FORUM

The Accuracy of Astronomical Observations at Sea

from G. A. Harding

It was with some surprise that I read Commander Sharpey-Schafer's 'Some Notes on Astronomical Observations at Sea' (this *Journal*, Vol. VI, p. 362), especially his conclusions regarding the fixing accuracy obtainable with marine sextant observations.

I can make no claim to be an experienced navigator myself, but, as a member of the staff of H.M. Nautical Almanac Office, I was privileged, in 1949, to spend three months as an observer on board H.M.S. *Dalrymple*, a newly-commissioned surveying ship, under the command of Captain (now Vice-Admiral Sir) A. Day.

The revision of the *Abridged Nautical Almanac* was then in progress, and it was felt that it was highly desirable that a member of the Nautical Almanac Office staff should spend a period at sea to collect information on a number of matters which might affect the design of the almanac. One of the main points requiring clarification was this question of the accuracy obtainable with a marine sextant. There were no practical navigators in the Office to advise on this matter and the views of those contacted differed widely, estimates of accuracy varying from ¼ mile to 2 miles. It was realized that the ship on which I was to travel was a surveying ship and that hydrographic surveyors require, apart from the purposes of en-route navigation, greater accuracy from their sights than the normal marine navigator—in fact they require the maximum accuracy obtainable, and take care to obtain it.

During the period February to May 1949, the ship sailed from Devonport to Malta, and proceeded to survey the channel between Malta and Sicily. For this purpose a chain of floating beacons was laid out, and, using a combination of taut-wire runs, radar ranges and horizontal angles from objects on land, the positions of these beacons were established with an accuracy of well within 1 cable. These beacons therefore provided a very convenient means of comparing a number of marine sextant fixes with known positions, as the ship was normally either close to a beacon, or within sight of the shore, at the time of morning and evening twilight.

As a result of the willing cooperation of the captain and officers—for which I should like to take this opportunity of publicly expressing appreciation—some 24 sets of sights were taken over a period of two months, and the results compared with the positions of the beacons. These sights are numbered 7–30 in Table I. The table shows not only the relationship of the fix to the known position of the ship, but also the nature and distribution of the errors of the individual position lines. The constant part of these errors, which does not affect the fix if the sights are properly distributed in azimuth, is due to personal error, erroneous dip and possibly to other causes.

For results numbered 1 to 6, for which no shore-connected fix was available, the errors are measured from the mean position of all available observations.

It is clear from the table that, due to the constant bias which generally appears

