

Economic Impact of Hydrographic Surveys

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SUMMARY

This paper discusses the inherent value of hydrographic services and bathymetric surveys beyond the obvious benefit of improved nautical charts. These direct and indirect benefits are not traditionally recognized for their economic value to coastal States as they are difficult to quantify. Also, their actual value is somewhat dependent on the specific economic, recreational, and defense activities of each coastal State. Convincing governments to invest in hydrography and bathymetry can be difficult. However even without quantitative analysis, there is strong logical and qualitative argument that recognizes the critical value of hydrographic services as an essential element of national infrastructure and a critical enabler of other maritime activities. Thus, providing government with information detailing the second and third order benefits of bathymetric surveys and hydrographic services may influence further investment in these essential enablers of economic growth.

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1. INTRODUCTION

The economic impacts of hydrography and bathymetry on safety of navigation have been studied and reported for a number of years. However it is important to recognize that many aspects of hydrographic services fall into the category of 'public goods'. A public good or service is that which is in the public interest but would not be supplied at optimal levels by market forces alone. There are three characteristics of a public good; non-rivalness in consumption, non-excludability and impossibility of rejection. The nautical chart is a noteworthy example of a public good. An individual using a chart does not impair another individual's ability to use a chart to navigate safely, hence satisfying non-rivalness in consumption. It displays non-excludability as it is impossible to prevent any member of the public from using the information the hydrographic service provides. Also, an individual cannot abstain from the benefits of the hydrographic service even if he or she wished to (impossibility of rejection). (Coochey, 1992)

Several studies have estimated that the return on investment from having a national hydrographic program is on the order of 1:10. (IHO, 2004) This certainly should be an incentive for coastal nations to invest in hydrographic services and to have properly charted waters that can support an ever growing need for maritime commerce. Improved charts may allow for faster transits of ships with deeper draughts, resulting in a greater amount of goods moving through navigational choke points and ports. Perhaps just as important is the need for hydrography and bathymetry to support the development of national and local strategies to preserve and protect ocean resources. Coastal zone management, hazard response and mitigation, national defense and maritime boundary delimitation are but a few examples of activities that require knowledge of the seafloor. (IHO, 2004) Hydrography and bathymetry provide the foundation layer on which many other programs can be built to provide essential, nationally significant information to government authorities.

Whilst the provision of hydrographic services can thus be seen as a fundamental enabler and an important boost to many aspects of economic development, it is also germane that large scale hydrographic surveys are extremely expensive. Whereas land mapping can be effectively conducted over large areas using satellite remote sensing techniques (which is relatively inexpensive), hydrographic surveying can not.

2. AREAS OF IMPACT

The Canadian Hydrographic Service (CHS) conducted a study of the cost benefits of having a hydrographic service. (Brinkman and Caverley, 1992) While specific to Canada, the general lessons of this study apply to any maritime nation. This study looked at six areas of impact:

commercial shipping, commercial fishing, recreational boating, national defense, Arctic development, and environment. For this discussion, similar themes will be built upon to capture the direct and indirect benefits of hydrography.

2.1 Marine Transportation and Safety of Navigation

A recent study by the U.S. International Trade Commission cites, for numerous countries, one of the main barriers to economic growth is the lack of adequate port facilities and infrastructure. (U.S. International Trade Commission, 2005) Improved ports will require dredging, new piers, enhanced terminal functionality and, of course, up-to-date nautical charts. Maritime transport remains the backbone of international trade with over 80 per cent of world merchandise trade by volume being carried by sea. During the past three decades, the annual average growth rate of world seaborne trade is estimated at 3.1 per cent. At this rate, global seaborne trade would be expected to increase by 44 per cent in 2020 and double by 2031, potentially reaching 11.5 billion tons and 16.04 billion tons, respectively. (UNCTAD, 2008) In the United States, more than 78 percent of overseas trade by volume and 43.5 percent by value comes and goes by ship, including nine million of barrels of imported oil daily. (Department of Transportation, 2007). Nearly 80% of U.S. import and export freight is transported through seaports (RITA, 2009); more than 80% of the nation's economy is supported in coastal states; and more than 50% of the population and U.S. economic activity are found in coastal management counties. (NOEP, 2009) In Australia these figures are even more empowering with a staggering 99.9% of trade by weight and 78% by value being carried by sea. (BTRE, 2007)

