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WHERE HAS SABLE ISLAND BEEN FOR THE PAST 200 YEARS?

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Abstract

The location of Sable Island (44°N, 60°W) has been positioned by six independent surveys over the past 200 years. This paper correlates the surveys based on the limited number of common points and comments on the surveying methods that were employed and concludes that the various positions are more due to the quality of surveying than to the shifting of the island. The implications, both in terms of hydrographic charting and legal basis of sovereignty of maritime areas, are also discussed.

INTRODUCTION

Sable Island is that crescent-shaped island 90 miles off Nova Scotia, Canada which conjures up thoughts of wild horses, or shipwrecks or shifting sands. This paper is not about the herd of wild horses that have inhabited the island for 200 years. Nor is it about the almost 200 known shipwrecks that are buried in the sand. Instead, by the end of this paper you might appreciate the fact that Sable Island is not shifting as much as other people have claimed it to be.

GEOGRAPHIC BACKGROUND

In many ways Sable Island is an anomaly. It is a crescent-shaped island of two parallel sand dunes 20 miles long by a mile wide that is situated 90 miles off the Nova Scotia coast, at 44°N latitude and 60°W longitude, almost at the edge of the continental shelf. According to the surveys and the relocations of the west lighthouse over the years, the island was longer and the line of dunes farther apart so that there used to be a tidal lagoon between them. The island is exposed to the erosive action

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of the Gulf Stream which flows eastward along both sides of the island, but primarily to the south of it. The last vestiges of the cold Labrador Current flow westward some distance north of the island creating fog banks when warm moist air meets its cold water. Sable Island's sand dunes rise to a maximum height of 25 metres and support only stabilizing grasses. Thus, the island and its sand bars, that extend off both the east and west ends of the island, are navigational hazards: the bars, the low profiles, the fog, the set and drift of the current and the fact that the island sits astride both the major transatlantic routes and the direct route home for many Grand Banks fishermen.

In the early 1800s, debates raged as to whether it was best to put lighthouse(s) on the island - thus tempting mariners towards the island to confirm their position - or whether to leave the island unlit - thereby encouraging mariners to keep well clear. In part, the debate was influenced by the capabilities of the light sources and optics of the day which were far inferior to present day equipment. Lighthouses were not built until 1873, but lifesaving stations were built and manned in 1801.

A mariner can only stay clear of a hazard if he knows where he is and where the hazard is. Thus, for the past 200 years hydrographers and surveyors have tried to position the island as accurately as possible to fulfill the second requirement. With respect to surveying, the island is also an anomaly. It is an isolated feature, not part of a continental coast or chain of islands where survey work could be carried out by triangulation. Instead, the island had to be astronomically positioned until after World War II when various airborne distance measuring techniques were developed, or until the 1970s when satellite positioning techniques became available. Survey work on the island has been frustrated by the fact that it is remote, there is no harbor, there are no permanent natural features and few permanent man-made features, and the shape and topography are not conducive to good survey quality.

Sable Island East Light is the key to the determination of the absolute location of the island over the years. It was built in 1873 as an octagonal wood tower. It was destroyed (perhaps just inoperable) in 1934 and replaced in 1935 "immediately westward of site of former light" (*Notices to Mariners* 217/34 & 197/35). It was moved further west in 1974 (Canadian Coast Guard construction date) and advertised in *Notices to Mariners* on 31 December 1976 as a new light. The Maritime Museum of the Atlantic, Halifax, has a photograph of, what is considered to be, the wood tower and steel tower side by side. (See Fig. 1.) There is a good survey connection between the pre- and post-1974 lights on the same geodetic datum to quantify that movement at 145.4 m (477 ft) on an azimuth of 265° 33'. Both reconstructions were in close proximity such that the same house was used as the lighthouse keeper's residence. The light became unwatched in 1960. Among all the *List of Lights, Buoys and Fog Signals* and *Notices to Mariners* as far back as 1912 no indication of other reconstructions have been founded.

On the other hand, West Light was built in 1873, moved in 1883, 1888, 1917, 1940 (to near the flagstaff at the Main Lifesaving Station whose astronomic coordinates were determined in 1851 and 1899, lighthouse positioned astronomically in 1947), 1951 (proposed site connected by survey to 1940 lighthouse), and 1971. Each time the move was eastward from one to three kilometres, except the last which was southeast by only 40 metres.

