

## **AN ECONOMIC EVALUATION OF HYDROGRAPHIC CHARTING WITH SPECIAL EMPHASIS ON THE AUSTRALIAN CASE**

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### **Abstract**

With increased financial stringency being imposed on Government bodies world-wide there is an increasing requirement for hydrographic services to "prove their worth". This paper covers the issues that have to be addressed in such an analysis and drawing from the Australian case describes some conclusions which show very high benefits which stem from the work of National hydrographic programmes. While it has not yet been possible to give such ratios with the accuracy that is customary in the work of navigational charting such benefits were found to be exceedingly favourable. This paper seeks to outline a methodology that may be followed by national bodies seeking to undertake similar studies of their own hydrographic programmes. To aid others in such endeavours an annotated bibliography of related studies and papers is included.

### **INTRODUCTION**

It would be difficult to find any maritime country on earth which does not depend on some form of hydrographic charting. However it is exceedingly difficult to find any genuine economic analysis of the benefits to the country in question from such charts or from the programme(s) which gave rise to them. There is good reason for this lack of analysis and it is not because such work lacks national economic value, it is because such investigations are exceedingly difficult and time consuming. It has to be said at the outset that, in the author's opinion, it is unlikely that exact benefit cost ratios will ever be developed for entire national hydrographic programmes. Fairly exact ratios may be developed for sub sets but not entire programmes. However not long after any quantitative study is started it will probably become apparent that the cost benefits of such programs are so high that

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a researcher may wonder if there is much purpose in continuing to try and develop more exact figures.

A word of warning to any economist thinking of undertaking such a study for a national hydrographic programme. The chances are that you will very soon come under pressure to come up with an exact benefit cost ratio. That is to say a quantitative measure of the benefits that the nation receives from the money invested in the programme. Naturally the higher the assessed benefit cost ratio the happier will be the members of the hydrographic programme in question. It would of course be embarrassing if countries with similar levels of maritime involvement came up with widely differing ratios.

There are two central problems in determining such a figure. One the benefits may be hard to assess with mathematical precision and two, the costs may be difficult to assess. That is because few government agencies, certainly in Australia, use accrual accounting. That is to say the programme in question may well know what its direct labour cost is but makes no allowance for such aspects as holiday pay, pensions and overheads such as office rental or depreciation on ships.

Unfortunately the benefit cost ratio, even if arrived at objectively, may not tell you very much, and certainly, in itself will not necessarily justify continued or increased government funding for the programme. For example, if a cost benefit ratio based on historical data is high that may not mean that future activity will also have such benefits. Once hydrographic information has reached a certain level diminishing returns may set in and any further activity have a lower rate of return. For example it may be worth while to resurvey a passage which was last surveyed five years ago but not one which was surveyed last week. In Australia's case the situation hardly arises because less than half the coast has been adequately charted using modern methods. What is much more important is to show that the ongoing benefits of the programme outweigh the costs and that the nature of the programme is such that government involvement is justified.

Just before any hydrographer becomes too disheartened and decides to turn to another article I must say that it is normal to expect the return from investment in a government programme to at least equal that of private sector investment. The return for private sector investments will obviously vary but it is usually assumed to be approximated by the rate of interest. In Australia this is now about eight per cent. The national rate of return from a hydrographic programme, at least in the opinion of this author, is in multiples. That is to say hundreds of percent.

Hydrographic charting has some interesting characteristics from the viewpoint of economic analysis, it is also these characteristics which make economic analysis difficult

The output of a national hydrographic programs is :

- a) an intermediate good
- b) almost always a public sector good
- c) a "public good", this is not synonymous with b) as will be shown later.

In short the paper charts produced by hydrographic programmes are of little use in themselves other than as wall decorations but the information contained in them is essential for much, if not the majority, of world trade, to mention just one economic use.

As these concepts are central to the problem of doing a proper economic analysis it is worth explaining them in detail at the beginning of the paper.

An **intermediate good** is simply one that has little utility in itself and has to be incorporated into something else before it really has any use.

Valuing a **public sector good** is often difficult because frequently they are not traded freely in the market place and may be subject to subsidies and/or constraints on the activities of the management. Often the full costs are not known as has been discussed earlier.

The issue of a "**public good**" is more difficult and has to be spelt out in detail to fully understand the issues that surround an economic analysis of a hydrographic programme. It cannot be over-emphasized that a "public good" is not synonymous with a good or service which is provided by the public sector.

