THE COST-BENEFIT OF CHARTING CAMEROON WATERS

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Abstract. The aim of the investigation was to examine the cost benefit to Cameroon of charting her navigational waters. This paper concentrates on examining the economic benefit of maritime trade in Cameroon and the potential economic consequences that result from poorly updated nautical charts. A cost benefit ratio was determined. The paper addresses:

- International and national trading activities
- The cost of surveying and charting activities
- The relationship between commercial, insurance and environmental costs.

The initial investigation compares Cameroon with other developing states. From a description of the waters and trade in Cameroon, the paper addresses resources in terms of ports, fishing, hydrocarbons and environmentally sensitive areas. It describes the role of navigational charts and its contribution to the growth of a state's economy. In order to determine the benefit of charting Cameroon Waters this paper provides a general assessment of the economic value and importance of shipping operations out of the three major ports in Cameroon, including fishery landings and foreign commerce. The estimated cost associated with implementing a hydrographic programme for Cameroon is examined and a cost- benefit ratio of 1:8 determined. Most coastal countries in the developing world especially on the West coast of Africa are still to appreciate the relationship and importance of hydrographic surveying to their economies. It is hoped that this paper will benefit countries in transition to understand this relationship and embrace the importance of implementing hydrographic programmes in their countries and charting their own waters.

Key words: Hydrography, charting, cost-benefit analysis, Cameroon

1 INTRODUCTION

In part fulfilment of the MSc Hydrography, Mr Mbeau Ache undertook an investigation into charting the waters of Cameroon. With membership of the International Hydrographic Organisation approved but waiting upon the Instrument of Accession (IHO, 2009), Cameroon is dependent on the French Hydrographic Office (SHOM) for a majority of its charting. It is a country that will benefit from increased national expertise.

The authors deliver and have been studying on an FIG/IHO Category A accredited programme, a year-long academic course with significant field work ranging from land surveying though single beam surveys to fully digital swathe surveys and flythrough of digital ground models.

As part of the studies, the students are required to utilise time within an 18 week summer period to investigate and write up an academic study on a mutually acceptable topic. The dissertation, from which this paper derives, has recently been submitted to fulfil this requirement.

2 CAMEROON

The Republic of Cameroon is located on the west, central African coast, with the port of Douala at approximately 04º 03' North and 009º 42' East. It has land borders with Nigeria, Chad, the Central Africa Republic, the Republic of the Congo, Gabon and Equatorial Guinea. Cameroon's coastline lies on the Bight of Bonny, part of the Gulf of Guinea in the east, central Atlantic Ocean. Cameroon has a total area of 475,440 km^2 of which 6,000 km^2 are inland waters and claims a 200 nautical miles EEZ with a continental shelf area of 13,062k m^2 (Sayer et al 1992). The coastal environment of Cameroon is open to the Atlantic Ocean with a length of about 402 km (Sayer et al 1992). Cameroon has a population of about seventeen million people (NISC, 2008).

From the Nigeria border to Idenau (Figure 1), the coast is low and marshy. It is watered by the mouths of Rivers Akwayafe, Ndian, Lokete and Meme which together form the Rio-del-Rey estuary. The vegetation along this coast is mainly mangrove and swamp.