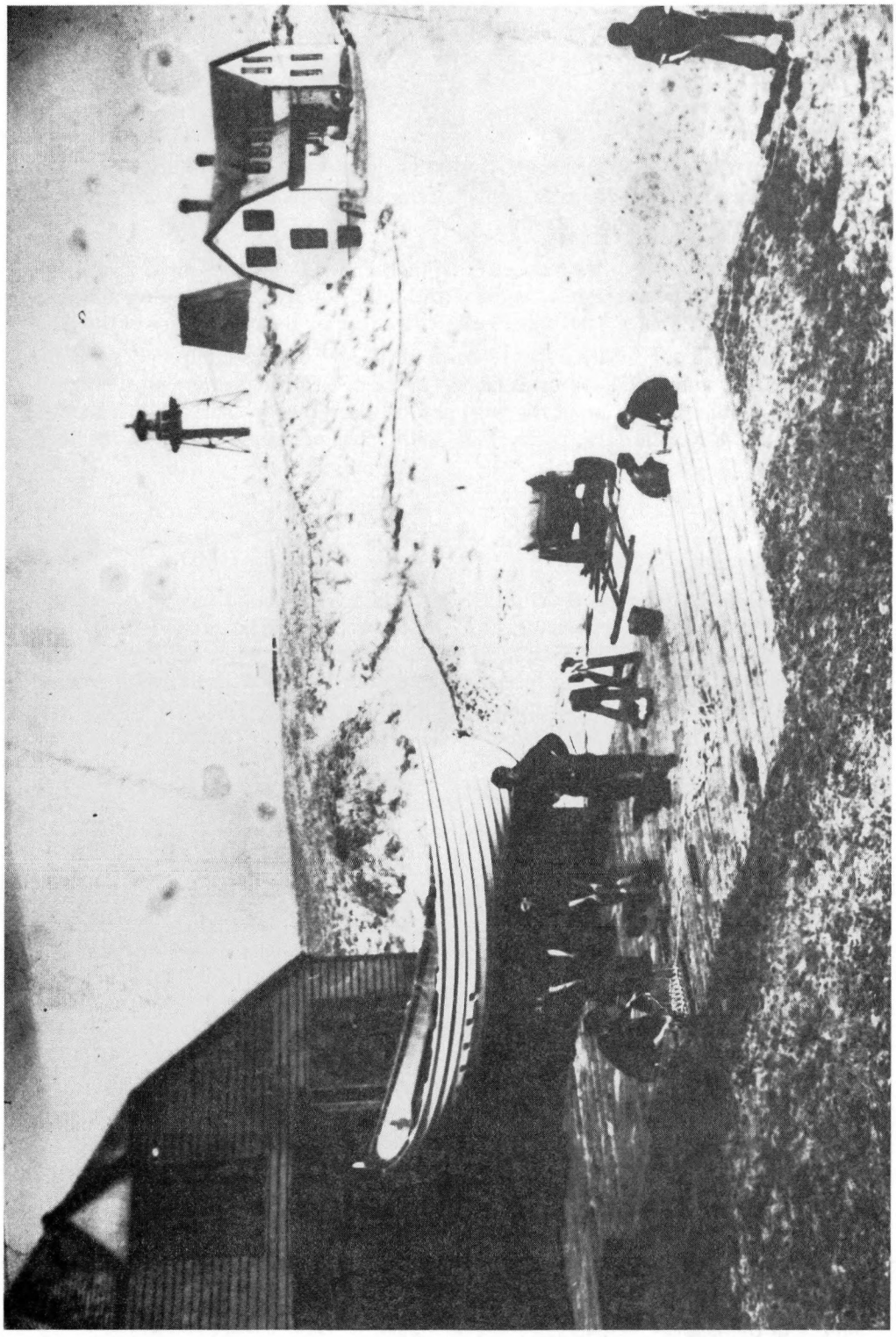

FIG. 1.- Sable Island Life Boat Station.

SURVEY WORK

1766-67

The 1766-67 map of Joseph DESBARRES places the island wholly north of 44°N and west of 60°W (map at Public Archives of Nova Scotia, Halifax and at Public Archives of Canada, Ottawa).

1828

The 1828 survey by Capt. Jones of HMS HUSSAR is compared by Capt. H.W. BAYFIELD in his 1851 survey as having the same east end, same central part but there was 2 miles of erosion at the west end between the two surveys [MCKENZIE 1984, p.lxxi, MCKENZIE 1986, p. 387]. The author has not personally seen the 1828 survey plan.

1851

In his 1851 survey, BAYFIELD's latitude determination seems correct and the longitude difference between the three locations on Sable Island and astronomic piers in Halifax and Quebec City also seems correct but the quoted longitude on chart 2171 is different from the present-day longitude by almost three minutes of arc because of the updating of longitudes in Canada circa 1855. The 1851 survey was done to resolve the discrepancies in the location of the island - one of the suspected reasons for so many shipwrecks.

