



## HMAS *Sydney* and HSK *KORMORAN*: Possible and Probable Search Areas

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This report was commissioned by the Western Australian Maritime Museum. The report is based on material, analyses and arguments supplied by Alan Pearce (CSIRO), John Penrose (Curtin University of Technology), Madeleine Gauntlett (Curtin University of Technology), Ray Steedman (Steedman Engineering), Gordon Laffer (Consultant) and Ean McDonald (Consultant) as well as the authors.



Report - Department of Maritime Archaeology, Western Australian Maritime  
Museum, No. 71

Australian Cultural Development Office

Department of the Arts and Administrative Services

## 1 SYNOPSIS

At a recent forum held to mark the 50th anniversary of the engagement between HMAS *Sydney* and HSK *Kormoran* (McCarthy & Kirsner, 1991), several papers used historical and/or search and rescue (SAR) data to estimate the position of the wrecks. The search areas considered by these papers covered approximately two degrees of longitude and one of latitude. The aims of this paper are as follows. First, identify the processes which contributed to the variation among papers at the forum. Second, select preferred values for each process by eliciting relevant information from experts with theoretical and applied knowledge about the relevant variables off the coast of Western Australia. Third, use the values thus defined to specify probable and possible search areas. These goals were achieved, and two search areas have been defined. Considerable convergence was achieved among the sources used to identify the probable target area, however the possible target area is substantially larger than the areas defined prior to the searches for Titanic and Bismarck (Ballard, 1987, 1990).

## 2 INTRODUCTION

The HMAS *Sydney* forum included six papers which involved systematic attempts to either estimate the positions of *Sydney* and/or *Kormoran*, or to answer the question of whether or not the ships could have been lost at or near the position given by *Kormoran* survivors (Hughes, 1991; Kirsner, 1991; McCormack & Steedman, 1991; McDonald, 1991; Pearce, 1991; Penrose & Klaka, 1991). Where the second question is concerned, the papers were in agreement; the ships could have been lost at or near the position given by *Kormoran* survivors. Where the first question is concerned however, the papers provided the Western Australia Maritime Museum with a range of possible locations which cover up to one degree of latitude and as much as two degrees of longitude. The aims of this paper are as follows; firstly, to identify the critical processes (i.e., wind, sea surface current, etc) which underlie this variation, secondly, to co-ordinate and describe a review process which was implemented to identify consensual estimates of the relevant value for each process, and, thirdly, to provide probable and possible estimates of the site or sites of the wrecks.

### Figure 1

## 3 HISTORICAL CONSIDERATIONS

Figure 1 has been included to place the following analysis in context. This figure depicts some of the positions provided by

officials and historians since the engagement. According to John Curtin for example (Montgomery, 1981), the battle took place "300 miles west of Carnarvon". Was the then Prime Minister of Australia just being geographically lax, for the position which he indicated was never even reached by SAR aircraft, or was he deliberately providing a false position for the benefit of his countries' enemies ? Ruge (1957), who, it may be assumed, had direct contact with Kormoran survivors, provided a similarly vague position, which receives no support from other sources. Gill (1957) used the position supplied by the Kormoran survivors, and assumed that the location supplied by them was accurate to the minute. It should be noted however that he used the initial co-ordinates despite the fact that this report did not include any reference to minutes as distinct from degrees. Among more recent accounts, Winter (1984) accepted the position provided by the Kormoran survivors, while Montgomery (1981, 1983) provided a new position just south of Cape Inscription.

Considered as a set, the positions provided by these accounts cover more than four degrees of longitude and nearly two degrees of latitude, about 80,000 km<sup>2</sup>. The analysis described below is based primarily although not exclusively on conventional Search and Rescue procedures.

The product is a by no means precise 'probable target area' of approximately 4,200 km<sup>2</sup>. For comparison, the final searches for Titanic and Bismarck involved areas of approximately 500 km<sup>2</sup>. It may be noted, furthermore, that Ballard (1987, 1990) and his colleagues had good reasons for being virtually 100% certain that the target areas actually included the targets. This degree of confidence is not justified for the 'probably search area' identified below. There are too many question marks hanging over our assumptions about the underlying variables. We have achieved a measure of consensus. But, unfortunately, variability in the direction and velocity of winds and sea currents is not achieved by consensus.

#### **4 OVERVIEW OF OBJECT SELECTION (§5), PARAMETER DEFINITION (§6), AND THE RECONSTRUCTION (§7).**

The reconstructions are developed in Sections 5, 6 and 7. Section 5 describes the procedures adopted to select and discard observations for use in the reconstructions. Five reconstructions are discussed in Sections 5 and 7. The first of these involves drifting objects without sailing potential; that is, the life-belts, floats, kennel and oil. The second reconstruction involves the two life-rafts with sailing potential. The first and second reconstructions follow conventional search and rescue methodology, except that the process is reversed. Instead of estimating where a life-raft may be found 100 or 200 hours after it entered the

water, the procedure adopted here works backwards from the positions where various objects were found, and provides an estimate of the position of the source of those objects.

The third reconstruction involves one of the life-boats which sailed more or less directly to the coast, *B/Meyer* (where the name is that of the sailor responsible for the life-boat). This reconstruction is based on a diary kept by one of the survivors, from that life-boat, von Malapert. This reconstruction probably applies to a second life-boat as well, *B/Kohn*, which reached a similar position on the coast shortly before *B/Meyer*.

The fourth reconstruction involves the third, fourth and fifth life-boats, *B/Detmers*, *B/Gosseln* and *B/Kuhl*. The reconstruction involving these vessels has been included in order to test the coherence of the results from the first three reconstructions. If all of the objects came from the same position, it must be possible to reconcile their movements from that position.

The fifth reconstruction involves the track followed by *HMAS Sydney* during earlier voyages under the same instructions. This reconstruction also amounts to a validity test. If it is assumed that *HMAS Sydney* was not specifically directed to search for *HSK Kormoran*, or any other vessel, it follows that she probably followed the same route on all of her voyages from Fremantle to Sunda Strait and vice versa.

The aim of the reconstructions is to use all available means to define possible and probable areas for the search for *HMAS Sydney* and *HSK Kormoran*. The combined use of the methods summarised above involves an application of a technique which is often referred to as 'converging operations' in other disciplines. The present application may be compared with 'triangulation' although, unfortunately, the data do not quite support this procedure.

Section 6 describes the parameters used for the reconstructions. Sea surface current, the Leeuwin current, wind, wind driven current, Coriolis Force, and leeway were all considered. In the last analysis however, only sea surface current, leeway (leeway is a fraction of wind) and wind are actually used in the reconstructions. It should be noted that this model departs

from search and rescue practice for both off-shore and on-shore conditions in Australia and elsewhere. The decision to omit the influence of these forces is discussed and justified in Section 6.

It may be apposite for the relevant bodies to examine the use of wind-driven current under off-shore conditions where the sea surface current values arguably include wind driven current and other Coriolis force effects.

**Table 1****5 OBJECT SELECTION****5.1 Overview**

Tables 1a and 1b summarise all of the available information about objects which were observed or recovered during and after the search and rescue operations off Carnarvon. Their positions is also indicated graphically in Figure 2.

Consideration of the arguments presented at and subsequent to the forum indicated that the data summarised in Tables 1a and 1b falls into two categories, concerning those which can and those which cannot be used to estimate point of origin. For example, the possibility that one or both of the rafts (see Table 1a: #1, #2) used wind-power compromised their value to the reconstruction. These objects were not therefore included in the basic reconstruction, although a supplementary reconstruction was conducted on the relevant data in order to assess the compatibility of their recovery positions with the estimated point of origin. The oil reported by a Catalina was discounted because it fell too far outside the area defined by the other drifting objects (Table 1a: #10). The raft discovered at Christmas Island was also discounted because the period (1876 hours) precludes accurate hindcasting.

**Figure 2**

Uncertainty about the tracks followed by the lifeboats (Table 1b: #11, #12, #13 & #15) indicated that, with the possible exception of *B/Meyer*, for which a diary record is available, they too could not be used for reconstruction of the point of origin. The observations extracted from accounts describing the history of the episode are noted, but they were discounted because precision was lacking (e.g., reference to "the morning" as distinct from a specific time), or because they were inconsistent with other data.

Consideration of the arguments presented at the forum produced a set of seven objects for which data is available (Table 1a: #3, #4, #5, #6, #7, #8, #9. This sub-set is described below, as well as the arguments which have been used to question the remaining objects. Dual process models, involving separate periods of drifting and sailing by the lifeboats, have been excluded from the basic reconstruction. However, the routes of the life-boats have been reconstructed in order to reconcile discrepancies between their positions, which fall into two distinct groups, and between their positions and the positions of the drifting objects.

**5.2 Drifting objects without sailing potential****5.21 Lifebelts and Floats**

There being no question of sailpower for the *Sydney* Lifebelt recovered by *Wyrallah* (Table 1a: #4), the *Kormoran* Lifebelt recovered by *Wyrallah* (Table 1a: #5), or the *Kormoran* Floats recovered by *Wyrallah* (Table 1a: #6) , these items are included. The *Sydney* Lifebelt recovered by *Evagoras* (Table 1a: #3) has also been included. Its position is a correction shown in the South Western Area Combined Headquarters Logbook (from 23° 6'S 110° 47'E to 24° 6'S 110° 47'E). Figure 2 depicts the SAR data for these objects and for the objects described in sections 5.22, 5.23 and 5.24.

#### 5.22 Life-rafts without survivors

There being no question of sailpower for the *Sydney* liferaft recovered by *Heros* (Table 1a: #9), this item is included. The alleged *Sydney* liferaft recovered near Christmas Island in 1942 was excluded from the reconstructions owing to the long interval involved.

#### 5.23 Kennel / Dog Box

The kennel discovered by *Wyrallah* is included (Table 1a: #7).

#### 5.24 Oil

The oil observation made by *Heros* (Table 1a: #8) is included.