The Dictionary of Economics and Business, second edition, edited by S.E. SIEGLER Bsc. defines a public good as:

"A good or service that cannot be priced accurately and hence cannot be efficiently supplied by private industry. It has three characteristics, nonrivalness in consumption, nonexcludability, impossibility of rejection. Nonrivalness in consumption of a good means that a good being supplied to one individual can be supplied to others at no extra cost, for example a radio station will not expend more power in transmitting to 5,000,000 than when transmitting to 1,000,000 people (if they live in the same geographical area). Nonexcludability means that an individual cannot be deprived of a public good even though he may refuse to pay for it, for example all the citizens of a country are protected by anti-rabies measures even if many refuse to pay for them. Impossibility of rejection means that an individual cannot abstain from consumption of a public good even though he may wish to, for example a pacifist is protected by nuclear weapons in spite of his moral objections to them.

...Consequently, normal market forces cannot provide the optimal amount (emphasis added) since an individual will not need to reveal how much he would pay to consume the good, as he feels it will be provided anyway. If everyone adopts this attitude the good will not be produced although it is to everyone's interest that it should be produced. *See externalities.*"

This gives rise to what is known as the "free rider" situation whereby a consumer or potential consumer knows that a good will be provided without him paying so there is no reason for any payment from him.

A further characteristic not spelt out in this definition is that consumption of a public good by one consumer does not diminish the amount available for other consumers. For example the fact that a ship is guided by a lighthouse in no way

diminishes the usefulness of that navigation aid to others. This is an example frequently used in standard economic textbooks and not especially picked for this journal.

Generally hydrographic programmes sell their output, charts, at something like the marginal cost, that is to say the cost of printing and do not recover the cost of the programme from such sales.

The central issue here is that the true value of the output is not shown by the market price of the good in question. While it is true that charts are not distributed freely the issue of knowledge being a public good is perhaps illustrated by the following example. In Australia the Royal Australian Naval Hydrographer is not only responsible for the preparation of navigational charts but also for the preparation of Oceanographic Charts which show currents and water temperatures off the east coast of Australia. These are prepared primarily in connection with anti submarine warfare measures but are increasingly used by the fishing industry especially for tuna. The fishermen at Eden, a major Australian fishing port do not all get their own copy of the report which is updated every two weeks, they simply go down to the local cooperative where copies are on public display

To further drive home this point, within the Torres Straits there is the possibility of a passage for bulk carriers through the Endeavour Straits. This would be a more direct and passage than the Prince of Wales Channel which is currently used. At present it is considered that the standard of survey is not sufficiently reliable to take bulk carriers through the Endeavour Straits. In fact it is not certain that a navigable channel exists without dredging. A major potential user of such a passage would be Queensland Alumina (QAL) which ships ore from Weipa to Gladstone. If QAL were to survey a passage through these waters it would not be able to retain property rights over it. I would soon become apparent that bulk carriers were using the straits. Even if QAL managed to keep all copies of its charts secret other enterprises could make use of the passage, if need be by simply following a QAL ship through the straits.

In short a private copy of a chart may not be a public good but the information contained on it certainly is.

A further complication is that almost all nations have had some form of navigational chart, if not from time immemorial then certainly for a very long time. For example, much of the Australian coastline was crudely charted from before European settlement. Charting has been an ongoing process with few if any quantum leaps forward. Thus intertemporal studies are difficult, whereas in the case of say an earth sensing satellite it is possible to compare the value of services that are available after its introduction with those before.

The critical point here is that when a good or service shows to a significant degree the characteristics of a public good the true value of that service will not be shown by the price that it is traded at in the marketplace.

So what should a would-be analyst do? Throw up his arms in dismay and look for another topic? Not necessarily, there are a number of methods which can be used to overcome these problems, or at least to minimize them.

### Initial Steps in an Analysis

The first two steps are to find out who uses hydrographic information and what is the economic value of what such organizations produce. This may sound naive in this context but an amazing number of Government publications (at least in Australia) have no discernible audience. The next step is to get some idea of the economic value of the organizations which use the output of the national hydrographic programme in question. There is little purpose in ascertaining that charts are essential to the prawn fishing industry if the national prawning fleet is composed of two ships. Likewise if it is decided to use a survey approach (see later) and that survey comes up with a value for charting that exceeds the value of the industries that use the charts then the results of the survey should be treated with suspicion.

