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Analysis of the Economic Benefits of the Provision of Hydrographic Services in the APEC Region

Summary Report

July 2002

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

Introduction

The project and report have been completed under the guidance and oversight of the APEC Transportation Working Group (TPT-WG). The objectives of the project and report are to provide Governments in the APEC region with:

i. An "in-principle" analysis of the economic benefit and value of hydrographic services to APEC member economies, and

ii. Policy guidance on appropriate levels of investment in hydrographic services, to ensure the safety and improve the efficiency of shipping while meeting international obligations.

The results of the project are intended to assist APEC maritime administrators to ensure that maritime trade will reap the efficiency benefits that flow from provision of comprehensive and accurate hydrographic services for regional and domestic seas.

Rationale for Hydrographic Services

Hydrographic services survey sea areas and provide nautical charts and other information that are essential for safe and efficient navigation. Without such charts vessels cannot know of or avoid the subsurface dangers that threaten their safety, nor can they plan and execute the shortest and most convenient voyages between two ports. Hydrographic services are an essential component of the national transport infrastructure, since they greatly facilitate the vital economic activity of import and export by sea. Shipping is a global activity, and the global delivery of services requires a significant degree of international and regional co-operation. Over 95% of international trade by volume is carried by sea.

The provision of good quality charts is also an important aspect of national programmes for the protection of the marine environment, since safe navigation helps to avoid shipwrecks and the pollution that often results from them. Prevention of pollution has economic as well as environmental benefits, because of the other communities and industries that depend upon clean seas, for example fishing, tourism, and desalination.

The Safety of Life at Sea (SOLAS) Convention of the International Maritime Organisation (IMO), requires contracting governments to provide hydrographic services.

There are other economic, social and legislative benefits that flow from a national hydrographic programme. Hydrographic information is a fundamental data set that informs decisions about the delineation, establishment, administration and sustainable development of the national maritime and coastal zones and resources.

There is much that APEC can do to promote the delivery of high quality hydrographic services on a regional basis.

APEC Region Hydrographic Services

The report contains details of the status of regional hydrographic services, compiled from the responses to a questionnaire.

Almost all of the APEC member economies have long coastlines and extensive EEZs. They have significant economic dependence on maritime trade, and extensive offshore economic interests in fisheries, minerals and oil, tourism, etc.

Many economies have not yet completed the surveying and charting of their coastlines to an adequate standard to support the safe navigation of modern ships, or the sustainable development of their EEZs. There are also some areas of international waters in East Asia [outside EEZs] where surveying and charting is unsatisfactory.

Some economies confine their hydrographic activities to support of the transport and defence sectors. If the full economic benefit of investment in hydrographic services is to be realised, it is important to extend the provision of services across as many economic sectors as possible.

These deficiencies are the result of the generally low level of annual hydrographic budget allocations in relation to the high cost and lengthy time requirements for the completion of hydrographic surveys and the publication of nautical charts.

In many economies the quantity of material resources, particularly the number of survey ships, appears to be small in relation to the unfinished tasks. However in most economies the ships and equipment in use are of high quality.

Most economies have only small numbers of skilled and experienced survey and cartographic personnel to undertake the tasks. The shortage of expertise inhibits the hydrographic agencies in completing their tasks on schedule.

Several economies are improving the cost effectiveness of hydrographic services through technology development, greater utilisation of assets, and outsourcing.

There is useful international co-operation within the region aimed at overcoming problems of surveying capacity and training. There is potential for increased regional co-operation in advancing the surveying and charting of poorly surveyed but heavily used sea lanes in East Asia and the South China Sea.

Economic Benefits

The analysis of economic benefits of hydrographic services in the APEC region has focused on the evaluation of navigational impacts of hydrographic services on one of the primary beneficiary groups, the commercial shipping sector.

An assessment model has been developed to allow direct evaluation of the impact relationship of hydrographic service expenditure on commercial vessel voyage duration and associated vessel-operating and passenger-time costs. This is illustrated through evaluation of an example APEC economy, that of the Philippines. This primary case study has then been utilized to infer relative economic sensitivity to hydrographic service investment for other APEC economies that responded to the hydrographic audit.