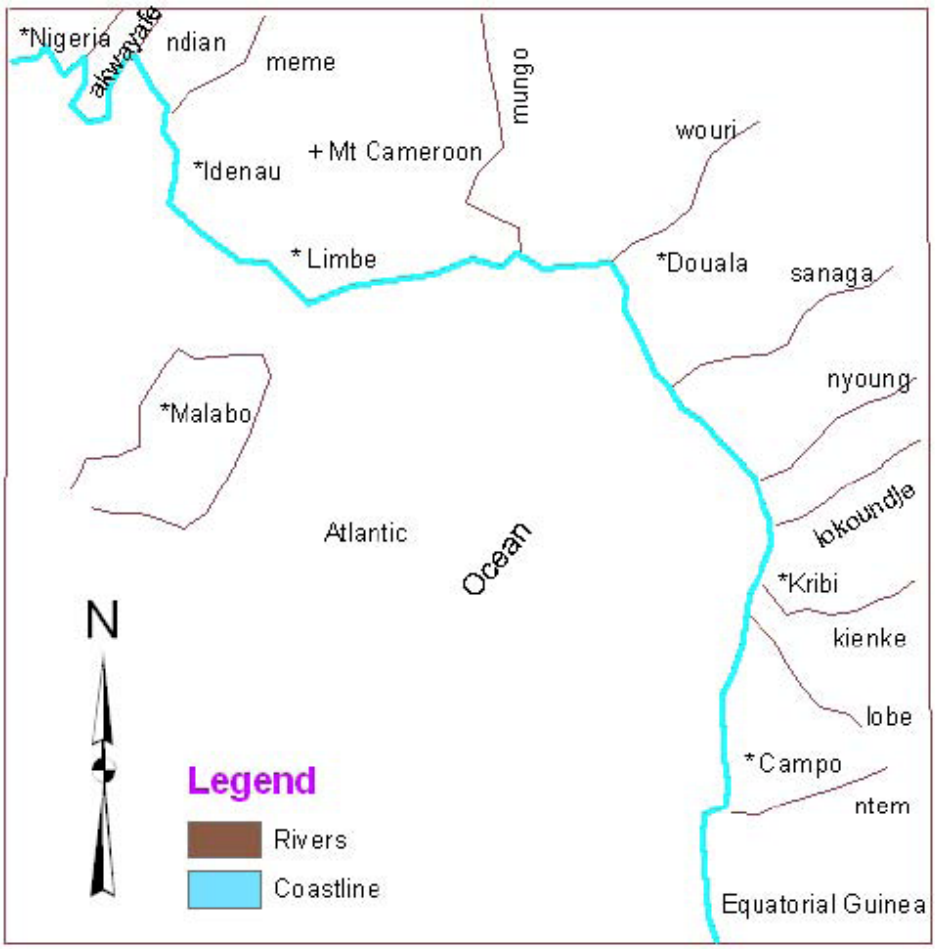

Figure 1: *The characteristics of the Cameroon coastline. Taken from Folack, 1997.*

From Idenau to Limbe, the coast is volcanic and overhung by Mount Cameroon (with a peak of 4,095 metres). The coastal vegetation type is low altitude mountain forest, rich in endemic species. It is characterised by frequent lava flows and the industrial plantations of the Cameroon Development Corporation (Folack and Gabche, 2009)

Limbe to River Nyoung is a low coast characterised by the presence of estuary and river mangroves and separated from the Atlantic forest by a marshy complex of brackish water. The rivers discharge a considerable quantity of sediments to the sea. The River Mungo enters the sea through a delta which other rivers forms the Cameroon estuary.

From the mouth of River Nyong to Campo the coast is high with rocky outcrops alternating with sandy mud. There are occasional mangroves (Folack and Gabche 2009). Table 1 below shows the Cameroon coastal river system and hydrological zones. River Sanaga has the greatest length followed by river Nyoung.

With rich oil resources and favourable agricultural conditions Cameroon has a strong primary commodity economy. Coincident development of the oil sector led to rapid economic growth between 1970 and 1985, ending in 1986 with the steep decline in the prices of major exports: coffee, cocoa and petroleum. By 2007, growth was estimated at 3.6% (OECD, 2008).

The overall trade balance shows a surplus of about US$477 million from oil revenue and US$488 million from non-oil trade (Ministry of Planning, Programming and Regional Development, 2006). Revenue and grants amount to about US$4.5 billion and expenditure stood at about US$ 3.7 billion. The investment budget for the Ministry of Transport was US$ 32 million (OECD, 2009).

The Ministry of Transport (MoT) is responsible for safety at sea, maritime and navigation regulations in Cameroon waters. Thus, the MoT should be responsible for collecting and disseminating maritime safety information as required by the IMO SOLAS Convention (IMO, 2009). However Cameroon has neither a national hydrographic service nor any investment directed towards this. A limited hydrographic capability is available at the port of Douala (Eastern Atlantic Hydrographic Commission report, 2004), managed by the port authority but with no responsibility to conduct surveys outside the port. Thus any issues of navigational significance beyond the port limit are neither detected nor charted.

