RECONSTRUCTION AND ANALYSIS OF NAVAL EXERCISES AND TRIALS

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1. THE ANALYSIS OBJECTIVE

1.1 Reconstruction and analysis of naval exercises and trials are undertaken to assess the performance of weapon systems, command and control procedures, and the implementation or otherwise of optimum tactical policies in the search, tracking and localisation phases of an attack.

1.2 In the context of this paper we are concerned with the performance of sonar systems in the search phase and whether maximum tactical advantage was taken of the underwater environment. Clearly, in order to establish optimum tactical policies within a given environment it is necessary to predict using acoustic propagation models the expected detection range. One objective of the analysis work is therefore to assess the accuracy of the prediction method by comparing predicted ranges with those actually achieved.

2. THE RECONSTRUCTION PROCESS

2.1 The tracks of surface ships and submarines involved in the trial or exercise are reconstructed from on-board positional information. The information is input to the Semi-Automatic Reconstruction and Analysis Facility (SARF) developed by YARD Ltd and based on Intergraph 1200 (Micro VAX II) with interactive dual screen workstations. Other data extracted from onboard records and stored in the SARF include information on hydrosounder policy and contact history.

2.2 The tracks are reconstructed from the input positional data using the interactive display capability. The positional data is often contradictory with satellite fixes showing a slightly different track to that indicated from onboard operational plots. The skill of the analyst is used to obtain the 'best track'. Following the reconstruction, which may involve up to fifty ships and submarines in the case of major NATO exercises, the SARF can zoom-in on particular interactions, between towed array ship and submarine say, and produce Event-Time plots for the period of interest. Range prediction data in the form of predicted range or estimated signal excess (ESE) can be added to the plot.

2.3 An example of a SARF reconstruction and a typical Event-Time plot are shown in Figures 1 and 2.

3. THE ANALYSIS PROCESS

3.1 Obviously the analysis objectives can differ depending on the nature of the exercise or trial but two questions always need to be answered:-

1) Why was contact lost?

2) Were there any missed opportunities?

To illustrate how these questions can be answered an Event-Time plot is shown in Figure 3 that illustrates many of the frequently occurring 'events'.

Event 1: Sudden loss of contact can be explained by submarine (S/M) moving to periscope depth (PD) and increasing speed. Bathy records may also show that S/M has moved out of strong sound-channel.

Event 2: Hydrosounder (H/S) switched off. Contact not possible even at short ranges.

Event 3: Contact lost despite closing range. Oceanography may show loss of sound channel or approach of ocean front. Possible loss if relative bearing shows contact in end fire beam (maximum self noise) of sonar.

Event 4: Contact held despite increased range. Check bathys to establish if oceanographic conditions have changed. Run acoustic model to predict range. Large ranges may be confirmed due to improved oceanography.

Event 5: No contact at short range despite good acoustic predictions. Investigate possible 'missed opportunity' by re-analysing raw data tapes. A missed opportunity would be identified if it was found that inappropriate sonar settings had been used. In many cases, however, high ambient noise from merchant shipping is found to mask any chance of detection.

4. SONAR RANGE PREDICTIONS

4.1 As discussed above acoustic propagation models are used together with the sonar equation to predict the detection range. The question that always needs to be answered is how accurate are the predictions and can they be improved. Information on initial detections form a database against which acoustic predictions can be compared. Work is ongoing to establish the causes of discrepancies between predicted and achieved ranges. This can be due to a number of factors such as deficiencies in model physics, environmental data, sonar parameters or alertness of the sonar operator.

5. TACTICAL ASSESSMENT

5.1 The performance of both active and passive sonars is highly dependent on the environment in which they operate. Sonar ranges can be reduced by a factor of ten or more between areas of good propagation and those of poor propagation. Tactics must be developed to exploit these conditions.

5.2 The track reconstruction clearly depicts the search pattern and area of search undertaken, for example, by a group of frigates maintaining a barrier defence against approaching submarines.

5.3 A detailed oceanographic analysis of the area is then undertaken based on bathy data taken by the frigates together with data taken by other units just prior to the operation. Acoustic propagation models are then used to predict sonar performance from which 'good' and 'bad' water can be identified. The work of the analyst is to assess if forces were deployed to take maximum advantage of the environmental conditions.

