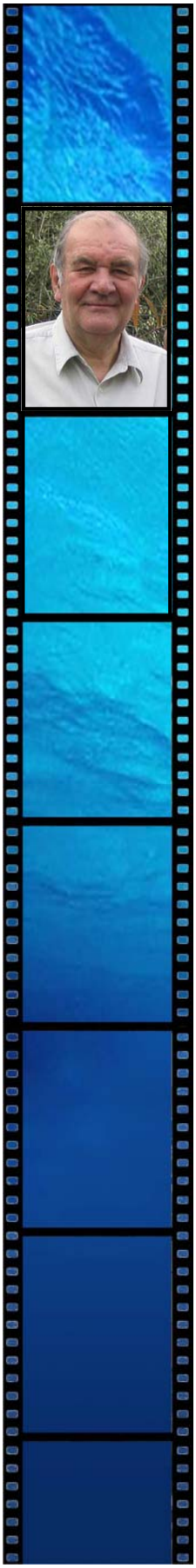

Article

NO SOLACE FROM SOLAS

The Effects that Deeper Draughts and the ENC are having on Safe Navigation

By Ian RUSSELL **(FRICS, MNI - UK)**

Abstract

Chapter V Regulation 9 of the SOLAS Convention, annexed for reference, requires contracting governments to provide hydrographic services. Many signatories cannot provide these unaided. This is despite the fact that new cruise ship itineraries and trade routes are being established in their waters for increasingly larger and deeper draught vessels. This article reviews a number of chart related casualties. These demonstrate that no chart, paper or digital, is infallible. This emphasizes the urgent need for new and better hydrographic data collection in some key oceanic areas. Potential innovative solutions for data acquisition and hydrographic capacity building strategies are considered.

Résumé

La règle 9 du chapitre V de la convention pour la sauvegarde de la vie humaine en mer (SOLAS), annexée à titre de référence, impose aux gouvernements contractants de fournir des services hydrographiques. Un grand nombre de signataires ne peuvent fournir ces services sans aide. Et ce, en dépit du fait que de nouvelles routes commerciales et de nouveaux itinéraires pour les navires de croisière soient adoptées dans leurs eaux pour des navires de plus en plus grands et aux tirants d'eau de plus en plus importants. Cet article examine un certain nombre de pertes liées aux cartes marines. Ces dernières illustrent le fait qu'aucune carte, papier ou numérique, n'est infaillible. Ceci souligne le besoin urgent de recueillir des nouvelles données hydrographiques de meilleure qualité dans certaines zones océaniques clés. Des solutions potentiellement innovantes pour l'acquisition des données et des stratégies de renforcement des capacités hydrographiques sont examinées.

Resumen

El Capítulo V de la Regla 9 de la Convención SOLAS, que se adjunta como referencia, requiere que los gobiernos contratantes proporcionen servicios hidrográficos. Muchos signatarios se ven ante la imposibilidad de proporcionar dichos servicios sin ayuda. Esto sucede a pesar del hecho que se están estableciendo nuevos itinerarios para los buques de cruceros y que se están estableciendo rutas comerciales en sus aguas para buques cada vez mayores y de calado más profundo. Este artículo examina un número de accidentes desafortunados relacionados con las cartas. Estos demuestran que ninguna carta, ya sea de papel o digital, es infalible. Lo anterior destaca la urgente necesidad de contar con una colección de datos hidrográficos nueva y mejor en algunas zonas oceánicas clave. Se consideran posibles soluciones innovadoras para la adquisición de datos y para nuevas estrategias de creación de capacidades hidrográficas.

Introduction

- **ENC Data Portrayal Issues**

The phased introduction of the mandatory Safety of Life at Sea (SOLAS) Convention Electronic Chart Display and Information System (ECDIS) carriage requirement, predicated the IHO Member States' commitment to full Electronic Navigational Chart (ENC) coverage. This poses the question whether the status of hydrographic survey and charting worldwide and the quality of hydrographic data is adequate to support the emerging technology. This is a concern, given the aspiration of the International Maritime Organisation (IMO) to implement the e-Navigation concept within the current decade.

It raises a number of questions for chart producers and users alike. The chart catalogues of International Hydrographic Organisation (IHO) Member States reveal that, away from the main traffic routes and major port approaches, ENC must have been compiled from charts of limited utility for the needs of contemporary shipping. This is compounded by the unsatisfactory portrayal of data quality in ECDIS. In many cases ENC producers have resorted to use of the "Unassessed" symbol for this critical attribute.

A review of the literature and the proceedings of the related IMO and IHO committees and working groups supports the contention that the presentation of ENC in ECDIS is capable of improvement. The evolution of ENC from the paper chart has resulted in the former inheriting the limitations of the latter. In the critical matter of enabling the user to assess the quality of bathymetric data, the ENC is frequently inferior to its predecessor.

- **Status of Hydrographic Surveys**

Table 1 indicates the extent of the data acquisition task facing even established hydrographic authorities, if they are to meet the perceived demands on their products. It also draws attention to the need for those developing States, parties to the SOLAS Convention Chapter V Regulation 9 (SOLAS V/9), to meet their obligations for the provision of hydrographic services. A significant number of coastal and Island States have signed up to SOLAS V/9 with no means of implementing it. This has produced a new and critical situation with regard to safe navigation.

Under this regulation, which came into effect in 2002, contracting governments undertake to execute hydrographic surveys, prepare, issue and update nautical charts and publications and ensure uniformity in their products and world-wide availability. These obligations must be based on the appropriate resolutions and recommendations of the IHO.