1862

The British Admiralty also apparently have some survey work dated 1862 but from the editions of chart 2171 between 1853 and 1904 that are held at the Public Archives of Canada, it appears that the 1862 survey was only offshore soundings.

1899

The 1899 survey, by Wm.P. ANDERSON, C.E., Chief Engineer, Dept. Marine and Fisheries, Canada, was next and first published on the 1904 edition of BA chart 2171. The Main (Lifeboat) Station was positioned astronomically and that position agrees with later determinations. The rest of the island was positioned by ground surveys which have a 15% (approx.) scale error since the charted position of East Light is in error by 2.4 miles on a radial line from the Main Station. It appears that the scale error may be more or less constant over the island since the position of the houses near No. 3 Station agree favorably with their positions in the 1851, 1947 and 1963 surveys. The 1941 Edition of the British Admiralty chart 1651 uses this 1899 survey of the island.

1947

The next survey was in 1947 by W.H. STILWELL of the Geodetic Survey of Canada. He positioned the East and West Lights astronomically and traversed between them as a check. The misclosure of 168 feet (1 part in 413) was attributed to observing errors in the astronomic observations (±100 ft (±30 m) in latitude and ±550 ft (±166 m) longitude at each site) and to deflection of the vertical. He also positioned by traverse and by triangulation the proposed site of the West Light that was finally commissioned in 1951. CHS plan (S-117) at a scale of 1:63,360 (1"=1 mile) of the island was published in 1947 and it incorporates STILWELL's observations. This rendition of the island is shown in the 1962 Edition of BA chart 1651 and in the 1952 New Chart, CHS 4490. It is CHS 4490 that is used as a reference chart in the Territorial Sea Geographical Coordinates Order [CRC 1978, c. 1550].

1952-59

Prof. H.L. CAMERON, Acadia University, did some research into the stability of Sable Island in the early 1960s and published an often quoted paper, *The Shifting Sands of Sable Island*, in which he provides additional coastlines of Sable Island in 1952, 1955 and 1959. His original compilation of map comparisons is held at the Public Archives of Nova Scotia, Map Division. Since the three coastlines added nothing to the absolute position of the island, this original source material was not copied, although the author has a copy of his published paper. Prof. CAMERON has made the comparison between various epochs by keeping the east end of Lake Wallace (the once large interior lagoon) at a constant location. He also has not recognized the scale problem in the 1899 survey, which is discussed later in this report. Therefore, his results show that the island wandered more widely than, in fact, was the case.

Modern surveys

The 1963 Aerodist survey, 1976 Doppler satellite survey, 1984 Laplace azimuth and Doppler satellite surveys and 1991 differential GPS positioning just strengthen the geodetic precision.

ANALYSIS OF MAPS AND CHARTS

Figure 2 shows the effect of accepting the maps and charts at face value as to location. The position of features that are known not to have moved are in radically different locations. Although it is normal to think of events in chronological order, it is necessary to use the reverse chronological order to bring all the old surveys up to the present day by relating common features to where they are now known to be located.