The economic assessment indicates that the entire national expenditure on hydrographic services in the Philippines can be justified exclusively from the navigational-related benefits accruing to the commercial shipping sector in terms of savings to vessel-operating costs and passenger-time costs. Furthermore, the benefits justify an increase in expenditure by approximately 70 percent of the current level.

Since there are many other benefits in addition to commercial navigational benefits, the cumulative economic benefits from the current hydrographic expenditures are substantially greater. The Philippine hydrographic service is therefore a considerable asset to the Philippine economy, and there is substantial potential for increased investment to yield even greater benefits.

The results have been extrapolated to those APEC member economies that responded to the questionnaire in order to assess their relative economic sensitivity to the impact of hydrographic service expenditure on their economies. The results of the assessment indicate three broad classifications of APEC economies; (i) where benefits from increased expenditure are considered to be of substantial value (Philippines, Indonesia and Mexico); (ii) of medium value (Canada, Australia, USA, New Zealand, Chile, Japan and Peru, and; (iii) and of lower value (Hong Kong, Korea and Singapore).

Recommendations

The report recommends that economies;

- Carry out an audit of their individual hydrographic department, in order to define aspects of the hydrographic programme that need attention, and to identify and establish priorities and time frames for completion of outstanding tasks.

- Carry out an economic analysis for their individual hydrographic requirements, using the model proposed in this report, in order to derive an optimum level of investment and budget for the hydrographic service.

- Ensure that necessary development of the hydrographic department is included in national or ministerial development plans, including development of human, material and financial resources, and administrative arrangements, appropriate to the national survey and charting plans.

- Ensure that national five-year plans for survey and charting are in place.

- Review the work practices of the hydrographic department in order to identify the potential for improving cost effectiveness.

- Review the institutional and co-ordination arrangements for hydrographic activities, and consider the benefits of establishing high-level formal arrangements.

And that APEC;

- Consider the economic and safety benefits of increasing co-operation in hydrography, especially in the South China Sea, and in the major straits and sea-lanes of East Asia.

- Consider undertaking research to provide data on the volume and characteristics of international shipping making transit voyages through the major straits and sea-lanes of the region.

- Consider undertaking research to provide some possible models for navigation levies on ships transiting the major sea-lanes and straits.

- Consider organising some technical assistance programmes in hydrography for those economies of the APEC region that are not currently APEC members.

2 INTRODUCTION

2.1 Background to the Project

The project *'Analysis of the Economic Benefits of the Provision of Hydrographic Services in the APEC Region'*, was endorsed by the APEC Transportation Working Group meeting (TPT-WG-17) in Singapore in March 2000, and by the APEC Ministerial meeting of 12 - 13 November 2000 in Brunei. The project was conducted under the guidance and oversight of the APEC Transportation Working Group (TPT-WG). Australia provided the Project Overseer. The United States co-sponsored the project.

The project was executed through a partnership between two companies, APP Technology of Australia, and GlobalWorks of USA, APP being the prime contractor. The project has been supervised on behalf of APEC by the Australian Department of Transport and Regional Services.

2.2 Project Objectives

The objectives of the project are to:

- Provide an "in-principle" analysis of the economic benefit and value of hydrographic services to APEC member economies, and to
- Provide Governments in the APEC region with policy guidance on appropriate levels of investment in hydrographic services, to ensure the safety and improve the efficiency of shipping while meeting international obligations.

The results of the project will assist APEC maritime administrators to ensure that foreign and domestic maritime trade will reap the efficiency benefits that flow from provision of comprehensive and accurate navigation services for regional and domestic seas. It will provide a tool to determine an appropriate level of investment in hydrographic services, related to projected trade patterns.

It will also provide benchmark information regarding the present status and resources of regional hydrographic services, which will assist policy makers in coming to investment decisions.

It will provide information relevant to future hydrographic co-operation between APEC members.

It may also assist shipping and insurance companies to understand the real value of a government service provided as a public good.

2.3 Project Structure

The project is a desktop study conducted in two phases.

Phase 1. Economic Benefits Analysis, and

Phase 2. Audit of the Status of Regional Hydrographic Services.

The Project Report is in eight parts:

Part 1 Executive Summary.

Part 2 The Introduction contains a summary of the objectives and structure of the project. It also provides a statement of the rationale for the work of government hydrographic services.

