain amount of arbitrariness about the curves, particularly the values of the interpolated maximum and minimum. Less arbitrary are the locations of these values which determine the observed bias direction. The agreement between the wind direction and observed bias directions indicate the curves are fairly representative and therefore typify s.w. collection curves. Though the wind directions would aid materially in defining the curves, i.e., the immediate establishment of the positions of minimum and maximum, they were purposely reserved for the forementioned test. Thus by proper interpolation and limited sampling, it is possible to adequately approximate the collection curve. A notable aspect of the curves is their general resemblance to sine curves.

The pertinent bias characteristics of the HOW collections are summarized in Table 1. The mean platform value is defined as the average of ten values taken at 20° intervals between the maximum and minimum values on the collection curve. The ground value is taken as the average of the ground collection values which are listed in Table A.1. In the case of Shot C, a ground value could not be computed because rains and unexpected water waves rendered the ground data unreliable. Particle density values are taken or extrapolated from other studies.[7,8] An analysis of the particle size data from incremental collectors has been completed; however, mean particle sizes have not been assigned to the platforms.[9] It must be emphasized that these instruments were also mounted in the platform and therefore subject to bias effects. Liquid fallout particles were produced by Shot C; no size measurements were taken on the HOW island collection.

TABLE 1

Bias Characteristics of HOW Collections

Event	Interpolated Collection Values Maximum (c/m)	Interpolated Collection Values Miminum (c/m)	Bias Ratio	Mean Platform Value (c/m)	Ground Value (c/m)	Ground Factor	True Wind Velocity Direction (degrees)	True Wind Velocity Speed (knots)	Bias Direction (degrees)	Particle Density (g/cm^3)
A	2.9[illegible]$ \times 10^6$	1.59×10^6	1.8	2.24×10^6	$(2.25 \pm 0.42) \times 10^6$	1.0	77	17	75	2.5
C	1.9[illegible]$ \times 10^4$	1.45×10^4	1.4	1.72×10^4	-	-	79	12	75	1.4
D	3.31×10^5	2.02×10^5	1.6	2.65×10^5	$(2.33 \pm 0.34) \times 10^5$	0.9	92	3.5	69	2.5

Note: Activity values in doghouse c/m per tray at H + 100.