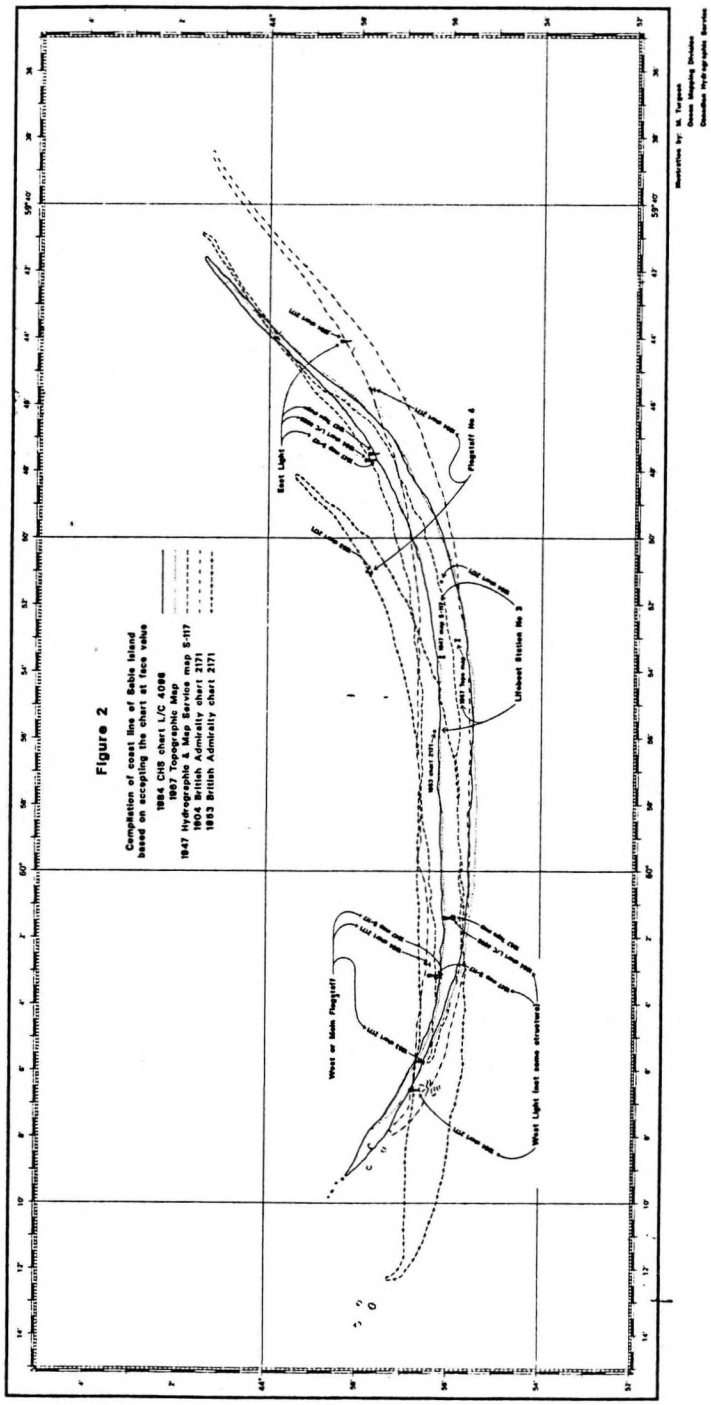

FIG. 2.- Compilation of coastline of Sable Island based on accepting the charts at face value.

NAD83 versus NAD27

Since geodetic coordinates have to be related to a specific datum, the geodetic coordinates listed in this paper are related to North American Datum of 1927 (NAD27) since there is not yet a full set of NAD83 coordinate values and since all charts and maps referred to in this paper that are related to a geodetic datum use NAD27 coordinate values.

The accepted NAD83 position of the survey point 'Red' is still the 1990 adjusted value which uses the 1976 and 1984 Doppler satellite determinations. The unconstrained 1991 GPS positioning of the same station provides an independent verification of its position.

NAD83 (1991 GPS)	43° 57′ 42.781"N, 59° 47′ 11.322"W		
NAD83 (1990 Adj)	43° 57′ 42.789"N, 59° 47′ 11.306"W		
Difference	-0.008"	0.016"	(0.42 m)

The difference between the two geodetic datums can be demonstrated by the comparison of the NAD83 and NAD27 coordinates of 'Red'. Essentially, 'Red' can be considered the origin of the coordinate system for the island because it is the survey point that was positioned by Doppler satellite and GPS techniques.

NAD83 (1990 Adj)	43° 57′ 42.789"N, 59° 47′ 11.306"W		
NAD27 (1985 Adj)	43° 57′ 42.551"N, 59° 47′ 14.088"W		
Difference	0.236"	-2.782"	(62.25 m)

1984 CHS Chart L/C 4098

The 1984 CHS chart L/C 4098 is the most recent published map or chart of the island and is used as a basis to compare all the other maps and charts. A composite map showing the movement of the island (or lack of it) is given as Figure 3. Chart 4098 is based on surveys of the specific infra-red photography taken at the time of low water to get a crisp definition of the Low Water Line. The waters around the island were surveyed by regular hydrographic means of launches steaming parallel lines roughly perpendicular to the shore and bottom contours. The nearshore area and bars at either end were surveyed by a few sounding lines and air-photo interpretation of the color photographs or by photogrammetry of stereo air photos taken simultaneously from a fixed frame attached to a helicopter [KERR 1983].

The positions of survey points on the island were computed in 1983 and are an amalgamation of surveys since 1963. Traversing by electronic distance measuring methods establish the scale to a few parts per million, azimuth control by sun shots control the orientation to a few seconds of arc, and Doppler satellite positioning control the absolute positioning to within a few metres. In 1984, the Geodetic Survey of Canada added more Doppler satellite positioning and a Laplace azimuth (azimuth derived by star shots coupled with astronomic longitude) to control the azimuth to a few tenths of a second of arc. The 1985 revised NAD27 position of station 'Vern' in the title block is insignificantly different from the 1983 position:

