Bowditch 2002 Errors and Issues

Dr.Robin G. Stuart

Valhalla, New York, 2015

Original text in black

Comments and suggestions in blue

2202. Calculations of Piloting (p.330)

- **Distance to the visible horizon in nautical miles** can be calculated using the formula:

  $D = 1.17\sqrt{h_f}$, or

  $D = 2.07\sqrt{h_m}$

depending on whether the height of eye of the observer above sea level is in feet (h_f) or meters (h_m).

The two constants 1.17 and 2.07 are inconsistent and it is the latter that is incorrect.

$$D = 1.17\sqrt{h_f} = 1.17\sqrt{3.28084 \times h_m} = 2.12\sqrt{h_m}$$

Uncorrected

Dip of the sea short of the horizon can be calculated using the formula:

$$Ds = 60\tan^{-1}\left(\frac{h_f}{6076.1d_s} + \frac{d_s}{8268}\right)$$

where Ds is the dip short of the horizon in minutes of arc; h_f is the height of eye of the observer above sea level, in feet and d_s is the distance to the waterline of the object in nautical miles.

This formula can be derived by setting H = 0 in the formula in the section in Bowditch that follows and solving for tan a. The argument of the arctangent function is necessarily small and so the formula can be simplified to the more easily evaluated form in which it is usually given

$$Ds = 0.56578\frac{h_f}{d_s} + 0.4158d_s$$

There is no practical benefit to retaining the arctangent.

Still unnecessarily complicated

Distance by vertical angle between the waterline and the top of an object is computed by solving the right triangle formed between the observer, the top of the object, and the waterline of the object by simple trigonometry. This assumes that the observer is at sea level, the Earth is flat between observer and object, there is no refraction, and the object and its waterline form a right angle. For most cases of practical significance, these assumptions produce no large errors.

The description applies for objects short of the horizon and has been shown to be adequate by W. C. Marlow in "Vertical Sextant Angles Short of the Horizon", Navigation: Journal of The Institute of Navigation, Vol. 28, Spring 1981, pages 55-64. Following the steps described yields

$$D = \frac{H}{6076.1 \tan h_s}$$

where D is the distance in nautical miles, H is the height of the object in feet and h_s sextant angle from the waterline to its top. This formula generates Table 16. For small h_s this is often simplified to

$$D = 0.56578 H / h_s$$

for h_s in arc minutes. It would be helpful to have these formulas give explicitly.

It appears that a section heading may be missing here as the explanation immediately continues with a formula used for objects beyond the horizon

$$\mathrm{D} = \sqrt{\left(\frac{\tan\alpha}{0.0002419}\right)^2 + \frac{\mathrm{H}-\mathrm{h}}{0.7349}} - \frac{\tan\alpha}{0.0002419}$$

where D is the distance in nautical miles, a is the corrected vertical angle, H is the height of the top of the object above sea level, and h is the observer's height of eye in feet. The constants (0.0002419 and 0.7349) account for refraction.

Whereas the formula above may be applied both to objects short of and beyond the horizon it is only needed in the latter case. The text does not explain its purpose or what is meant by the term "corrected vertical angle". This formula generates Table 15 and is fully explained on p. 560 (although it appears with a typographical error there). Either a fuller explanation of reference to p. 560 is needed.

The formula is derived by simple geometry taking account of the curvature of the Earth and introducing refraction by using the old surveyor's standard trick of increasing the radius of the Earth by a prescribed amount. W. H. Guier in "Note on Determining Range from Sextant Altitude", Navigation: Journal of The Institute of Navigation, Vol. 15, Winter 1968-69, pages 366-375 proves that the above formula is an adequate approximation to his more rigorous range equation.

Unchanged

2410. Composite Sailing (p.350)

$$\cos DLo_{VX} = \tan L_x \cos L_v$$

The subscripts on the right hand side are of a different style to the left hand side and usage elsewhere in the text. It would be better written

$$\cos DLo_{vx} = \tan L_x \cos L_v$$

Corrected

2416. Mercator Sailing (p.358)

$$D = 284.0 \text{ arc min} \times \sec(58.2°)$$

$$D = 537.4 \text{ miles}$$

Answer:

$C = 301.8°$

$D = 538.2$ *miles*

The value of *D* given the worked problem and the final answer are inconsistent. $D = 538.2$ *miles* is the correct result. Note also that $D = 284.0$ *arc min* $\times$ *sec (58.2°)* yields $D = 538.9$ *miles* due to rounding.

Inconsistency corrected, rounded value of $D = 538.9$ is used. Elsewhere in the chapter intermediate angles are carried to 4 decimal places. Not doing it here results in an error of 0.7nm.

2416. Mercator Sailing (p.360)

L_1	=	75°31.7'N
l	=	3°58.8'N
L_2	=	71°32.9'N
M_1	=	7072.4
M_2	=	6226.1
m	=	846.3

The values of M_1 and M_2 are incorrect and this is not the result of interpolation. Direct calculation of the Meridional Parts gives

M_1	=	7072.6
M_2	=	6226.3

Linear interpolation from adjacent values in Table 6 produces the same result. Note that the value for *m* is unchanged and so the error does not affect the final answer.

Unchanged

Table 15. Distance by Vertical Angle Between Sea Horizon and of Object Beyond Sea Horizon (p.560)

The table was computed using the formula

$$D = \sqrt{\left(\frac{\tan\alpha}{0.0002419}\right)^2 + \frac{\text{H}-\text{h}}{0.7349} - \frac{\tan\alpha}{0.0002419}}$$

The correct formula is

$$D = \sqrt{\left(\frac{\tan\alpha}{0.0002419}\right)^2 + \frac{\text{H}-\text{h}}{0.7349}} - \frac{\tan\alpha}{0.0002419}$$

as can be easily verified by checking against the values in Table 15. This formula also appears on page 330.

Corrected

Table 16. Distance by Vertical Angle Measured Between Waterline at Object and Top of Object (p.560)

The procedure for calculating the table is described but no formula is given. The table is generated using

$$D = \frac{H}{6076.1\tan h_s}$$

where D is the distance in nautical miles, H is the height of the object in feet and h_s sextant angle from the waterline to the its top.

Unchanged