Table 1: *Cameroon's coast, modified from Angwe and Gabche (1997).*

Major rivers	Length (km)	Drainage catchment (area; km^2)	Sediment yield (kg yr-1)	Annual mean flow (m3s-1)
Cross	160	800	-	171,570
Ndian	-	-	-	246
Meme	-	-	-	300
Mungo	150	2,420	###1.0 109	27,236
Wouri	250	82,000	-	49,1425
Dibamba	150	2,400	-	480
Sanaga	890	135,000	28,109	500,5700
Nyoung	800	1,400	-	26,376
Lekoundge	185	-	-	-
Kienke	100	-	-	-
Lobe	80	1,900	-	-
Ntem	460	31,000	-	50,764

2.1 Maritime trade

In one publication (Pedlow, 2001), 15 ports and offshore terminals are listed, although three coastal ports, Limbe, Kribi and Douala, have greater significance. Limbe is Cameroon's second largest port, lying at the foot of Mount Cameroon. It consists of:

- Limboh Oil terminal, for the transportation of crude oil, capable of handling vessels ranging from 33,000 DWT class to 95,000 DWT class. It has a minimum water depth at low water of 17m with the maximum allowable draft of 14m. The 14m sounding line is marked by three yellow buoys on the east side of the terminal. A report from a U.S Navy fleet has indicated various short comings on the available charts, with uncharted objects and visual aids not visible at night.
- Currently only about 800,000 tonnes of goods are handled by the Limbe Sea port (Cameroon national shippers' council). It is very small with a short single jetty. The main use of the port jetty is the small ferries running along the coast to Nigeria.

Kribi is a small coastal town with a small port with a very picturesque coastline.

- It has busy artisanal fishing activities and timber exports. There is also an offshore terminal and an anchorage without restrictions.
- The river port is situated 300metres from the mouth of the river Kienke running through Kribi. Dredging is often needed to maintain the navigational channel.

The principal port is Douala International Seaport and 97% of commercial trade in Cameroon passes through Douala. It is situated on the South East shore of the River Wouri estuary, about 40km from the Atlantic Ocean. It is the largest city in Cameroon, with an estimated population of 2.5 million people (Asangwe, 2002) and the principal centre of economic development.

- It handles a high percentage of the international exchange of goods with its neighbouring countries, Chad and the Central African Republic. Therefore, Douala plays a central role in foreign trade. At low water it can receive non-oil cargoes in ships to 6.2 m draft and oil tankers to 9.5 m. There is a 2.2 m tide.
- The volume of cargo at the Douala port has increased since its creation from about 4.1million tonnes in 1995 to more than 7.1 million tonnes in 2008. The number of ships entering the port per year has increased from about 1,053 to 1,236 (Cameroon National Shippers' Council, 2009).

3 CHARTING

The French Naval Hydrographic and Oceanographic Service (SHOM) publishes information for navigation security in certain zones of the West African Coast, including Cameroon. This is made possible through bilateral agreements between Cameroon and France. However many nautical charts on the African coast are old and were established in the fifties. The local geodetic reference systems are uncertain, making GPS navigation difficult (Table 2).

Cameroon is a member of the International Hydrographic Organisation and participates in other maritime and charting bodies. However, of waters less than 200 metres depth, only 9% are adequately surveyed and none of the waters deeper than 200 me-

Table 2: *National Hydrographic Capability (Eastern Atlantic Hydrographic Commission, 2002).*

Country	IHO Member	EatHC Member	NHC Proposed	Phase 1 Capacity	Phase 2 Capacity	Phase 3 Capacity
Cameroon	Yes	Associate	Yes	Partial	Partial	No
Republic of the Congo	No	No	Yes	Partial	Partial	No
Gabon	No	No	Yes	Partial	Partial	No
Equatorial Guinea	No	No	Yes	No	No	No
Nigeria	Yes	MS	Yes	Partial	Partial	Partial