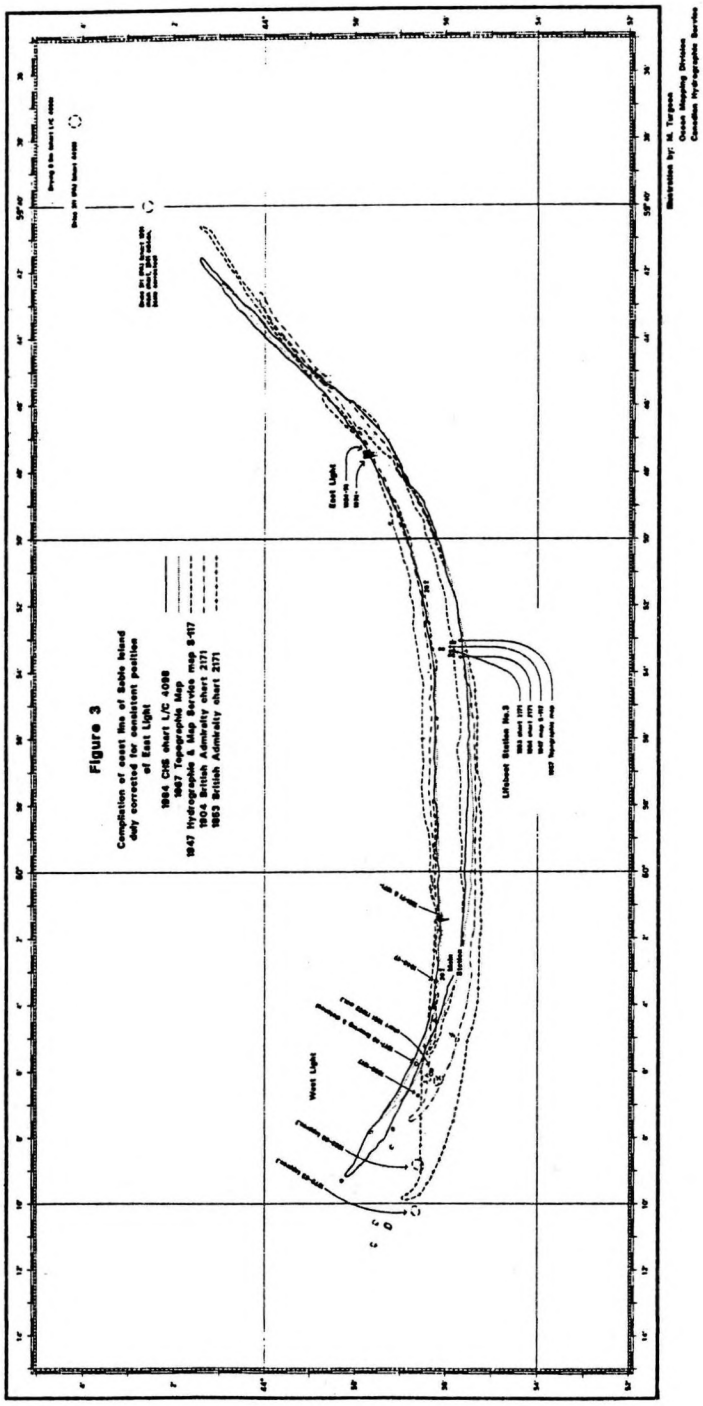

FIG. 3.- Compilation of coastline of Sable Island duly corrected for consistent position of East Light.

1985 adjusted position	43° 56′ 12.834"N,	60° 04′ 30.037"W	
1983 adjusted position	43° 56′ 12.82 "N,	60° 04′ 30.04 "W	(Title Block)
Difference	0.014"	-0.003"	(0.4 metres)

1967 Topographic Map

The 1967 First Edition of the 1:50,000 National Topographic map of Sable Island was based on air-photos and field surveys done in 1963. Again scale was provided by electronic distance measurements, azimuth by sun shots, and absolute positioning by Aerodist lengths from four first-order triangulation points in Nova Scotia to an accuracy of ±10 metres. The position of the East Light (1934-74) has since been modified:

1985 adjusted position	43° 57′ 36.088"N,	59° 47′ 22.439"W	
1963 adjusted position	43° 57′ 36.252"N,	59° 47′ 22.269"W	
Difference	-0.164"	0.170"	(6.3 metres)

1947 Map S-117

The 1947 survey by W.H. STILWELL of Geodetic Survey of Canada and published as map S-117 by the Hydrographic and Map Service of Canada is based on the astronomic positions of the East (1934-74) and West (1940-47) Lights. He also traversed (by steel tape) between the two lights and misclosed by 168 feet or 1 part in 413. The astronomic positioning was done by the equal altitude method; i.e., observing stars as they crossed a specified (usually 60°) altitude. This method is usually accurate to a second of latitude and about 7.5 seconds of longitude (i.e., 0.5 seconds of time). The position of East Light (1934-74) has since been improved:

1985 adjusted position	43° 57′ 36.088"N,	59° 47′ 22.439"W	
1947 astro. position	43° 57′ 39.64 "N,	59° 47′ 38.87 "W	
Difference	-3.552"	-16.431"	(381.1 metres)

The difference in position is caused, to a large extent, by the astronomic to geodetic differences. As a coarse check to prove that it is mainly an astro-geodetic difference, the proposed site of the 1951 West Light can be compared to the 1963 adjusted position.(The 1985 adjusted position was not computed.)

1963 adjusted position	43° 55′ 54.925"N,	60° 01′ 24.784"W	
1947 astro. position	43° 55′ 59.34 "N,	60° 01′ 39.88 "W	
Difference	-4.415"	-15.096"	(361.9 metres)

A more independent check is provided by the comparison between astronomic and geodetic coordinates at the 1984 Laplace station ('Red'):

1985 adjusted position	43° 57′ 42.551"N,	59° 47′ 14.088"W	
1984 astro. position	43° 57′ 47.36 "N,	59° 47′ 22.81 "W	
Difference	-4.809"	-8.722"	(244.1 metres)

The difference between the 1947 and 1984 astro-geodetic differences is totally within the expected accuracy of measuring latitude (±0.3 seconds for Horrebow-Talcott method and ±1.0 second for Equal Altitude) and longitude (±1.0 seconds for Meridian Transit and ±7.5 seconds for Equal Altitude).

1899 Survey

The 1899 survey done by Wm.P. ANDERSON, C.E., Chief Engineer, Dept. Marine and Fisheries, only positioned the Main Flagstaff (near the 1940-47 West Light). Either, he would have observed the sun at local noon for latitude and in the morning and afternoon as it crossed various altitudes for longitude (Bayfield's method in 1851), in which case he would have used a mercury bath as an artificial horizon; or, he observed stars as they crossed his local meridian noting either the elevation angle to determine latitude or the time to determine longitude. The latter method was used in the Great Lakes surveys by the forerunner of the Canadian Hydrographic Service. As Chief Engineer, this organization was under his charge [FILLMORE and SANDILANDS 1983, p.66]. Position accuracy by either method is typically several tens of seconds of latitude and longitude, particularly longitude because ANDERSON's time would have to have been brought by chronometer from Halifax. (STILWELL had the advantage of short-wave radio time signals.) The comparison between his position of the flagstaff and STILWELL's position of the 1940-47 West Light are sufficiently good as to indicate no major positioning problems.

1947 astro. position	43° 55′ 59.34 "N,	60° 01′ 39.88 "W (lighthouse)
1899 astro. position	43° 56′ 24. "N,	60° 02′ 47. "W (flagstaff)
Difference	-24.64 "	-67.12 "W (1628.3 m)

When the 1899 survey (i.e., Fairsheet B8922, the 1904 edition of chart 2171 or the 1941 edition of chart 1651) is brought to the scale of chart 4098 (1:100,000) and the flagstaff is positioned on the appropriate hill (20± metre spot on 4098), the position of East Light is in error by 2.4 nautical miles on a radial line from the flag-staff. This is the first indication of a major scale error in ANDERSON's work. ANDERSON was a Civil Engineer who was the Chief Hydrographer's immediate superior. He would not have a lot of practice in hydrographic survey techniques and I would guess that he might have applied the ship triangulation method of extending control that had been successfully done by the Chief Hydrographer in the 1890s in Lake Erie between Long Point and Point Pelee where he had anchored rafts with survey targets in the lake and then intersected them, and the adjacent survey points, from various points on shore. He then carried the triangulation calculations through these intersected points. Gross errors in the Lake Erie survey were detected by astronomic observations at every major triangulation point (every 10± miles) and eliminated by re-measuring the triangulation. ANDERSON, when he applied the same technique, was faced with an Atlantic swell, tidal currents, and did not have check astronomic positions. Nevertheless, the error appears to be in the overall scale which would , more likely, find its source in the one length that was measured to control the scale of the whole survey. When the chart is reduced to the correct distance between the flagstaff and East Light (knowing that the 1873-1934 East Light is only slightly east of the 1934-74 position), then the position of the houses at No. 3 Lifeboat station fall within a reasonable distance (1/4 mile) of their position on the 1853,

1947 and 1967 maps. The chart shows the No. 4 flagstaff that is used in the locating of the 1851 survey.