Commercial shipping relies on current nautical charts for one important reason, time is money. Good charts provide the most direct routes between ports, reduce the number of pilots required, decrease the number of groundings (and reduce insurance rates), and allow deeper draft vessels (i.e. more cargo) to be used. The National Oceanographic and Atmospheric Administration (NOAA) reported that one additional foot of draft may account for between \$36,000 and \$288,000 of increased profit per transit into Tampa, FL. (NOAA, 2000) This is also demonstrated in a study completed by Thompson Clarke Shipping (AMSA, 2007) which examined Torres Strait shipping trends and investigated the economic impact of increasing the maximum draught of the Prince Of Wales Channel, currently 12.2 metres, by 30 cm and 60 cm. In the financial year of 2005-2006, 602 vessels with a draught in excess of 11.0m transited via the Torres Strait and of these, 161 were loaded to exactly the maximum draught. If the maximum draught can be increased to 12.5m, the increase in cargo carried would amount to AUD 10.3 million. If extended to 12.8m, it would increase again to AUD13.3 million. Given this potential for substantial economic benefit, re-surveying the Prince of Wales Channel to a very high degree of confidence has been allocated high priority for the Australian Hydrographic Service.

In areas with inadequate charting, shipping companies deploy a fleet that is older, less efficient and capable, and more likely to be involved in a maritime accident due to the age of the equipment and caliber of the crew. (Brinkman and Caverley, 1992) The economic benefits and savings associated with preventing marine accidents through more adequate

survey are significant. The cost of an oil spill can be measured by the revenue lost through the loss of cargo, the vessel and days at sail, as well as the cost of cleanup. For example, the *Exxon Valdez* oil spill of 1989 cost Exxon USD 2.1 billion for clean up, USD1.1 billion for settlements and in 1994, a US jury found Exxon negligent and fined them USD 5 billion for the incident. The destruction of wildlife, habitat and future resources are more difficult to assign dollar value to however the estimated price that the residents affected were willing to give their pristine environment for one degraded by the spill was approximately USD 7.9 billion.

Additionally, most marine accidents, (groundings in particular) are the result of operator error. Approximately 25% of all serious ship accidents occur in coastal waters or during harbor approach. Of these, greater than 75% result from insufficient information, mistaken interpretation or assessment, and lack of timely preventative action. (Hecht, et al, 2002) The introduction and implementation of Electronic Chart Display and Information Systems (ECDIS and Electronic Navigation Charts (ENC into the maritime industry has the potential to significantly reduce the margin for human error during pilotage navigation scenarios such as that which afflicted the *Exxon Valdez* and therefore reduce the monetary costs to companies and environmental cost to the global community.

In Africa's Gulf of Guinea, commercial shipping is the primary method of trade for coastal nations, whereas interior landlocked countries rely on train and truck connections to seaports. Increased production of oil and gas requires substantial infrastructure to support the export of petroleum products, as well as the import of commercial goods into the region. U.S. imports from Africa increased 40.2% in 2005. Oil-producing countries showed the greatest increases; Nigeria up 48.9%, Angola 87.7%, Gabon 14.1%, and Congo 89.5%. U.S. exports to West Africa are dominated by heavy machinery & equipment, oilseeds & grains, and industrial chemicals; products that must be transported by maritime commerce. (US Dept. of Commerce, 2006)