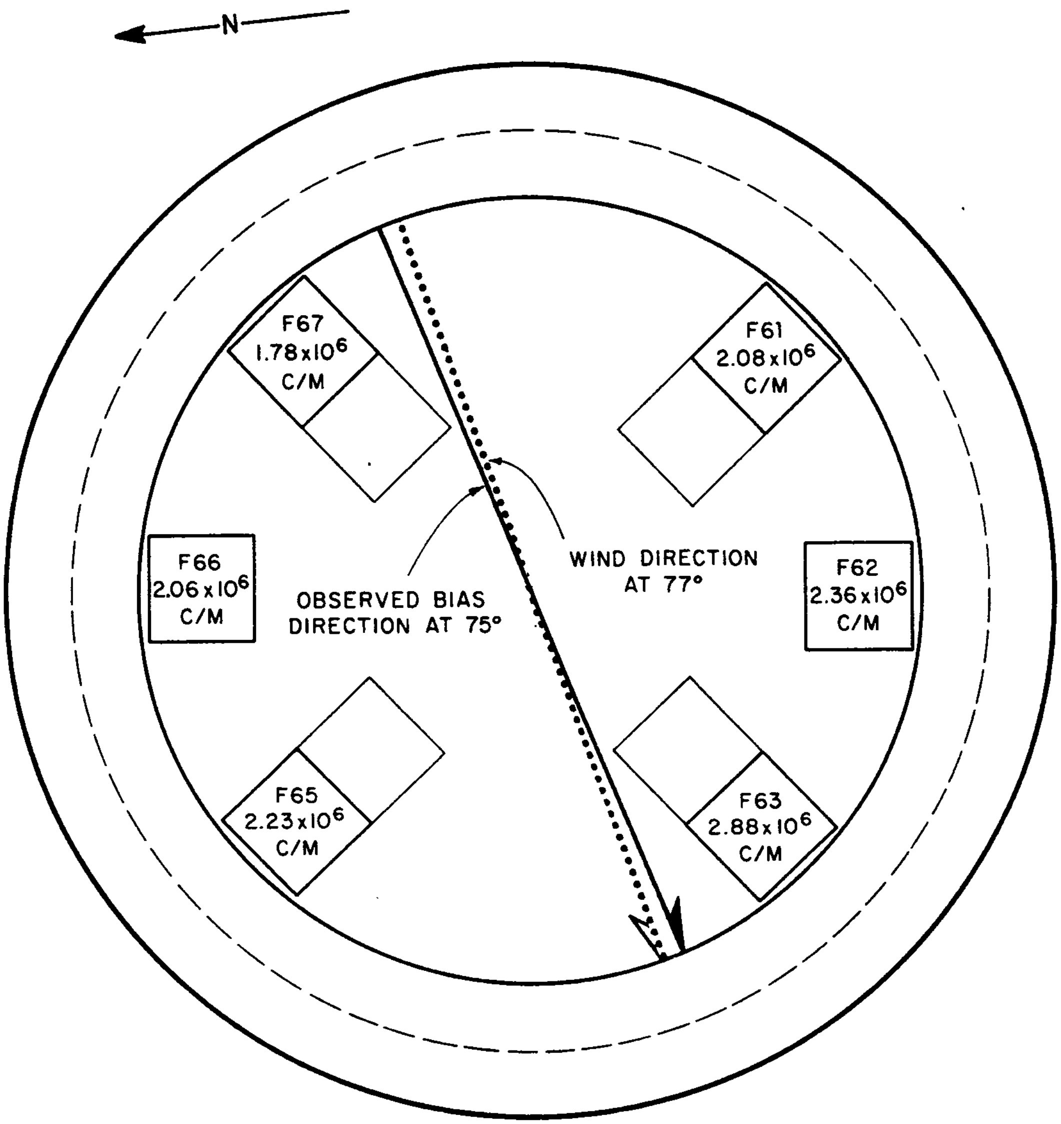

Fig. 3 Platform Collections, HOW-A

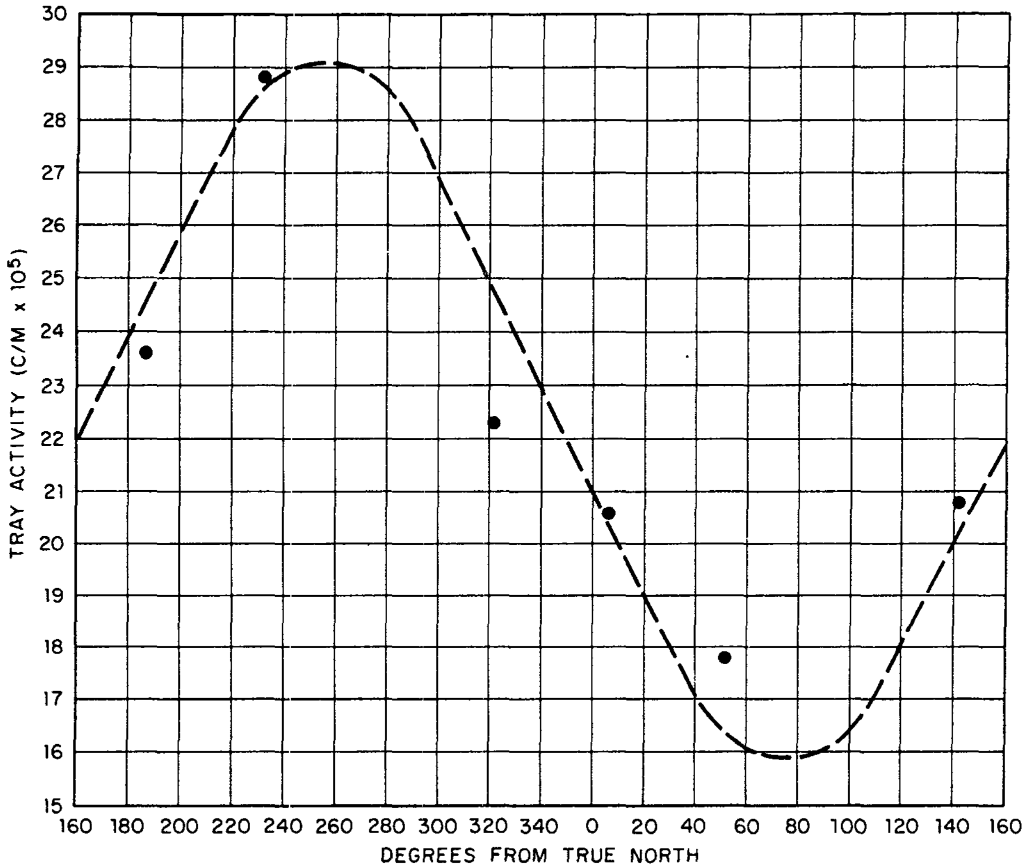

Fig. 4 Interpolated Fallout Collection Curve
HOW-A

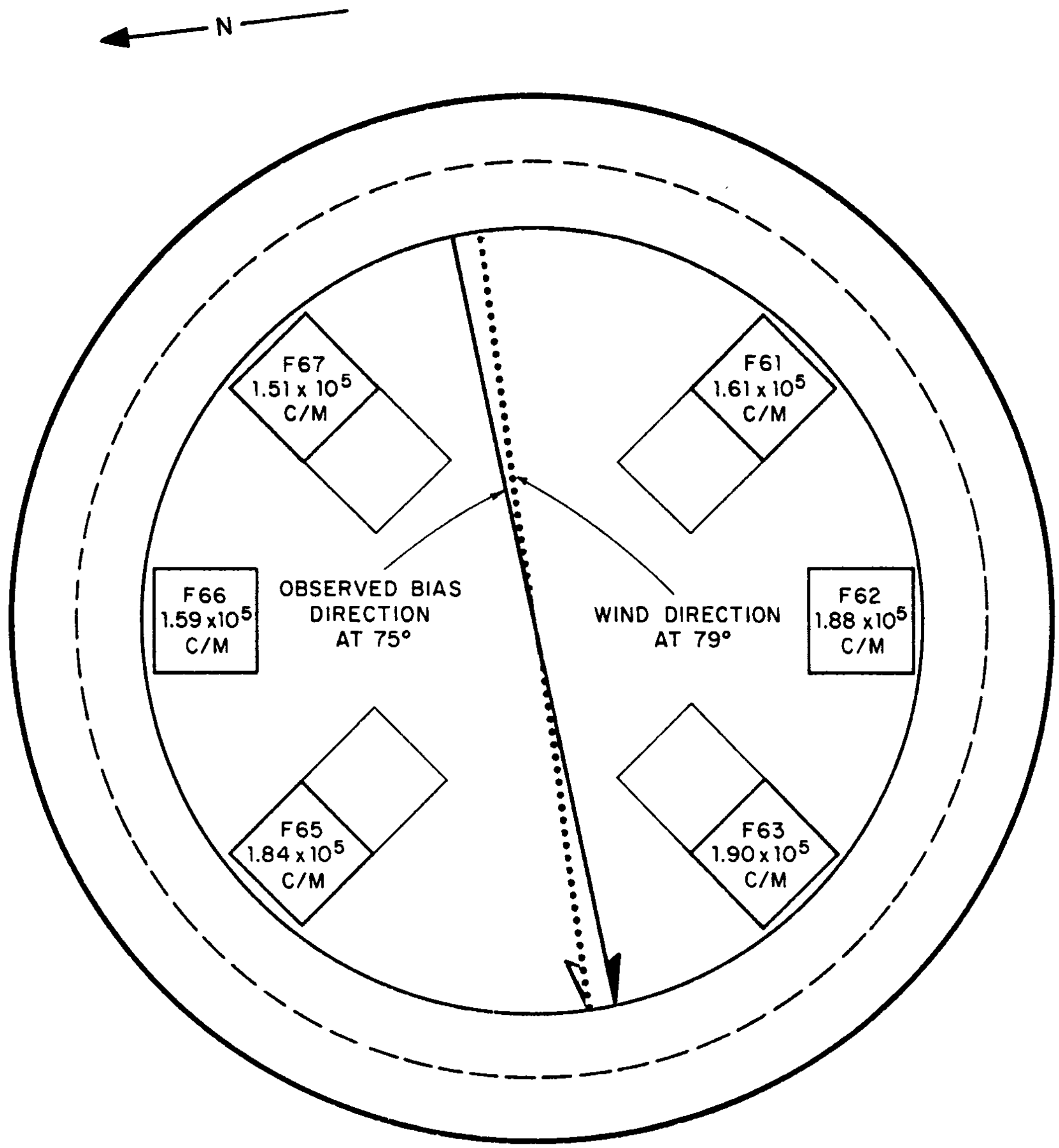

Fig. 5 Platform Collections, HOW-C

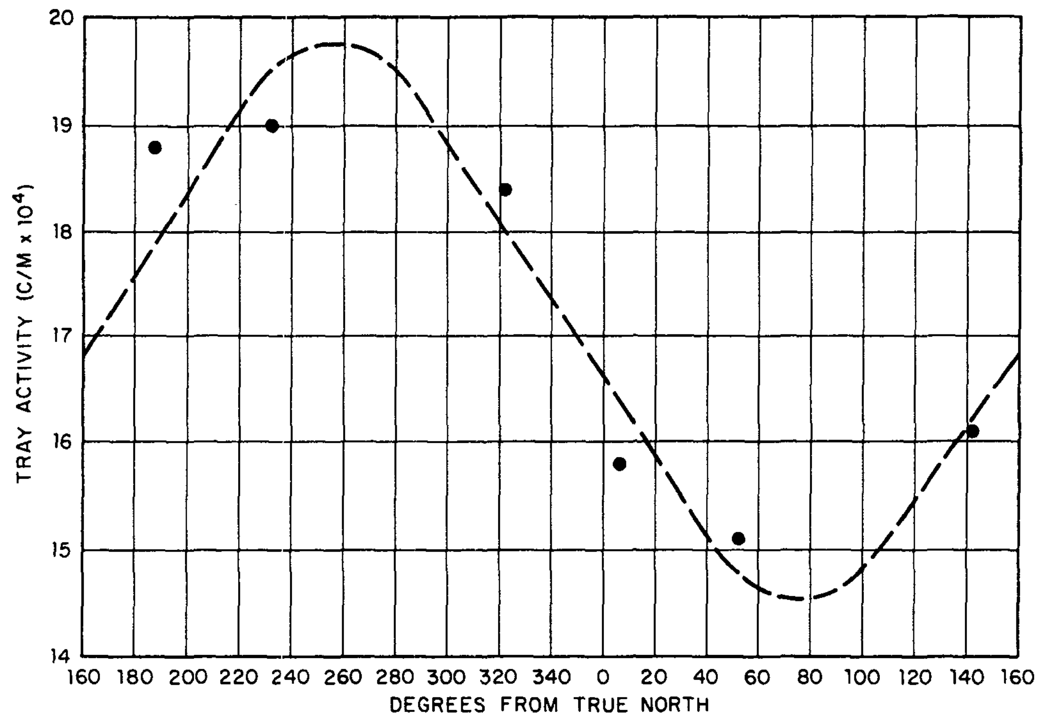

Fig. 6 Interpolated Fallout Collection Curve, HOW-C

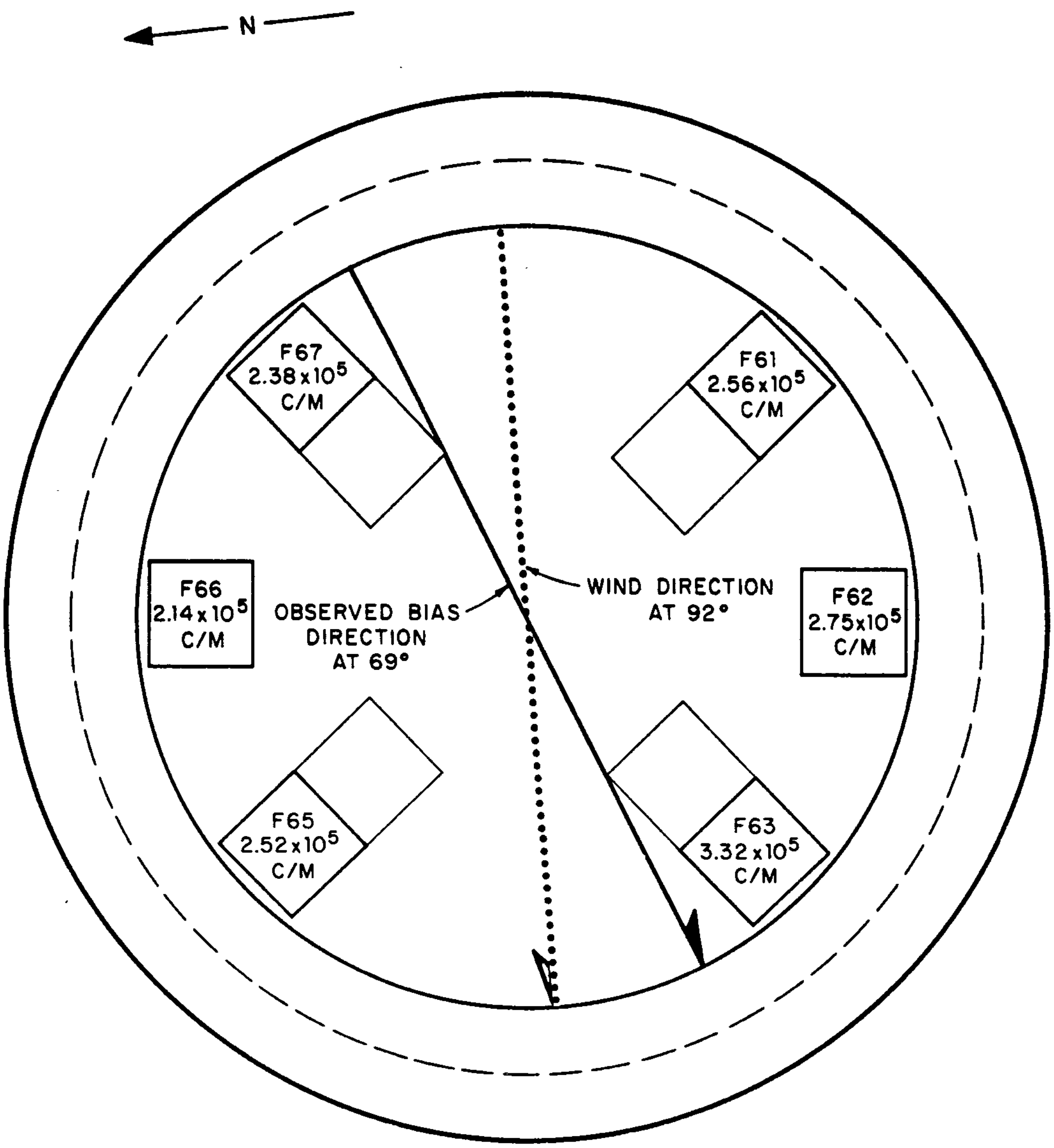

Fig. 7 Platform Collections, HOW-D

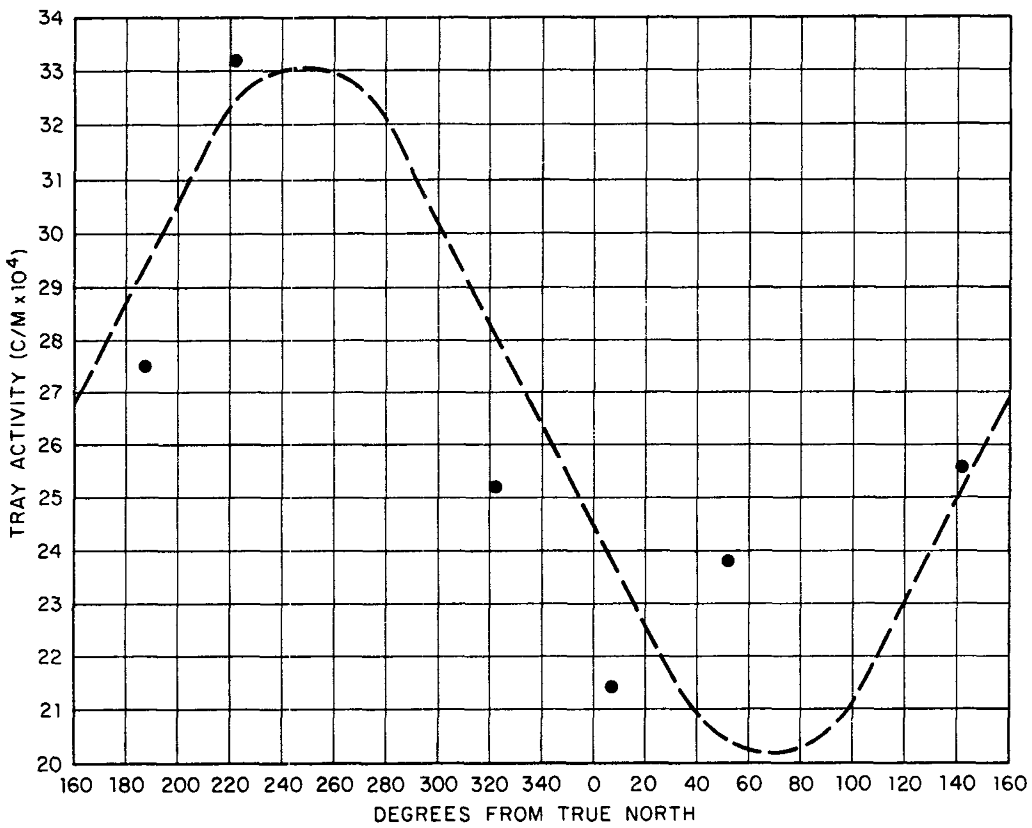

Fig. 8 Interpolated Fallout Collection Curve, HOW-D

The HOW collections in general contribute little information regarding the variation of ground factor with bias ratio, since the three observed bias ratios differ only slightly. This only set of platform-ground data is too limited for extrapolation to other s.w. system. Little differences are shown by the ground factors of Shots A and D as expected; there is no reason to believe Na was otherwise.

MULTI-WIND SYSTEM

Multi-Wind Relative Bias

In the case of multi-winds the variation in sampling is further complicated by an air-flow pattern that varies in orientation and intensity with the different winds. To study the sampling bias of the complex m.w. system, it has been assumed that the system is the summation of several s.w. systems and the bias effects are cumulative. This assumption is based on the analysis of m.w. collection data and the success of a vector system, described below. The collection data shows that the m.w. collection curve is very similar, if not identical, to the s.w. curve and it is likely that this similarity is due to the resemblance of s.w. curves to sine curves. The addition of several s.w. curves is analogous to the summation of several sine curves of identical period but varying phase angles and amplitudes whereby the resulting curve is another sine curve with the same period.

In the case of uniform collection, relative bias does not exist; however, the problem of ground bias remains and therefore platform values are not ground values. This unique situation occurs when the relative winds rotate uniformly around the platform an integral number of times or when there occur two opposing winds with equal fallout amounts and equivalent combination of fallout variables (wind speed, particle size and density).*

A vector system has been developed to aid in the analysis of m.w. relative bias. Representing each constituent s.w. system is a bias vector whose direction is the wind direction and whose magnitude is proportional to the relative amount of fallout that occurs within the particular time-increment. In general, wind speeds, which account for the intensity of the flow pattern, must also be considered; however, since the wind speeds encountered were relatively uniform, this complication is avoided in this study. One important application of bias vector summation is the correlation of the observed bias direction relative to the many wind directions involved since the

*Consider the analogous summation of two identical sine curves 180° out of phase.

resultant vector direction should be the bias direction. This resultant direction has been designated as the computed bias direction to distinguish it from the observed bias direction.

Since sampling variation is reduced or even eliminated by the variance of wind direction, vector analysis aids in the explanation of certain bias effects. In a hypothetical sense the bias vector concept regards the final collection variation as the result of a portion of the fallout being deposited biased and the remainder being distributed uniformly.* Thus in the event of a resultant vector with zero magnitude, the entire fallout is uniformly deposited; but in the case of a s.w. system where the vector resultant is equal to the arithmetic sum of the individual vectors, the entire fallout is deposited biased in a given direction. A quantity designated as the bias fraction provides a relative measure of this division of fallout and is defined as follows:

$$\text{bias fraction} = \frac{\text{final amount of fallout that is assumed to be deposited biased}}{\text{total amount of fallout}}$$

$$= \frac{\text{magnitude of resultant vector}}{\text{arithmetic sum of vector magnitudes}}$$

A bias fraction approaching unity indicates a s.w. system is in effect (assuming wind speeds are comparable). The opposite extreme is a value close to zero which indicates uniform deposition and no relative bias.

Multi-Wind Ground Bias

Due to the complexity of the m.w. system, equivalent ground value determinations by the bias ratio-ground factor method involve complicated qualifications and therefore will require an exceedingly large amount of data. For instance two m.w. cases of equal bias ratios have equal ground factors only if both have relative correspondence in wind and fallout variation. Until further platform-ground information is available no reliable method of determining ground value is known. If necessary the mean platform value, since it is a weighted mean, may be used as a lower-limit approximation of the ground value.

*As an example, consider the situation of two opposing consecutive winds A and B of uniform fallout rate and equal fallout variables. Assume the fallout duration of wind A as t and wind B as 2 t. At the conclusion of wind A fallout, wind B fallout begins and after t time, uniform collections exist at this particular intermediate time point. Proceeding further, a wind B fallout of t duration (1/3 of the total fallout) is then added to the uniform collection.

Analysis of YAG Data

Sample values of the ship and barge platforms are listed in Table A.2. The biases of the YAG platforms are considered typical m.w. biases and those of the LST and barges atypical because of interference from ship structures. The analysis of these atypical biases is limited and is discussed in the following subsection. Collection diagrams and curves for YAG 40-C, YAG 39-C and YAG 40-D are illustrated by Figs. 9 through 14. Observed and computed bias directions are shown for comparison. The bias fractions of the respective platforms are 0.16, 0.44 and 0.85. Collection curves of all the YAG platforms were also completed by interpolation as in the case of the HOW curves and the three illustrated curves typify the curves of the remaining YAG platforms and m.w. systems.

Only the YAG collections were subjected to bias vector analysis. For each platform the number of winds involved, their directions, their velocities and their durations were available from RA data. The relative amounts of fallout associated with each of these winds were derived from TIR data rather than the results of the biased IC's. In a relative sense, a TIR curve shows the over-all time variation of activity within the platform and this variation is attributed to both decay and fallout arrival. With the exception of decay, the curve is an approximation because of non-uniform fallout deposition in the platform and the variable directional response characteristics of the TIR. To eliminate the decay contribution, the TIR curve was corrected point-for-point to a common time; the resulting curve then represents the approximate relative build-up of fallout with time. Relative fallout amounts, to which vector magnitudes are proportional, are represented by the increase of activity per time increment of approximately constant wind velocity.