Part 3 The Overview of Hydrographic Services describes the in-principle functions, capabilities, and services provided by a national hydrographic service. It also touches on institutional arrangements and comments on international co-operation. The objective of this part is to provide policy makers with benchmark information.

Part 4 APEC Hydrographic Service Status reviews the present status of the hydrographic services in the APEC economies, based on information obtained during the audit. It also provides some comment on options available to improve the performance of hydrographic agencies. The objective of this part is to provide policy makers with current status information to assist policy development.

Part 5 The Analysis of the Economic Value of Hydrographic Services focuses on the evaluation of navigational impacts of hydrographic service provision on one of the primary beneficiary groups, the commercial shipping sector. This is illustrated through evaluation of an example APEC economy, that of the Philippines, which has then been utilized to infer relative economic sensitivity to hydrographic service investment for other APEC economies who responded to the hydrographic audit.

Part 6 The Key Issues and Recommendations draw together the findings of the Hydrographic Audit and the Economic Analysis.

Part 7 Policy Implications suggests policy directions and actions that may be considered by maritime administrators.

Part 8 Attachments contains the detailed reports from the Hydrographic Audit and the Economic Analysis.

3 OVERVIEW OF HYDROGRAPHIC SERVICES

3.1 Rationale

The provision of an adequate coverage of high quality nautical charts is essential for safe and efficient navigation. Without such charts vessels cannot know of or avoid the subsurface dangers that threaten their safety, nor can they plan and execute the shortest and most convenient voyages between two ports. A good system of charts is essential to the efficient operation of the maritime transport infrastructure, in the same way that a good system of roads is essential to the efficient operation of the terrestrial transport infrastructure. Nautical charts are an important component of the national transport infrastructure, since they greatly facilitate the vital economic activity of import and export by sea. Over 95% of international trade by volume is carried by sea.

The provision of good quality charts is also an important aspect of national programmes for the protection of the marine environment, since safe navigation helps to avoid shipwrecks and the pollution that often results from them. Prevention of pollution has economic as well as environmental benefits, because of the other communities and industries that depend upon clean seas, for example fishing, tourism, and desalination.

So important are the safety and environmental aspects of national charting programmes that the International Maritime Organisation (IMO), in revising the Safety of Life at Sea (SOLAS) Convention, has mandated that all contracting governments should provide hydrographic services.

It is also important to recall that shipping is an international activity, and that the provision of hydrographic services to support shipping has an essential international dimension. International delivery of services requires a significant degree of international co-operation. There is much that APEC can do to promote the delivery of high quality hydrographic services on a regional basis.

In the modern world there are numerous other benefits accruing from the provision of hydrographic services. These include;

(i) for the commercial fisheries sector, improved resource location, economic zone maintenance, regulatory enforcement and reduced equipment losses;
(ii) definition and maintenance of sovereign zones;
(iii) enhanced coastal resource management;
(iv) assistance in the exploration of minerals;
(v) improved emergency response;
(vi) contributions to national defence;
(vii) assistance to the recreational boating and fishing sector; and
(viii) overall environmental protection.

The hydrographic programme is also of great importance to the defence of the realm, since comprehensive charts are essential to the successful conduct of maritime military operations.

It should be noted that, in economic parlance, the national hydrographic programme is regarded as a “Public Good”. That is to say that the necessary services required in the public interest will not be supplied at optimal levels by market forces alone. In every IHO Member State the provision of hydrographic services is a function of central government.

3.2 Principal Functions of the Hydrographic Service

3.2.1 Nautical Cartography

The principal service offered by the hydrographic department is the national chart series. It is the general practice of hydrographic offices to publish their charts in three groups.

Small Scale charts are provided for passage planning and for navigation out of sight of land. Medium Scale charts are provided for making landfall and for passage along the coast. Large Scale charts are provided for the approaches to ports, internal waters of ports, and other areas where navigation is constrained by land formations, navigational hazards, traffic density etc. The number of charts in the national chart series will depend upon the length of the national coastline and the extent of the national EEZ. For planning purposes it is usual to publish a national chart scheme, illustrating the chart coverage at each scale. The national chart series meets the requirement of Regulation 9 of Chapter V of the SOLAS Convention that Contracting Governments undertake “to prepare and to issue official nautical charts.”