Three ports in the Gulf of Guinea rank in the top ten African container ports: Abidjan, Lagos, and Tema. As container traffic flow continues to rise, not only from the United States, but also from Europe and Asia, new shipping companies expand into the region. For example, the Gold Star Line from China has established a direct trade route into West Africa from Chennai, India. (UNCTAD, 2006) On average, the current charts for the region are based on surveys that are over 25 years old and were not conducted with the benefit of GPS and modern echosounders. The US Navy conducted a cooperative hydrographic survey in Tema, Ghana and observed discrepancies of 35-125 m in shoreline (horizontal) features and .5m - 5.8m in depths when compared to available charts. It can be expected that similar discrepancies exist in the many areas of the world utilizing charts based on dated surveys or with insufficient data. Unless there is further investment in improving the standard of surveys and charting it is likely that increasing shipping volumes will yield a similar increase in navigational incidents.

2.2 Marine Resources

Marine resources can be broken down into two categories, living and mineral, which cover the majority of renewable and non-renewable resources found in the ocean. Activities associated with marine resources include: commercial and recreational fishing, aquaculture, sand and gravel mining, ocean dumping, oil, gas, and mineral exploration and extraction, channel dredging, dredge material disposal, pipeline/cable installation, and pollution. Control/regulation of these activities is critical to the overall success of a coastal region, either as a protected area or as an economically viable fishing ground.

2.2.1 Living Resources

As marine living resources, such as those associated with fishing and aquaculture, are so vital to the economies of coastal nations, the information that hydrography can provide to ensure efficient use of these resources is equally as vital. In 2006, commercial and recreational fisheries supported over 2 million jobs and contributed over \$73 billion to the United States gross national product. (NMFS, 2009) Commercial fishermen benefit from accurate charting through safe navigation, knowledge of preferred fish habitats, locating wrecks and other hazards that can interfere with nets, and improving the speed and efficiency of onload/offload operations. Bathymetry is a critical component of the characterization and delineation of fish habitats, as well as, the proper location and extent of aquaculture areas.

The United States has undertaken significant efforts to characterize and describe seafloor and open ocean habitats and associated fish assemblages on spatial scales relevant to fishery management and habitat protection. In order to manage these resources they must be mapped. Substantial hydrographic effort has been expended to delineate and map important habitats including coastal shorelines, estuaries, salt marsh wetlands, anadromous streams, riparian zones, submerged aquatic vegetation (e.g. eelgrass), deepwater corals, pinnacles, seamounts, and fishing grounds on the Continental Shelf and Slope. (NMFS, 2009) Coastal, estuarine, and marsh waters serve as the nursery for many species of fish that live in the deep ocean as adults. Fresh water streams and rivers also serve as vital pathways for ocean fish, such as salmon, which travel upstream to spawn. By carefully mapping the features mentioned above, it is possible to effectively manage, protect, and preserve marine living resources through mechanisms like marine sanctuaries, protected areas, and reserves. Proper planning of aquaculture projects based on modeling of the ocean environment can not only maximize production, but also help developers avoid areas that will undoubtedly fail to meet financial expectations.

2.2.2 Mineral Resources

Mineral resources include sand, gravel, oil, and other economically important resources found on, or below, the ocean bottom. Hydrography, by definition, characterizes the nature of the seafloor and thereby is a direct contributor to the discovery of areas of mineral resources available for exploitation. Sidescan sonars, or acoustic backscatter from multi-beam echosounders, are capable of bottom profiling—a technique that allows hydrographers to

determine the type and extent of different bottom characteristics. This incidental activity can significantly reduce the cost of exploration by private businesses whilst at the same time continuing to improve navigation safety. Bathymetric information is also critical to selection of routes for submarine pipelines and cables.

Whilst exploration companies may focus their data collection on sensors such as sub-bottom profilers and magnetometers to gain detailed information of what is lying on and below the seabed, the concurrent collection of standard hydrographic information and these additional data is a cost efficient means of satisfying the dual purposes of improved safety of navigation and marine resource development. Clearly, the national interest is best served when the base hydrographic information collected by oil and gas companies is added to the national archive.