Table 1. *Examples of the status of Hydrographic Surveys 2013 (source: IHO C-55)*

Region	Unsurveyed or requires better data (0-200m deep)	Remarks
SW Pacific	>95%	
Polar regions	>95%	
Caribbean	>80%	
W. Africa	>80%	
E. Africa	>76%	Includes Somalia
W. Indian Ocean	>73%	Excludes Maldives
Papua New Guinea	>72%	
Australia	>65%	
Greece	>65%	
USA	>40%	
UK	>30%	
France	>19%	

The International Hydrographic Bureau (IHB), as the Secretariat of the IHO, provides guidance, advice and support in all hydrographic areas, in particular to those countries interested in establishing or expanding their hydrographic capabilities in order to fully satisfy the obligations of the new regulation. The IHO Capacity Building Strategy policy document was published in 2006 to provide guidance on the implementation of this remit. The strategy is currently under review as discussed later.

The advent of deeper draught shipping has increased the urgency for national programmes to review and upgrade coverage based on surveys carried out before the development of sidescan sonar and multi-beam echo sounder (MBES). The increasing tendency of cruise liners to seek new routes, anchorages, and port calls, has highlighted the need for more rigorous survey of areas which were originally explored in the nineteenth century. This is a major challenge for developing hydrographic services in the Caribbean, Indian Ocean and SW Pacific areas.

The projected increase in commodity shipments to and from the emerging economies and the continuing search for and exploitation of new mineral deposits is having similar consequences elsewhere e.g. Indonesia, Papua New Guinea and the South China Sea. Significantly there is no information available on the status of hydrographic surveying in Indonesia or the disputed Paracel and Spratly Islands in the South China Sea.

An example of some of the work needed elsewhere, is that for updating the 1970's single beam echo sounder surveys of the Malacca Strait. This has been requested by the International Chamber of Shipping (ICS). It would significantly enhance the utility of the proposed Malacca and Singapore Straits Marine Electronic Highway. Commercial survey companies have the capacity to undertake the work if funding is forthcoming.

Deeper Ships Dangerous Seas

Table 2 shows the progressive increase in the size of vessels.

Table 2. *Progressive increase in the size of vessels. The dimensions of those now at sea and on order, reflect the shipping industry's response to changing operational and trading patterns.*

No.	Vessel	L.O.A. (m)	Beam (m)	Draught (m)	Remarks
1	Great Eastern (1858)	211	25.0	8.5	4,000 passengers and 418 crew
2	Panamax (Panama Canal transit Limits)	294	32.3	12.0	Permitted vessel dimensions
3	Queen Mary (1936)	311	36.0	11.9	Trans Atlantic Liner
4	USS Iowa (1942)	270	33.0	11.3	Transited Panama canal (1945)
5	QE 2 (1969)	294	32.0	9.85	Liner specification also cruised
6	Cape Size (1997)	305	53.0	17.0	Can now use Suez canal
6	Carnival Spirit (2001)	294	32.3	7.8	Now cruising in SW Pacific
7	Ultra Large Crude Carrier (ULCC)	380	68.0	24.5	TI Class (4) Entered service 2003
8	Queen Mary 2 (2004)	345	41.0	10.1	Liner specification but also cruises
9	Royal Caribbean Oasis of the Seas (2009)	362	60.5	9.3	Beam @ W/L 47m
10	Valemax (2011 -)	362	65.0	23.0	Ore Carriers Brazil - Asia
11	Maersk *Triple E* class (2013 -)	400	59.0	14.5	Container Ship (18.000 TEU)
12	Royal Caribbean Quantum Class	348	41.0	8.5	Delivery 2014
13	New Panamax	427	55.0	18.3	Planned new lock dimensions

Contemporary vessel draughts have dictated the survey and charting requirements and the depth criteria for the definition of a dangerous wreck. For UKHO this is currently 28m (15 fathoms). Until 1960 it was only 14.6m (8 fathoms).

Despite a steady increase in the length of cruise ships the draught of the current vessels in service has not increased proportionately and averages 8.4m. The increased length will mean that unless host ports can expand and deepen berthing areas and approach channels, more attention will need to be given to surveying roadstead anchorages. An example of the work required is shown in ***Figure 1***.

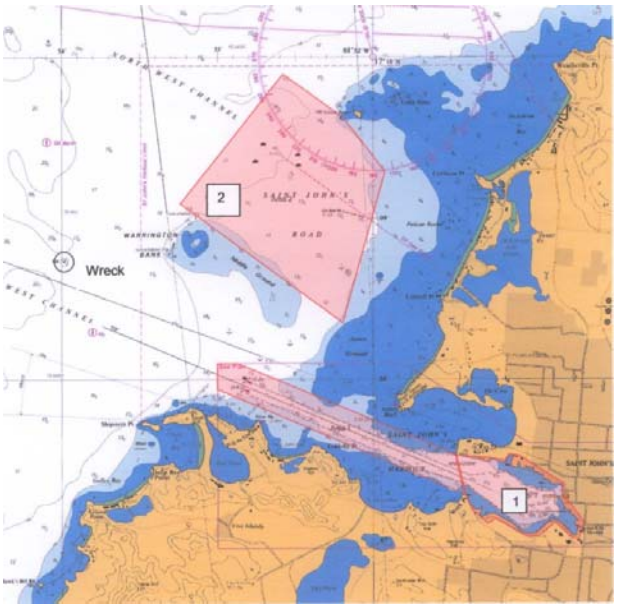

Figure 1. *Antigua 2011 - Full seafloor coverage of St John's Harbour and St John's Roads (last surveyed in 1849)*

Source UKHO [1] *presentation to Meso-American and Caribbean Hydrographic Commission.*
Extract from Admiralty Chart 2065 © Crown Copyright and/or database rights. Reproduced by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office (www.ukho.gov.uk)

Cruise ships are now venturing into increasingly remote and poorly charted areas such as the Polar Regions, SW Pacific, Indian Ocean and the Caribbean. Itineraries that seek to provide optimum passenger experience could have unintended consequences.