NHC: National Hydrographic Commission Phase 1: Collection and circulation of nautical information, necessary to maintain existing charts and publication up to date Phase 2: Creation of a surveying capability to conduct: coastal projects and offshore projects Phase 3: Produce charts and publications independently

Table 3: *Status of Hydrographic Survey in Cameroon and Neighbouring countries (after IHO, 2006).*

Country	200 < Status of Survey depth		200 > Status of Survey depth	
	A1	B1	A2	B2
	Adequate %	% resurveyed	Adequate %	% resurveyed
Cameroon	9	0	0	100
Republic of the Congo	0	100	0	0
Gabon	37	0	0	100
Equatorial Guinea	0	100	0	0
Nigeria	21	70	10	10

A1/A2 = % adequately surveyed 0–200m/ >200m B1/B2 = % requiring re-survey at larger scale or to modern standards 0–200m/ >200m

Table 4: *Status of charts in Cameroon and neighbouring countries (after IHO, 2006).*

Country	Offshore Passage/Small			Landfall coastal Passage/Medium			Approaches Ports/Large		
	A	B	C	A	B	C	A	B	C
Cameroon	100	100	100	100	100	0	100	100	0
Republic of the Congo	100	100	100	100	100	0	100	100	0
Gabon	100	100	100	100	100	0	100	100	0
Equatorial	100	100	100	100	100	0	100	100	0
Nigeria	100	100	100	100	100	0	100	100	0

A = % covered by international charts B = % covered by Raster navigational charts C = % covered by Electronic navigational charts

Table 5: *Status of Maritime Safety Information (IHO, 2006).*

Country	Local	Note	Coast	Note	NAV	Note	Port Information	Note
Cameroon	No	Not provided	No	Not	No	Not	Yes	Partial data for Douala harbour is received by SHOM
Republic of the Congo	Yes	Partial information provided	No	Not	No	Not	Yes	Partial information provided
Gabon	No	Not provided	No	Not	No	Not	No	Not provided
Equatorial Guinea	No	Not provided	No	Not	No	Not	No	Not provided
Nigeria	Yes	Partial	No	Not	Yes	Available	Yes	To UKHO

Local = Local MSI warning provided Coastal = Coastal MSI warnings provided NAV = NAVAREA warnings provided

tres. Even that area surveyed to date requires resurvey to modern standards. (Table 3, IHO, 2006).

Charts at scales larger than 1:1,000,000 are not referenced to WGS84. Some countries in the region yet to market digital charts in vector form (Table 4), denying mariners and the wider community the significant safety improvements which are associated with the use of electronic charts.

Cameroon is also a member of the International Maritime Organisation (IMO) and a signatory to the Safety of Life at Sea (SOLAS) convention obligating contracting Governments to arrange for the collection and compilation of hydrographic data and the publication, dissemination and maintenance of all nautical information necessary for safe navigation. Yet, there is a clear shortage of maritime safety information (IHO, 2006).

It is fundamentally important to provide maritime safety information timely to mariners to alert them of any changes in charted information through the system of "Notices to mariners" which are published regularly. This is crucial as, lights and buoys and underwater obstructions are changing their character and position all the time. In the entire region these information is lacking. In Cameroon only partial data is made available to the French Hydrographic office (SHOM) for the port of Douala (Table 5).

4 OPPORTUNITIES

Hydrography is most commonly associated with updating nautical charts, but hydrographic information is essential for numerous non-navigation purposes. Accurate and up to date hydrographic products (e.g. nautical charts) and services (e.g. notice to mariners) are paramount for navigation safety, and for supporting and expanding safe and reliable maritime commerce and tourism for the continuous sustainable growth of the global economy.

More than 80% of global trade is carried by sea (IHO 2005). The shipping industry has seen a general trend of increases in total trade volume over the last century. In 2007, international seaborne trade was estimated at 8.02 billion tons of goods loaded (UNCTAD, 2007). Increasing industrialization and the liberalization of national economies have fuelled free trade and a growing demand for consumer products (UNCTAD, 2007). The global economy cannot simply function without ships and the shipping industry (UNCTAD, 2007) and national boundaries offer little impediment to multi-national corporations.