2.3 Environmental Concerns

Hydrographic surveys provide the base layer for environmental monitoring, impact modeling and consequence management. Physical environmental characteristics, such as bathymetry, are required to support numerical modeling efforts in order to provide accurate representations of the impact from a variety of man-made and naturally occurring events. If no controls on the use of the environment are in place, nations developing their coasts may be vulnerable to degradation as industrialization and economic expansion occurs.

2.3.1 Coastal Zone Management

As more of the world's population is concentrated around our coasts, the focus on coastal zone management must continue to grow if we are to maximize utilization without damaging the environment. In the United States, population density along coasts is five times greater than that of the rest of the nation.. (OCRM, 2007) Internationally, government authorities and resource managers struggle to find the balance in allocation of valuable water space to a diversity of interests including recreational and commercial fishing, diving, pleasure yachting, professional navigation, beach access, tourism activities, and marine farming. Archaeological studies of areas with historic or cultural value require precise mapping of the ocean bottom. Bathymetry also provides the necessary information for underwater construction and development. Pipelines, telecommunication cables, and offshore drilling platforms cannot be arbitrarily placed; bathymetry must be used to ensure their locations are safe from potential hazards.

Without proper governance over coastal construction and development, significant negative impacts to property and people may occur. For example, groins, jetties or revetments built along a coast to create a clear channel or safe harbor for fishing boats may result in the erosion of sand down-drift of the structure area due to blocking of sediment transport by longshore currents and subsequent accretion of sand in other areas. Proper modeling of the environmental consequences of proposed man-made features along a coast must be conducted to avoid potentially significant economic impacts due to loss of shoreline and beaches. Hydrographic survey provides information that is essential to enable proper planning to ensure that coastal zones are effectively and sustainably managed.

2.3.2 Offshore Aquaculture

Offshore aquaculture, although in its infancy, is an exciting development into sustainable fish farming. Aquaculture, probably the fastest growing food-producing sector, now accounts for almost 50 percent of the world's food fish and is perceived as having the greatest potential to meet the growing demand for aquatic food. Given the projected population growth over the next two decades, it is estimated that at least an additional 40 million tonnes of aquatic food will be required by 2030 to maintain the current per capita consumption. (FAO, 2006) One of the major barriers to development is finding suitable sites in coastal areas, where aquaculture must compete with many other coastal uses. (NOAA Aquaculture Program, 2006) The selection of an Aquaculture site is a process that not only involves market forces but also governmental designation of sites. The planning of offshore aquaculture zones takes into account not only hydrological and biographical factors, but also topographical and hydrographical factors. Accurate hydrographic information can provide assistance in the selection of appropriate aquaculture sites to enhance a nation's ability to plan efficiently for sustainable harvest into the future.

2.3.3 Climate Change, Natural Disasters, Pollution, and Hazard Mitigation

Many natural and man-made occurrences can have a significant impact on the ecology and biology of a coastal region. Rising atmospheric and ocean temperatures can have adverse affects on marine vegetation and organisms which, in turn, can impact the economy of a coastal nation. By surveying habitat boundaries, changes in expanse or volume can be easily monitored and immediate actions taken to mitigate negative trends, where possible. Increased erosion can be expected with rising seas and more energetic storms, which will decrease water clarity and quality, as well as increase sedimentation and silting.

The results of a rise in sea level along a typical beach profile are twofold: first, a direct landward encroachment takes place (shoreline recession) followed by a beach face readjustment by waves to a flatter slope (erosion above the waterline and some accretion offshore). (CHL-ERDC, 2007) It is possible to predict the extent of a sea-level rise and take early action to mitigate negative impacts on economic activities in the coastal zone.

Increased oil and gas production/export and increases in commercial shipping increases the possibility of a major environmental disaster in coastal regions. Coastal development can also heighten chances of introduction of contaminants into the marine environment. For example, placing a pipeline over rock outcrops or coral heads can place stress on the pipeline and possibly result in a break and release of the pipeline's contents. Pollution from ports, agricultural run-off, and other sources is becoming a significant issue for maritime nations. Hydrographic survey is imperative to environmental monitoring through the establishment of baseline conditions and will thereby assist in the development of mitigation plans in the event of a maritime accident.