- **Cruise Ship Crashes**

An example of what such ventures may lead to occurred in January 1971 when the French passenger liner *Antilles* (l.o.a.183m, beam 24.4m and draught 8m), recently converted into a cruise ship, on passage from La Guaria in Venezuela to Barbados, struck an uncharted reef half a mile off the NW coast of Mustique in the passage which separates that island from Baliceaux in the Grenadine Islands. As the ship proceeded at a speed of 16 knots, the impact caused her to break in two, catch fire and become a total loss.

The passage being attempted was through apparently open water, with charted depths of 13 and 16 metres some 3½ cables (640m) wide, between two rock outcrops, in a coral and reef-strewn area last surveyed in the 19th century. This followed an alteration to the planned voyage. It was authorised by the master in order, as the subsequent legal proceedings revealed, '*to provide his passengers with a better look at this enchanting isle*' and was consistent with his desire to implement the Owner's policy of making *Antilles*' *cruises entertaining and unique.*

Two decades later another ocean liner undertaking a cruise provided a further example of the danger involved in such a vessel operating in inshore waters. In August 1992, *Queen Elizabeth* 2 (l.o.a. 294m ((63 ft), beam 32m (105 ft), draught 9.85m (32 ft)) grounded on uncharted and previously unsurveyed rocks to the south of Cuttyhunk Island, off the east coast of the USA. She was then on passage from Martha's Vineyard to New York. In trying to make up time for an ETA at her next port of call, speed was increased to about 25 knots. This was not warranted by the general depth of water and induced 4 feet of squat. Consequently the vessel grounded on rocks which a subsequent survey found to have a least depth of 33 and 34 feet. The charted least depth in the vicinity was 39 feet; this was confirmed by the re-survey. The nature of the seabed was shown as rock.

The owners of the QE2 sued the USA for negligence on the part of the charting authority for failing to carry out a more thorough hydrographic survey of the area. In particular, they claimed that the 39 foot sounding had not been examined. The charting authority stated that there was no reason to develop the 39 foot sounding further because it was outside the normal shipping lanes and that in 1939, when the area had last been surveyed, large vessels such as the QE2 never frequented those waters. The court accepted this argument and dismissed the claim.

In April 2000, the "Adventure" cruise ship *World Discoverer* (l.o.a. 87m, beam 15m, draught 4.57m) grounded on a large allegedly uncharted rock or

reef in Sandfly Passage, Solomon Islands. The ship was fatally holed and the master beached her in Roderick Dhow Bay, where the hulk remains.

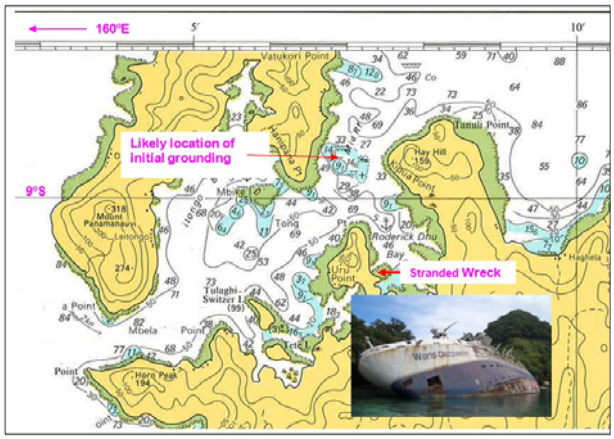

Figure 2. *Portion of chart BA 1713 current at the time of the grounding showing the shoals in the northern entrance to Sandfly passage, on which it is presumed World Discover struck and her final resting place in Roderick Dhu Bay. [2].*

Extract from Admiralty Chart 1713 © Crown Copyright and/or database rights. Reproduced by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office (www.ukho.gov.uk)

Neither the Australian Hydrographic Service nor the UK Hydrographic Office, the Primary Charting Authority, has any record of the incident. The stranded wreck of *World Discover* is clearly visible on Google Earth, but is not shown on the latest (2012) edition of chart BA 1713. The Pacific Island Pilot, current at the date of the incident, advises that; "*Deep-draught vessels should not attempt the passage owing to the reefs in the N entrance.*" The latest (2007) edition of the Pilot directs vessels west of Mid Reef; passing clear of the 9.1m patch. This remains the least depth shown in the passage other than the reef itself.

- **Uncharted Rock**

Such dangers also exist for large cargo vessels navigating in poorly charted waters to service the exploitation of newly-found mineral resources. A prime example occurred in late 2010. The bulk carrier *Noble Hawk* (l.o.a.190m (623 ft), beam 33m (108 ft), draught 12.5m (41 ft)), starting a passage to China from Pulau Mabuli on Halmahera Island in Eastern Indonesia, grounded on an uncharted 5m (16 ft) shoal. The surrounding depths were 29 to 32 fms (53 to 58m). Her course lay across Teluk Buli which is much encumbered with islets, reefs and shoals. She was loaded with nickel ore embarked from a berthing facility somewhere on the coast of the bay, which does not seem to have been charted. However, jetties with vessels alongside and a large ship offshore can be seen on Google Earth. As can what appear to be open cast mineral workings.