The national chart series must be supported by a means of supplying mariners with Maritime Safety Information. This is rapid advice about new dangers to navigation and other information such as failure of navigation aids, temporary obstructions etc, in order to keep the charts up to date. This meets the requirement of Regulation 9 that Contracting Governments will “promulgate notices to mariners”

A high quality nautical charting service must be underpinned by an appropriate data management system, so that all necessary information may be easily accessed for compilation of products and services, and for quality assurance processes. Databases must also be able to provide data into the national spatial data infrastructure for research, administration and development. This meets the requirement of Regulation 9 that contracting governments will “ provide data management arrangements”

The charting service also requires effective distribution arrangements to ensure that mariners may easily and conveniently access the services provided by the Hydrographic Office. Distribution has national and international components.

3.2.2 Spatial Data Services

An increasingly important function of the hydrographic department is to ensure that hydrographic data are available in the national interest to researchers, administrators and producers working in the national exclusive economic zone, who require comprehensive data to support complex decisions. Increasingly this is being achieved through the contribution of meta-data to the national spatial data infrastructure. This procedure allows users to discover the availability of data sets, whilst allowing government agencies to retain control of access and distribution.

Many advanced hydrographic agencies are restructuring themselves and their priorities in order to provide more effective service to this new and very large community of users.
On a regional and global scale, nations are co-operating and co-ordinating their activities to provide regional and global spatial data infrastructures.

3.2.3 Hydrographic Survey

The facilities for hydrographic surveying are the most expensive facilities in the hydrographic department, since they involve the use of research vessels that have high capital and operating costs.

Generally it is necessary to have, or to have access to, vessels that are capable of operating for long periods in the national offshore areas, and in shallow coastal waters. A combination of ocean going ships and inshore vessels is effective, or ocean-going ships fitted with embarked survey launches. A wide variety of vessels are described in the book “Jane’s Research Ships”. Aircraft fitted with lidar (laser) systems may also be used.

The number of vessels required will depend upon the size of the survey task. This in turn depends upon the length and characteristics of the coastline, the size of the unsurveyed areas, the need for resurvey in some places, and the timeframe for the completion of the work.

The survey vessels should be fitted with the equipment necessary for them to execute surveys to the standards laid down in IHO Publication S-44, IHO Standards for Hydrographic Surveys. The duty of care imposed on the hydrographic department requires the use of appropriate modern equipment.

This meets the requirement of Regulation 9 that Contracting Governments will “carry out

4 APEC HYDROGRAPHIC SERVICES - STATUS AND POTENTIAL

This assessment of the hydrographic capabilities in APEC Member economies is based on responses to a questionnaire that was sent to the principal hydrographic agency in each economy. Thirteen of the twenty-one member economies responded to the questionnaire. The questionnaire was designed to provide information about the status of each hydrographic agency, in order that the results might provide some benchmarks for decision makers. The questionnaire asked for details of the:

- Geographic Fundamentals;
- Institutional arrangements and legislation;
- Status of Surveying and Charting;
- Material and Human Resources;
- Budget;
- Future developments;
- Innovation in process and service;
- Co-operation;
- Strategic Issues.

4.1 Conclusions of the Hydrographic Audit.

The conclusions that follow are reproduced from Attachment 1 to this report. This attachment contains the details of the responses to the questionnaire, and a detailed analysis of those responses, upon which the conclusions are based. The principal conclusions of the hydrographic audit are as follows;

4.1.1 Geographic and Economic Circumstances

Almost all of the APEC member economies have long coastlines and extensive EEZs. They have significant economic dependence on maritime trade, and extensive offshore economic interests in fisheries, minerals and oil, tourism, etc.

Fundamental Geographic Data

Country	Coastline [km]	EEZ km^2	Major Ports
Australia	59,736	8,941,759	12
Canada	244,000 [1]	6,500,000[1]	9
Chile	84,000	1,576,886	8
Hong Kong	1140	N.A.	
Indonesia	80,570	2,692,762	4
Japan			
Korea	11,542	376,000	27
Mexico	11,208 [1]	3,150,000	17
New Zealand	18,252	4,000,000	
Peru	3,080	800,000	6
Philippines	31,800		21
Singapore	495	Nil	6
USA	152,950 [1]	11,533,395 [1]	9

1. Includes Atlantic coasts for Canada, Mexico and USA and Arctic coasts for Canada and USA.

4.1.2 Status of Activities and Services

Status of Surveying and Charting for Marine Navigation

Many economies have not yet completed the surveying and charting of their coastlines to an adequate standard to support the safe navigation of modern ships, or the sustainable development of their EEZs. In the case of navigation some economies are not yet fully compliant with the requirements of the SOLAS Convention. This is the most important conclusion of this audit.