A naval rating on *Heros* during the search, Mr R T Crooke, recently provided Mike McCarthy with the following information about the oil discovered by *Heros* (Western Australian Maritime Museum, 1991). According to Mr Crooke,

"On or about November 27 we came upon a huge patch of linseed oil. .... Previous references to this oil always describe it as a 'slick' . I think this term underrates the size of it, as one visualises a slick as a long narrow streak. This large mass was circular in pattern and generally of unbroken formation. My immediate reaction was that a ship lay below us and this oil was welling up from it".

And,

"Judging from the actual steaming time taken to cross it, I would estimate it to be 1/2 mile wide. This is a conservative guess. It had a clearly defined edge".

And, finally,

"Given the weather conditions, which could not be considered calm at the time of the discovery, it is puzzling that after 8 or so days the patch could still be so concentrated. My simple logic says that if a large amount of oil is found, that is known to come from a sunken ship, that ship must be somewhere nearby".

Mr Crooke also noticed that

"one day I spotted a pipe and slipper float past some

30 feet apart".

The second oil observation, involving a Catalina (Table 1: #10) is excluded because its position is several standard deviations from the mean of the remaining items, with or without hindcasting. It is unlikely that it comes from the same sample as the other objects.

### **5.3 Life-rafts with sailing potential**

Owing to the possible influence of sailpower the liferafts recovered by *Aquitania* and *Trocas* were excluded from the first analysis, an outcome which is particularly unfortunate given the fact that this excludes those items for which data less than four days old is available, a period beyond which estimation may be unreliable (Penrose & Klaka, 1991). The SAR data for the rubber rafts are shown in Figure 2.

### **5.4 Life-boat *B/Meyer* based on diary data**

Hughes (1991) and Kirsner (1991) used von Malapert's diary to reconstruct the track of *B/Meyer* from the point at which *B/Meyer* reached the coast. Von Malapert did not make daily reports, but the pattern of his diary entries suggests that he made a new entry whenever it was demanded by changing sailing procedures or weather conditions. From von Malapert's description, then, *B/Meyer* drifted for 12 hours (from 1800 on November 19), sailed at  $68^\circ$  / 1.24 knots for 24 hours, sailed at  $68^\circ$  / 1.73 knots for 36 hours, drifted for 12 hours, sailed at 1.73 knots /  $45^\circ$  for 36 hours, drifted for 9 hours, and sailed at 1.73 knots /  $45^\circ$  to the coast. Based on von Malapert's diary, together with 5% leeway at the wind values specified by Courtney (1991) and Southern (1991), when drifting, the Total Sailing Vector for *B/Meyer*'s voyage is  $46^\circ$  / 1.28 knots for 134 hours. *B/Meyer* landed on the WA coast at approximately  $24^\circ 02' S$   $113^\circ 25' E$  (#14). The reconstructions prepared by Kirsner and Hughes (1991) on the basis of the above summary yielded points of origin of  $111^\circ 09' E$   $25^\circ 57' S$  and  $111^\circ 30' E$   $26^\circ 00' S$ , respectively. The approximate route for *B/Meyer* is shown in Figure 3.

Although there is no diary data for *B/Kohn*, as it reportedly remained in sight of *B/Meyer* for the first 48 hours, and reached the coast at a similar point a few hours before *B/Meyer*, it may be assumed that it followed a similar route to the coast.

### **5.5 Life-boats *B/Detmers*, *B/Gosseln* and *B/Kuhl* based on separate periods of drifting and sailing**

Arguments presented at the forum support a sharp distinction between objects which could have been influenced by sailpower and objects which could not have been influenced by sailpower

(e.g., Steedman & Clark, 1991). The latter have been excluded from the reconstructions, except for *B/Meyer*, where the reconstruction was based on diary data. *B/Kohn* probably followed more or less the same route as *B/Meyer*, and the reconstruction from von Malapert's diary probably applies to that life-boat as well

The other three life-boats apparently followed a different route after the loss of *HSK Kormoran*. A reconstruction for these life-boats was implemented to reconcile their movements with that of the life-rafts, the drifting objects, and the other lifeboats. The observations on which this reconstructions were based are shown in Figure 3.

**Figure 3**

### **5.6 SAR Performance**

Figure 4 depicts the extent to which the sea SAR operation conducted in November 1941 covered the critical region in which objects #3 to #9 were discovered. The ellipse is centred on the area where most of these objects were reported. It is evident that up to 30% of the area within 75 - 80 km of the debris was searched on November 27 or November 28, . 1941. While it may be assumed that the SAR vessels did not detect all of the available targets, the probability that they failed to detect large amounts of debris is low.

**Figure 4**

## **6 PARAMETER SELECTION**

The material summarised in the following section provides the basis for all of the reconstructions.

### **6.1 Elapsed Time: ET = 0 at 1800 on November 19, 1941.**

Elapsed time (ET) was counted from 1800 on November 19, 1941. The case for locating ET0 at 1800 on November 19 is as follows. First, *Kormoran* and possibly *Sydney* were without power from about 1800, and they, as well as their remaining occupants, were therefore subject to current and wind *from that time*. Second, the rafts and some of the key survivors (i.e., Gosseln, see Gosseln, 1953) were in the water before dark on November 19, and they were therefore subject to current and wind *from that time*. Furthermore, as Gosseln did not re-board *Kormoran*, but nevertheless joined a lifeboat launched from *Kormoran* some hours later, it must be assumed that the debris released from *Kormoran* at 1800 was still in company with *Kormoran* at 2400, for whatever reason.

## 6.2 Sea Surface Current

Table 2

Table 2a is a summary of the surface current speeds and directions used in the papers at the forum. Table 2b is a summary of the surface currents from published atlases and charts. This information has been brought together in this way to emphasize several points. The first point concerns the number and complexity of the factors which influence total surface current. The list includes, for example, local and global surface wind stress, density differences, including the Leeuwin current, ocean scale sea level changes, and the wind wave induced Stokes drift. This complexity over many space and time scales prevents simple analysis. It is difficult therefore to estimate the individual components of current.

The second point concerns the use of the mean velocity and direction values from the atlases and charts derived from ship's logs (e.g., Sverdrup et al, 1942). We will refer to these values as the ship's drift. Ship drift includes the combined effect of sea surface current, wind and waves on the difference between the ship's dead reckoning and actual position over a period of 24 hours. There is considerable variability among the estimates summarised in Table 2, but this is not surprising because there is no generally accepted method of averaging the ship's drift vector over space or time (Defant, 1961). It should be noted that the average of all of the estimates of the surface drift speed for the chosen period during November 1941 is reasonably small, at 0.16 knots, a value which is not inconsistent with Pearce's recommendation that surface current be discounted altogether. However, although the magnitude of sea surface current is small, its cumulative effect makes a far from trivial 63 km difference to the estimated point at ET188; that is, at 1400 hours on November 27, 1941. The summary values for sea surface current shown in Table 2b were used in basic reconstruction described below.

The third point concerns the number of observations and the interpretation of the mean. Although each chart is handicapped by the small number of observations involved, collectively the reported number of observations is not so small. Presumably the Routing Chart and the Australian Pilot have compiled a considerable number of observations, particularly about the trade routes which pass close to the area of interest. Thus, assuming that the ship drift data are similar, on averaging all of the data of Table 2b, it is reasonable to expect that there must be a surface current similar to the ships' drift of something like

the mean speed of 0.16 knots and a direction of 6 degrees. From the statistical notion of the mean, it is also reasonable to expect that this averaging process will effectively remove the local short-term variability of the ships' drift.

Ship's drift is used in the present analysis. Mean November ships' drift will be set to equal to the surface current and this is included in the analyses of the target position. The relevant value is 0.16 knots / 6°

### 6.3 The Leeuwin current

Although the characteristics of the Leeuwin Current are well understood (Cresswell, 1991; Pearce, 1991a), the implications of the Leeuwin Current for the search for *Sydney/Kormoran* are not clear. According to Pearce (1991b), for example, the influence of the Leeuwin Current extends to at least 111°E (e.g., Figure 4), where its meandering or eddying nature could influence drifting objects in unpredictable ways. However, based on evidence that coastal mean sea level is correlated with the strength of the Leeuwin Current (Pearce & Phillips, 1988), and the low sea level reported for November 1941, Steedman and McCormack (1991) claimed that the Leeuwin Current was not flowing at the time. Hughes (1991), too, rejected the Leeuwin Current, assuming that it was not very active during November, and probably not so far to seaward.

The Leeuwin Current could have influenced drift material from *Sydney/Kormoran* by either: (a) exerting a southerly influence on drifting objects, a process which would have counter-acted wind effects to some extent, and pushed the apparent position of *Sydney/Kormoran* to the south of the real position, and / or (b) increased dispersion, if the drifting material were caught up in a series of large scale eddies over a period of eight days for example. That the Leeuwin Current could have influenced the movement of *Sydney/Kormoran* debris under some circumstances is clear. The critical question concerns the status of the Leeuwin Current in November 1941.

The Leeuwin Current was not included specifically in the reconstructions. Ship's drift (see above) may have been influence by this variable.

### Table 3

#### 6.4 Wind

Table 3a is a summary of the wind values presented at the forum by a current Bureau of Meteorology expert (Courtney, 1991), a retired Bureau of Meteorology expert (Southern, 1991), a private company meteorologist (McCormack in McCormack & Steedman, 1991).

The values presented by Hughes (1991), Kirsner (1991) and McDonald (1991) were derived from one or more of the above sources.

Courtney (1991) and Southern (1991) used their knowledge of the climatology of the area for November, together with archival information from 1941 about: (1) surface synoptic pressure from a number of land sites, and (2) low level winds (from balloon flights) to estimate wind speed and velocity for successive 24 hour periods for the period November 18 - November 28, 1941. McCormack (Steedman and McCormack, 1991) also used information about surface synoptic pressure from records involving a number of land sites for November 1941. McCormack and Steedman compared the November, 1941, synoptic surface pressure patterns with modern analogies, to obtain an estimate of the offshore surface synoptic pressure. These inferred offshore surface pressures were converted to hind-cast surface wind speeds and directions in the usual manner.