The TIR curve of each station and the YAG 40 decay data used to correct these curves (with extrapolations) are listed in Ref. 3. The corrected TIR curves for the three illustrated platforms are shown in Fig. B.1 and the curve points of the remaining YAG stations are listed in Table B.1. Because of a possible transient-dose peak, the decay-corrected platform TIR curves of YAG-39-D and YAG-40-A were adjusted to agree with the curves of the TIR located on the forward deck. The wind and vector information for each platform are listed in Tables B.2 to B.5. In the case of a wind of constant directional variation (ship turning), the amount of fallout was proportioned among a number of wind increments, each accounting for a direction sector of 30° or 40°. To simplify the final vector solution the effective (resultant) vector of each group of wind increments was separately determined and substituted accordingly. The graphical analysis for YAG 39-C is illustrated by Fig. 15.

The results of the collection and bias vector analyses of the YAG platforms are listed in Table 2. In two cases the collection curve minimum is slightly higher than the lowest collection but these occurrences are insignificant in view of the interpolated nature of the curves. The effective wind speed for each platform is the weighted mean of the wind speeds based on fallout amounts. Approximate particle densities and some estimated particle sizes from other studies are also listed.[4,5] The agreement between the observed and computed bias directions is to be noted. Vector analysis revealed that the YAG 39-C, YAG 40-D and YAG 39-D experienced s.w. bias and their higher bias ratios agree with this. Their ground values should be determinable from s.w. platform-ground relationships as discussed. The lower bias ratios of the m.w. systems are due to the inherent reduction of bias effects by winds of different direction. The low bias ratio of YAG 40-C is in full accord with its low bias fraction. As mentioned, m.w. equivalent ground value determination must await further platform-ground information. Some indirect information concerning the equivalent ground value of the YAG collections has been obtained by water sampling; however, correlation between platform and water sampling is not attempted in this study but is discussed elsewhere.[3,10]

Analysis of LST and Barge Data

In addition to the normal air flow disturbances, the LST and barge platforms, because of their low positions, probably experienced other wind disturbances. Withthe winds impinging about the vessel's bow and sides the resulting updrafts and flow distortions could produce other bias effects. In the case of the stern platform, which was approximately 14 ft above the preceding top deck, the deck expanse and obstruction of the front platform contributed their share of flow irregularities with frontal winds. The resultant effect of these flow conditions is to complicate the normal bias and such complications cannot be defined at the present time.

In order to present some indications of the bias situation, collection studies were performed (where possible) in the same manner as for the YAG platforms. The results are listed in Table 3; but it must be emphasized that these bias characteristics are, at best, rough approximations. In some cases it was exceedingly difficult to plot the collection curves and in others it was altogether impossible. The relationship between the two platforms of the YFNB 29 cannot be determined at this time. Further studies of the LST and barge biases were not attempted.

CONCLUSION

The variation of fallout collection within the standard platforms has been correlated with the air flow characteristics above the platform. In the case of multi-winds, sampling bias was further correlated to the variability in wind direction and associated fallout amount by a vector system.