This is because incomplete surveying and charting of the national maritime areas results in inefficiencies in ship operations, affecting the competitiveness of trade. It inhibits decision making for national development in maritime zones. It also exposes the economy to risks of pollution from accidents that could cause significant damage to the coastal environment and the coastal economy.

Status of Services to Users Outside the Transport Sector

The hydrographic agencies in a few economies are extending their services to provide information to the many users who are not navigators through the national spatial data infrastructure. However several economies continue to confine their hydrographic activities in support of the traditional transport and defence sectors. If the full economic benefit of investment in hydrographic services is to be realised, it is important to extend the provision of services across as many economic sectors as possible. This is another important finding of this audit.

Status of Activities and Services

Country	Status of Surveys			Status of Charts			Spatial Data Services
	% Adequately surveyed	% Requiring re-survey	% Un-surveyed	Paper Charts Required	% Paper Charts Available	Digital Charts Available	Number Available
Australia	32	44	24	752	51	Yes	1
Canada	45	30	25	672	60	Yes	2
Chile	No Data	No Data	No Data	721	75	Yes	3
Hong Kong	100	0	0	12	66	Yes	0
Indonesia	25	60	15	520	89	Yes	4
Japan	100	0	0	1050	100	Yes	1
Korea	60	40	0	258	100	Yes	3
Mexico	23	2	75	406	22	No	3
New Zealand	No Data	No Data	No Data	175	94	No	1
Peru	80	10	10	205	58	No	1
Philippines	20	55	25	212	100	No	0
Singapore	100	0	0	24	100	Yes	0
USA	No Data	No Data	No Data	1025	100	Yes	1

4.1.3 Status of Resources

Budget

The situation in many economies described above is the result of the generally low level of annual hydrographic budget allocations in relation to the high cost and lengthy time requirements to complete hydrographic surveys and to publish charts. One major economy [USA] has recognised this situation and has recently significantly increased the budget allocation of the hydrographic programme. One economy [Peru] provides the majority of its hydrographic budget from shipping charges under a user pays regime.

A major strategic concern of the agencies that responded to the questionnaire is the size of the budget and the consequent limitations on obtaining capacity and expertise to adequately discharge the agencies' responsibilities. The budget is used to purchase material and human resources.

Material Resources

In many economies the quantity of material resources appears to be small in relation to the unfinished tasks, particularly the number of survey ships. However in most economies the material resources are of high quality. The majority of economies are using modern equipment appropriate to the achievement of international standards for hydrographic surveying and nautical charting. Most economies are making the difficult transition to electronic media for the management of data and the provision of navigation services.

Human Resources

Most economies have only small numbers of skilled and experienced survey and cartographic personnel to undertake the tasks. It is clear that such expertise is in short supply, and much sought after. The shortage of expertise is a threat to the ability of hydrographic agencies to complete their tasks on schedule. In seeking to meet their responsibilities many economies will require to make a significant investment in personnel training and development.

New Resource Developments

A number of economies reported significant plans to finance new initiatives. Several of these were related to the introduction of electronic chart services. Others were for the introduction of spatial data services outside the marine navigation sector. Some noted recent investments in new ships and digital navigation services.

Cost Effectiveness

A few economies are improving cost effectiveness via technology development, for example by using lidar survey techniques in appropriate circumstances. Some economies are also improving cost effectiveness via greater utilisation of assets, particularly by introducing dual or rotating crew arrangements for their survey ships, which has the potential to double available sea time.

Outsourcing is an avenue to improve performance without major capital expenditure and without increases in staff. A few economies are using outsourcing to good effect for the provision of equipment and expertise, and this practice is worthy of consideration by all economies.