TABLE I. OBSERVATIONS ON H.M.S. *Dalrymple*, FEBRUARY TO MAY 1949

No.	Date	Observer	Observed Position		Distance from true position	Sight Errors		Conditions
			Lat.	Long.		Constant bias	Mean deviation	
			° ′	° ′		′	′	
1	a.m. Feb. 24	C	N. 48 33·2	W. 8 47·2	No shore connected fix available	−0·5	±0·1	Poor
2	a.m. Feb. 24	N	48 32·6	8 46·7		−0·5	0·1	Poor
3	p.m. Feb. 24	C	48 15·8	9 32·5		+0·5	0·3	Poor
4	p.m. Feb. 24	N	48 15·4	9 33·1		+0·3	0·5	Poor
5	a.m. Feb. 25	N	48 15·8	9 33·4		+0·3	0·3	Poor
6	p.m. Feb. 25	N	48 15·7	9 34·0		+0·5	0·4	Fair
7	p.m. Mar. 8	H	41 35·2	W. 9 27·2	*	+1·0	0·5	Good
8	p.m. Mar. 18	C	36 47·4	E. 1 48·1	*	−0·5	0·3	Good
9	p.m. Mar. 18	H	36 46·9	1 47·9	*	0·0	0·5	Good
10	p.m. Mar. 18	T	36 47·1	1 48·7	*	0·0	0·5	Good
11	a.m. Mar. 21	H	36 12·5	14 01·3	0′·2	−0·5	0·2	Fair
12	p.m. Mar. 28	N	36 01·5	14 25·2	0·2	−0·5	0·2	Good
13	p.m. Mar. 28	H	36 01·3	14 24·8	0·7	−1·3	0·7	Good
14	p.m. Mar. 28	T	36 01·4	14 25·3	0·3	0·0	0·5	Good
15	p.m. Mar. 28	C	36 01·5	14 25·1	0·3	−0·5	0·3	Good
16	p.m. Mar. 31	R	36 01·7	14 27·5	0·3	−1·0	0·3	Good
17	p.m. Mar. 31	H	36 01·3	14 27·8	0·4	0·0	0·4	Good
18	p.m. Mar. 31	C	36 02·1	14 27·3	0·6	0·0	0·4	Good
19	p.m. Apr. 5	C	36 00·7	14 24·0	0·3	0·0	0·2	Good
20	p.m. Apr. 5	T	36 00·5	14 23·3	0·6	0·0	0·4	Good
21	p.m. Apr. 5	H	36 00·4	14 24·5	0·4	−1·4	0·4	Good
22	p.m. Apr. 6	D	35 59·8	14 24·2	0·9	0·0	0·9	Fair
23	p.m. Apr. 6	R	36 00·3	14 23·9	0·2	+0·4	0·2	Fair
24	p.m. Apr. 6	H	36 01·3	14 23·9	0·8	−1·3	0·8	Fair
25	p.m. Apr. 12	H	36 35·5	14 51·6	0·5	+0·2	0·5	Good
26	p.m. Apr. 13	H	36 32·3	14 42·8	0·4	−0·7	0·4	Good
27	p.m. Apr. 13	T	36 31·6	14 43·3	0·4	−0·5	0·3	Good
28	p.m. Apr. 13	W	36 31·9	14 42·9	0·3	0·0	0·3	Good
29	p.m. May 2	H	35 00·6	14 13·9	*	+0·2	0·7	Fair
30	p.m. May 2	N	N. 35 00·6	E. 14 12·5	*	−0·7	0·6	Fair

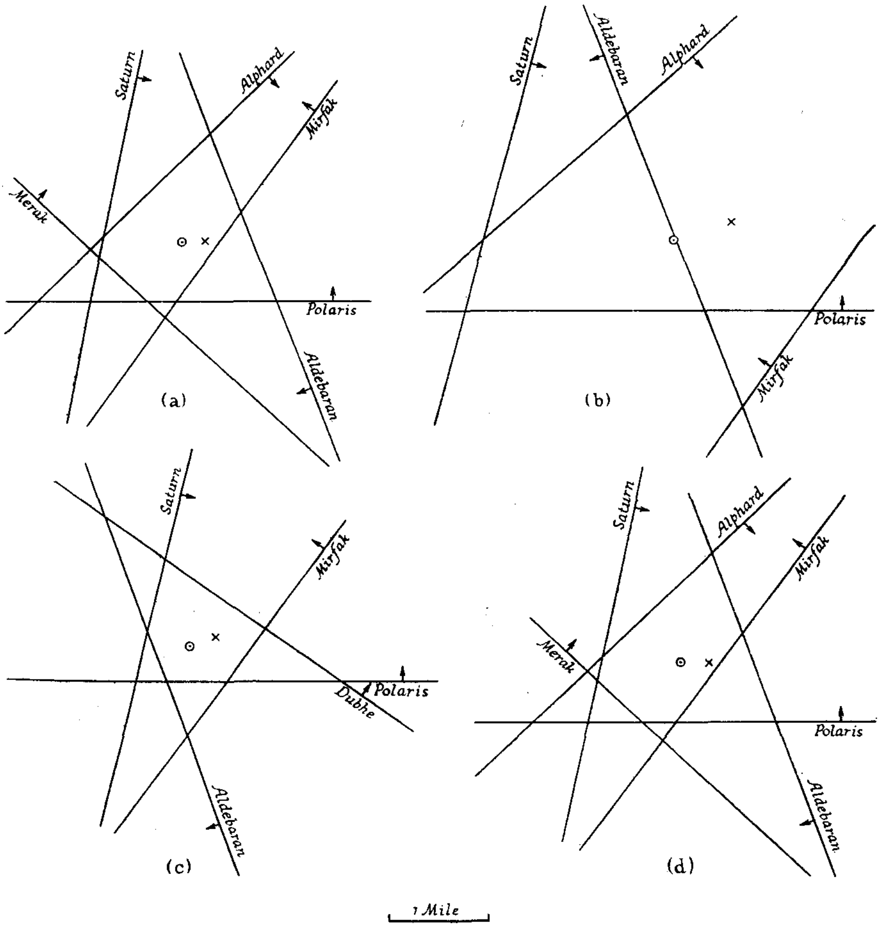
* True position known only to 1′·0.

