'Mammoth Vessels and Coriolis Force'

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Mr. ANNEVELD's paper (24, 50) would have us believe that the effects of coriolis force on a ship may become appreciable as ship size increases. It is true that the drift angle does increase as the ship's size increases, because the coriolis force given by equation (1) increases as $(\text{length})^{3.5}$ and the resistive forces increase as $(\text{length})^3$ (on the assumption of geometrically similar ships and Froude scaling). However there is a fundamental flaw in his argument because equation (2) only applies to a vessel with zero forward speed. Moreover the effect of coriolis drift will also be to induce a yaw angle on the ship (because the centre of pressure is forward of the centre of gravity, where the coriolis force may be assumed to act) and this will automatically cause the helmsman or autopilot to apply starboard rudder in the northern hemisphere. This will immediately produce a force on the ship in the port direction, i.e. opposing coriolis force.

We may write the equations of motion of the ship as follows:

$$\text{Sway: } Y_v v + Y_\delta \delta + Y_c = 0 \qquad \text{(i)}$$
$$\text{Yaw: } N_v v + N_\delta \delta = 0 \qquad \text{(ii)}$$

where

v = sway velocity/U
δ = rudder angle (radians)
Y = sway force/$\frac{1}{2}\rho L^2 U^2$
N = yaw moment/$\frac{1}{2}\rho L^3 U^2$
U = forward speed

These equations have been written in non-dimensional form in order that values for the force and moment coefficients obtained from the literature may readily be substituted. It will be noted that the sway damping coefficient, Y_v, depends upon the first power of the drift velocity, and not the second as stated by Mr. Anneveld: this has been found in innumerable model experiments conducted at an appreciable forward speed.

Relevant values for the coefficients are taken from reference 1, in which tests were conducted on a model of the tanker *Tokyo Maru*, L 290m $\times B$ 47·5m $\times$ T 16m $\times$ C_b 0·805. The speed was 3·92 m/sec. or 7·6 kt. (Fn = 0·0675). Measurements were made both in deep and shallow water, and the following values were given:

	Depth = ∞	Depth = 24m (1·5T)
Y_v	−22·5	−48·3
Y_δ	3·49	3·98
N_v	−5·03	−15·8
N_δ	−1·85	−2·03
δ/v	−2·72	−7·8
$Y_\delta \delta/v$	−9·5	−31·1
Yc/v	+32·0	+79·4

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The above values should all be multiplied by 10^{-3}. The coefficients Y_δ and N_δ are the ones given for a speed of 6m/sec., but in general they are little altered by changes of speed.

Now the coriolis force, non-dimensionalized by division by $\frac{1}{2}\rho L^2 U^2$, amounts to $4C_b\, BT\, \dot{w} \sin \phi / LU$, and when we insert the values given above, and $\phi = 50°$, we obtain, in deep water, $v = 0.2°15$, and in shallow water, $v = 0.087°$. For the same conditions, Mr. Anneveld predicts a drift angle of

$$0.0136 \times 57.3 \sqrt{\frac{47.5}{3.92} \frac{0.805}{0.95}} = 2.°5$$

Thus even in deep water the effect will be less than one-eleventh of his prediction, and in shallow water (such as is highly important for a tanker manœuvring) he has over-predicted by a factor of 28.

It does not appear that Mariners need be unduly worried about coriolis, after all!

REFERENCE

1 Fujino, M. (1968) 'Experimental studies on ship manœuvrability in restricted waters. Part 1.' *International Shipbuilding Progress*, vol. 15, August 1968, pp. 279–301.