2.4 Maritime Boundaries

The United Nations Convention on the Law of the Sea (UNCLOS) has established the basic framework for boundary definitions of territorial seas, the exclusive economic zone (EEZ), and the continental shelf. The delineation of these zones are increasingly important in determining the rights and responsibilities of coastal states. One of the most important economic impacts of UNCLOS is the ability of a coastal nation to extend their claims beyond the 200 mile EEZ based on the bathymetry, change in slope of the continental shelf and geology of the seafloor. National hydrographic offices are the recognized, official provider of this information. (IHO, 2004) As noted above, marine resources can provide viable economic activity for coastal nations and any opportunity to increase area available for exploitation should be seriously considered. In 1998 Australia entered into a program of detailed offshore surveying to map the limits of the extended continental shelf. After submission in November 2004, Australia's extended continental shelf claim was approved by the United Nations in 2008 and resulted in the recognition of an additional 2.5 million square kilometers of continental shelf. Clearly, the additional seabed resources in the region justify the cost of surveying and charting to support the claim.

Hydrographic surveys are also the source of the fundamental data used to provide the baseline information for determining maritime boundaries between countries. For example, if two countries have agreed that their maritime boundary will follow the thalweg of a channel, bathymetry is the only method to accurately determine where the thalweg is located. In other cases where maritime boundaries are in dispute the determination by courts will invariably rely substantially on the positions, and delineation of offshore islands, reefs and outcrops determined by detailed hydrographic surveys.

2.5 Law Enforcement and Defense

Coastal nations generally desire to organically monitor maritime activities and conduct law enforcement and defense operations within their territorial waters and EEZ. Small navies and coast guards with limited assets are often under-resourced to deal with the host of threats found on today's oceans. People, drug and weapons smuggling, piracy, illegal fishing, and proliferation of terrorism provide significant threats to the economies of coastal nations, which must protect their commerce, marine resources and residents.

The economic value of the knowledge that a hydrographic service provides cannot be underestimated in terms of its ability to enable 'Maritime Power'. Maritime power is described by Bateman and Bergin as a countries ability to use the sea to promote it national interests – economic, political, strategic and environmental. (Bateman and Bergin, 2009) It in turn ensures that "good order at sea" is maintained, to permit the free flow of seaborne trade. The free flow of trade not only improves economic growth by opening the most efficient routes and thereby cutting transportation costs, but also minimises other economic losses. These monetary losses can be incurred through piracy, maritime terrorism, the illegal trade of people, arms or drugs and the unregulated pollution of the marine environment. The strategic benefit that hydrographic surveys provide is not only immense but immeasurable. Accurate

charts provide increased freedom of manoeuvre for the law enforcement agencies of these countries - a tactical advantage when dealing with the threats discussed here. In addition, hydrographic surveys can provide critical information for mine warfare applications. Locating mines, determining mine burial rates, modeling mine drift, and choosing mine avoidance routes are all enabled through high resolution bathymetry and acoustic imagery that is gathered during hydrographic surveys.

3. OPPORTUNITIES FOR ASSISTANCE TO DEVELOPING NATIONS

As can be seen for the above discussion, hydrographic surveys of national waters and in particular the provision of comprehensive hydrographic services provide substantial intrinsic value to a nation's economy and the opportunity to participate more actively in the global economy. The non-intrusive, environmentally supportive and non-controversial nature of hydrography also make it an ideal avenue for economic assistance to developing nations. Below, an example is presented for a specific region to demonstrate how developing states might benefit from the investment in hydrographic services.