1851 Survey

The 1851 survey by Capt. H.W. BAYFIELD was done near the end of an illustrious career as a hydrographer. He regularly endured great hardships and took painstaking care to get his surveys correct. And indeed they were! According to his journal, he observed the astronomic position (see above for method) at the east and west ends and at the Main Station. He brought 13 chronometers with him and calibrated them at Arichat Island before and after the trip to Sable Island. According to BA chart 2171 (1853 edition) the East Point has a position of 43° 59′ 05"N, 59° 48′ 27"W but the fair sheet describes the longitude relative to Dockyard Tablet, Halifax, and Observation Bastion, Quebec City. Therefore, BAYFIELD's values for the longitude of these two points are:

Dockyard Tablet, Halifax	63° 37′ 47.4"W,
Observation Bastion, Quebec City	71° 16′ 00.4"W.

On the 1829 BA chart 319 of Quebec City (surveyed by BAYFIELD in 1827), the position of the Observation Bastion is quoted and this position can be compared to its transferred position onto the 1990 edition of CHS chart 1316 of the Port of Quebec:

1990 CHS chart 1316	46° 48′ 56"N,	71° 12′ 41"W	
1829 BA chart 319	46° 49′ 08"N,	71° 16′ 00"W	
Difference	-12"	-3′ 19"	(4435 metres)

The 1854 original printing of BA chart 2320 of Halifax Harbour, which was surveyed by Capt. BAYFIELD in 1853, and also the 1869 reprint of the same chart show the location of the astronomic pier in the Halifax Naval Dockyard. When this position is transferred to the modern chart of Halifax Harbour (CHS chart 4202) by its relationship to nearby cultural features; e.g., roads and buildings such as the Citadel, and the positions quoted on or derived from the older charts, the positions are:

1990 CHS chart 4202	44° 39′ 38"N,	63° 35′ 17"W	
1869 Reprint of BA chart 2320	44° 39′ 38"N,	63° 35′ 10"W	
1854 BA chart 2320	44° 39′ 37"N,	63° 34′ 57"W	
Derived from BA chart 2170		63° 37′ 47.4"W	
		-2′ 30" ±	(3300 metres)

The position of West Flagstaff, which later became Main Flagstaff can be compared with the 1899 and 1947 positions:

1947 astro. position (of 1940-47 West Lt)	43° 55′ 59.34 "N,	60° 01′ 39.88 "W	
1899 astro. position	43° 56′ 24. "N,	60° 02′ 47. "W	
1853 astro. position	43° 56′ 33. "N,	60° 05′ 44.6 "W	
		-3′ 00" ±	(4000 m)

Each of the 1853 West Flagstaff, Halifax (as derived from the 1853 BA chart 2171) and the 1829 Quebec City positions appear to be too large by about three minutes of longitude, confirming a systematic longitude error (relative to Greenwich) throughout Eastern Canada at this point of time.

In 1852, the longitude of Halifax was corrected to agree with the longitude of Harvard University through the exchange of telegraphic time signals. [THOMSON 1978]. Thus in 1853, at the time of the survey of Sable Island, BAYFIELD was in the midst of changing longitudes. He had the old version of longitudes, based on Quebec City, and the new version of longitudes based on Harvard and a major difference of 3 minutes of arc between them. This may explain why he quotes the two sets of longitude differences on fair sheet L7820. In 1855, the longitude of Quebec (the base station for longitudes in Canada at the time) was amended by about three minutes of arc following longitude difference determinations with Harvard University [THOMSON 1978].

If one accepts BAYFIELD's position of the island at face value from the 1853 edition of chart 2171, then all information is too far west by 4.4 km (2.4 n.m.). Main Station and eastern flagstaff are capable of being used to locate the island, since it was 22 years before the construction of the first two lighthouses.

From BAYFIELD's journal, one can read that he left Cdr. SHORTLAND to do the topographic and hydrographic survey of the island after having secured assistance from the Lifesaving staff. Thus his survey was confined to small boats. The Fairsheet shows adequate evidence that he triangulated the length of the island using hills on either side of Lake Wallace since it shows the elevation of the many hills that he used. There does not appear to be any scale problem in the comparison of this survey with any survey after 1900.

CONCLUSIONS

The conclusion that can be drawn from all the maps and charts is that there have been a multitude of positions for Sable Island (see Figure 2), more due to the quality of the surveying than to the wholesale shifting of the island. These differences have been resolved in Figure 3. The accuracy of relating these old coast lines in the modern day geodetic reference system is still limited by the old surveying methods of positioning features. This is demonstrated by the various locations of Lifeboat Station No. 3 on Figure 3 which shows that positions are only accurate to about a quarter nautical mile.