Table 3b shows estimates of mean wind direction and velocity based on von Malapert's diary (Western Australian Maritime Museum, 1991). Table 3c shows estimates of mean wind direction and velocity based on the USN Marine Climatic Atlas (1976). Contemporary observation (von Malapert, 1941) and the expert reconstructions (Courtney, 1991; Southern, 1991; McCormack & Steedman, 1991) provide very similar estimates of direction, although the former, perhaps surprisingly because of his position at the time, provides a lower estimate of velocity. These reconstructions all depart considerably from the historical data summarised in the USN Marine Climatic Atlas (1976)

Table 3d describes the analyses submitted by Courtney (1991) and Southern (1991) in detail, for the six hour period from 1800 on November 19, 1941, and for each of the succeeding 24 hour periods until November 28 .

The 24 hour records derived from Courtney (1991) and Southern (1991) were used in the reconstructions described below.

### **6.5 Wind-driven current**

Wind driven current is included automatically as a variable in SAR solutions at the local and national levels in Australia (e.g., Hughes, 1991) and elsewhere (e.g., the NZ and Canadian SAR Manuals). Direct use of wind driven current in the following analysis was complicated by two questions however. The first of these concerns the issue of double counting. As the sea surface current values reported in the Atlases reflect the combined influence of sea surface current, wind driven current and other

variables (see above), wind driven current should only be treated as an additional variable when wind velocity or direction departs substantially from historical values. Put in other words, when historically typical mean wind values are observed, their impact will be included in ship's drift, and further consideration is not required. However, as the values summarised in Table 3 are greater than the historically typical values for the area of interest (c 21 knots versus c 13 knots, although the difference is compromised by differences in direction), a case can be made for estimating the difference between the historical and hind-cast values for the period in question, and providing for the impact of this value on sea surface current (Steedman, 1992, personal communication).

The second problem was discussed by Penrose and Klaka (1991, p2). Based on published data (Churchill & Csanady, 1983; Kirwan, McNally & Pazan, 1979), their argument is that wind driven current effects are most significant in the surface layer (0.0 - 1.8 metres), but that, in that layer, they are nearly parallel to the wind and to the predominant wave propagation velocity. This layer would of course include virtually all parts of the relevant drift objects from *Sydney /Kormoran*..

Wind driven current was omitted from the following analysis. Inclusion of this variable would move the points shown in the reconstruction some distance to the south-east (160°).

#### **6.6 Leeway**

As most or all papers deferred to the Australian Maritime Safety Authority for information about Leeway, there was consensus about this variable. Based on information supplied by Hughes (1991), the values adopted are summarised in Table 4.

**Table 4**

#### **6.7 Coriolis Force**

Coriolis force was omitted from this analysis. It should however be considered for inclusion in the final analysis as the period the objects were adrift was greater than the inertial period at latitude 25°S.

#### **6.8 Dispersion**

Steedman and McCormack (1991) and Hughes (1991) used assumptions about wind drift distance error, uncertainty about sea surface current, turbulent diffusion error, and other sources to estimate total error. The values which they supplied are broadly similar, at 65 km (for six days ?) from Steedman and McCormack (1991), and 93 km (for eight days ?), from Hughes (1991). We will use

these values to define the possible region for the drift reconstruction. In principle, our use of converging operations involving several procedures should reduce the possible region relative to that defined by one procedure alone. However, in the absence of a suitable technique for adjusting the possible region to reflect the use of several procedures, this change cannot be quantified.

**Table 5**

## **7 THE RECONSTRUCTION**

### **7.1 Drifting objects without sailing potential**

Table 5 and Figure 5 depict the basic reconstruction. The reconstruction is based on the seven drifting objects identified in Table 5a, and on the reconstruction of *B/Meyer's* voyage based on von Malapert's diary is summarised in Table 5b. The ellipse is an estimate of the 95 percent confidence interval for these observations, a conventional statistic used to identify a region for which scientists can be 95 percent confident that the mean of the population (i.e., the position of the wrecks in the present case) is included. The target position is  $111^{\circ} 22'$  ( $\pm 10'$ ) E  $26^{\circ} 17'$  ( $\pm 22'$ ), where the values are the sample standard deviations. The 95% confidence interval identified by the ellipse covers approximately 7100 km<sup>2</sup>.

**Figure 5**

### **7.2 Life-rafts with sailing potential**

Figure 5 also depicts the reconstruction for the rubber life-rafts found by *Aquitania* and *Trocas*. The estimated point of origin for the raft found by *Aquitania* (Figure 5, #1) falls inside the ellipse defined by objects #3, #4, #5, #6, #7, #8, #9 and #10 provided that the leeway figure of 5% is used (i.e., #1a). The estimated point of origin for the raft found by *Trocas* lies far to the east (Figure 5, #2a). Presumably this raft was able to use its improvised sails to good effect.

### **7.3 Questions and qualifications**

The data set described in Table 5 and Figure 5 could misrepresent the real distribution of objects if it is a limited or distorted sample of the objects from *Sydney / Kormoran* then available in the ocean. The proposition that the sample was unrepresentative is difficult to disprove. But, as discussed above, Figure 4 suggests that the critical area for the period in question (e.g., ET180 - ET214) was given substantial coverage during this period. The ellipse provided in Figure 4 has a radius of 75 - 80 km. The grey bars represent the area covered by SAR observation,

assuming that items of interest could be detected at about 5 km (a figure which may be generous). The pattern suggests that about 25 - 30 percent of the total area was covered by the SAR vessels alone, a figure which is too low to rule out errors of omission, but high enough to discount the proposition that the area outside the ellipse was rich in debris.

The estimated point of origin is subject to numerous sources of error. The list includes wind drift distance error, turbulent diffusion error, uncertainty about the direction and velocity of both sea surface current and wind, a measure of uncertainty about leeway values, and some doubt about exclusion of the Leeuwin Current and both the direct and indirect impact of Coriolis Force.

It should be emphasized that the error values specified above (e.g., 26° 17' ±43'S) reflect variance among the objects only. They do not reflect variance among the process estimates for wind direction, wind velocity, sea surface current direction, sea surface current velocity, Coriolis force, and leeway.

#### **8 INFORMATION SUPPLIED BY SURVIVORS FROM HSK *Kormoran***

Although the forum papers offered general support for the approximate position supplied by *Kormoran* survivors, the absence of minute and second (as distinct from degree) information in most of the survivors' reports, together with variation between estimates, even from the same observer, suggests that the positions given by them were only meant to be accurate to the nearest degree on each axis, if that. It is, moreover, unclear from the secondary descriptions of the survivor's reports whether they were referring to point of contact or point of loss, a factor which would add another 11 nautical miles to the error, assuming that the officially accepted account of the engagement is correct. The position identified above is, however, consistent with the location provided by the survivors.

#### **9 WHICH ROUTE: SUNDA STRAIT to FREMANTLE or SUNDA STRAIT to CAPE LEEUWIN ?**

The conclusion that contact occurred on the Sunda Strait to Cape Leeuwin route involves several considerations. These are discussed in the following three sub-sections. The arguments presented here provide further support for the proposition that HMAS Sydney and HSK *Kormoran* met on the Sunda Strait to Cape Leeuwin route despite the fact that Fremantle was her next port of call.

Several contributors to the *Sydney /Kormoran* debate (e.g., McDonald, 1991; Montgomery, 1983) claimed that *Sydney* and *Kormoran* were on the Sunda Strait to Fremantle route, and that the wrecks should therefore be sought on or near that track. Against this, however, there is a considerable body of argument and evidence that the vessels were on or near the Sunda Strait to Cape Leeuwin route, some 80 km to the west, a conclusion which is consistent with the position supplied by *Kormoran* survivors.

### 9.1 The relationship between *Aquitania's* track and the drift vector

#### Figure 6

The first argument concerns the relationship between the Sunda Strait to Cape Leeuwin track (i.e., c. 163°) and the direction of the Drift Vector for the flotsam and jetsam from *Sydney /Kormoran* (i.e., c. 343°)<sup>7</sup>. As depicted in Figure 6, the second is the reciprocal of the first. We will return to this point after we have summarised the known and possible contacts between *Aquitania* and other objects from the *Kormoran*; that is, between objects on reciprocal courses.

The first observation is that *Aquitania* recovered survivors from a raft from *Kormoran* at 0800 on November 23 (i.e., ET84 in Figure 6). If sailpower is discounted for this object, the track of *Aquitania* must fall on or near the position of the wrecks, simply because the raft was drifting 'up' *Aquitania's* track. It may also be noted that this contact occurred within four days of the engagement, although it is compromised to some extent by a report that the survivors were trying to use their jackets as sails (Winter, 1984).

The second, third and fourth observations involve *B/Detmers* and *B/Gosseln*. Detmers claimed to have sighted *Aquitania* on November 23, and, although the exact time of this contact is unclear, the context supplied by Detmers suggests that the observation took place just before noon (ET 85? in Figure 6; Detmers, 1957). *B/Detmers* was at this time in the approximate path of the debris discovered some days later, assuming that the sea surface current and wind directions and velocities summarised above are more or less correct. The third observation involves Gosseln (Gosseln, 1953). He reported that he saw *Aquitania*, but he did not indicate either the day or time of day (ET85? in Figure 6).

The fourth observation (ET80 in Figure 6) should be treated with caution. It involves an alleged report from a survivor from *B/Gosseln* (Robothom, circa 1970, manuscript to be lodged in Battye Library). According to Robothom, this survivor made two

comments; first, that he saw the *Aquitania* at 4 o'clock in the morning of November 23 (p79) and, second, that *Aquitania* passed over the scene of the action early on the following Sunday morning (p81). The first of these comments is interesting<sup>8</sup>. This comment is interesting because it places *B/Gosseln* over 70 km north of the position where *Aquitania* picked up the raft from *Kormoran* (see Figure 3), and another 100 km plus North of the official position of the wrecks. These observations can only be explained only if it is assumed that *B/Gosseln* was motor-powered or if *B/Gosseln* was being towed by a motor-powered boat. This is essential because *B/Gosseln* was finally detected by SAR aircraft over 100 km to the SSE of the 0400 position reached on November 23, following a voyage into the wind and current. On balance, we are inclined to assume that the details provided by Robothom involve a recording or transcription error, although, given contemporary and recent evidence about the speed and range of the motorboat carried by *Kormoran*, it cannot be discounted entirely. It should be noted that there is no reason to assume that the report was fabricated; it is unlikely that the way in which the information has been used in this account would have been foreseen.