Accurate charts are an important factor for the protection of the environment. Pollution resulting from spills can have serious economic consequences - the 1989 Exxon Valdez oil spill on the South-Central Alaska's fisheries resulted in serious economic losses, with up to an

11.1 % reduction in the local commercial fishing economy. It was the most expensive oil spill in history with cleanup costs in the region of US$2.5 billion and total costs (including fines, penalties and claims settlements) estimated atUS$9.5 billion (Cohen, 1995).

The Cameroon coastline that stretches from Rio Del Rey to Campo (a distance of about 402 km) and the adjacent marine environment is rich in aquatic organisms and mangroves of serious economic benefit to the country. The Cameroon coastal zone is sited along major international petroleum transportation routes, such as internally to Chad or along the coast to Equatorial Guinea, and Gabon (Alemagi, 2007). Also, important

petroleum exploration and exploitation activities take place within the country. For example the terminal of the pipeline that transports crude oil from Doba in Chad to Kribi in Cameroon is located some 12 km from the seashore. Any oil spill or wrecks would inevitably lead to serious economic consequences to the country.

Promoting the safety of navigational activities, protecting the environment and its natural resources, and the management of coastal areas should be the main objectives of the government and/or government-authorized hydrographic institutions (Kopacz *et al*, 2003)

Excellent charts are particularly important to the development of the economically important industry of tourism, especially involving cruise ships. The potential of cruise ship industry is very important to the developing countries. This important source of revenue cannot be exploited if safe navigation to remote touristic sites is limited due to poor charts. Tourism is one of the sectors on which the State of Cameroon is counting to sustainably revive the economy. With the coastline open to the Atlantic Ocean, Cameroon has an environment conducive to resort tourism, with the natural sandy beaches of Kribi and Limbe and the mangroves along its coast. Most of these tourist sites are in remote areas of the country. The potential for a cruise ship industry is an exciting prospect for Cameroon.

In the 2008 investment budget, the government allocated 8659075 USD (Services du Premier Ministre, 2009) for the tourism industry. Yet there was no investment in hydrographic surveying to produce better charts for the coastline that would help protect the mangroves and beaches from possible pollution resulting from ship related accidents in her waters or for the development of the cruise shipping industry.

Maritime safety and insurance costs are inextricably linked. The structure of the global marketplace requires that goods and materials be delivered not only to the geographical location where they are required but also within a very precise timeframe. This can only happen if the mariners are using up to date charts. The risks from poorly produced charts are enormous. Accidents are not only undesirable outcomes in themselves; they also lead to the loss of lives. Lloyd's Register of Shipping estimates that between 1983 and 1992, 10,013 lives were lost either from collision or wreck resulted accidents (Alderton, 2004). A very good example of the attribution of poor charts to maritime accidents is the case of the Sea Diamond that sunk off the Aegean island of Santorini in April 2007 (Lloyds List, 2007) (www.lloydslist.com/ll/news/...chart.../20017602633.htm).

There have been accidents in Cameroon waters, though the causes are rarely established. The reduction of accidents through the use of good charts and provision of maritime safety information could contribute to the lowering of insurance costs, which is a major operating cost factor for shipping companies. Anecdotal evidence suggests ships using waters with little hydrographic survey information have a high insurance premium related to the risk. When transportation is subject to risk factors the cost of transportation and product is increased (Bryant *pers com*, 2009)

Hydrography plays a crucial role in the definition for establishing the maritime delimitation of the different zones recognized in the United Nations Third Convention on the Law of the Sea (UNCLOS III). They allow the countries to extend their territory far beyond the coastline. The Territorial Waters, the Contiguous Zone, the Exclusive Economic Zone and the Continental Shelf provide countries with the opportunity to explore, through scientific research, the better use of water, sea floor, and of the existing living

and non-living organisms. A number of maritime boundary delimitation disputes exist in the West African region, for example the Cameroon/ Nigeria case (Merrils and Evans, 2000) requiring foreign expertise (consultants and contractors) rather than a national hydrographic programme from where local expertise could be employed. These opportunities can only be supported with a clear knowledge of the associated hydrographic regime of the environment.