3.1 Pacific Island Context

Of geopolitical interest to the US and Australia are the Pacific Island countries which typically have small economies, are remote in geographic and political position and could be characterized as developing. Often these counties are unable to take hydrographic responsibility for themselves, and rely on the assistance of regional powers with larger hydrographic services. This section aims to describe how the provision of hydrographic services in developing island states can contribute to sustainable economic development of island nations by opening up these often poorly surveyed and therefore inaccessible areas to trade and tourism. This can be counted as a direct injection into the local economy of these counties, and should be considered as a key target area for overseas aid.

3.1.1 Investment in Infrastructure

Shipping to Pacific island states is currently very expensive due to long distances between ports, low trade volumes, imbalanced trade (exports far outweigh imports) and poor facilities suffering from inadequate investment and maintenance. Many of these aspects can be addressed by improving hydrographic services in the region. For example, many inter-island routes contain archipelagic routes that are unattractive and dangerous to the bulk carrier. More accurate surveys of these areas could open shorter, safer and more efficient sea lanes which could increase trade to the region. Once accessibility is improved, industry will be more willing to improve port facilities in the region, which in turn, will require regular surveys in order to maintain its functionality. (Asian Development Bank, 2007) Hydrographic surveys therefore contribute to building much needed infrastructure in the region, eventually enabling Pacific island states to take advantage of economic opportunities and better participate in the global economy.

3.1.3 Contribution of Tourism

In a study conducted by Carnival Australia, a multinational in charge of recreational cruise providers such as P&O and Princess cruises, it was recognised that currently, the cruise ship industry cannot meet the demand in the sector. (Access Economics, 2008) The larger the demand for cruise holidays, the larger the cruise ships required in order to satisfy demand and obtain economies of scale. However, the larger the cruise ship the larger the draught and the more restricted the access to certain ports. Pacific Island port visits make up a majority of destinations of Australian based cruise liners. The report indicates that new larger cruise ships are unable to access the ports they wish due to inadequate hydrographic information, for example Yasawa and the Lau Group, Fiji. The report concludes that development of cruise tourism in the region is being seriously restricted by the low levels of marine infrastructure and there is potential for substantial growth. Clearly, there are untapped opportunities awaiting those island states that could provide adequate hydrographic information and port facilities. There are also the second order benefits of increased local employment as cruise companies prefer to recruit from the island nations, as well as enhanced incentives and opportunities to showcase and preserve customs and culture.

4. CONCLUSION

Despite the comprehensive justifications offered above, when allocating funds to requirements, governments often give a low priority to hydrography. The reasons range from a lack of interest or a lack of understanding to the pragmatism of political survival. Investments in national infrastructure, in genuine public goods such as hydrography, just don't attract the populist gratitude of a tax reduction or a welfare handout, neither do they satisfy the feel-good sentiment of an industry sector assistance package. Hydrographic infrastructure provides benefits to the nation as a whole and not to any one lobby group in particular. Investing in hydrography saves lives by making navigation safer, it enables maritime activities that support national security and economic prosperity while contributing to protection of the environment. It is akin to investing in infrastructure and insurance, perhaps not very exciting but invariably a very sound investment!

This paper does not seek to argue that every coastal State should establish its own organic hydrographic organization as the dollar and personal resource costs may exceed the capacity of many developing States. It does however; argue the high national value of hydrographic services and where such capability is beyond a nation's own means, it recommends the provision of hydrographic support as a prime area for a cooperative bilateral arrangement or foreign aid support. It also emphasizes the criticality of national governments recognizing the value and importance of hydrographic information and putting in place arrangements that ensure any hydrographic information collected within that nation's waters is contributed to the national hydrographic database.

Finally, this paper provides supplemental information that can be used to overcome at least one of the impediments to hydrographic investment referred to above, the deficiency in knowledge. It provides a comprehensive overview of the 'public good' benefits and intrinsic economic values of hydrography. This information may assist in imparting the importance of

the requirement for hydrographic surveys among government officials. In doing so it also provides arguments to support the provision of hydrographic infrastructure as a viable, effective and indeed attractive avenue of providing external aid to developing coastal States.

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BIOGRAPHICAL NOTES

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