Regardless of the validity of Robothom's account, it is clear from the preceding examples that *Aquitania*'s track and the drift vector are reciprocals. This claim fixes the wrecks on or near *Aquitania*'s track, a track which is defined by:

- (a) position of egress from Sunda Strait (c.105°E 6°30'S) or Christmas Island (a turning point on the usual route)
- (b) turning point for Cape Leeuwin (c.114° 45'E 34°28'S)
- (c) position of *Kormoran* raft discovered by *Aquitania* (110°57'E 24°35'S), and
- (d) the fact that (c) is barely 10 km off the great circle route between (a) and (b).

In summary, given the reciprocal relationship between the Drift Vector and *Aquitania*'s track, survivors in *Kormoran*'s life-boats (*B/Detmers* & *B/Gosseln*) and the life-raft would have seen *Aquitania* if they were drifting from a point on *Aquitania*'s track. The fact that *B/Gosseln* was sighted by a SAR aircraft at ET133 on the Drift Vector (i.e., 343°) is also consistent with the assumption that this vector and the track of *Aquitania* are reciprocals. Our analysis supports the conclusion that *Sydney* and *Kormoran* met on the Sunda Strait to Cape Leeuwin track, and that the wrecks therefore lie on or near this track.

**9.2 The supplementary reconstruction: B/Detmers, B/Gosseln and B/Kuhl**

### Figure 7

The second argument involves the supplementary reconstruction involving *B/Detmers*, *B/Gosseln* and *B/Kuhl*. Figure 7 is a possible reconstruction of the progress made by *B/Detmers*, *B/Gosseln* and *B/Kuhl* after they left the vicinity of HSK *Kormoran*. This reconstruction explains why: (a) two of these vessels observed *Aquitania* on November 23, and (b) how they came to be observed travelling more or less due east toward the coast, under sail, after November 25. It should be noted that they were observed by a SAR aircraft at ET133, and this time represents a quantitatively appropriate point of division. Prior to ET133 it may be assumed that the three lifeboats were subject to drift and leeway assumptions. After ET133 the three lifeboats were under sail.

It should be noted that one of these lifeboats was operating under virtually identical sailing conditions to *B/Meyer*. It was a sister vessel, it carried a similar load, and it had similar problems with its sailing and rowing equipment. The calculated directions and velocities for these vessels are very similar; once they started heading for the coast their sailing qualities were more or less identical (Kirsner, 1991). It must be assumed therefore that the track taken by these lifeboats was selected deliberately, and that the crews of these boats subsequently concealed this decision from their RAN interrogators. It should be noted however that the crews of these boats included two or three Chinese sailors (rescued from ships destroyed by HSK *Kormoran*), and that their survival until they reached land, is at least a counter-indication to the more grisly accounts which circulated during and subsequent to 1941 (e.g., Montgomery, 1981).

### 9.3 Route of HMAS *Sydney* on previous voyages

#### Figure 8

The second consideration concerns HMAS *Sydney*'s route on previous war-time deployment between Singapore / Sunda Strait and Fremantle. Data about three deployment is available and, apart from the outward route on the first of these, they are remarkably consistent. Specifically, HMAS *Sydney* passed through 26° 0' S or 26° 1' S at 110° 49' E (course 328°), 111° 34' E (162°), 111° 39' E (342°), 111° 37' E (163°), 111° 22' E (349°), and 111° 25' E (162°) on June 1 1941, June 9 1941, June 15 1941, June 20 1941, September 29 1941 and October 6 1941, respectively (Laffer, 1992, personal communication). On the first of these voyages, HMAS *Sydney* changed course to return to the direct route just to the North of 26° S. The mean for the last five observations is 111° 31' ± 7' E. Figure 8 includes estimates of the 95%

confidence intervals for the track of HMAS Sydney (dashed lines). The track was also defined by HMAS Sydney's known routes. If the limitation depicted in Figure 8 is super-imposed on the target area depicted in Figure 5, it can be seen that the 95% confidence interval for Sydney's voyages set limits which are consistent with the basic reconstruction.

Figure 8 also includes two further lines (solid) to allow for pre-battle movements of *HMAS Sydney* and *HSK Kormoran* as described by the survivors. These lines are offset to the west by 11 nautical miles. This distance is based on Gosseln's account (Gosseln, 1953), including a figure which indicates that *Kormoran* was sailing west or WSW at 14 - 16 knots for not more than 45 minutes before her engine room was damaged. Gill's (1957) and Winter's (1984) analyses yield a similar estimate. The adjusted lines do not provide a better fit than Figure 5.

One final consideration concerns the Lombok to Cape Leeuwin route. This route converges on the Sunda Strait - Cape Leeuwin route at 27° 0' S 111° 50' E, providing an obvious target for a raider in this region.

## 10 HOW MANY TARGETS ?

Consideration of the SAR data summarised in Table 5a indicates that the mean positions for the items from *HMAS Sydney* and *HSK Kormoran* are very similar. In fact, the most southerly and the most northerly estimated points of origin each involved objects from *HMAS Sydney*. The mean estimated point of origin for the three objects from *HMAS Sydney* is 110° 52' E 26° 12' S. The mean estimated point of origin for the three objects from *HSK Kormoran* and the estimated point of origin for *B/Meyer* is 110° 58' E 26° 11' S. There are too few items for useful statistical comparison. One implication of this point is that the effective search area actually includes two targets. Relative to the total target area, the probable separation between the vessels is small.

## 11 THE TARGET AREA: CONVERGING OPERATIONS

### Figure 9

Figure 9 provides a summary of the evidence based on a method which may be compared with triangulation. Figure 9 includes the products of several independent analyses. The first of these involves the basic reconstruction described above. This involves the movement of the drifting objects. The second analysis

involves the reconstruction for *B/Meyer* voyage from Malapert's diary. These analyses are independent except that the drift components of *B/Meyer's* voyage involve reference to the same wind and leeway assumptions. It may be noted that, firstly, the analyses produce more or less identical solutions and, secondly, that the most obvious sources of error in these analyses point in opposite directions, to the SSE for the basic reconstruction, because wind-driven current was treated conservatively, and to the north for Malapert, because strong off-shore wind estimates were used to estimate the drift components throughout *B/Meyer's* voyage.

The drift and diary analyses together identify the ellipse shown in Figures 5 and 9. The area of this ellipse is approximately 7100 km<sup>2</sup>. As shown in Table 6, this figure is more than ten times larger than the target areas defined by Ballard (1987, 1990) for *Titanic* and *Bismarck*. Finally, although quantification is impractical, confidence of detection for the area defined for *HMAS Sydney* and *HSK Kormoran* must be lower than it would have been for the target areas for the earlier searches. Thus, where *Titanic* and *Bismarck* are concerned, errors associated with dead reckoning were taken into consideration. In the present analysis they were ignored because they were regarded as trivial compared to the problems of estimation associated with the oceanographic variables.

As depicted in Figure 9, two further procedures were used to evaluate or set limits on the target area. The first of these involved knowledge of the route taken by *HMAS Sydney* on previous voyages between Fremantle and Sunda Strait. The E limit is the eastern 95% confidence interval for *HMAS Sydney*. The W limit is the western 95% confidence interval adjusted for the westerly movement of the two vessels prior to the battle. These limits are virtually identical to the eastern and western edges of the target area as defined by analysis of the drift and diary data.

Von Malapert's diary can be used to set a weak southerly limit to this modification. The line S Limit in Figure 9 represents perhaps the largest directional error which an experienced sailor could make. This line depicts the voyage of *B/Meyer* assuming that the lifeboat was pointing approximately 22° further off the wind (or, nearer to 0° True) than recorded by von Malapert. Given a mean error of this magnitude the search area identified in this article just includes *B/Meyer's* starting point. It should be noted, furthermore, that any further error in the same direction would have placed *B/Meyer* in a position where the crew should have seen the light from the lighthouse on

Cape Inscription and, possibly, Cape Ronsard (see Figure 9 for estimated visibility for the Cape Inscription light in 1941). They did not, although inquiries to the relevant lighthouse authority indicates that the Cape Inscription light at least was in operation at this time. Finally, it should be noted that *B/Meyer* did not follow a direct route from the wrecks to the coast. As summarised in Table 5b, *B/Meyer* followed a course to the south-east of a direct course. If the battle occurred to the south of about 26° 40' S, and *B/Meyer* followed the approximate route indicated by von Malapert, the crew should have seen the lights if not the land. They did not, and it may be inferred that *B/Meyer* probably commenced her voyage north of 26° 40' S.

The extent to which these solutions converge on the same location despite major differences in methodology and assumption provides evidence that the area which they identify is correct.

## 12 TITANIC, BISMARCK AND KORMORAN / SYDNEY

Table 6

Table 6 is a summary of the comparative evidence for *Titanic*, *Bismarck* and *Sydney*, in so far as it is available. The major points of interest are as follows. First, whereas *Titanic* and *Bismarck* rest at depths in excess of 3500 metres, *Sydney* and / or *Kormoran* appear to be in shallower water. The minimum and maximum depths for the area indicated are approximately 800 and 2500 metres, respectively. Second, like *Bismarck*, but unlike *Titanic*, it is possible or even probable that *Sydney* and / or *Kormoran* have come to rest on a slope, thereby raising the possibility that, like *Bismarck*, evidence of a 'landslide' may facilitate the search. The value of 1 in 50 is the average slope of the edge of the continental shelf in the area of interest. Informal communications suggest that the sea-floor in the area may have many canyons, thereby increasing the possibility that the sea-floor will have been disturbed over a substantial area by one or both vessels. The third and final point concerns the target area involved in each search. The target area for *HMAS Sydney* and *HSK Kormoran* is approximately 7100 km<sup>2</sup>. The corresponding values for *Titanic* and *Bismarck* were 500 km<sup>2</sup> or less.