Fishing is also an important source of national wealth in Cameroon. Trends in the annual catches of Cameroon's marine fish industry showed that the total fluctuated between 30,000 and 45,000 metric tonnes (t) between 1970 and 1978 with an increase to 70,000 t between 1979 and 1981 (Gabche et al 2001). Fishermen need marine information not only for the safe navigation of their vessels but also for the safe deployment of their fishing gear.

Economic security is interwoven with national security of a country. Navies are major users of charts and must rely on accurate and up to date charts. Accurate charts are essential in providing quick response and maximum and safe manoeuvrability. A visit by the West African Action Team (WAAT) formed from the East Atlantic Hydrographic Commission in 2004 described maritime and security arrangements as weak. Concerns have been raised about piracy and criminal activity off the coast Cameroon (Associated Press, 2009).

Good quality and well managed spatial data are important ingredients for commercial and economic development as well as for the protection of the environment. Hence many nations tend to establish national spatial data infrastructures that brings together services and data sets of major national spatial data providers, for example topography, geodesy, geophysics, meteorology, and bathymetry. A Hydrographic Office is therefore an integral part of the national spatial data infrastructure. Cameroon has a National Oceanographic Data Centre. There is however no good system to track data from national and regional institutions and data gathering capacity in many institutions is weak. The centre does not have data for tidal readings from the port of Limbe and only partial data for the port of Kribi and Douala (Folack, 2003). This stresses the need for the implementation of a national hydrgraphic programme that should be an integral part of the data centre.

5 COST-BENEFITS

Cost-benefit analysis helps in the appraisal of a potential project, and in this study, the implementation of a national hydrographic programme for Cameroon to chart her waters.

Cost-benefit analysis faces both conceptual and practical challenges, not being an exact methodology for evaluating the benefits a project can generate. Project assessment is only based on a limited set of factors that are clearly measurable in monetary terms while ignoring factors that cannot be readily quantified. One economic study, including a cost-benefit analysis of nautical charting was by the Royal Australian Navy's Hydrographic Office (Australian Department of Defence, 1992). It indicated that it is difficult to obtain exact cost-benefit ratios, but concluded that,

> "What is beyond reasonable doubt is that the existence of official up-to-date charts has a benefit to the national economy that greatly exceeds the cost of the hydrographic programme".

A similar study was carried out by the Canadian Hydrographic Service, which in 1989 cited benefit to cost ratios ranging between 9.49 and 11.85, (Intercambio Ltd, 1992).

The method used to evaluate the cost-benefit to Cameroon of charting her waters, is as described in 'Charting a Course into the Digital era': Guidance for NOAA's Nautical Charting Mission (Dorman 1994). It explains the principles of cost-benefit analysis applied to surveys. It states that,

> 'It is not realistic to encompass all the costs and benefit associated with implementing a project. So long as all the major costs and benefits are considered, this should be sufficient to give an estimate of the cost-benefit'.

The United Kingdom Hydrographic recently announced a net profit of £7.6 million (http://www.epsiplus.net/news/hydrographic_data_is_essential). This reflects the benefit that a national hydrographic programme can bring to state's economy.

For Cameroon the estimated cost associated with implementing a hydrographic programme to collect data for the production of a nautical Chart was examined and the economic benefits associated with the accomplishment was calculated in economic terms. The next step was to determine the net benefits of implementing a hydrographic programme minus the same measures if the project is not executed. Thus, a benefit cost ratio was calculated.

The critical surveys require up-to-date charts of the harbour approaches and harbours. This is crucial for ships to enter and leave the port safely. Only the Douala port channel and port harbour are routinely re-surveyed; Limbe and Kribi are not. These charts should be of scales 1: 5,000 to 1: 50,000.

