OPTIMUM WIDTH OF HARBOUR ENTRY SWEPT CHANNEL AT COCHIN

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ABSTARCT

The width is limited by the paucity of mine-sweepers that can be engaged continuously on the job. The width should be sufficient to cover the likely lateral sets in a ship's passage upto 30 fathom line. In calm weather and most of the channel length coinciding with direction of currents if any, the required channel width is less than 100 yds. and may be swept again and again by the same two mine-sweepers (LL sweep). In rough weather or when direction of currents and drifts is different, in order to use the above narrow channel Decca navigation should be provided. Electric or Magnetic field of a Guide Cable can also be used; marking buoys can be used but they are not entirely dependable on account of drifts or interference or use by enemy.

In the absence of marked channel or navigational aids, a wide channel is necessary depending on the lateral set by currents. Even when this lateral set is small, the width should be at least 600 yds. to cope with spontaneous shifts of course in bad weather for traversing say 26 miles long channel. It should, however, be borne in mind that suggested width is for traversing a 26 miles long channel. If the required length is reduced, the width will also be reduced.

Spontaneous set in the course of a vessel proceeding at a given speed in a particular time is calculated in appendices.

Requirements where there is no lateral drift

The optimum width will depend on class and speed of ships, the nature of sea, swell and weather, and any lateral currents or wind induced drifts. For a ship that can sail exactly along a set course, the width required is just the width of the effective magnetic field of the ship. This width for cruisers is about 50 yards. In case the sea is calm and the ship is properly balanced in construction, the spontaneous alterations in course will have random distribution and lateral shift will not be more than say 15 yards (Appendix I) so the width of the channel required would be 65 yards. For a ship that tends to swerve to some extent preferably in one direction than the other, the likely lateral shift is 400 yards (Appendix II) and so the width of the channel should be 400+50=450 yards.

Requirements in the presence of lateral drift

Consider a lateral component of current of s_1 knots. As the distance to 30 fathom line (limit of mine swept channel) is 24 nautical miles at Cochin the shift will be $\frac{24}{3} s_1 \times 2000$ yds. If speed of ship is 8 knots, the shift is 600 0 s_1

yards. Now s_1 at Cochin is not likely to be more that 1.Sin 10°=·17 knots *i.e.*, nearly 1000 yards. For, at most an apparent drift current of 1 knot may be effective at 10° angle to the shortest route to 30 fathom line. In such a case the effective width required will be 1000+400+50= 1450 yards. Lateral current is not important near shore, but correction due to this should also be allowed for.

Optimum width without Navigational Aid

To be able to use above information, current measurements in different seasons at about 10 fathom line should be taken. The estimate in para 5 is likely to be the upper limit. Also most common value of p of Appendix II should be investigated and seasons known when p is inordinately high. p is a measure of preference in direction if any, in the spontaneous alterations of course. Once currents and drifts are very well charted, the swept channel should be along the path of current for most of its length, this will materially reduce the optimum width. The figure of 1000 yards can safely be reduced to say 150 yards, and one can perhaps get away with only 150+400 (of App. II)+50=600 yards wide channel. So a six hundred yards wide channel may be used all the year around except when large changes in currents are expected and lateral drifts are likely to increase. The optimum width will be less if the required length of the channel is reduced. For example if the channel is considered to be only upto 15 fathom line, *i.e.*, length is 13 miles, the figure of 600 yards is reduced: 75 yards (due to small current drift)+200 (preferred spontaneous wheel)+50 (spread of field)=325 yards.

Sweep requirements

An LL sweep is effective only over about 100 yds. For sweeping 600 yds. wide channel, six journeys or 3 round trips to the 30 fathom line of a mine-sweeper are required. This means about 150 nautical miles of mine-sweeping. In day-time a mine-sweeper can perhaps travel only 100 miles. So a force of four mine-sweepers will give little more than a single sweep over the channel each day. This is not enough protection. A large number of mine-sweepers therefore will be required to give adequate protection. For reduced length of the channel, the width required is less and so number of mine-sweepers engaged will also be less.

The major requirement is due to navigational requirements in relatively rough weather. For calm weather and adequate orientation of channel with respect to currents, the optimum width is only 65 yards which can be covered by a single LL sweep and same two mine-sweepers can cover this width again and again giving about 4 sweeps over the channel which is not bad.