Early in 2012 the Indonesian Navy Hydrographic Service (DISHIDROS) carried out a single beam

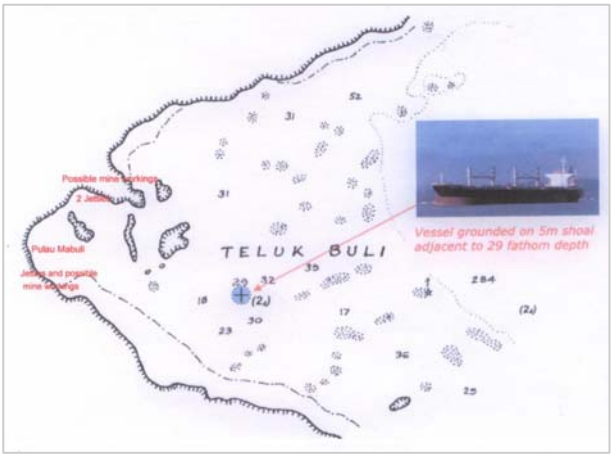

Figure 3. *Sketch map derived from Chart BA 2788 showing position of grounding in relation to Noble Hawk's departure point, adjacent depths and shoal areas.*

and sidescan sonar survey of the grounding site and found a least depth of 3m (10 feet) and an adjacent depth of 15.3m (8fm 2 feet) in general depths of 50m (27fms). Mindful of the significant activity of large cruise ships and bulk carriers in these waters, DISHIDROS recommended the installation of a navigation beacon on the feature. It is uncertain whether or not this recommendation has yet been acted upon.

- **Oceanic Dangers**

The significant draughts in the ***Table 2*** are those of the large cargo vessels which now exceed 17m and are as much as 24.5m. New Panamax vessels transiting the Caribbean may not be able to do so with the same confidence as their predecessors. Elsewhere ULCC and large bulk carriers are vulnerable to an encounter with an uncharted seamount rising close to the surface. In the deep areas of the ocean, most mariners consider that there is little chance of such a mishap. Unfortunately, this is a misconception.

In 1973 the cargo ship *Muirfield*, with a draught of 16m, was on passage from the Cape of Good Hope to Selat Sunda. There was a 2-3m swell running when she struck the top of a seamount, 75

miles south west of the Cocos Islands. A subsequent survey showed this to be half a mile in extent; with a least depth of 18m in charted depths of over 5,000 metres. Two further examples of navigationally significant seamounts, discovered in the South Atlantic and Indian Ocean, include Vema Seamount (with a charted depth of 11 metres - about 1,000 km west-north-west of Cape Town) and Walters Shoal Seamount (with a charted depth of 15 metres - about 400 nautical miles south of Madagascar). These seamounts rise up from ocean depths of about 4,000 and 2,000 metres respectively.

More than 90% of all seamounts greater than 1km in height (estimated to be more than100,000) are unobserved by either ship soundings or satellite gravity [3]. This observation is consistent with the statement in IHO publication C-55 that renewed attention needs to be given to the disproving of vigias especially adjacent to the maritime shipping routes in the Pacific and adjacent seas. The danger to submarine navigation is self evident. This is exemplified by the incident involving a nuclear powered submarine of the US Pacific fleet that collided with a seamount about 364 nautical miles southeast of Guam.

The submarine was travelling at maximum speed at a depth of 525 feet (160 m). The seamount that she struck did not appear on the chart in use at the time of the accident. Other charts available for use showed an area of "discoloured water", an indication of the probable presence of a seamount. The US Navy investigation [4] determined that information regarding the seamount should have been transferred to the charts in use; particularly given the relatively uncharted nature of the ocean area that was being transited and that the failure to do so represented a failure to follow proper procedures. Fortunately the pressure hull was not breached enabling the submarine to surface and be escorted to Guam for temporary repairs.

- **Caveat Navigator**

This submarine accident is indicative of the fact that the failure to make proper use of limited charted information, whether on paper or a screen, applies as much to the bridge personnel of naval vessels as to those of commercial vessels. The unsatisfactory portrayal of the reliability of charted information in ECDIS means even more caution needs to be currently exercised by mariners when away from regular routes. Two further examples, although separated by more than 40 years, are pertinent to this general discussion.

In June 1970 a fleet auxiliary vessel of the Royal Navy, the tanker *Ennerdale*, (l.o.a. 744 ft (227m), beam 98 ft (30m), draught 40 ft (12m)) struck a rock pinnacle about 8 miles NNE of Port Victoria in the Seychelles. This opened up her starboard side, causing her to heel over and settle on the seabed. The pinnacle, which was charted at 9fms (16.5m), lay adjacent to a 10fm sounding in general depths of 13 to 16fms. The vessel, travelling at 12kts, was crossing a line of pinnacles and islet outcrops which extend north eastwards from the north tip of the Island of Mahé within the 20 fathom line.

The chart in use was compiled from a 19th century (lead line) survey, as clearly stated in the title block. Considering this fact the least depth of water over the pinnacle (subsequently established at 10.8m (35ft)) may well not have been shown on the chart in use. However, there was sufficient indication on the chart that shoaler water may well have existed in the vicinity. The prime cause of the accident, leading to a total loss of the vessel, was poor execution of the navigational departure plan, which would otherwise have taken the vessel clear of the danger.

A far more recent incident took place in January 2013, when a mine counter-measures vessel USS *Guardian* (l.o.a. 68m (224 ft), beam 12m (39 ft), draught 4m (13 ft)) ran aground on Tubbataha reef in the Sulu Sea. On the coastal scale Digital Nautical Chart (DNC) being used the reef was positioned 8 miles to the east of its correct position, in contradiction to the general scale DNC and the standard paper chart. Unfortunately, the approved voyage plan in the Voyage Management System used the coastal DNC and no attempt was made to investigate the discrepancy. This decision was based on the supposition that it was well known '*that general charts are inaccurate*', a remark which, aided by the bridge team's preference to rely on the DNC rather than to take corrective action when a light on the reef was raised, resulted in the total loss of the ship.

The focus for future survey effort: some examples

- **Traffic Routing**

Traffic surveys using the satellite Automatic Identification System (AIS) can provide preliminary indications of where future data acquisition effort might need to focus. This can be augmented in consultation with the IMO and representative

industry bodies such as, the International Chamber of Shipping (ICS), the International Association of Independent Tanker Owners (INTERTANKO), the International Association of Dry Cargo (INTERCARGO), and the Baltic and International Maritime Council (BIMCO).