In the 'constant bias' column : ± indicates the average sextant altitude was $\begin{cases}\text{high.}\\ \text{low.}\end{cases}$

https://doi.org/10.1017/S0373463300045355 Published online by Cambridge University Press

to be present in sight-taking, the information from a single-position line is rarely as accurate as that from a well-distributed set of sights.

It is clearly not possible to show the details for all of the individual sights, but one typical set for four observers—that for evening stars on March 28—is illustrated. The conditions during this period were fair to good. It will be seen



× . . *True position of the ship*
⊙ . . *Position deduced from the sights*

Fig. 1.

Plots of sights taken on the evening of 1949 March 28. The true position of the ship was N. 36° 01′.5; E. 14° 25′.5.

The sights were taken as follows:

(a) *By navigator.*

(b) *By myself. This set shows a large spread, probably due to the inexperience of the observer. Aldebaran had a very poor horizon and is given little weight.*

(c) *By Lieut. T. Although this appears a good set of sights three stars are towards and two away from the centre of the plot. Notice the effect on the errors as shown in the table.*

(d) *By Captain. The correspondence between this and set (a) is remarkable.*

The constant bias and the mean errors of the individual sights are given in the accompanying table.

that the observed position is in remarkably good agreement with the true position and that the comparison between observers shows a high degree of consistency.

The sights numbered 1 to 6 are to me even more remarkable in their consistency, as they were taken under very poor conditions. Before proceeding to Malta the ship was required to survey the area of the Little Sole Bank for reported shallow water. On arrival at the site two beacons were laid under very poor conditions, and the only means of fixing their positions was by astronomical sights. The captain and navigator obtained the results shown as sights 1 and 2 on the morning of February 24 when a very heavy sea was running, and a gale blowing. On the evening of February 24 and at both twilights on February 25, the captain and navigator obtained the results shown as sights 3 to 6 for fixing the second beacon. Here again conditions were very poor until the evening of February 25.

We found that the main aid to good fixing at sea was to obtain the sights with the brightest possible horizon, by means of good precomputation of altitudes and azimuths for presetting of the sextant. From observations made during this voyage we reckoned that stars and horizon are normally visible when the Sun is at a depression of between about 3° and 9° below the horizon. Therefore, unless the twilight is excessively long, a star globe set up for the time of civil twilight will give altitudes and azimuths within a degree or two for the whole of the observing time; it should enable stars to be picked up some minutes before they are visible to the naked eye, and provide sights with good horizons. The aim should then be to obtain sights in the quickest possible time, consistent with accuracy—we aimed to observe five stars, taking the mean of five altitudes for each, in ten minutes. This meant that if the first star was picked up early the set of observations was complete before the time of civil twilight, when the horizon was still good.

The preparation of the tabulated results of these observations has been simplified by the encouragement and assistance given by Mr. D. H. Sadler.

These notes are not intended as, and I trust will not be taken as, a reflection on the standard of navigation of Commander Sharpey-Schafer and his shipmates, but merely as a report on the standard which I found in H.M.S. *Dalrymple*—a standard which still seems exceptionally high.

Navigation and Oceanography

VICE-ADMIRAL SIR ARCHIBALD DAY, the Hydrographer of the Navy, who was chairman at the Institute discussion on 15 May 1953, has received the following comments from Rear-Admiral Robert W. Knox, Assistant Director of the U.S. Coast and Geodetic Survey.

I have just finished reading the discussion on navigation and oceanography appearing in the October 1953 *Journal of the Institute of Navigation*. This is of great interest to me, but I cannot agree with at least one statement, that by Captain Shaw (retired master mariner), regarding kelp in Alaskan waters. He states that when navigating in south-east Alaska, he always avoided the open channels and sailed through channels full of kelp. I have spent about 13 seasons in Alaska avoiding kelp except in small boat hydrography when we were engaged