HYDROGRAPHIC IMPLICATIONS

The significance of the multitude of independent surveys of Sable Island that have only now been correlated shows that modern charts, particularly ones used in

electronic charts, must recognize that old survey positions, particularly isolated islands, are not as accurate as those determined by modern survey methods.

The 1851 survey by Capt. BAYFIELD shows that the origin of astronomic longitudes of old surveys must be considered since the base station for eastern Canada was updated in 1855 by three minutes of arc. There are still several CHS charts (and probably of other nations too) based on astronomic datums where the astronomic/geodetic differences are in the order of 30 arc seconds or more.

The 1899 survey by ANDERSON shows that all surveys where scale (length) was extended through either ship or conventional triangulation are very susceptible to error. It is the author's experience of analyzing other ship triangulation surveys that errors are not usually as large as exhibited here, since the error is apparently almost constant throughout the island, the errors not so much due to the ship triangulation method *per se* but due to the baseline length determination. It is utterly surprising to the author that there was no check on the scale of the survey either by a second length determination or by a second astronomic observation.

The 1947 survey provides examples of astronomic to geodetic coordinate differences that are significant; e.g., 1/4 mile, given present day navigation equipment such as Loran-C, Doppler satellite and GPS.

LEGAL IMPLICATIONS

According to the 1958 Territorial Sea Convention and the 1982 Law of the Sea Convention, "the normal baseline of the territorial sea is the low water line along the coast as marked on large-scale charts officially recognized by the coastal state." [*United Nations Convention on the Law of the Sea* 1983, Article 5]. On the presumption that this legal basis for determining the territorial sea limit was a legal presumption before being codified in 1958 and 1982, one can then state that the 1851 survey, as reflected on chart 2171 would have endured from the 1853 edition until the first edition of the same chart showing the 1899 survey, which may well have been the 1904 edition. The 1899 survey would have endured from then until the first navigational chart showing the 1947 survey, which might have been the 1952 edition of CHS chart 4490. The 1947 survey would have been accepted as the low water line from that time until the publication of CHS chart L/C 4098 in 1984.

Given Canada's history of being a British colony, or part of the British Empire or Commonwealth, it is not presumptuous to say that British Admiralty charts would have been officially recognized by Canada. In the case of the 1899 to 1947 time frame, there would have been even less qualms for Canada to accept the British Admiralty chart since it was based on a survey by a senior officer of the Canadian government.

The topographic map published in 1967 and the 1947 special map, S-117, would not have been recognized as appropriate charts for the depiction of the low water line because they are not, in themselves, navigational charts although the latter

was obviously used as the basis of the 1952 edition of CHS chart 4490 and the 1962 edition of BA chart 1651.

"So what?", you may ask. The legal implication came to the fore recently when a possible litigation in Canada posed the question as to where the territorial sea limit was in 1941 with respect to other positions determined in the 1970s. The court action has since been dropped based, in part, on these technical findings. This paper is not the forum to discuss the pros and cons of the case, since there were other facets, but is used to demonstrate that the exercise is not trivial. So, as we have discussed, the territorial sea limit of Sable Island in 1941 would have been based on the 1899 survey of the low water line even with its 15% scale error, and with the quarter mile astro/geodetic deflection that was evident from the 1947 survey. The fact that the 1947 survey, being only six years later, is probably more likely to reflect the 1941 coastline than the 1899 survey, is irrelevant when 1941 is the date in question. Thus, the 1899 survey has to be accepted as being the official source for the baseline of the territorial sea limit although one now know that it is not positioned geodetically and that it has a large survey scale error.

SUMMARY

The results of the analysis of the positioning of Sable Island show that the island has physically moved far less than has previously been thought, that there has been at least one major survey error committed, that most survey data is within the expected accuracy limits of the equipment and procedures used, that there are hydrographic charting repercussions to incorporating old surveys into new charting, and that there are legal implications in terms of sovereignty that still persist even after the surveys have been superseded.

ACKNOWLEDGEMENTS

A research paper such as this one cannot stand alone on the modern day evidence, but depends on the quiet, diligent, work of various archivists who are always pleasant in retrieving the material from their storage places. Patrick MCINTYRE of the Map Library of the Public Archives of Canada, Garry SHUTLAK of the Public Archives of Nova Scotia and Mary BLACKFORD of the Maritime Museum of the Atlantic (Halifax) are such people. A special word of thanks goes to Rear Admiral J.A.L. MYRES, R.N., and the archive staff at the Hydrographic Department of the Royal Navy at Taunton who provided the rough sheets and fair sheets of the 1851 and 1899 surveys and copies of BA charts 1651 and 2171.

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