Charts of the vessel routes to ports and harbours should be the next priority at a scale of 1: 100,000 to 1: 300,000. Charting the remainder of the coastal region is not pressing. Even though this could be essential for fishing and other related activities, a careful prioritization would have to take place based on the availability of fund and against the requirement to improve the economy by international trade. These later charts should be at a scale of at least 1: 300,000.

Maritime safety information must be obtained and promulgated. Other opportunities exist in the charting of the Exclusive Economic Zone and surveys to allow for boundary delimitation.

There is a limited survey capability available at the Douala port but this is the logical base on which to build a national hydrographic programme. A survey spread and survey personnel were costed at US$1.0M and US$0.1M annually respectively. Chart compilation and production were planned to be covered through bi-lateral agreements. Fishing was estimated at an export value of US$3.0M, and shipping revenue at the three principal ports as US$13.1M. The expected benefit from implementing a national hydrographic programme was estimated as US$ 24.1M. A simple annual cost: benefit computes as 1:8

6 CONCLUSIONS

Many coastal countries in Africa are still to appreciate the relationship and importance of hydrographic surveying to their economies. Cameroon has significant economic dependence on maritime trade and extensive offshore economic interests in the oil and

gas, fisheries, minerals and developing tourist industry. Competitiveness in trade can be seriously impaired and national development slowed, when the waters of coastal state are not charted to modern standards. It also exposes the country to high risk of pollution.

Cameroon, being a member of the International Maritime Organization (IMO), is a signatory to the SOLAS convention. Yet the coastline and much of her waters remains uncharted to an adequate standard (Tables 2 and 3); even the provision of maritime safety information is still ineffective with only partial information received by SHOM from the Douala autonomous port. Most of the large scale charts require modernization (Table 3). The visit of the West Africa Action Team formed from the EAtHC (East Atlantic Hydrographic Commission) to assess the national hydrographic capability observed that there was a limited capability existing in Douala port (Table 2).

Yet, Douala port would be a logical base upon which to build a national hydrographic capability for the country. It is true that the implementation of a national hydrographic programme is costly (training, equipment acquisition) but the cost is low compared to total port revenues, safety, continued trade and environmental protection. Many hydrographic surveys could be conducted with a single beam echo sounder, tide poles and GPS. The report on the Douala port by a United States Navy ship, suggested the need for some of the port revenue to be reinvested in the maintenance of the buoys.

Further, companies carrying out exploration activities off the coast of Cameroon should be encouraged to submit information on surveys carried out prior to their exploration - there is a clear need for co-ordination between these entities.

It is beyond reasonable doubt that the benefit to Cameroon of implementing a hydrographic programme that would allow her to chart her waters far outweighs the cost. Using a COST-benefit criterion, the benefit accrued from such an implementation compares favourably to the cost. An implementation of a hydrographic program for Cameroon could realise a theoretical cost:benefit of about 1:8. Further to this estimate, the real value would be exceeded if as-yet unquantified benefits are included.

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BIOGRAPHICAL NOTES

Mr Cyril Mbeau Ache graduated from the University of Dschang, Cameroon in 1999 with a BSc Zoology. He taught in a Government Bilingual High School (GBHS) at Fontem, Cameroon from September 2002 to February 2007 and commenced the MSc Hydrography at the University of Plymouth in September 2008. He recently completed

his course. He will be looking for work in the offshore hydrocarbon exploration industry, in charting or in environmental support.

Dr Victor Abbott, worked as a land and hydrographic surveyor from 1976 to 1987. He took up lecturing, first at the (now) University of East London, UK and then at the University of Plymouth. He is the Lecturer in Hydrographic Surveying with research interests stretching from the mitigation of the effects of seismic exploration activity on marine mammals to the visualisation of surface and sub-surface objects in 3D through chromo-stereoscopy. He has worked variously for the Hydrographic Society, the Royal Institution of Chartered Surveyors, and the Institute of Marine Engineering, Science and Technology. He has recently published in *Marine Policy* and *The Hydrographic Journal*.

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