Sometimes, and drawing from the Australian case, the hydrographic service may find a new passage and the economic value of the passage can be calculated. Such savings would include fuel savings and shortened sailing times meaning that, over time, the same amount of cargo can be carried in less ships. This lowers the price of imports and makes exports potentially cheaper and thus more desirable on world markets. Such a case in Australia is the Hydrographer's Passage which was a new passage found and charted through the Great Barrier Reef off the east coast of Australia. This will be examined in more detail later. It is a relatively simple task to capitalise the future savings over time into the equivalent lump sum in today's values.

Another aspect which is of particular concern to Australia but would have parallels elsewhere is knowing the exact depth of water at different states of the tide. In great passages this can be of great importance. One unpublished study of Australian waters indicated that if a certain channel were dredged to one meter more the number of bulk carriers used on that run could be reduced by one quarter and still carry the same amount of cargo as before. In short find a route that is a meter deeper and reduce your costs by twenty five percent. Now to return to the issue of a public good, no individual company will have the full incentive to search for better routeways, or for that matter to improve them by dredging as they will not be able to retain ownership of what may well be an international waterway. Others will soon start to use the new passage without having paid for its discovery.

This is different from the situation that exists with mineral exploration where the company carrying out the exploration has an incentive to do the necessary research of the ocean floor because it is necessary for either the extraction of the minerals or to see if it is worth trying to obtain the mineral lease to the area in question. Methods of allocating off-shore leases to private companies obviously vary enormously between different countries but the basic point here remains the same.

In short, national hydrographic programs are without doubt a public good, as the term is used by economists, but not all hydrographic work is necessarily a public good.

### Uses of the Hydrographic Programme

The Australian Study of the Hydrographic Programme analysed the work of the Australian Hydrographic Programme under the following headings:

- . Safe Passage of Cargo and Passenger Vessels
- . Commercial Fishing, including Policing of Fishing Zones
- . Recreational Fishing and Sailing, including Power Boats
- . Mineral Exploration
- . Pollution - Prevention of Environmental Damage from Shipwreck (primarily oil, including bunker fuel, and chemicals). Minimisation of environmental damage should it occur. (Knowledge of tides etc. allowing effort to be concentrated in key areas.)
- . Safety of Life at Sea. (Both by preventing or minimising accidents and facilitating search and rescue action should it be necessary).
- . Scientific Research
- . Establishing and Policing Australia's Economic Zone
- . Complying with Australia's International Obligations.
- . Asserting Australia's Territorial Claims Including areas of Antarctica.

It is obvious that these categories are interlinked and are not mutually exclusive.

When it came to quantifying the value of activity in these categories it was surprising which were easy to quantify and which were not. The situation will obviously be different in other countries. Assuming that time and other resources are limited, and they almost always are, it is essential to analyse and adapt existing Government and non Government studies wherever possible. For example Government statistics for the number of recreational boats were found, in the Australian case, to be less detailed than those of the Australian Yachting Federation.

### Putting Some Numbers In

Economists tend to be rather like accountants. When it comes to adding up apples and oranges the best common denominator they can come up with is monetary value. It is in fact surprisingly easy to put values on certain of the categories listed above. While it is usually difficult to put a value on national sovereignty, or free movement of naval forces in time of peace, putting monetary values on natural assets and even human life can prove surprisingly easy.

To give a few examples.

### **The Full Economic Value of a Reduction in the Trade Bill**

It is sometimes difficult for a non-economist to appreciate the flow on effects from a decline in the international trade bill of the country concerned. Just to give one example; in 1989 the Australian Industries Assistance Commission undertook a study which in part analysed the effect of a quarter of one percent reduction in the cost of both imports and exports. This particular study was in the context of greater efficiency in the docks. Australia being notorious for the inefficiency of stevedoring services. That study found that, after economic resources had been re-allocated the savings would amount to \$A1.4 billion p.a. in today's values. The immediate saving on the trade bill would amount to only \$185 million, that is to say the savings on both imports and exports. It is obvious that the long term gains greatly outweigh the initial savings. This was done using the "ORANI" model of the Australian economy. Contacts with the Industry Commission suggest that similar levels of long term gains would eventuate from similar savings in transport costs brought about by other methods, for example more efficient routing. Without doubt similar economic models will exist for other nations.