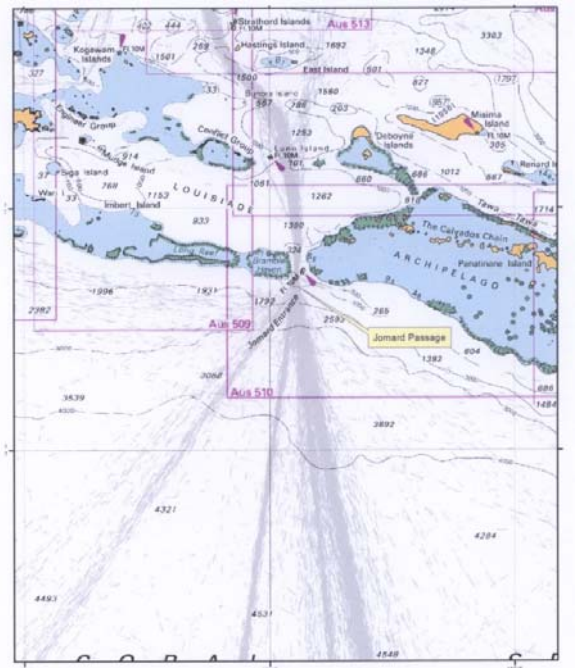

Figure 4. *Ship traffic in the vicinity of Jomard Entrance, Papua New Guinea*

Taken from NAV 59/INF.3 31 May 2013 [5]
Extract of Chart Aus 4621 Copyright Commonwealth of Australia (2011). Used with permission of the Australian Hydrographic Service.

In Figure 4, AIS data marks the route through Papua New Guinea waters from Eastern Australian to Asian ports and substantiates the assessment that:

> Papua New Guinea is experiencing a marked increase in the volume of international ship traffic through its waters. It is estimated that some 7,360 ships transited its waters in 2012. The majority of this traffic was to and from ports on the eastern seaboard of Australia. There are growing risks to the safety of navigation and protection of the sensitive marine environment associated with this increasing traffic. Areas of particular concern are Jomard Entrance and the area east of Rossel Island. However, the quality (Zone of Confidence or ZOC) of the hydrographic surveys in the Jomard Entrance area is category "C". Therefore, it would be necessary to improve hydrographic information available for the area, before any ship routeing systems are established.

C-55 notes that *the banks and vigias near Coetivy Island (Seychelles) lie on the flanks of a trans-ocean sea-lane and require thorough examination*. This route is used by ships transiting the Mozambique Channel and turning eastward north of Madagascar. Similarly surveys are required south of Mauritius as ships divert eastwards from the shortest route to the Gulf to avoid pirates as evident from ***Figure 5***.

Figure 5. *Satellite AIS data in the WIO Marine Highway Development area*

Image from presentation by South African Marine Safety Agency (SAMSA) on the results of the Global Environmental Facility (GEF) - Western Indian Ocean Marine Highway Development and Coastal and Marine Contamination Prevention Project.

The French Hydrographic Service (SHOM) completed a route survey in the Mozambique Channel in 2010 for the Western Indian Ocean (WIO) Marine Highway. SHOM is deploying a survey vessel to the Indian Ocean again in 2014 and there is mention of a survey en-route of a possible gap (unspecified) in the Highway. Recent (2012) Satellite AIS data (refer Figure 5) clearly shows where survey priorities should lie. Even though the situation in the Mozambique Channel is probably understated as vessels frequently turn off their AIS to avoid revealing their position to pirates.

Ships diverting south of Mauritius now pass closer to that island to embark or disembark security personnel. The pattern of risk to the region's ecosystems has therefore changed, increasing the exposure of the south coast of Madagascar, Mauritius, Rodrigues and the Maldives.

In hindsight the route survey in the Mozambique Channel was perhaps not the best use of limited deep water multibeam survey resources. The WIO Marine Highway Development (MHD) project participants' proposal to establish a new recommended route for all ships in the Mozambique Channel was rejected by IMO Member Sates. The route would have been approximately 1,000 miles long. The compelling need for the measure was

unclear. No statistical evidence had been provided regarding shipping casualties or near misses. This omission made it very difficult to quantify the anticipated benefit that the proposal might have delivered. The route would have needlessly denied the full use of a wide deep water channel. It was felt that concentrating shipping into restricted lanes could potentially have increased the risk of collision.

The refusal of the IMO to designate a recommended route through the Mozambique Channel could have unintended consequences for any future international effort to focus survey effort on routes rather than the traditional area surveys. Although the Mozambique Channel was not a typical case, the World Bank's assessment [6] of the WIO MHD project found that '*the relevance of the marine highway concept to increase the safety and efficiency of navigation in the Mozambique Channel is questionable'* and that '*The Mozambique Channel is not appropriate for such a scheme for two reasons: it is wide (400 km wide at the narrowest point), and the density of the traffic is relatively low*'.

- **Need and Risk Assessment**

The figures used to determine percentages of the seas and oceans remaining poorly charted or not at all, while alarming, are perhaps unrepresentative of the practical situation. Rather what is needed is a figure for that portion of useable sea space suitable for shipping that is in urgent need of survey. As a starting point one might refer to the routes in UKHO's NP136 (Ocean Passages for the World). An example of which is given in ***Figure 6***. Details of current and potential cruise ship destinations can be sought from operators. Analysis is required of the likely demands for updated charts to support emerging new trading patterns. These will be associated with developing exploitation and shipment of mineral resources and hydro carbons and with consumer demand and export growth in the emerging economies of this decade and beyond.