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**Table 1a**  
**Search and Rescue Data: Rafts, Belts, Floats, Debris and Oil**

#	ET	Object	Vessel	Source	Long E	Lat S
1	84	rubber raft	Kormoran	<i>Aquitania</i>	110 57	24 35
2	109	rubber raft	Kormoran	<i>Trocas</i>	111 40	24 0
3	188	belt	Sydney	<i>Evagoras</i>	110 49	24 06 <sup>1</sup>
4	192	belt	Sydney	<i>Wyrallah</i>	110 49	24 22
5	206	belt	Kormoran	<i>Wyrallah</i>	110 54	24 10
6	207	float	Kormoran	<i>Wyrallah</i>	110 54	24 10
7	208	kennel	Kormoran	<i>Wyrallah</i>	110 54	24 10
8	209	carley	Sydney	<i>Heros</i>	110 58	24 07
9	209	oil	?	<i>Heros</i>	110 58	24 07
10	209	oil	?	<i>Catalina</i>	110 10	23 49

1. South-West Command Record.

**Table 1b**  
**Search and Rescue Data II: Life-boats**

#	ET	Object	Source	Long E	Lat S
11a	84	<i>B/Detmers</i>	Detmers sighted <i>Aquitania</i>	110 57	24 35
11b	133	"	Detmers sighted aircraft circling <i>B/Gosseln</i>	111 05	24 52
11c	157	"	SAR observation (air)	112 02	24 39
11d	169	"	SAR rescue (sea, <i>Centaur</i> )	112 17	24 39
12a	84	<i>B/Gosseln</i>	Gosseln sighted <i>Aquitania</i> <sup>3</sup>	110 57	24 35
12b	133	"	SAR observation (air)	111 05	24 52
12c	180	"	SAR observation (air)	112 04	25 04
12d	186	"	SAR rescue (sea, <i>Yandra</i> )	112 22	24 59
13	120	<i>B/Kohn</i>	SAR observation (air)	113 25	24 06
14	134	<i>B/Meyer</i>	SAR observation (air)	113 25	24 02
15a	158	<i>B/Kuhl</i>	SAR observation (air)	112 24	24 14
15b	169	"	SAR rescue (sea, <i>Koolinda</i> )	112 47	24 07

Table 2a

Sea surface current estimates from papers presented at the forum

Source	Direction degrees	Velocity knots
Hughes (1991)	0°±30	0.25 - 0.50
Pearce (1991) <sup>1</sup>	0	0
Steedman & McCormack (1991) <sup>2</sup>	340	0.37
McDonald	340	0.75
Kirsner	3	0.33

1. Based on comment that "current data cannot be used with confidence" (Pearce, 1991)

2. From November Routing Chart

Table 2b

Sea surface current estimates from atlases and charts

Source	Direction (degrees)	Velocity (knots)	Number of Observations
KNMI (Dutch) Marine Atlas <sup>1</sup>	317	0.23	36
Meteorological Office Routing Chart	340	0.37	??
Surface Current Data System <sup>1</sup>	16	0.09	12
Australian Pilot <sup>2</sup>	23	0.13	??
US Hydrographic Office	68	0.12	21
Mean ship drift	6	0.16	69+

1. Based on Pearce (1991).

2. Estimate

**Table 3a**  
**Hindcast mean wind speed and direction presented at the Forum**

<b>Source</b>	<b>Direction</b> (degrees)	<b>Velocity</b> (knots)	<b>Period</b> (ET)
Courtney (1991)	349	20	0-192
Southern (1991)	333	23	0-192
Steedman & McCormack (1991)	340	21	0-192
Hughes (1991) <sup>2</sup>	349	20	0-192
McDonald (1991)	315	?	0-192
Kirsner (1991) <sup>3</sup>	340	21.3	0-192

1. For ET0 -- ET134

2. Based on Courtney.

3. Based on Courtney *and* Southern (1991).

**Table 3b**  
**Mean wind speed and direction as observed and estimated by von Malapert (1941)**

<b>Source</b>	<b>Direction</b> (degrees)	<b>Velocity</b> (knots)	<b>Period</b> (ET)
von Malapert (1941)	347	15	0-134

**Table 3c**  
**Mean wind speed and direction as estimated by the USN Marine Climatic Atlas (1976)<sup>1</sup>**

<b>Source</b>	<b>Direction</b> (degrees)	<b>Velocity</b> (knots)
	10	13.2

Steedman (1992, personal communication).

**Table 3d**  
**Mean wind values for ET0 - 209 based on Courtney (1991) & Southern (1991)**

<b>Date</b>	<b>Hours</b>	<b>Direction</b> (degrees)			<b>Velocity</b> (knots)		
		<b>Southern</b>	<b>Courtney</b>	<b>Mean</b>	<b>Southern</b>	<b>Courtney</b>	<b>Mean</b>
19	6	157	165	161	18	17.5	17.75
20	24	139	150	145	24	14.5	19.25
21	24	148	165	157	24	17.5	20.75
22	24	149	165	157	26	24	25
23	24	129	155	142	40	26	33
24	24	143	155	149	28	19	23.5
25	24	162	180	171	23	24.5	23.75
26	24	200	190	195	20	17.5	18.75
27	24	230	240	235	20	13	16.5
28	24	144	190	167	20	17	18.5

**Table 4**  
**Leeway values recommended by the Australian Maritime Safety Authority**

<b>Type of object</b> (knots)	<b>Leeway</b> (percentage of wind)
Kennel	0 - 3
Lifebelts	2
Oil	3
Carley Liferrafts ( <i>Sydney</i> )	4 (with drogue)
Carley Liferrafts ( <i>Sydney</i> )	5 (drogue & ballast bucket)
Life-boats (1 ton steel)	5
25 man liferaft (rubber)	7 (5 with drogue)

---

Table 5a  
Estimated point of origin for objects 1 - 9

# Object	Source	SAR	ET	Leeway	SAR datum	Origin	Vector
1 rubber raft	Kormoran	Aquitania	84	7%	110 57 24 35	112 01 26 44	262/336
1 "				5%		111 43 26 11	193/337
2 rubber raft	Kormoran	Trocas	109	7%	111 40 24 06	113 18 27 00	362/333
2 "				5%		112 50 26 15	268/334
3 Lifebelt	Sydney	Evagoras	188	2%	110 49 24 06	111 14 25 49	196/347
4 Lifebelt	Sydney	Wyrallah	192	2%	110 49 24 22	111 12 26 07	198/349
5 Lifebelt	Kormoran	Wyrallah	206	2%	110 54 24 10	111 16 26 02	211/350
6 Float	Kormoran	Wyrallah	207	2%	110 54 24 10	111 16 26 02	211/350
7 Kennel	Kormoran	Wyrallah	208	3%	110 54 24 10	111 30 26 42	288/348
8 Carley	Sydney	Heros	209	3%	110 58 24 07	111 34 26 40	289/348
9 Oil	?	Heros	209	3%	110 58 24 07	111 34 26 40	288/348

Table 5b  
Estimated point of origin for *B/Meyer* based on von Malapert's diary<sup>1</sup>

Longitude	Latitude	Force	Duration <sup>1</sup>	Velocity (kph)	Direction (degrees)
111 09	25 57	Drift	6		
111 07	25 52	Drift	6		
111 37	25 41	Sail	24	2.3	68
112 41	25 17	Sail	36	3.2	68
112 38	25 10	Drift	6		
112 33	25 03	Drift	6		
113 21	24 19	Sail	36	3.2	45
113 18	24 13	Drift	6		
113 17	24 09	Drift	3		
113 25	24 02	Sail	5	3.2	45

1. Assumptions: Sea current = 0.16 knots/6°; wind based on Courtney (1991) & Southern (1991). Vector = 1.28 Knots/46°.

Table 5c  
Estimated points of origin for *B/Detmers*, *B/Gosseln* and *B/Kuhl*<sup>1</sup>

11a	0	<i>B/Detmers</i> Estimated point of origin (N)	24 43 110 01
12a	0	<i>B/Gosseln</i> Estimated point of origin (N)	24 5 109 35
13a	0	<i>B/Kuhl</i> Estimated point of origin (N)	25 48 107 00

1. The estimated points of origin for these life-boats were calculated by least squares method for latitude and longitude as functions of Elapsed Time. The calculations were based on the data summarised in Table 1b. The zero intercepts of these functions provided the estimated points of origin for *B/Detmers*, *B/Gosseln* and *B/Kuhl*. The calculation is based on the assumption that the life-boats maintained the same direction and velocity both before and after the first SAR sighting of *B/Gosseln*.

**Table 6**  
**Summary of site, search, debris and wreck information for Titanic<sup>1</sup> and Bismarck<sup>2</sup> and Sydney**

Parameter	Metric	Titanic	Bismarck	Sydney
Year (s)		1980-85	1988	
Depth	metres	3785	4700	800 - 2500
Area:				
Landslide	km <sup>2</sup>	nil	1.9	
Debris	km <sup>2</sup>	1.7	5.2	
Slope	ratio	1 in 1000	1 in 15-20	1 in 50 <sup>4</sup>
Search Area	km <sup>2</sup>	500 <sup>4</sup>	484	4200 - 7100
Search Time	days	48	20	?

1. Estimate based on Ballard (1989)

2. Estimate based on Ballard (1990)

3. 1985 search only.