Necessity of Navigational Aid

For bad weather and random or shifting currents, the best alternative to a large number of mine-sweepers is to have controlled navigation. For ground wave Decca coverage the accuracy is limited to only about 50 yards and so the optimum width will be 100 yds. which can be covered by a single LL sweep. Thus in calm weather and no lateral drifts due to currents a narrow channel without navigational control is effective while the same narrow channel is sufficient in disturbed weather if Decca aid is provided. Since, Decca aid is expensive, a submerged guide cable can be used, alternating field impressed on

the cable can be radiated and detected by suitable field measuring coils on the ship, or magnetic field due to a steady current in the guide cable can be detected.

An elementary alternative to radio aid may be marking the channel by anchored buoys, but these buoys cannot be entirely dependable due to drifts and these may also be meddled with by the enemy, or the channel may then be used by the enemy.

Timing of passage of ships at any particular place

Finally, it is important that the ships or mine-sweepers do not pass the channel in a time table that can be forecast by the enemy as mines can be constructed that will go off after a particular number of actuations. It may be recommended that the mine-sweepers do not sweep the same exact length of channel everytime. They should sweep sometimes to 28 fathoms line and sometimes to 32 fathom line thus making the time of passage at a particular spot somewhat uncertain. The ships leaving the harbour should be given their time of departure on a random basis each day. The incoming ships should usually be escorted behind the inward sweep of mine-sweepers.

APPENDIX I

Problem—How much a ship can move laterally out of its set course in fully calm weather when there is no preferred direction of spontaneous alteration of head.

Solution—The lateral drift from dead-reckoned position will be small depending upon the speed of the vessel. It will be a magnitude less than 5 S ft. where S is speed in knots except in one in 100,000 cases.

Spontaneously the ship will experience at random a slight +ve (in one lateral direction) or a negative alteration of course. The helsman will try to correct it immediately. Sometimes the maximum shift will be less, sometimes more. If largest shift is 4°, on the average maximum shift will be 2°, In a representative case the ship swerves out of set course and in a few seconds it reaches 2°, when the helsman has noticed it, he corrects the course back to normal in another few seconds. During this total period of about 5 seconds the mean path can be supposed to be at 1° angle to set course. Now if such an alteration of course were to occur a number of times, the lateral set will increase correspondingly. But since the alterations are at random they tend to cancel out. The largest lateral shift will only depend on the probability of finding a number x of alterations in succession in the same direction. If x is not large, the probability is $(\frac{1}{2})^x$. The value of x which will be exceeded only in one in 100,000 cases (a safe limit) is obtained by solving the equation.

$$\left(1 - 10^{-5}\right) = \int_0^x 2^{-x} dx$$

From this x=17.

As this number can occur in both +ve and —ve direction. The lateral shift is:

$$2 \times 17 \times \frac{5}{3600} \times s \times 6000 \times \sin 1°$$
$$= 5s \text{ ft.}$$

Thus if near a harbour, speed is low, *i.e.*, 8 knots then max. shift is 40 ft.

APPENDIX II.

Problem—How much a ship can move laterally out of its course when there is no lateral drift or current, but the spontaneous alterations of course have predominance in one direction (let this be called +ve direction) due to disturbed sea or currents etc.

Solution—In extremely disturbed weather or bad propeller adjustment the ship will again and again try to swerve into the +ve direction. Let the number of negative shifts in any given large time be 1/p of the total number. Thus p=2 for random distribution and p=∞ for strongly biased movement. The maximum shift is given by $33\times(p-2)/p$ H. S. yards using the arguments in Appendix I, where H is the number of hours and S is speed in knots. For random motion this shift is zero and for strongly biased motion it is 33 H. S. yds. In coastal waters, unless there is a hurricane or strong swell, for average ships largest p will be of the order of 4. If the speed as before is taken as 8 knots and time spent as 3 hours to get to say the 30 fathom line from the harbour, the lateral shift that is likely to occur is $33\times\frac{4-2}{4}\times3\times8=396$ yds.

If there are strong seasons, the shift is likely to be in +ve or −ve direction and so total lateral distance that may be covered by different ships in a year is $2\times396=792$ yards.

At Cochin the seasons or direction of swell are not likely to alter much. The largest lateral distance covered may be taken to be 396 yards all the year round.

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