### **The Economic Value of Finding and Charting a New Passage.**

In the Australian case the example used was the Hydrographer's Passage which is a major passage off the east coast of Australia through the Great Barrier Reef. In 1982 the Australian Bureau of Transport Economics had done a study on the cost benefits of marking this channel with navigational aids. The Bureau calculated the likely users of the passage and made allowance for the fact that traffic bound to or from certain ports would make little use of the passage. That study also largely confined itself to coal ships bound for the North Pacific as these were considered to be the likely major users of the passage. It also made allowance for the likely increase in coal exports in the future.

The discounted present value (i.e. the lump sum value, not annual benefits) of the future savings stemming from this passage were calculated and equate to \$A 177 million in 1990-91 dollars. The direct budget cost of the Australian Hydrographic Programme is some \$35 million dollars p.a., so it could be said that this passage paid for five years budget allocation to the Australian Hydrographic Programme (whereas if it could be shown that up to date charts only resulted in a quarter of one per cent difference in the trade bill then the saving every year equates to fifty years of direct budget allocation.)

The original BTCE study took a team of four plus support staff three months, a more detailed study using actual historical data could take a similar sized team five to eight months. This emphasises the importance of using existing studies where it is at all possible.

### **Search and Rescue-the value of human life**

This proved to be a surprisingly easy aspect to quantify. It would be an incomplete analysis to work out the role of the hydrographic service in either search and rescue if it was impossible to even put a minimum value on human life. In the case of the Australian study the minimum value was put at somewhere in excess of \$700,000. Cold blooded as this may seem it is simply the discounted present value of money that a victim would have earned had he not been killed plus an allowance for economic production for which he would have not been paid. This was based on two studies, one a UK study done in 1980 and one done in Australia published in 1988. Both of these are in the annotated bibliography. To emphasise the importance of using existing studies whenever possible the Australian study into the value of human life took two economists eleven months.

What proved much more difficult in the Australian case was to find the actual numbers of rescues!

This is because in Australia there are no consolidated search and rescue statistics and in fact there are a myriad of separate rescue organisations ranging from surf life saving clubs to the Australian Maritime Safety Authority which coordinates major off-shore search and rescue activity. Moreover there is evidence of almost competition between organization to inflate their rescue rate with a view to prestige and further funding.

Nevertheless if only fifty lives are saved in Australia each year because of accurate up to date charts then this, once again, covers the annual direct budget outlay. In 1990 the Royal Australian Coastal Patrol, just one of the myriad of organizations involved in search and rescue in Australia, reported 5460 persons rescued.

One estimate is that there are two wrecks a year in Australian waters due to uncharted hazards, possibly with an average crew size of twenty. This of course does not make any allowance for those ships and lives which are not put at risk because of the existence of up to date charts.

### **Value of Natural Assets**

The issue of pollution has become of much higher profile in recent years and with it the process of putting a value on the assets that could be harmed in the event of for example, an oil spill. As such assets are not traded in the market place they are in themselves a public good. In the Australian study the Great Barrier Reef was used as an example. It was relatively easy to obtain an economic value from an earlier study done in connection with damage being done by starfish. That gave a total annual value of \$A1.1 million dollars for the reef. An element of this was a contingency valuation of the reef. This could be summarized as the value placed on it by individuals who are not at present visiting it. An assessment of the methodologies for such a study has been published by The Australian Resources Assessment Commission. Support for the value of such assessments in giving objective defensible data, is given by the work of, amongst others, J. Walter MILAN.



Thus in the event of a hydrographic programme wanting to show its role in protecting national assets, by preventing shipwrecks, much of the methodology is already in place.

### **The Use of Consumer Surveys in Calculating the Value of National Hydrographic Programmes**

As charts and maps are traded in the market place at below their average cost one method that has been used is to survey users as to what their "consumer surplus" is. Consumer surplus is simply the difference between the cost of a good and the value that a consumer puts on it. Surveys have been used with some success in the US for assessing the value of topographic mapping (LYDDAN) and with somewhat less confidence in New Zealand (HOOGSTEDEN 1988). It was a major element in an unpublished study done for the Canadian Hydrographic Service.

There are two methods of doing such a survey

- a) Interviews
- b) Postal surveys

There are certain problems common to both approaches. The most obvious is that of the respondent not knowing the answer in other than the broadest terms. This led HOOGSTEDEN to abandon the interview approach for his NZ study. Another problem common to both interviews and postal surveys is that the respondent may choose to deliberately colour the answers depending on how he views the future. If someone is asked how much they would be prepared to pay for a map or chart they may suspect that they will in the future be charged this price and thus have an incentive to minimize their stated consumer surplus. If on the other hand they foresee the possibility of, what they view as, a subsidised service being withdrawn or curtailed then they may maximise the reported value of the service in the hope that the Government will feel compelled to continue it.