4. Average value based on slope of edge of continental shelf

**Figure 1**  
Sample of 'official' and 'historical' positions for the engagement  
between Kormoran and Sydney

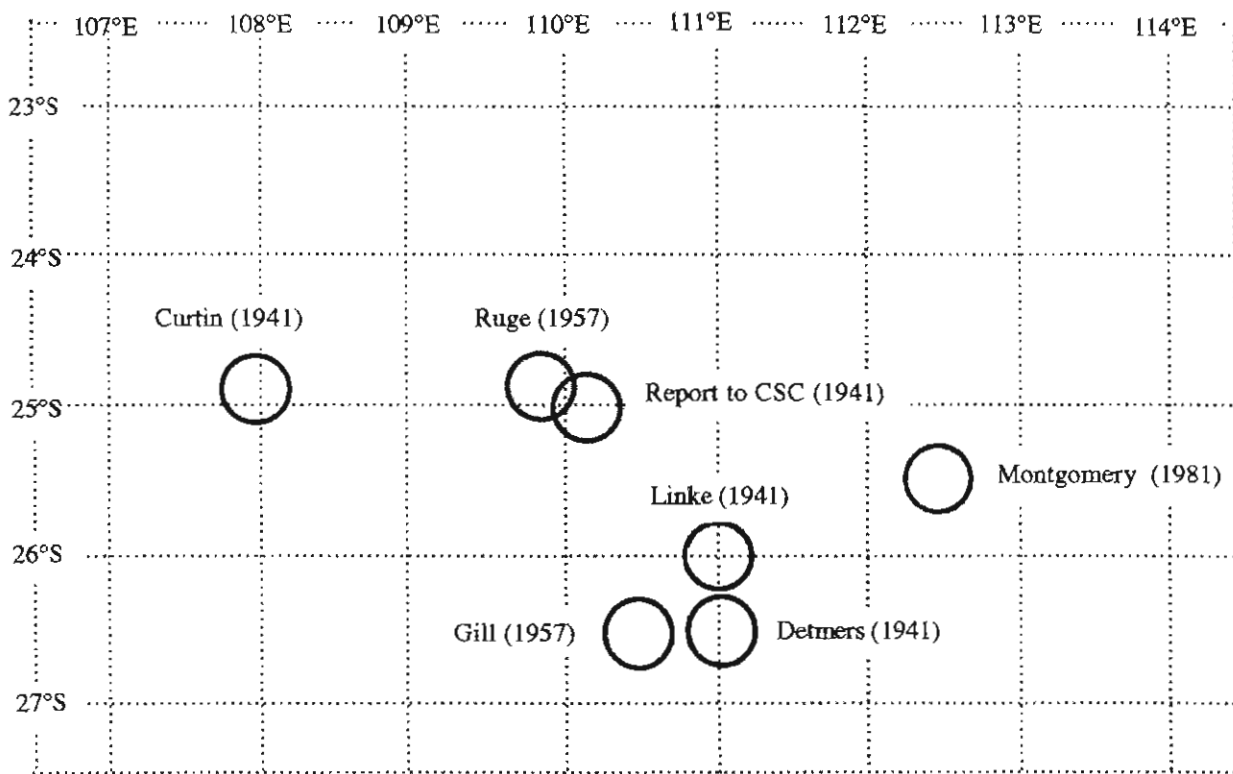


Figure 2  
SAR Data I: Rafts, Belts, Floats, Debris & Oil

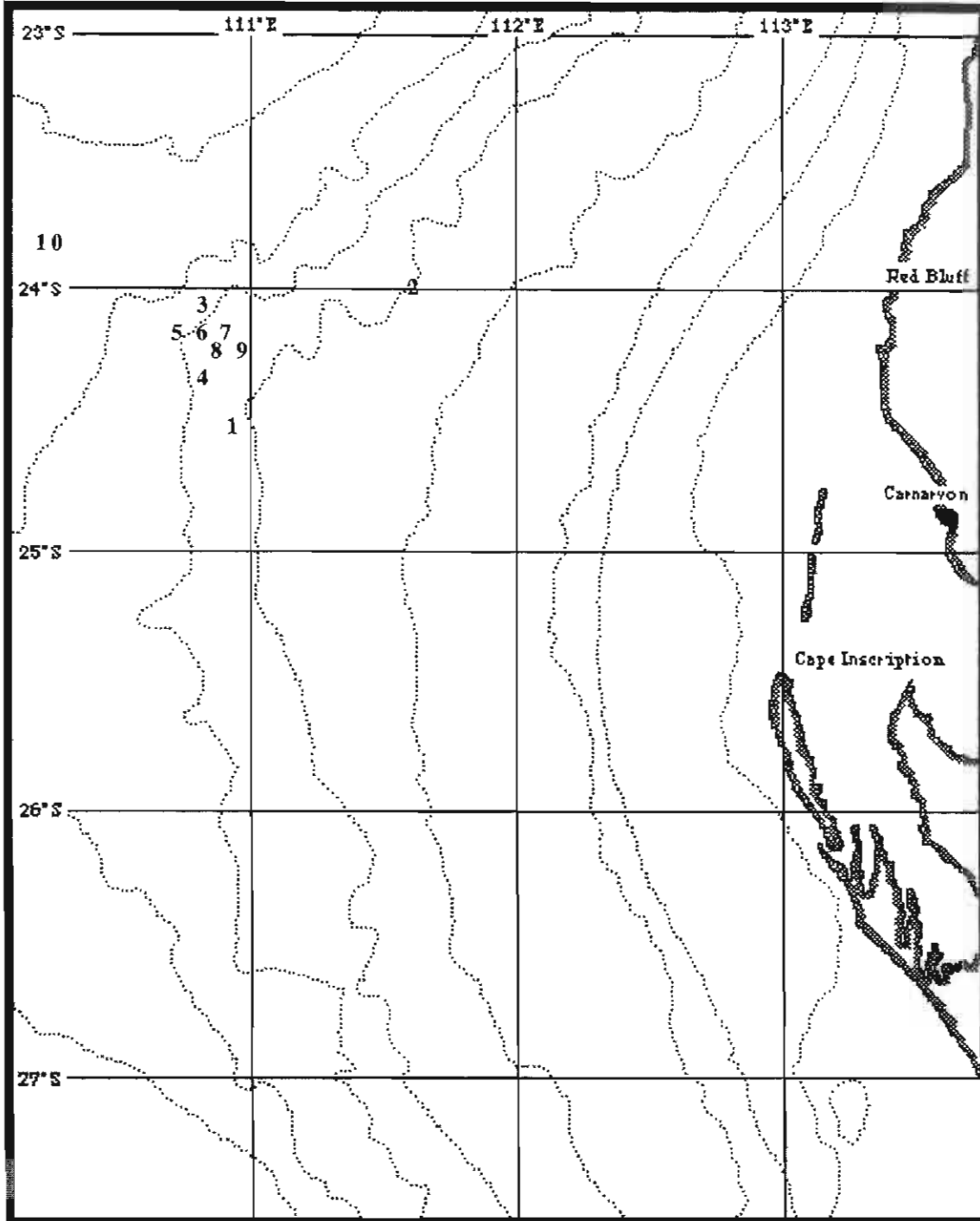


Figure 3  
SAR Data II: Life-boats

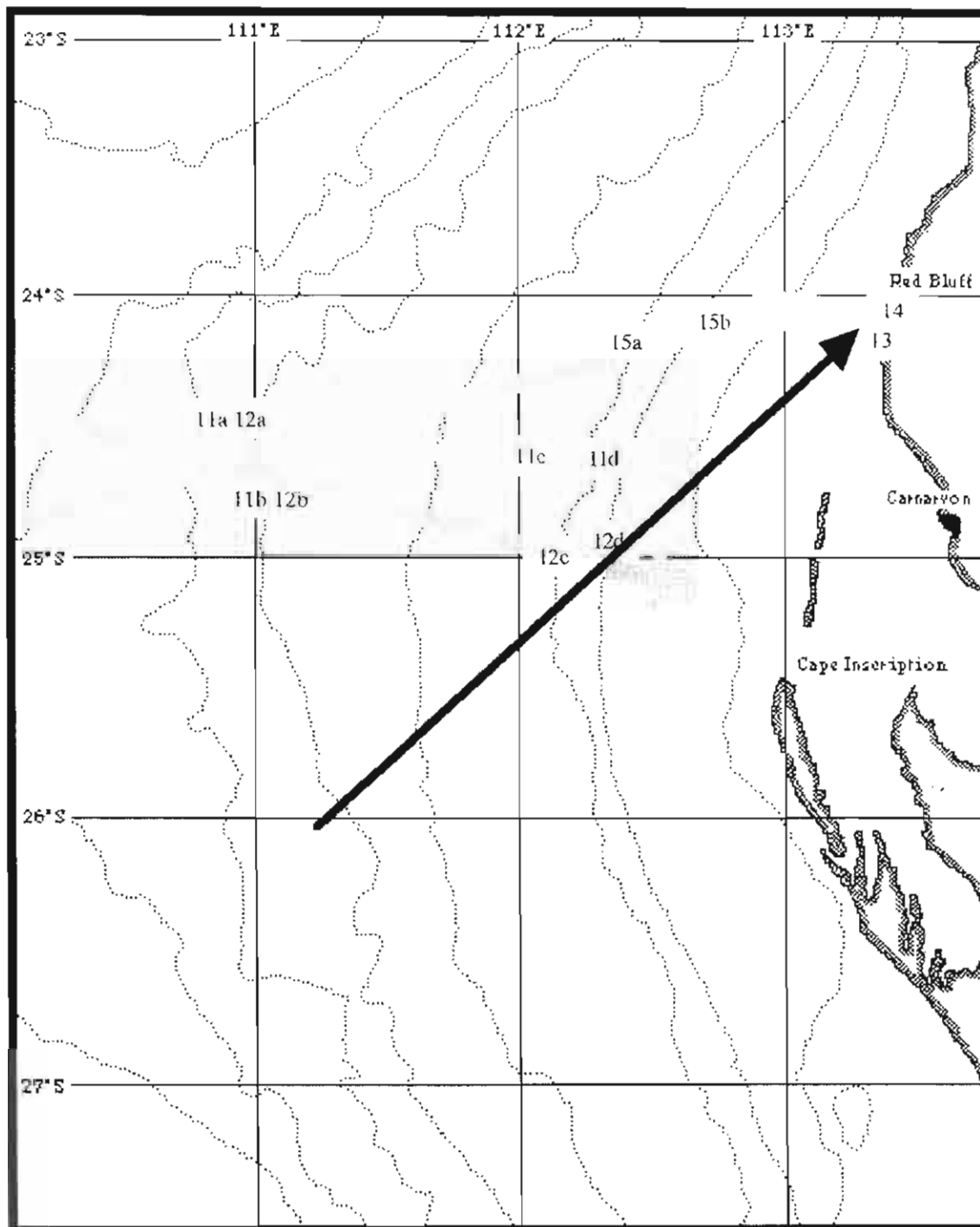


Figure 4  
SAR coverage from ET180 - ET216 within  
c. 75km of debris concentration  
(vessels only)