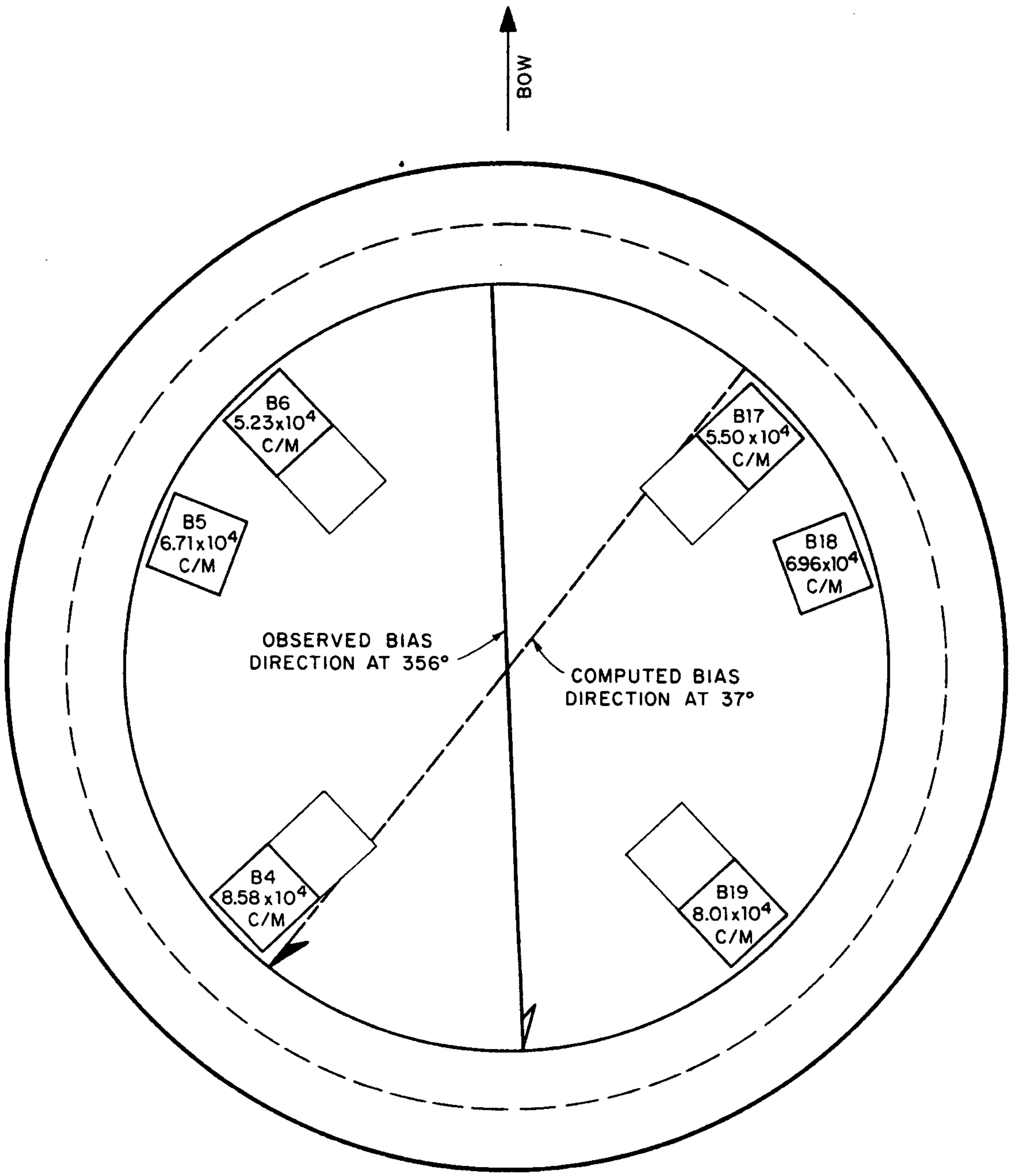

Fig. 9 Platform Collections, YAG-40-C

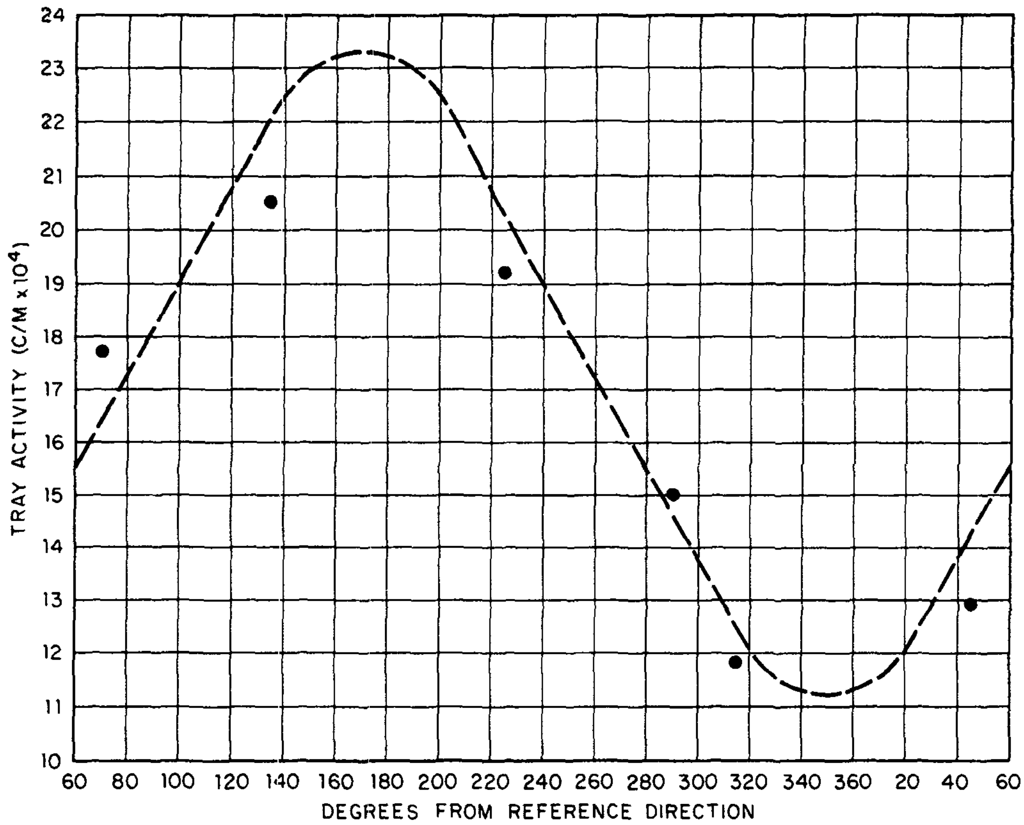

Fig. 10 Interpolated Fallout Collection Curve, YAG-40-C

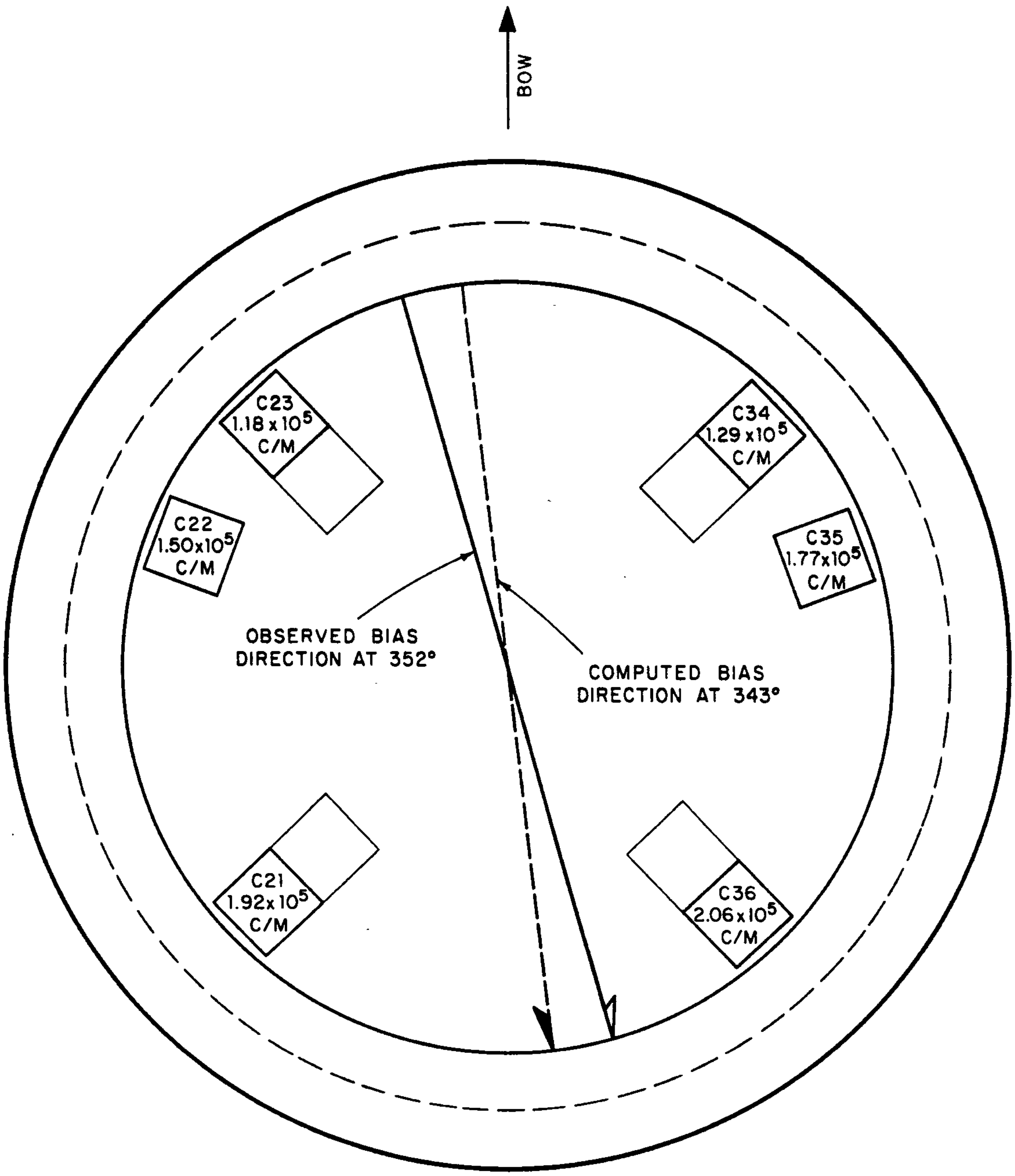

Fig. 11 Platform Collections, YAG-39-C

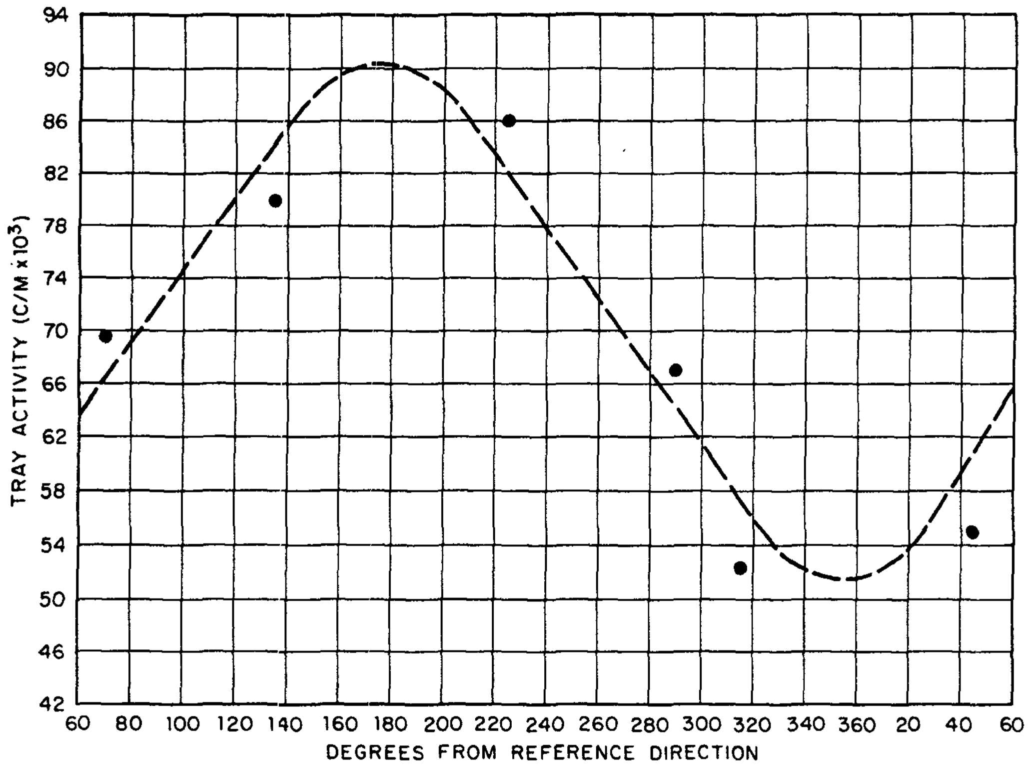

Fig. 12 Interpolated Fallout Collection Curve, YAG-39-C

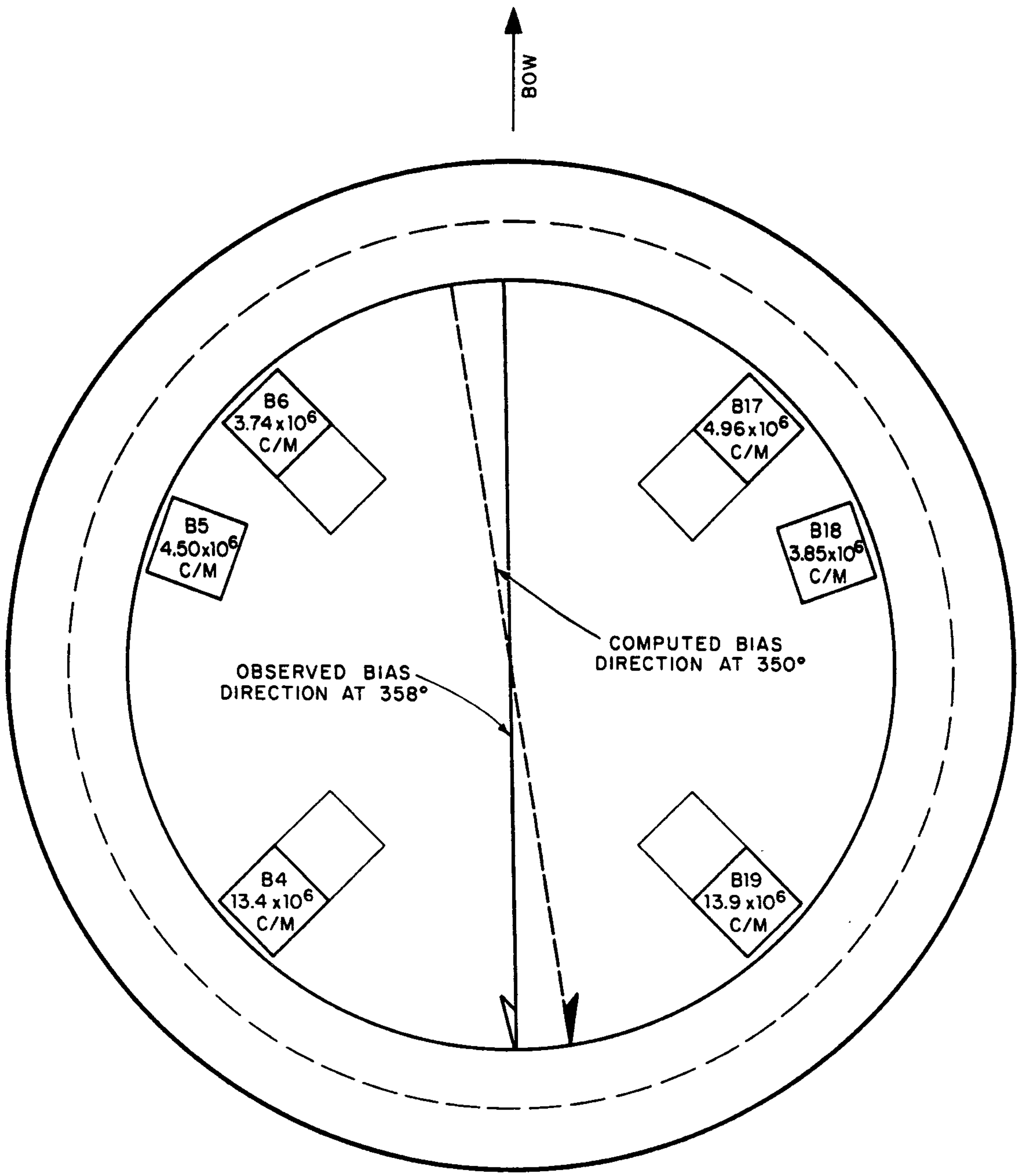

Fig. 13 Platform Collections, YAG-40-D

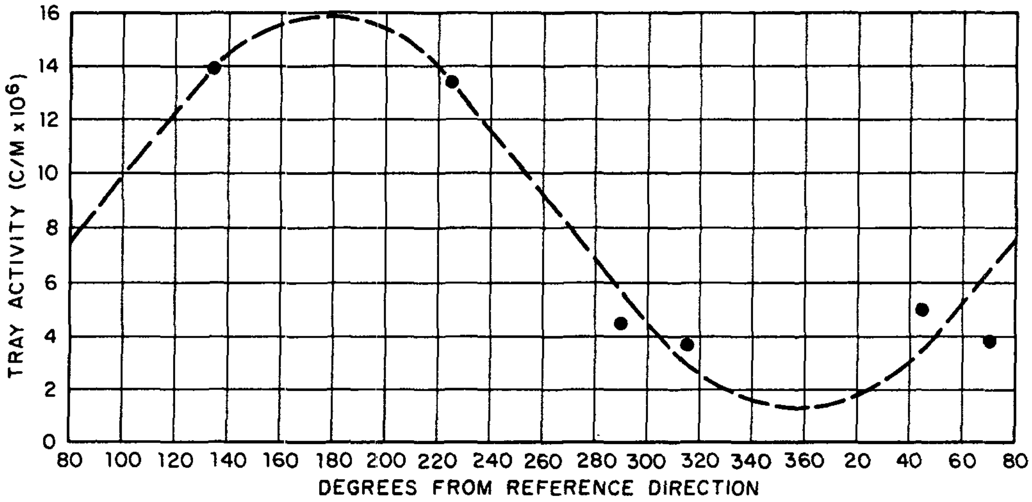

Fig. 14 Interpolated Fallout Collection Curve, YAG-40-D

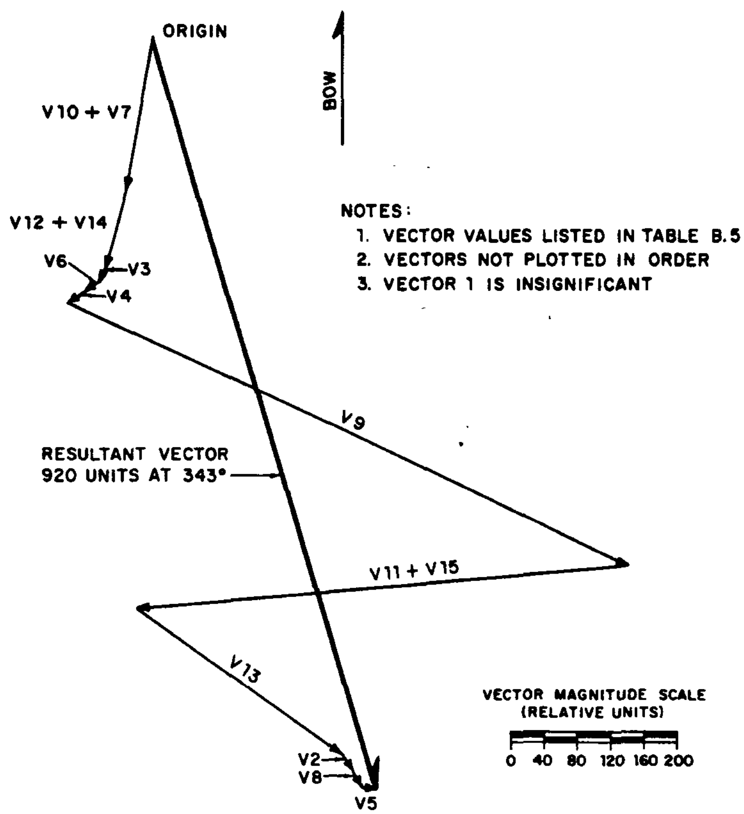

Fig. 15 Graphical Analysis of YAG-39-C Bias Vector System

TABLE 2

Bias Characteristics of YAG Collections

Event	Bias Fraction	Computed Bias Direction (degrees)	Observed Bias Direction (degrees)	Interpolated Collection Value Maximum (c/m)	Interpolated Collection Value Minimum (c/m)	Bias Ratio	Mean Platform Value (c/m)	Effective Wind Speed (knots)	Particle Size (μ)	Particle Density (g/cm^3)
					YAG-40					
Shot A	0.68	126	152	7.48×10^6	3.76×10^6	2.0	5.61×10^6	13	-	2.5
Shot B	0.98	342	0	4.57×10^5	0.229×10^5	20	2.25×10^5	16	125	1.35
Shot C	0.16	37	356	9.04×10^4	5.14×10^4	1.8	7.07×10^4	14	100	1.33
Shot D	0.85	350	358	15.8×10^6	1.30×10^6	12	8.39×10^6	15	-	2.5
					YAG-39					
Shot A	0.97	353	345	13.8×10^4	1.45×10^4	9.5	7.54×10^4	17	-	2.5
Shot B	0.41	12	327	11.5×10^4	2.12×10^4	5.4	6.79×10^4	16	112	1.29
Shot C	0.44	343	352	2.33×10^5	1.12×10^5	2.1	1.71×10^5	17	229	1.50
Shot D	0.97	357	358	2.82×10^7	0.282×10^7	10	1.50×10^7	14	-	2.5

Note: Activity values in doghouse c/m per tray at H + 100.