It should not be automatically assumed that all charts compiled from single beam echo sounder surveys are no longer fit for purpose. Particularly if used with appropriate discernment and where relevant, complemented by modern aids to collision avoidance such as masthead CCTV and forward looking sonar. An alternative to the latter in inshore tropical waters and when entering and leaving harbour, might be a bow lookout with Polaroid glasses. Such measures, complementing the existing careful and informed appraisal of legacy data by Hydrographic Offices, could well result in some reduction in the perceived magnitude of the re-survey requirement.

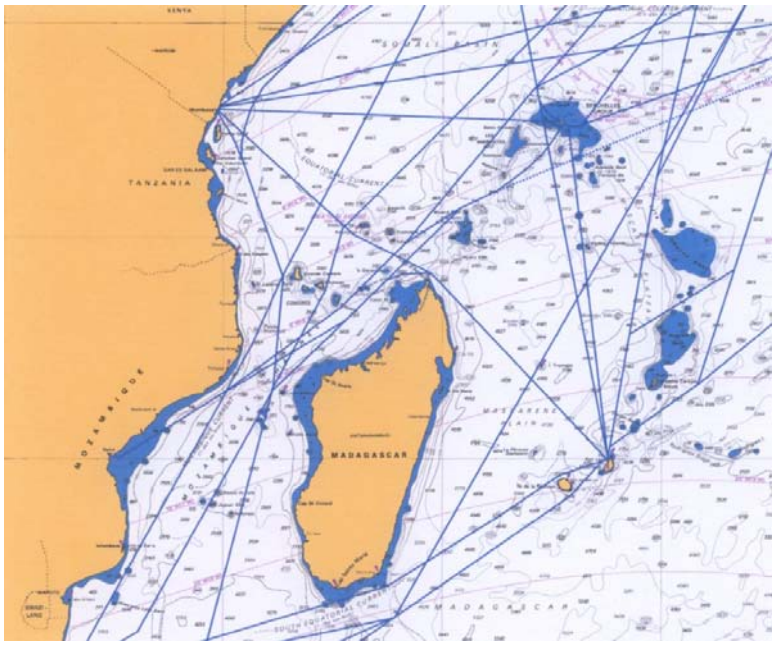

Figure 6. *Ocean routes in the Western Indian Ocean marine Highway Development project area*

Source: Admiralty Ocean Passages for the World NP136 4th Edition. Extract from Admiralty Chart 4071 © Crown Copyright. Reproduced by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office (www.ukho.gov.uk).

For example, an enduring Hydrography Risk Assessment Framework [7], such as that established for a South West Pacific maritime infrastructure comprises the following:

a) A Regional Risk Assessment;
b) An Economic Impact Analysis; and
c) A Regional Risk Assessment Implementation Plan and funding mechanism agreed by donors/key stakeholders

This assessment process seems to be a pragmatic and commercially relevant method to prioritise the survey needs of the Small Island Developing States, scattered throughout the region. It is notable that this initiative is led not by a Hydrographic Office; but by the New Zealand Ministry of Foreign Affairs and Trade, Aid Programme.

- **Filling in the White Space**

The President of the Directing Committee of the IHB acknowledges that alternatives to the deployment of survey ships must be found for "Filling in the White Space on Charts and Ocean Maps" [8]. This is in the interest not only of safety of navigation but to service the wider blue economy. Against this background, any viable alternative methods of obtaining suitable depth information in a cost effective and reliable manner should be investigated and promoted.

- **Satellite Derived Bathymetry**

In the opinion of the IHB [9], shallow water bathymetry derived from multi-spectral imagery, should be considered as a potential technology for obtaining bathymetry for charting purposes in areas where existing surveys are poor or non-existent. Bathymetric and other useful environmental data can be derived extremely cost effectively by this means. However, the information content of these data must be well understood and not regarded as a replacement for acoustic, Light Detection and Ranging (LiDAR) or other high resolution surveying sensors.

Over the past decade, there have been significant advances in the methods used to derive bathymetry from multi-spectral satellite imagery. It is now acknowledged that Satellite Derived Bathymetry (SDB) has the potential to make substantial improvements to otherwise inadequate charts. It can provide useful hydrographic data in areas where existing charting is based on little or no hydrographic surveying and there is little prospect of conventional surveys being conducted in the reasonable future.

- **Crowd Sourcing**

Crowd sourced bathymetric (CSB) data from ships of opportunity and recreational vessels can be used to check and supplement SDB; as well as provide inshore and ocean bathymetry independently. Currently there are issues about data quality, reliability and chart producers' liability. The IHB is being invited to address these by producing standards and methods of qualifying and identifying CSB data if used for charting inshore waters.

Passage soundings have been and remain a useful source of information for the nautical cartographer and ocean mapper. CSB updates this process and UKHO is a major participant in CSB trials in Antarctica [10]. Participating cruise ships, belonging to the International Association of Antarctic Tour Operators (IAATO), have been fitted with the ARGUS CSB system which plugs into the vessel's navigation system and echo sounder. Data is recorded and down loaded virtually autonomously with minimal crew involvement.

Successful surveys have also been carried out in uncharted Antarctic waters by an IAATO yacht *Xplore* [11], provided with survey systems and with a SHOM hydrographer embarked. The results were of charting quality. IAATO has clearly identified the potential for suitably equipped yachts and cruise ship tenders to complement the survey efforts of government vessels, particularly in inshore waters. Trials with a hydrographic data logger are taking place this year under an IHB/ Professional Yachting Association (PYA) initiative. The ideal would be to see the system installed in every professionally crewed ship.

Figure 7. *Luxury yacht providing Antarctic cruises*
Source IAATO presentation to Hydrographic Commission on Antarctica Meeting December 2013

- **Invisible Data**

Large bathymetric data sets from both commercial and scientific sources remain inaccessible to charting authorities for various reasons. A system needs to be devised which at least acknowledges that such data exists and might in time become generally available; if necessary at a price. This would certainly not equate to the cost of a repeat survey.