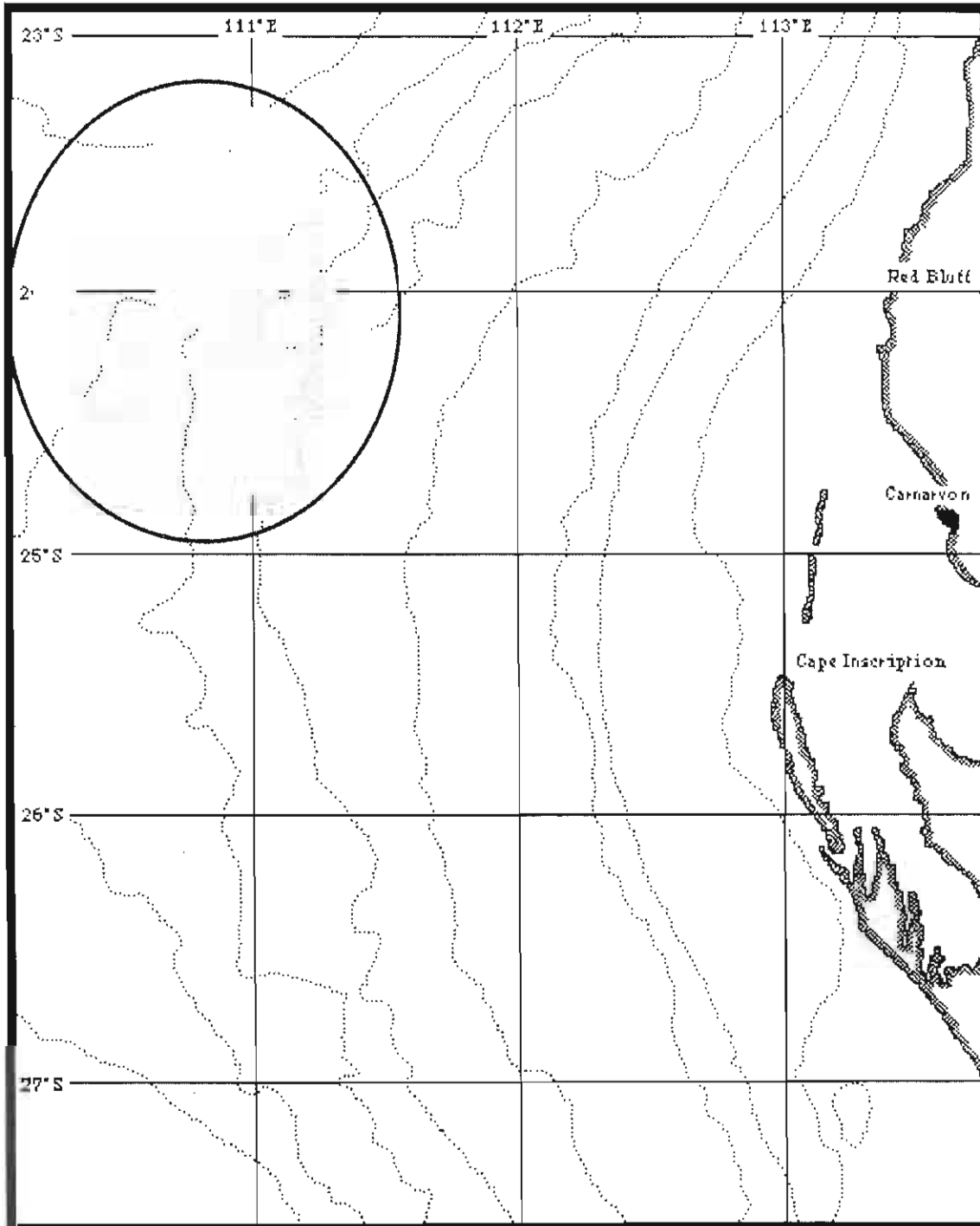


Figure 5  
 Reconstruction based on seven drifting objects (#3 - #9),  
 one rubber liferaft (#1 with leeway @ 5% wind),  
 and *B/Meyer* based on von Malapert's diary (#10).