TABLE 3

Approximate Bias Characteristics of LST and YFNB Collections

Station	Event	Interpolated Collection Value Maximum (c/m)	Interpolated Collection Value Minimum (c/m)	Bias Ratio	Mean Platform Value (c/m)	Bias Direction (degrees)	Relative Wind Velocity Direction (degrees)	Relative Wind Velocity Speed (knots)	Particle Size (μ)	Particle Density (g/cm^3)
LST	Shot A	No fallout, collectors not exposed								
	Shot B	a	a	a	a	a	-	18[c]	112	1.29
	Shot C	b	b	b	b	b	-	16[c]	166	1.41
	Shot D	18.8×10^5	8.34×10^5	2.3	13.5×10^5	332	-	15[c]	-	2.5
YFNB 13	Shot A	5.12×10^6	2.54×10^6	2.0	3.84×10^6	15	-	20[c]	-	2.5
	Shot B	7.36×10^6	4.42×10^6	1.7	5.86×10^6	13	-	16[c]	-	1.3
	Shot C	8.43×10^5	6.39×10^5	1.3	7.41×10^5	354	-	18[c]	272	1.38
	Shot D	6.90×10^6	1.92×10^6	3.6	4.28×10^6	349	-	15[c]	-	2.5
YFNB 29G	Shot A	5.81×10^6	3.49×10^6	1.7	4.65×10^6	342	348 ± 53	20	-	2.5
	Shot B	3.12×10^5	2.01×10^5	1.6	2.56×10^5	350	10 ± 75	16	57	1.28
	Shot C	1.21×10^4	0.85×10^4	1.4	1.03×10^4	17	5 ± 50	18	-	1.4
	Shot D	3.90×10^7	1.56×10^7	2.5	2.73×10^7	10	22 ± 43	15	-	2.5
YFNB 29H	Shot A	9.10×10^6	4.98×10^6	1.8	6.97×10^6	346	348 ± 53[c]	20[c]	-	2.5
	Shot B	b	b	b	b	b	10 ± 75[c]	16[c]	57	1.28
	Shot C	b	b	b	b	b	5 ± 50[c]	18[c]	-	1.4
	Shot D	6.73×10^7	3.32×10^7	2.0	4.99×10^7	0	22 ± 43[c]	15[c]	-	2.5

a. Instruments malfunctioned, analysis not attempted.
b. Collection curve could not be constructed.
c. Estimated value, RA malfunctioned or no RA.

Note 1: YFNB wind directions indicate axial direction and "swing" of vessel. Oscillation periods were about 10 minutes.