Coastal States should always endeavour to get data from Hydrographic Surveys and Marine Scientific Research conducted within their EEZ. This is not always straight forward, as interpretation of the UNCLOS provisions concerning the collection of marine scientific data and Hydrographic Surveying is a contentious area. Additionally, as C-55 states; "… *failure to apply IHO S-44 criteria in Marine Scientific Research and offshore industrial surveys leads to the loss of opportunity data for SOLAS charting purposes".*

Meeting the SOLAS V/9 Challenge

- **IHO Initiatives**

The IHB's response to its mandate under SOLAS V/9 was to establish a Capacity Building Committee (CBC), which first met in 2003. This is now the Capacity Building Sub-Committee (CBSC) of the Inter-Regional Coordination Committee (IRCC). The CBC replaced the previous Technical Assistance Coordination Committee whose remit was narrowly focused on specific education, training and limited equipment provision. The CBC drew up the more broadly based Capacity Building Strategy of the IHO (published in 2006). This better reflected the IHO's contribution to safety of navigation as complementing that of IMO and the International Association of Lighthouse Authorities (IALA). At the last International Hydrographic Conference (IHC) in 2012 the CSBC was tasked to review the strategy and report to Member States at the Extraordinary IHC in October 2014. This injunction perhaps reflects the fact that earlier capacity building initiatives have been unavailing and unsustainable. It is now recognised that these did not engage top decision makers; but rather assumed that Hydrography *per se* was self-evidently beneficial to the national well being. That said, reports from the IHO Technical Visits to the Caribbean region in 2006 and subsequent ones to E Africa, Madagascar, Seychelles and Mauritius in 2011/12 clearly reflect a new approach.

The conclusion [12] from the comprehensive IHO technical assessment visits to the Caribbean region in 2006 bears setting out in full in the context of this discussion. It exemplifies the challenge confronting all developing coastal States bordering busy seaways and included in the itineraries of cruise ship operators.

> "This mission covered a sea area of immense international and regional significance. It encompassed many of the main passages from the Atlantic into the Caribbean and onwards to the Gulf of Mexico and Panama Canal. The countries bordering these strategic seaways are small island states or dependencies dealing with a multitude of challenges to good governance with limited financial and human resources. Their coastal waters are traversed by some of the biggest passenger-carrying vessels in the world, yet a significant percentage of those waters have not been surveyed since the nineteenth century. It is imperative that the countries visited are assisted to implement appropriate and sustainable arrangements to meet their obligations under SOLAS Chapter V."

Subsequent initiatives by the member States of the Regional Hydrographic Commission (RHC), in cooperation with UKHO and NOAA have made some advances in improving charting and other Marine Safety Information (MSI) services, in particular around Antigua, British Virgin Islands and in Belize/Honduras. This suggests that the revised strategy of staged and focused technical assistance and engagement of top decision makers is starting to pay off. Despite this improvement, efforts to establish effective MSI capabilities remain heavily dependent on outside technical assistance and responsible national agencies continue to be under-resourced.

There is a similar pattern in the waters of East Africa and the West Indian Ocean where US, India and France are undertaking surveys and providing technical assistance. A series of IHO Technical visits in 2011 and 2012 established that local MSI capability is limited and that Capacity Building (CB) needs a regional component. There was a consensus among visit teams that pooling of survey equipment for deployment in craft of opportunity could be beneficial.

Figure 8. *Antigua and Barbuda Coastguard craft with MBES and a positioning and motion sensing system temporarily fitted*

Source UKHO presentation to Meso American and Caribbean Hydrographic Commission 2011

- **Non-compliance with SOLAS V/9**

Coastal States, in the regions identified in C-55 as poorly charted, are generally signatories to the SOLAS Convention, but do not appear to have accepted their obligations for provision of Hydrographic Services. Many have invested in offshore surveys and costly technical and legal advice to establish entitlement to an extended continental shelf (ECS) beyond 200M. This is understandable and was driven by the time limit imposed on submissions as well as the prospect of gaining access to additional seabed resources. The SOLAS requirement to ensure the safety of navigation within existing maritime zones has clearly not engaged decision makers to the same extent. In most cases the momentum generated by the ECS submission process and the raising of awareness of maritime matters was not sustained. Consequently it did not translate into the necessary government actions required to fulfil national SOLAS obligations despite attempts by donor agencies to demonstrate the connection.

The unfortunate reality has been that donor funded projects have rarely been sustainable. Boats and equipment have gradually fallen victim to the climate and lack of maintenance. Trained personnel have moved on, unable to fully exercise their new-found skills. Accessory funding has not been forthcoming and most projects focused on technical provision rather than institution strengthening and encouraging top level government support. Recipients have failed to take ownership of projects or to shoulder any financial burden.

- **Concerted Action by International Organisations**

The need for collective action between all organisations with responsibility for *safety of life at sea* and the *protection of the marine environment* has now been recognised. The latter, more than the potential for loss of life or property, seems to attract the attention of Coastal States' governments and funding agencies. Hence the Global Environmental Facility was persuaded to finance both the Malacca and Singapore Straits and WIO Marine Highways demonstrations to minimise the risk of collision involving the VLCC and other vessels constrained by size, transiting those waters.

At the last International Hydrographic Conference in 2012, it was agreed that IHO member States should commit to working with IMO Member States to promote the need for improved hydrographic survey and nautical charting services as required by SOLAS V/ 9 and to provide support through the respective IHO and IMO capacity building programmes. The IHB has since held a Capacity Building coordination meeting with IMO, IOC, WMO, IALA and others and has called particular attention of Regional Hydrographic Commissions (RHC) to the initiation of the IALA World Wide Academy [13]. The objectives of the Academy under the headings of Awareness, Assessment, Analysis and Actions serve as a template for capacity building to which the IHO subscribes in its own capacity building strategy.