It is obviously easier to undertake a postal survey if a significant proportion of the charts are sold directly by the Hydrographic Service concerned, especially if such sales are made by mail. An alternative approach for a formulating a market survey is to use the national statistical gathering agency. In Australia's case the Australian Bureau of Statistics. The records of such agencies are usually computerised and it is sometimes possible, if need be by paying a fee, to identify likely users of charting services and to mail out surveys on behalf of the Hydrographic Service.

This is not to say that all thoughts of a survey should be halted before they start, but merely that there will be uncertainties. This is especially important when the study is being done partly to justify public funds for the service. In Australia the Department that seeks to minimize expenditure is the Department of Finance. No doubt it has its equivalents in other bureaucracies. As they usually see their objective as minimising expenditure rather than getting maximum benefit from it, it may be difficult to use a survey to persuade them no matter how objectively such a survey has been done.

In the north of England there is a saying that "there are none as deaf as those that do not want to hear"

### **Some Issues Regarding Cost Recovery for Hydrographic Services**

At the outset of this paper it was stated that the output of hydrographic services is a public good. That is not true in the very narrowest use of the concept. Charts are sold, although usually well below their full value. The commercial benefit will obviously vary greatly between different classes of users. A large merchant ship may gain great financial value from a chart, an amateur yachtsman much less. From the hydrographer's view, in an ideal world it would be possible to charge the different classes of users different prices. That is to say to charge what the market will bear and minimize consumers surplus. In reality this is not possible. Shipping companies could simply send in representatives posing as yachtsmen or whatever. Likewise once the price reached a certain level charts would be illegally copied as is happening already at current price levels. There is anecdotal evidence of captains of multi million dollar trawlers in Australia whose primary charts are photocopies! If all charts were priced at what it was estimated commercial users would pay this would deny them to yachtsmen and other such users and probably result in an increase in loss of life and search and rescue bills.

It is also an interesting point whether it is morally or politically acceptable for a democratic government to withhold knowledge which it already has and which may be lifesaving. If charts are made for military strategic purposes, can or should the Government deny such knowledge from certain sections of the population just because it seeks increased revenue? In the United States all published chart information is considered to be in the public domain.

It is interesting to look at the situation which exist internationally regarding the provision of physical navigation aids such as lighthouses. The mechanisms for financing such facilities varies considerably between different countries.

Some countries such as Great Britain, Australia and New Zealand have established a custom of levying light dues on shipping calling at their ports to cover the cost of providing and maintaining navigational aids, whereas others, notably France, Germany, Holland, Japan, USA and Canada, consider the provision of navigational aids so essential to the economy of the country, that they make no charge to shipping for the lights and meet the cost out of the national budget.

In Australia the provision of charts is the responsibility of the Royal Australian Navy Hydrographer whose staff are a mixture of navy and civilians. All payment from general taxation is allocated via the defence budget and only about two per cent of costs are met from map sales. In 1946 a Government decision passed responsibility for hydrography to the RAN. It stated that sixty percent of the cost (remember that this was one year after World War II) would be met by Defence and forty percent by the civil sector. The current Australian practice contrast with that of say, Sweden where 70% of the hydrographic budget is met from navigation levies.

A number of options are being canvassed to try and increase the contribution of the civil sector in Australia. One is obviously to increase the cost of

charts but it is considered that this would not greatly increase revenue. Another is to levy ships using Australian ports with a similar charge to that of the existing light dues but to use that money for charting. This is not without some drawbacks, these include the fact that light dues are only levied on ships of a certain size and small boat owners and fishing fleet are currently "free riding". It has been suggested that some of this gap could be filled by a tax on marine fuels or on boat licenses. This again would have certain problems. Australia has a federal constitution and any such licences are the responsibility of the States. They would be reluctant to raise taxes on behalf of the federal Government. Fuel taxes would be electorally unpopular at either the State or federal level.

In short, there are no simple solutions to the problem and individual solutions will vary according to the circumstances which exist in each country. What is clear is that from both the position of theoretical economics and practical experience and, from the point of view of the national economy an optimal level of hydrographic activity will not result from a programme which is financed solely from the sale of charts.

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