5.4 Figure 4 presents an hypothetical scenario. Three frigates have been deployed to predetermined search areas to detect submarines approaching from the North. Has best use been made of the water conditions?

Search Area A: This straddles an ocean front across which propagation is difficult and therefore this tactic will give an opportunity of detection on both sides of the front and within the frontal zone itself.

Search Area B: Searching in open water with no oceanographic features will give good opportunities of detection.

Search Area C: In order to maintain the barrier axis this search area has been assigned totally within 'bad water'. The chances of detection are poor. Given that no enemy submarines are already within the 'bad water', a good case can be made for moving the search area further North to C'. However, environmental conditions are just one of the many constraints placed on the Force Commander when assigning search areas. There may well be good operational reasons why the barrier axis cannot be moved.

6. CONCLUSION

6.1 This paper is intended to stress the importance of acoustic propagation models both in the analysis process and in assessing whether optimum tactical use was made of the environment. The need remains to improve the accuracy of acoustic models, particularly in the range dependent environment.

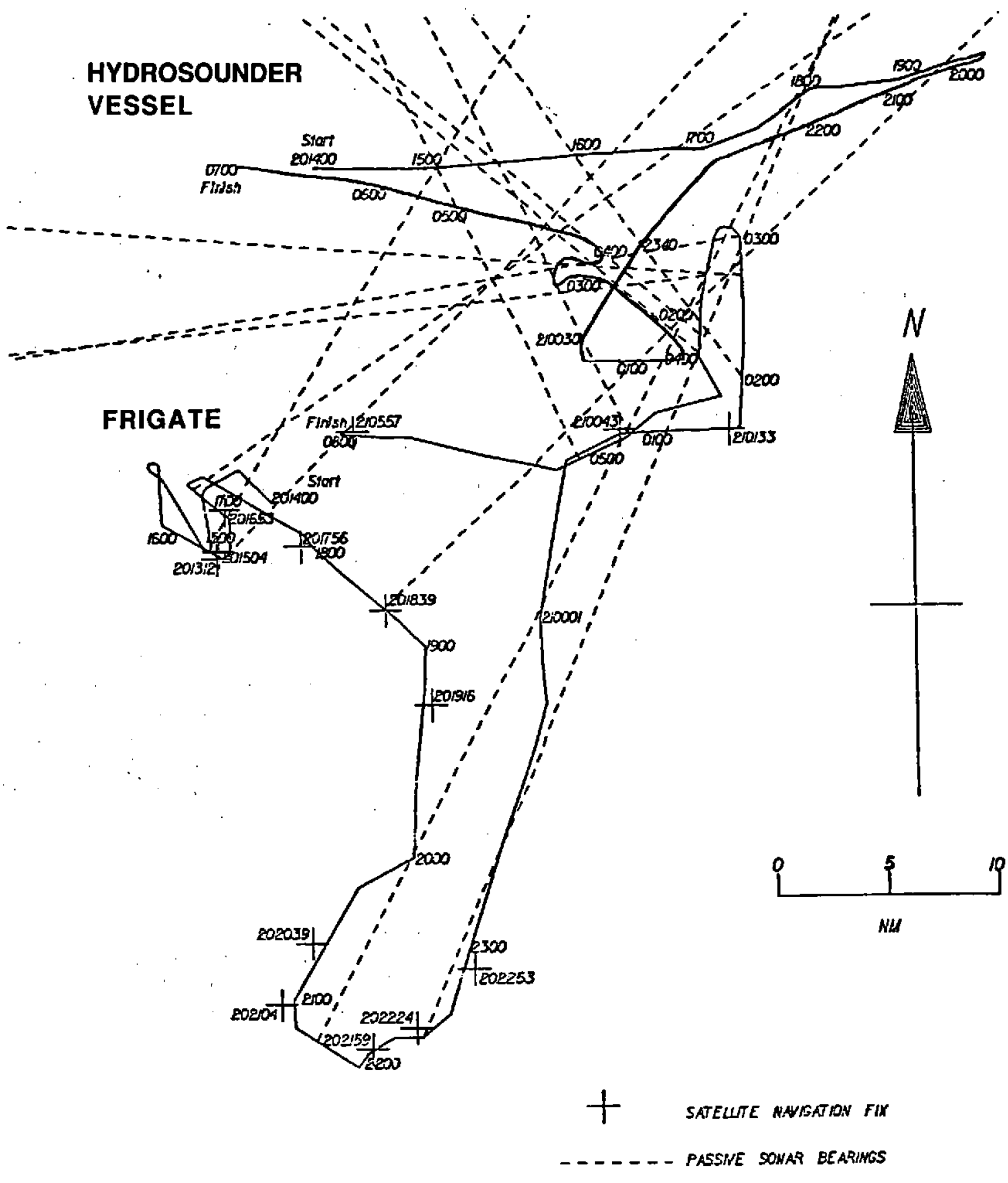

Figure 1 - SARF RECONSTRUCTION

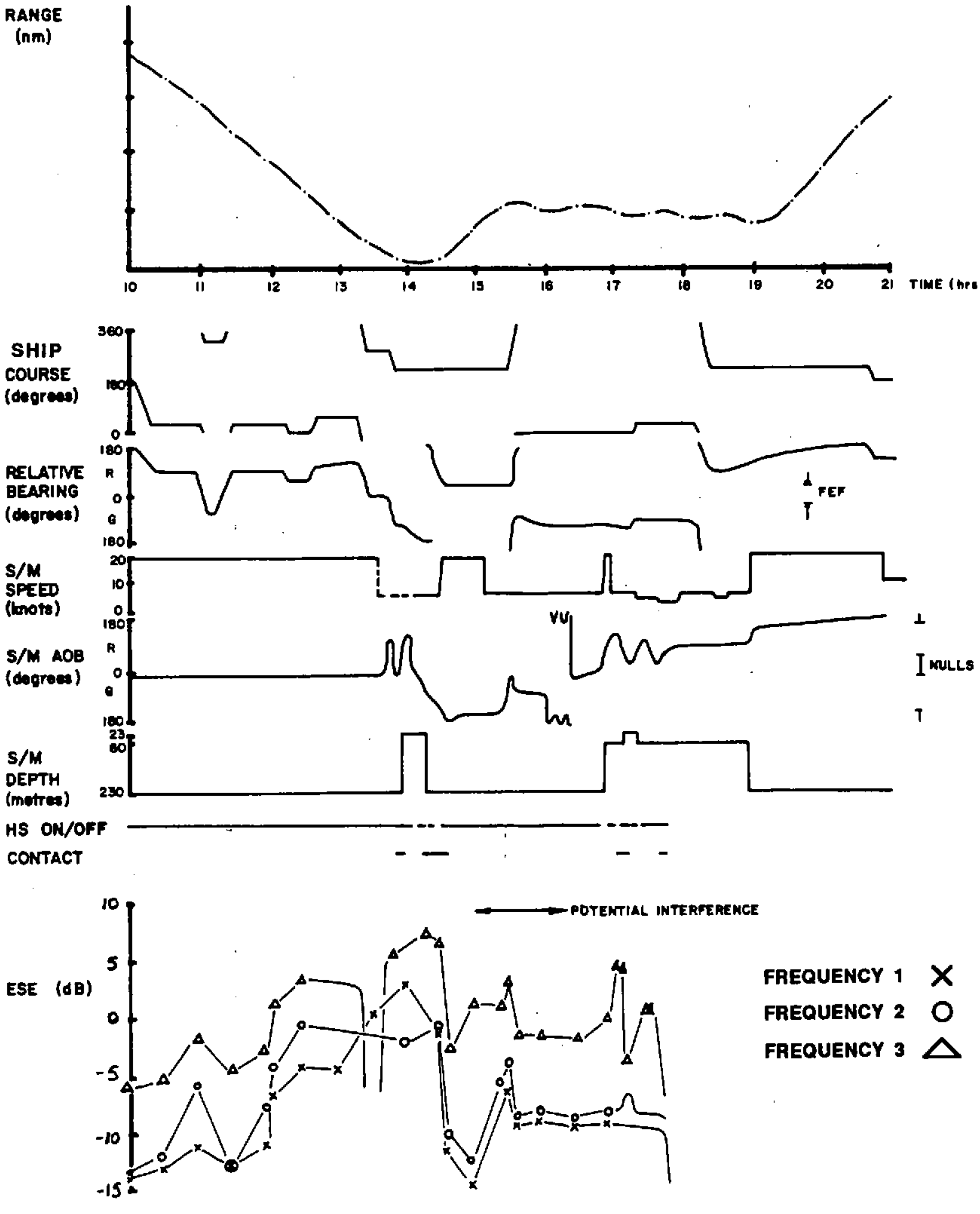

Figure 2 - EVENT TIME PLOT

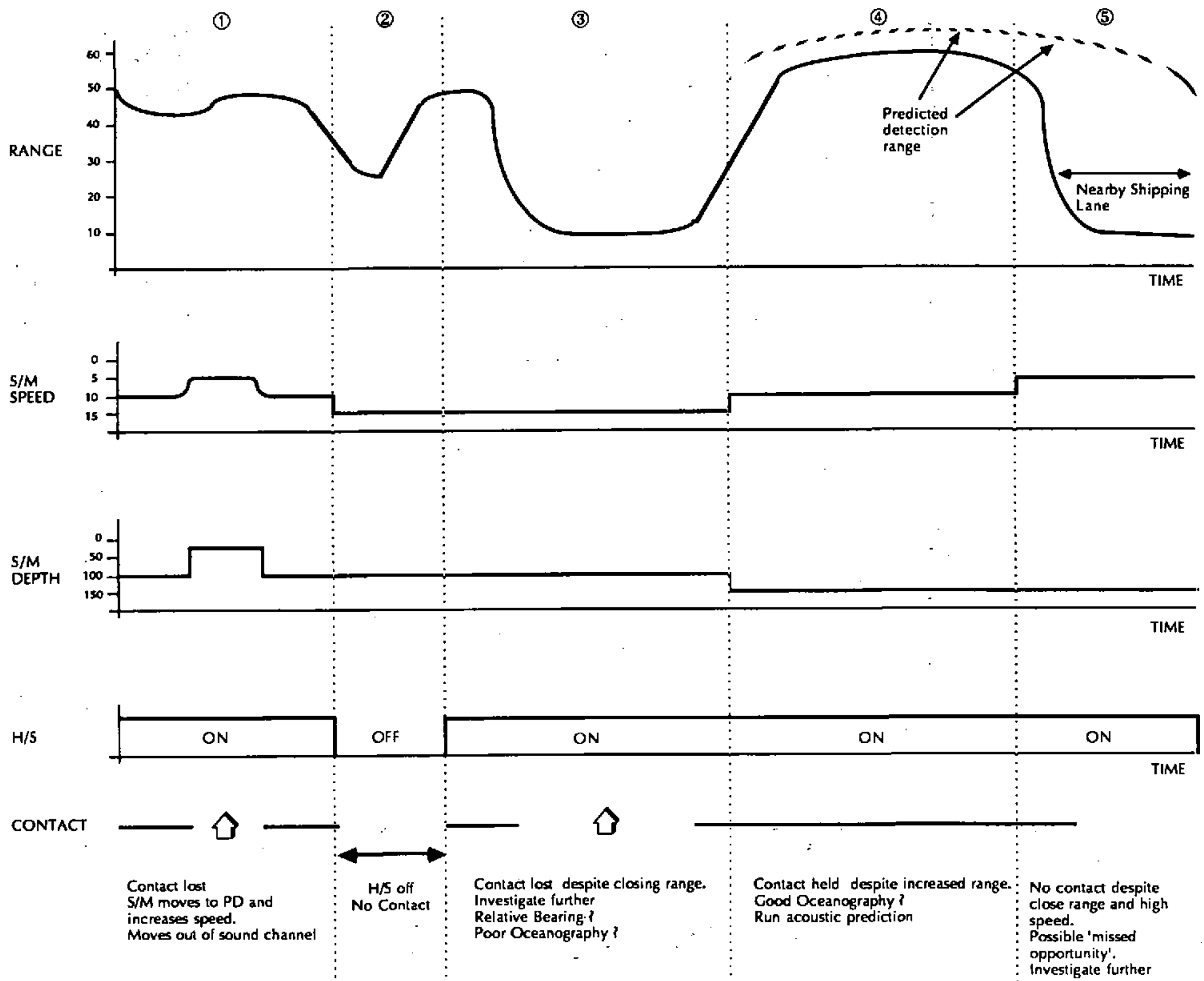

Figure 3 - EVENT TIME PLOT

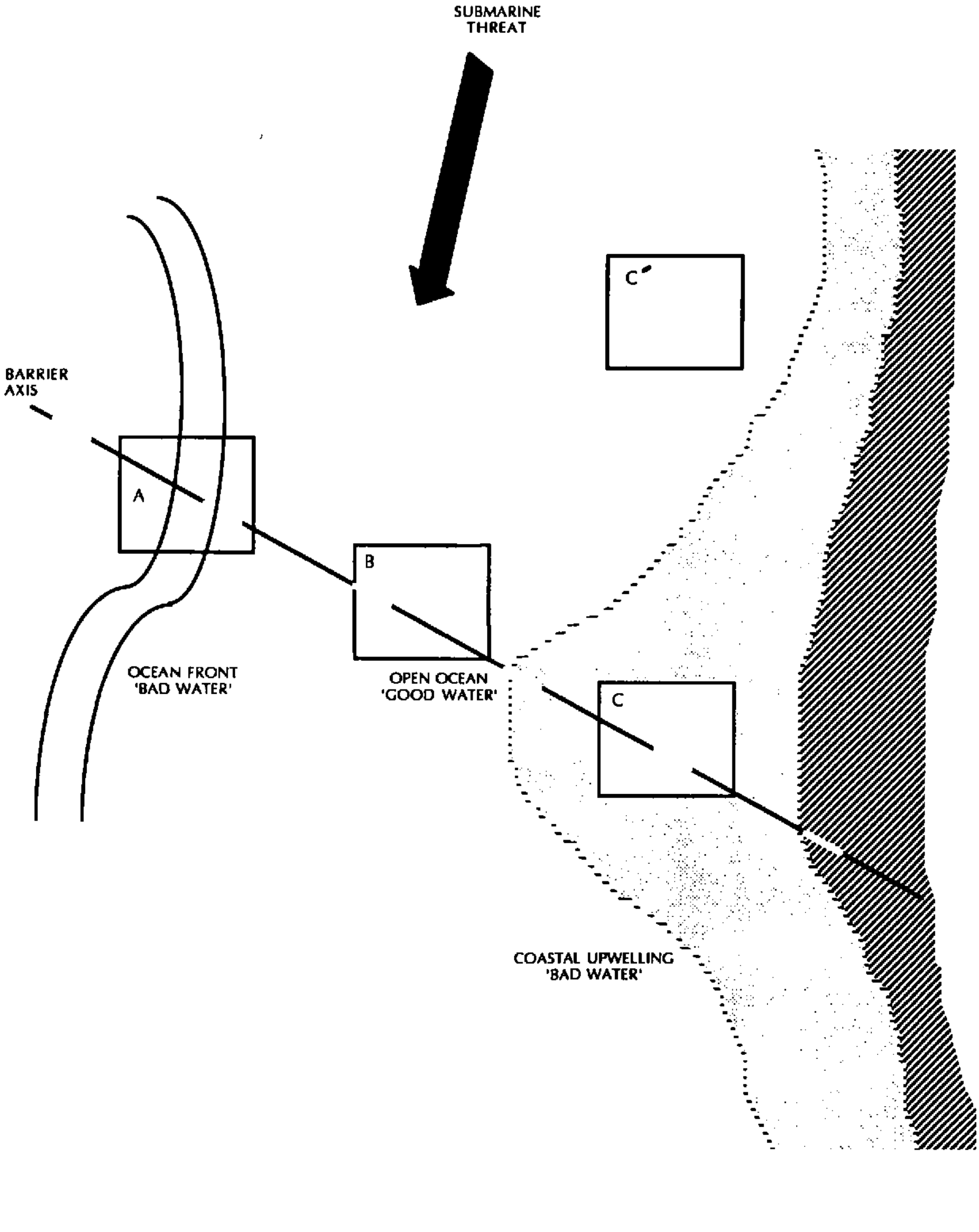

Figure 4 - HYPOTHETICAL SEARCH PLAN