The collection curves of both single and multi-wind systems resemble sine curves; these curves were completed by interpolation. Bias properties of both systems can be described by certain parameters. For the HOW platform, a single-wind system, its bias ratios varied over a narrow range of 1.4 to 1.8 where the ground factor is close to unity. The platform-ground data of the HOW station is too limited to permit extrapolations to other single-wind systems. In the case of the YAG's, the bias ratios ranged from 1.8 to 20 and the bias fraction from 0.16 to 0.97. Bias vector summation showed that the YAG-40-B, YAG-39-A and YAG-39-D experienced single-wind bias. The sampling bias of the LST and YFNB's could not be completely defined because of the complications caused by the ship structures. Their approximate bias ratios varied from 1.3 to 3.6.

The determination of equivalent ground values of shipboard collections was not possible because of the undefined platform-ground relationship in the multi-wind cases and the lack of bias ratio-ground factor data in the single-wind cases.

Approved by:

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For the Scientific Director

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APPENDIX A

SAMPLING VALUES

TABLE A.1

HOW Station Ground Array Collection Values

Collector	Tray Activity (Doghouse c/m at H+100) Shot A	Shot D
	x 10^6	x 10^5
B-1	2.15	2.63
B-2	2.26	2.51
B-3	2.02	2.03
B-4	1.96	2.47
B-5	2.74	2.07
B-6	1.54[a]	3.04
B-7	3.45[b]	3.30[b]
B-8	2.30	1.39[a]
B-9	2.17	2.08
B-10	2.46	2.00
B-11	1.29[c]	0.39[c]
B-12	2.19	2.17

a. Located in platform wind shadow.
b. Located directly under platform.
c. Located on sand embankment.

TABLE A.2

Ship and Barge Collection Values

Station	Collector	Activity Per Tray (Doghouse c/m at H+100) Shot A	Shot B	Shot C	Shot D
YAG-40		(x 10^6)	(x 10^5)	(x 10^4)	(x 10^6)
	B- 4	0.43[a]	42.2	8.58	13.4
	B- 5	4.54	8.45	6.71	4.50
	B- 6	7.46	3.52	5.23	3.74
	B-17	5.87	3.41	5.50	4.96
	B-18	2.83	10.2	6.96	3.85
	B-19	4.05	44.0	8.01	13.9
YAG-39		(x 10^4)	(x 10^4)	(x 10^5)	(x 10^6)
	C-21	8.73	8.21	1.92	23.6
	C-22	3.56	3.14	1.50	5.75
	C-23	3.56	1.78	1.18	6.31
	C-34	3.44	5.03	1.29	6.19
	C-35	6.42	9.24	1.77	9.09
	C-36	13.1	10.6	2.05	27.3
LST			(x 10^4)	(x 10^3)	(x 10^5)
	D-38	No	7.31	16.9	13.4
	D-39	Fallout	1.36	18.1	8.11
	D-40	Collectors.	1.16[a]	9.02	9.63
	D-51	Not	2.18[a]	8.72	12.6
	D-52	Exposed	13.6	17.8	13.4
	D-53		24.1[a]	19.6	18.3
YFNB-13		(x 10^6)	(x 10^6)	(x 10^5)	(x 10^6)
	E-54	2.81[a]	4.96	7.28	2.58
	E-55	3.31	5.60	4.76	3.62
	E-56	4.66	6.89	8.05	5.74
	E-58	1.78	5.88	8.06	4.18
	E-59	3.07	7.36	7.14	2.15
	E-60	4.00	4.98	6.75	2.45
YFNB-29		(x 10^6)	(x 10^5)	(x 10^3)	(x 10^7)
	G-68	4.32	2.20	8.33	1.79
	G-69	4.42	2.67	9.50	b
	G-70	5.88	3.04	11.4	3.27
	G-72	5.28	2.72	10.9	3.75
	G-73	4.05	2.34	5.29[a]	1.89
	G-74	4.88	2.30	10.1	1.87

Continued

TABLE A.2 (Contd)

Ship and Barge Collection Values

Station	Collector	Activity Per Tray (Doghouse c/m at H+100)			
		Shot A	Shot B	Shot C	Shot D
YFNB-29		$(\times 10^6)$	$(\times 10^5)$	$(\times 10^3)$	$(\times 10^7)$
	H-75	5.73	3.17	13.1	3.74
	H-76	7.48	2.72	7.55[a]	4.61
	H-77	8.89	3.03	14.1	6.44
	H-79	7.48	2.99	16.7	6.14
	H-80	6.18	3.10	17.1	4.58
	H-81	5.62	2.48	11.6	3.79

a. Imperfect collection - instrument malfunctioned; hexcell and/or liner lost.

b. Absurd value.

APPENDIX B

BIAS VECTOR DATA

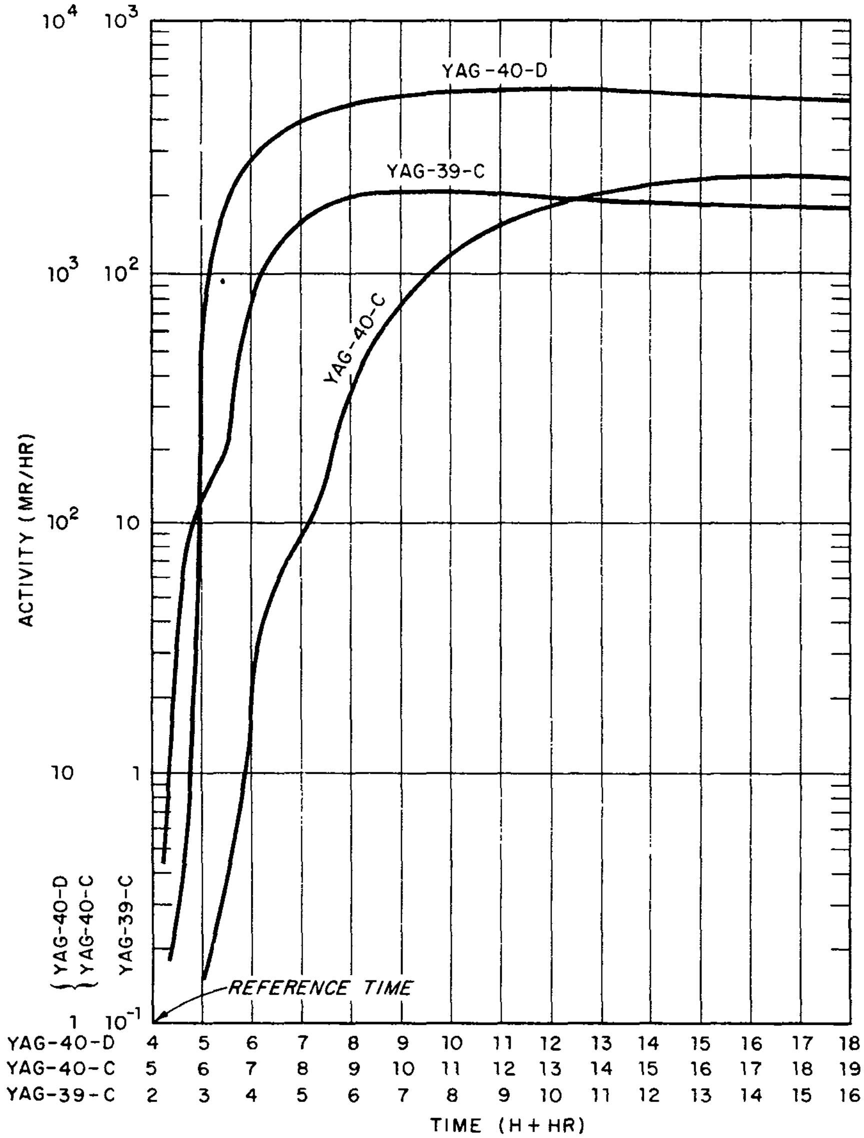

Fig. B.1 Decay-Corrected TIR Curves

TABLE B.1

Decay-Corrected TIR Curve Points

YAG 40-A (H+3 Reference Time)		YAG 39-A (H+12 Reference Time)		YAG 40-B (H+6 Reference Time)		YAG 39-B (H+4 Reference Time)		YAG 39-D (H+2 Reference Time)	
Time (H+hr)	Ionization Rate (mr/hr)	Time (H+hr)	Ionization Rate (mr/hr)	Time (H+hr)	Ionization Rate (mr/hr)	Time (H+hr)	Ionization Rate (mr/hr)	Time (H+hr)	Ionization Rate (mr/hr)
3.35	2.48	12.7	0.593	6.0	0.050	4.35	0.450	2.2	19
3.55	19.3	13.1	0.762	8.0	0.726	4.55	0.717	2.5	254
3.75	53.5	13.6	0.864	9.0	7.44	5.1	4.13	2.8	994
4.05	165	14.1	1.06	10.0	28.0	5.4	8.17	3.0	1,630
4.35	635	15.1	1.81	11.0	85.4	6.05	15.7	3.2	2,510
5.05	2,250	16.1	3.82	12.0	138	6.5	24.2	3.5	4,500
6.05	5,910	17.1	5.88	15.0	169	7.0	36.8	3.8	7,490
6.7	8,000[a]	18.1	9.42	16.0	208	8.0	54.9	4.0	12,300
7.05	7,900[a]	19.1	12.5	17.0	219	9.2	71.7	4.2	16,400
8.05	7,800[a]	20.1	14.8	18.0	233	10.1	75.9	4.5	26,000
9.05	7,600[a]	21.1	16.7	19.0	213	11.0	99.8	4.8	32,000[a]
11.1	7,400[a]	22.1	17.5	20.0	225	12.1	102	5.0	34,000[a]
14.1	7,000[a]	23.1	19.0	21.0	233	13.1	116	5.5	34,500[a]
18.1	6,500	24.1	20.4	22.0	207	14.1	102	6.0	34,000[a]
		25.1	21.9	23.0	212	15.1	101	6.5	33,500[a]
		27.1	24.0	25.0	209	16.0	101	7.0	32,000[a]
		29.1	24.4	30.0	185	17.0	102	7.5	31,500[a]
		30.1	25.0	35.0	194	18.0	104	8.0	31,000[a]
		32.1	24.5	40.0	190	19.0	104		
		34.1	25.3			20.0	104		
		36.1	23.4			21.0	104		
		38.1	23.1			22.0	98.6		
		40.1	23.2			23.0	101		
		42.1	22.8			24.0	96.8		
						26.0	96.8		
						28.0	93.1		

a. Adjusted value.