At the 2013 meeting of the CSBC the UK, drawing on findings from recent meetings of those RHC for which it is CB co-ordinator and noting the dramatic increase in demand for CB made the following points:

a) That initial assessments of CB requirements be jointly compiled as one 'Country Profile' by IMO, IALA and IHO;

b) That both IHO and IALA should become part of the team for the IMO Member State Audit Scheme;

c) The need for a top down approach;

d) Acknowledgement that IHO member States should derive CB benefits as well as contributing to the needs of non-members.

- **Risk Assessment – Economic Benefit**

New Zealand has developed a risk assessment and cost benefit methodology to enable informed

decision making about investment in improving charting and MSI for Island States in the SW Pacific. This seems to be a very sensible approach and much more likely to result in Government, Donor and Stakeholder engagement. An initial assessment of through traffic, local trading patterns and the increasing number of cruise ship visits in Vanuatu (New Hebrides), has concluded that updating of the charts and improvements to and/or refurbishment of aids to navigation would yield significant economic benefit. As a result a survey programme has been initiated and work is currently in progress.

- **Industry co-operation**

As an example Carnival Australia (the largest cruise ship operator in the Pacific) is to develop a public-private partnership that aims to foster linkages between the cruise ship industry and local economic development opportunities. Carnival has identified the need for improved maritime safety information (MSI) and that the major barrier to expansion of cruise ship activity in Vanuatu, Tonga and Fiji is the lack of accurate and adequate charting.

The above approaches may well be something that should be looked at in the Caribbean. It is encouraging to note that in 2011 a Marine Superintendent from a Cruise Ship operator participated in a meeting of the RHC. The company's ships are over 1,000 feet (305m) in length with a draught of 27 feet (8.2m) and carry a total of 4,000 passengers and crew. Surveys such as those of St John's Antigua cited earlier (see Figure 1) are clearly a response to the needs of such vessels.

The IHO has for some time encouraged cooperation with industry and representatives of commercial survey companies and equipment manufacturers have enjoyed observer status at meetings of IHO committees, Working Groups and RHC. They have also participated in workshops and training courses. Suggestions have been put to the IHO Inter-Regional Coordinating Committee for an industry contribution to the successful implementation of an enduring Capacity Building policy. These include exploiting the industry's association with donor organisations, full participation in education and training provision, addressing the issue of sustainability and ultimately collaborating with developing States in the identification of survey needs, procurement of survey services and the design and execution of surveys.

- **Too much technology**

In the digital age there seems to be a perception that developing countries can bypass the essential learning curve of traditional survey and cartography and move directly to multibeam E/S surveys and ENC production. This was an unrealised expectation of the Hydrographic and Maritime Safety Information (MSI) components of the WIO Marine Highway Development Project. There is concern even in established Hydrographic Offices, that the automation of many critical cartographic functions could adversely affect product quality.

In order to meet the IHO commitment to full ENC coverage it is considered that CB has been skewed towards training in ENC production. This is phase 3 of the IHO CB strategy. It should have been preceded by enabling the collection and circulation of nautical information, necessary to maintain existing charts and publications up to date. This then would be followed by the creation of a surveying capability. The feasibility of implementing phase 3 is acknowledged to be questionable. Bi-lateral agreements for charting can provide easier solutions in production and distribution of ENC through Regional Electronic Chart Coordination Centres.

Conclusions

The unsatisfactory state of global hydrographic data and resulting poor quality of global charting undermines the improvements to the safety of navigation anticipated from ECDIS. It will require concerted action from all coastal and Island States Parties to the SOLAS convention to remedy this. For many signatories to the convention, the need to honour their undertakings for the provision of hydrographic services is not a high priority. There are more urgent demands on slender human and financial resources. Any attempt to create a global network of indigenous cartographic and hydrographic entities for the production of even usage band 5 and 6 ENC, is unlikely attract the required support from governments. The current review of the IHO Capacity Building strategy is therefore welcomed.

The decline in national hydrographic survey assets is permanent. A mechanism needs to be found to harness the resources of the commercial sector to fill the gap. The successful outcome from the Introduction to Hydrographic Surveying and Nautical Charting training course in Antigua (see *Figure 1*) showed what could be achieved in this respect.

The wider use of SDB could prove cost effect and attractive to cash strapped administrations, particularly in many small-island developing States. CSB also has merit as in Antarctica and to verify SDB elsewhere. Gravity anomalies inferred from satellite altimetry can assist in the eradication or confirmation of vigias as potential dangers on ocean routes.

It is never going to be possible to fill in all the "white spaces" on the charts and consequently a rigorous and informed analysis of need and allocation of survey resources is necessary. The prototype Hydrographic Risk Assessment methodology developed by New Zealand to assist decision makers to prioritise hydrographic surveys is one solution to this problem. The WIO Marine Highway Development Project was an ambitious attempt to focus survey effort; but was only partially successful. The hydrographic component failed to identify the actual rather than the perceived route survey requirements. Increasingly, as in Australia and Oceania, the shipping industry is likely to have to accept more routing restrictions. This will place the onus on the littoral states to install and maintain the necessary aids to navigation and MSI infrastructure.

The implementation of SOLAS Chapter V concerns all aspects of navigational safety; of which the maintenance of nautical charts and publications and the dissemination of safety critical navigational information is but one. It is therefore essential that all international bodies with responsibilities for oversight of safe navigation coordinate their regulatory, promotional and mentoring activities. This is particularly important when raising awareness of maritime safety issues with governments and funding agencies. Past attempts at capacity building have been largely unavailing because recipient countries have not taken ownership of these initiatives.

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