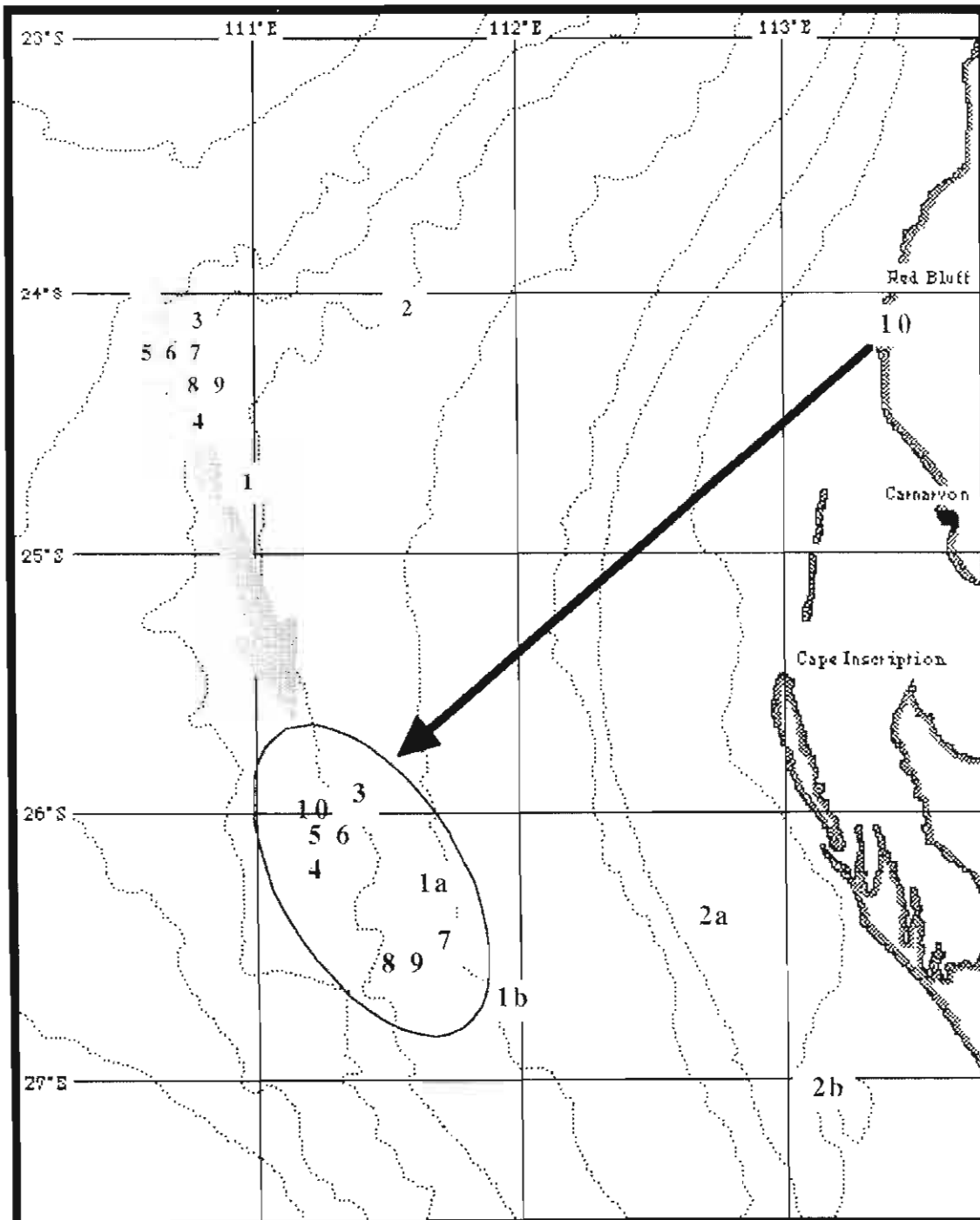
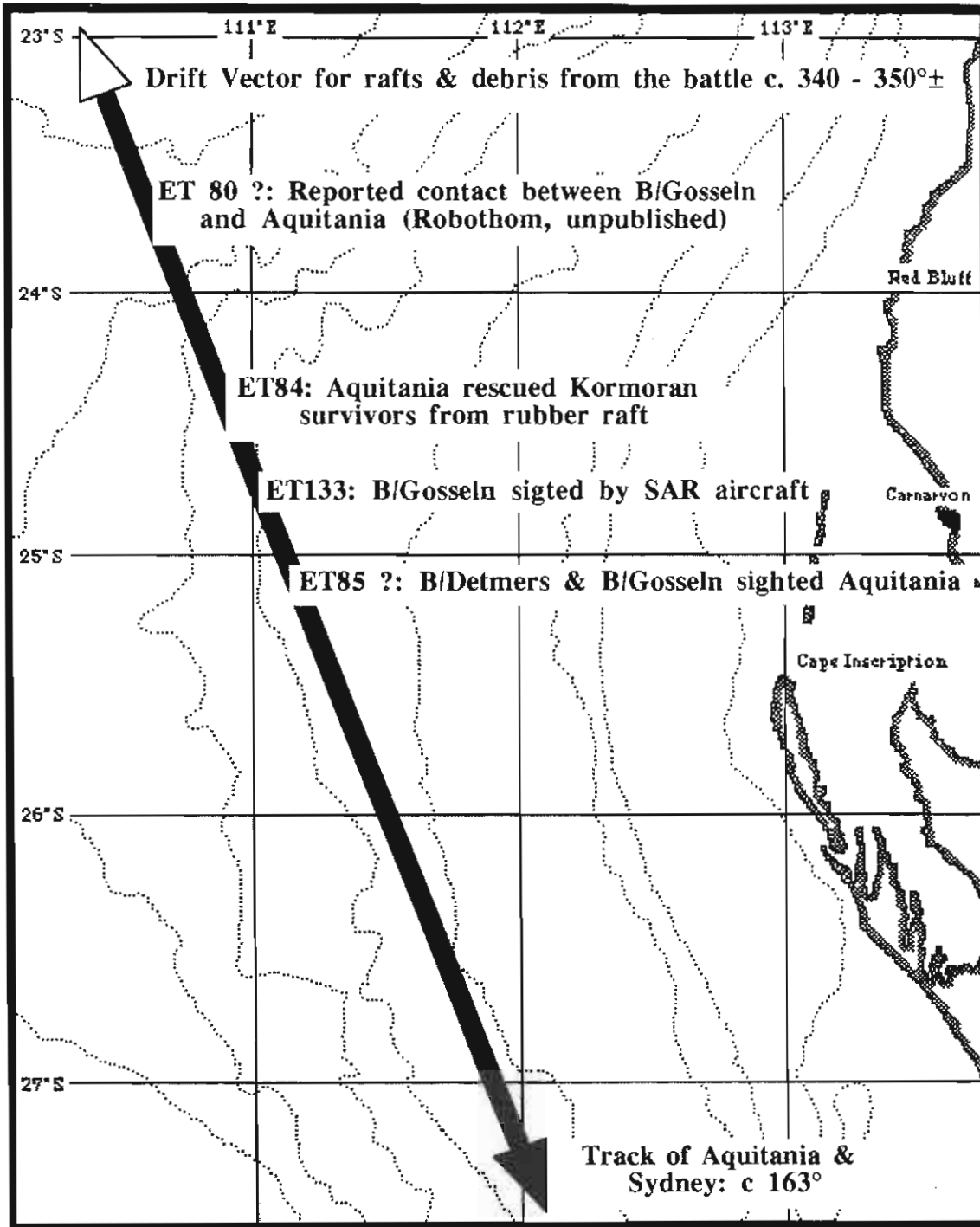
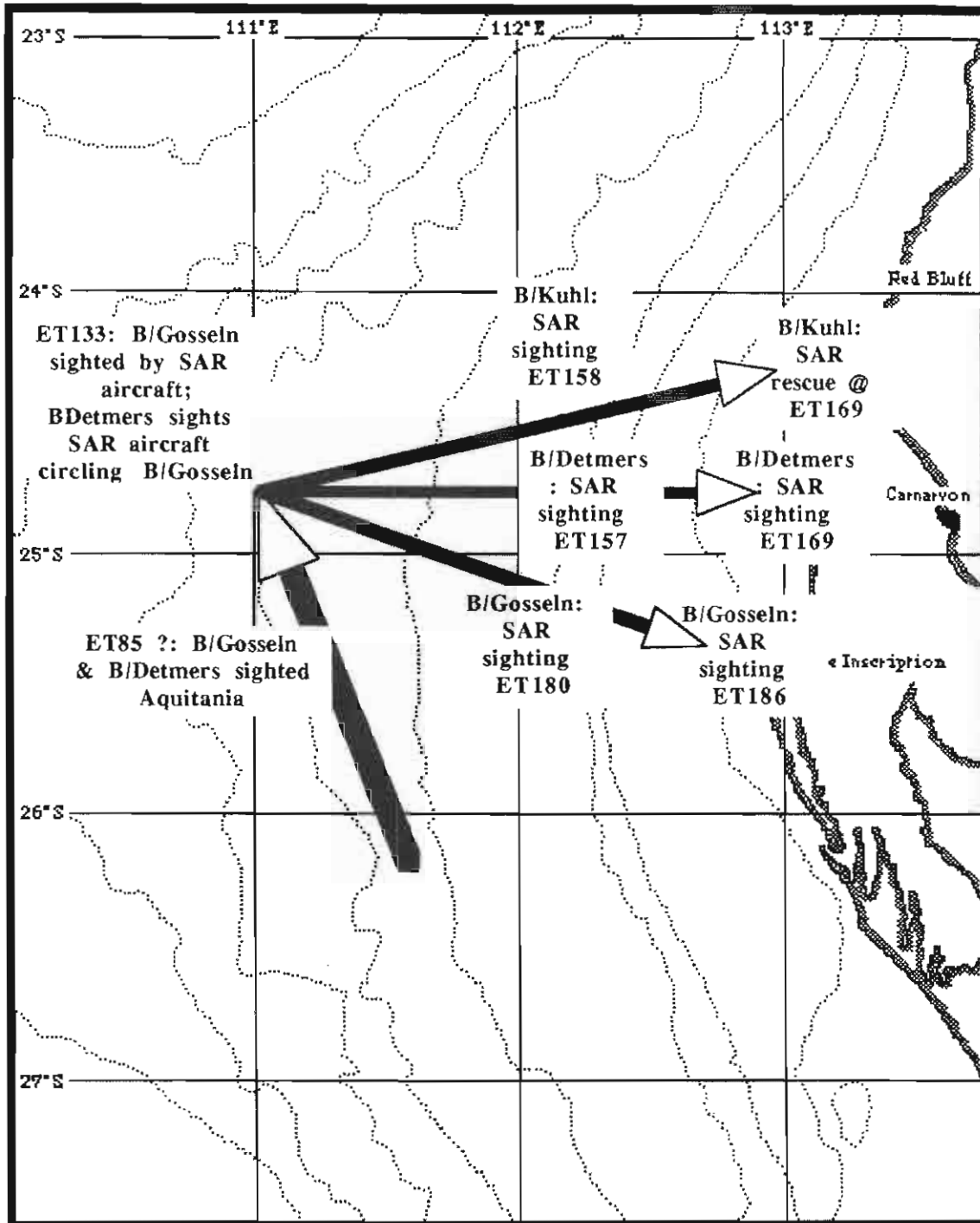


Figure 6  
The reciprocal relationship between Track of Aquitania and Drift  
Vector: Known and possible contacts



**Figure 7**  
**Reconstruction for B/Detmers, B/Gosseln and B/Kuhl**  
**Drifting from ET0-133; Sailing from ET133 to rescue as depicted**



**Figure 8**  
**95% Confidence Intervals for track of Sydney based on last five occasions when she crossed 26° S.**

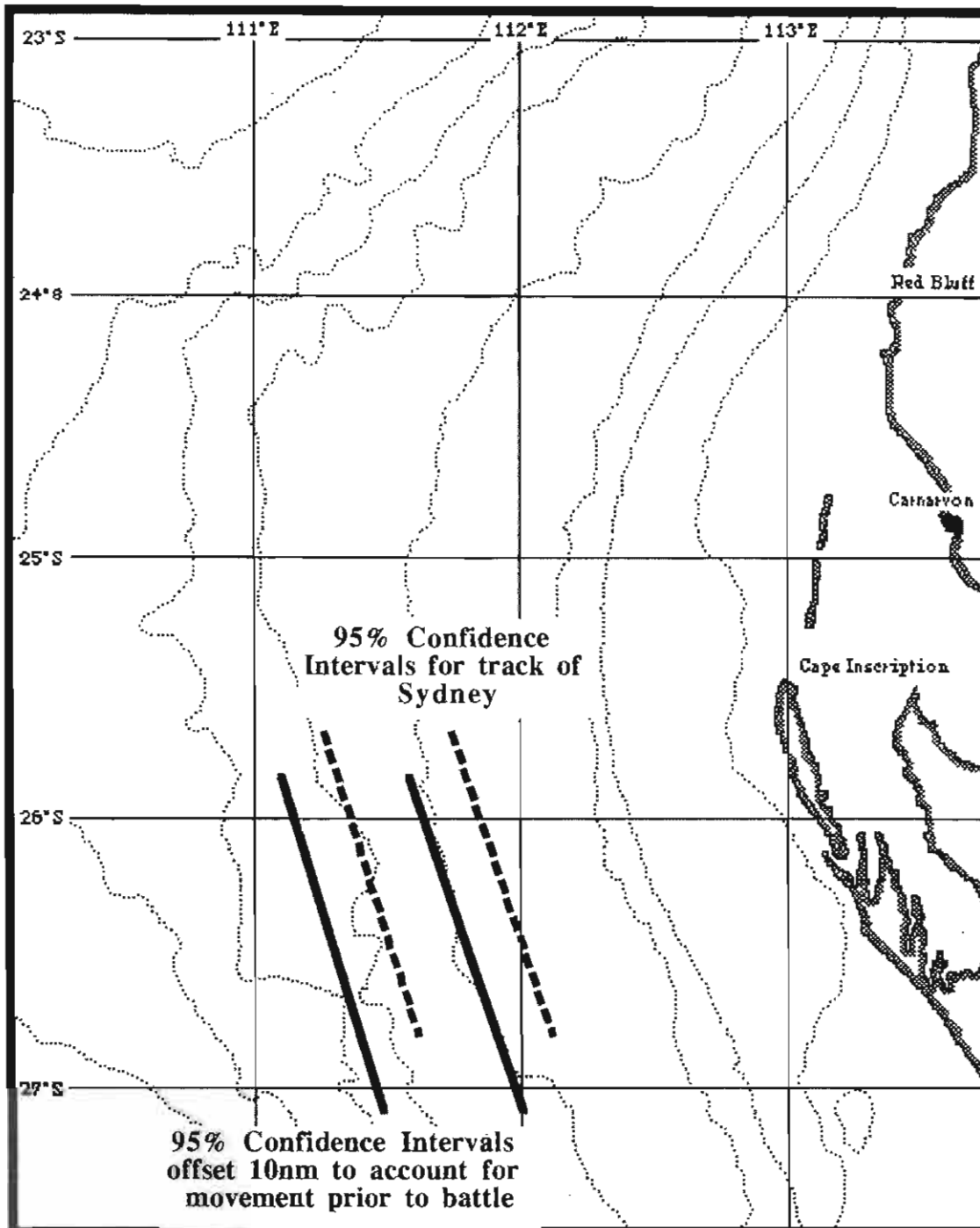


Figure 9  
Reconstruction based on drifting objects, diary records,  
and tracks from HMAS Sydney's previous deployments.