TABLE B.2

Bias Vector System, Shot A

Vector	Duration (H+hr) From	To	Vector and Wind Direction (degrees)	Wind Speed (knots)	Magnitude (Relative Units)
			YAG 40		
V 1	3.35	3.55	125	11	8
V 2	3.55	3.85	130	12	65
V 3	3.85	4.20	130	11	254
V 4	4.20	4.55	130	10	570
V 5	4.55	4.85	130	13	900
V 6	4.85	5.20	135	10	1000
V 7	5.20	5.55	135	11	1200
V 8	5.55	5.85	135	10	1200
V 9	5.85	6.15	130	14	1000
V 10	6.15	6.25	130 to 350[a]	17	800
V 11	6.25	6.55	350	19	700
V 12	6.55	6.85	355	21	300
			Total		7997
			YAG 39		
V 1	12.7	13.0	10	19	6
V 2	13.0	14.0	0	18	37
V 3	14.0	15.0	0	17	88
V 4	15.0	16.0	355	18	170
V 5	16.0	17.0	340	17	250
V 6	17.0	18.0	335	18	290
V 7	18.0	19.0	340	17	300
V 8	19.0	20.0	350	16	200
V 9	20.0	21.0	0	16	200
V 10	21.0	22.0	350	17	180
V 11	22.0	23.0	0	18	140
V 12	23.0	24.0	355	18	140
V 13	24.0	25.0	355	18	120
V 14	25.0	26.0	5	19	70
V 15	26.0	27.0	25	18	70
V 16	27.0	28.0	30	17	60
V 17	28.0	29.0	25	18	40
V 18	29.0	30.0	15	15	80
			Total		2441

a. Counterclockwise variation.

TABLE B.3

Bias Vector System, Shot B

Vector	Duration (H+hr) From	To	Vector and Wind Direction (degrees)	Wind Speed (knots)	Magnitude (Relative Units)
			YAG 40		
V 1	7.3	7.55	255	13	1
V 2	7.55	7.65	255 to 325[a]	18	1
V 3	7.65	9.00	325	15	64
V 4	9.00	10.00	340	15	283
V 5	10.00	11.00	340	15	520
V 6	11.00	12.00	335	15	450
V 7	12.00	13.00	335	17	300
V 8	13.00	14.00	345	17	210
V 9	14.00	15.00	355	17	190
V 10	15.00	16.00	355	17	100
V 11	16.00	17.00	15	15	80
V 12	17.00	18.00	0	16	50
			Total		2249
			YAG 39		
V 1	4.35	5.65	5	17	102
V 2	5.65	5.80	5 to 85[a]	16	25
V 3	5.80	6.70	85	18	180
V 4	6.70	6.80	85 to 295[b]	16	15
V 5	6.80	8.30	295	15	295
V 6	8.30	8.45	295 to 80[a]	16	20
V 7	8.45	10.30	80	15	220
V 8	10.30	10.60	80 to 290[b]	13	30
V 9	10.60	12.25	290	15	110
V 10	12.25	12.60	290 to 75[a]	14	20
V 11	12.60	13.30	75	17	20
V 12	13.30	13.35	75 to 15[a]	14	0
V 13	13.35	15.25	15	15	10
			Total		1047

a. Clockwise variation.
b. Counterclockwise variation.

TABLE B.4

Bias Vector System, Shot C

Vector	Time Interval (H+hr) From	To	Vector and Wind Direction (degrees)	Wind Speed (knots)	Magnitude (Relative Units)
			YAG 40		
V 1	6.05	6.60	350	18	4
V 2	6.60	7.00	350 to 235[b]	18	7
V 3	7.00	7.05	235	13	6
V 4	7.05	7.50	235 to 135[a]	18	41
V 5	7.50	8.35	135	11	67
V 6	8.35	9.20	135 to 25[b,c]	16	295
V 7	9.20	9.30	25	18	50
V 8	9.30	9.50	25 to 275[a]	14	90
V 9	9.50	9.70	275	15	40
V 10	9.70	10.00	275 to 25[b]	14	150
V 11	10.00	10.30	25	15	120
V 12	10.30	10.40	25 to 315[a]	14	30
V 13	10.40	10.45	315	16	20
V 14	10.45	10.90	315 to 325[b]	12	210
V 15	19.90	11.10	325	16	70
V 16	11.10	11.25	325 to 60[a]	15	40
V 17	11.25	11.60	60	15	140
V 18	11.60	11.65	60 to 45[a]	12	120
V 19	11.65	11.90	45	14	20
V 20	11.90	12.40	45 to 90[b]	12	160
V 21	12.40	12.55	90	11	20
V 22	12.55	12.90	90 to 85[a]	13	80
V 23	12.90	12.95	85	12	10
V 24	12.95	13.40	85 to 70[b]	12	110
V 25	13.40	13.45	70	13	10
V 26	13.45	13.70	70 to 25[a]	10	60
V 27	13.70	13.75	25	14	10
V 28	13.75	14.10	25 to 15[a,c]	12	70
V 29	14.10	14.20	15	15	20
V 30	14.20	14.60	15 to 325[b]	12	60

Continued

TABLE B.4 (Cont'd)

Bias Vector System, Shot C

Vector	Time Interval (H+hr) From	To	Vector and Wind Direction (degrees)	Wind Speed (knots)	Magnitude (Relative Units)
			YAG 40		
V 31	14.60	14.65	325	15	10
V 32	14.65	14.90	325 to 275[a]	12	40
V 33	14.90	14.95	275	13	10
V 34	14.95	15.00	275 to 335[a]	14	10
V 35	15.00	15.05	335	15	10
V 36	15.05	15.10	335 to 295[b]	16	10
V 37	15.10	15.25	295	16	10
V 38	15.25	15.30	295 to 275[b]	16	10
V 39	15.30	16.00	275	16	60
V 40	16.00	16.30	275 to 70[b]	15	20
V 41	16.30	18.00	70	15	80
				TOTAL	2400
			YAG 39		
V 1	2.20	2.35	265	16	7
V 2	2.35	2.50	265 to 25[a]	18	24
V 3	2.50	2.60	25	18	19
V 4	2.60	2.70	25 to 90[a]	18	26
V 5	2.70	2.80	90	18	17
V 6	2.80	2.90	90 to 10[b]	16	17
V 7	2.90	3.10	10	16	26
V 8	3.10	3.30	10 to 295[b]	17	25
V 9	3.30	4.10	295	17	735
V 10	4.10	4.30	295 to 85[a]	18	200
V 11	4.30	5.00	85	18	520
V 12	5.00	5.20	85 to 305[b]	18	80
V 13	5.20	6.10	305	17	300
V 14	6.10	6.30	305 to 85[a]	17	30
V 15	6.30	7.00	85	17	50
				TOTAL	2076

a. Clockwise variation.
b. Counterclockwise variation.
c. Variation after 360° revolution.

TABLE B.5

Bias Vector System, Shot D

Vector	Duration (H+hr) From	To	Vector and Wind Direction (degrees)	Wind Speed (knots)	Magnitude (Relative Units)
			YAG 40		
V 1	4.35	4.65	255	11	4
V 2	4.65	4.70	255 to 230[b]	12	1
V 3	4.70	4.90	230	12	60
V 4	4.90	5.05	230 to 355[a]	12	130
V 5	5.05	7.30	355	15	3800
V 6	7.30	7.35	355 to 360[b]	15	50
V 7	7.35	7.40	360 to 305[b]	15	20
V 8	7.40	8.25	345 ± 40[d]	15	510
V 9	8.25	8.30	305 to 355[a]	15	20
V 10	8.30	8.55	355 to 60[b,c]	14	150
V 11	8.55	9.15	260	13	200
V 12	9.15	9.50	260 to 300	14	100
V 13	9.50	9.55	300	14	50
	9.55	10.00	300 to 330[a,c]	14	100
				TOTAL	5195
			YAG 39		
V 1	2.20	4.80	355	14	32
V 2	4.80	5.00	355 to 100[a]	14	2
				TOTAL	34

a. Clockwise variation.
b. Counterclockwise variation.
c. Variation after 360° revolution.
d. Oscillating winds, 12 minute period.

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