Status of Resources

Country	Survey				Charting			Spatial Data Services	Budget $ US M
	Ships	Boats	Survey-ors	Tech-nicians	% Digital Equipment	Carto-graphers	Drafts-men	Extra Staff	
Australia	6	10	56	130	95	35	na	0	20
Canada	4	50	100	0	98	100	na	5	38
Chile	1	1	21	29	90	10	9	0	No Data
Hong Kong	0	3	20	29		No Data		No Data	No Data
Indonesia	7	1	242	237	60	10	25	10	2
Japan	5	7	90	60	50	30	15	No Data	27
Korea	6	0	4	26		No Data		7	1
Mexico	4 + os	2	11	22	90	5	6	0	No Data
New Zealand	os	os	os	os	os	os	os	os	No Data
Peru	3	1	58	190		No Data		0	1
Philippines	4	4	12	24	60	10	2	4	3.5
Singapore	1	4	12	8	90	1	9	0	0.5
USA	7	0 + os	28	4	100	107	na	4	71

Note; OS indicates work is outsourced

4.1.4 Status of Institutional Arrangements

Co-ordination Arrangements

In order to achieve optimum value from the Hydrographic Service it is desirable to have some formal co-ordination arrangements across government departments. Co-ordination arrangements in several of the economies that responded to the questionnaire are formal in nature, but others are informal and it would seem useful to formalise them.

All economies appear to have legislation or statutory instruments in place to mandate the activities of the hydrographic service.

Regional Co-operation

There is useful international co-operation within the region aimed at overcoming problems of surveying capacity and training. It would be advantageous to increase the amount of co-operation and development aid between hydrographic programmes in the APEC region, including extension to those economies that are not yet APEC members.

There is currently some good regional co-operation in surveying major straits and sea-lanes that carry large volumes of international shipping in transit, but there appears to be potential for further co-operation. Increased regional co-operation in advancing the surveying and charting of poorly surveyed but heavily used sea lanes in East Asia and the South China Sea is regarded as particularly important. The need for this could be further assessed, based upon a study of movements of ships in transit, and the nature of the charting requirements of those international sea-lanes.

Status of Institutional Arrangements

Country	Responsible Ministry	Law or Decree	Co-ordination Arrangements	Regional Co-operation
Australia	Defence	Decree	MOUs/Informal	Yes
Canada	Oceans	Law	MOUs	Yes
Chile	Defence	Law	Informal	No
Hong Kong	Planning	-	-	No
Indonesia	Defence	Decree	Decree	Yes
Japan	Transport	Law	-	Yes
Korea	Maritime	Law	Law	No
Mexico	Navy	Law	MOU/Formal	Yes
New Zealand	Land	Law	Informal	No
Peru	Defence	Decree	-	No
Philippines	Environment	Law	MOUs	Yes
Singapore	Communications	Law	-	Yes
USA	Commerce	Law	MOUs	Yes

4.1.5 Key Issues and Constraints

The responses to the questionnaire exposed a large number of strategic issues and concerns. The most often repeated include:

1. Value of the budget;
2. Surveying capacity;
3. Surveying expertise;
4. ENC production capacity;
5. ENC compilation expertise.

Given the responses concerning the status of the national chart series, it is surprising that chart production capacity and expertise were not so widely mentioned.

Several developing economies suggested that some of these difficulties could be resolved through international and regional co-operation, and this is worthy of further examination.

APEC member economies should review these important issues and take action to ensure that they do not compromise the safety and efficiency of navigation.

Key Issues and Constraints

Country	Budget Value	Chart Status	Survey Status	Surveying Capacity	Surveying Expertise	Carto Expertise	ENC Capacity	ENC Expertise
Australia		Yes				Yes		Yes
Canada		Yes	Yes	Yes	Yes	Yes		Yes
Chile	Yes							
Hong Kong								
Indonesia		Yes					Yes	Yes
Japan		Yes					Yes	Yes
Korea								
Mexico	Yes			Yes			Yes	
New Zealand					Yes	Yes		
Peru								
Philippines								
Singapore								
USA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

4.2 Future Potential

Based on the results of the audit, we make some suggestions for the improvement of the services and effectiveness of the APEC hydrographic services.

4.2.1 Improvement of Services

Navigation Services

All of the economies that responded to the questionnaire are producing charts and other services for navigation. However it is clear that, while the chart series of some economies are complete and up-to-date, the chart series of others are incomplete, and some have reduced utility because of age. If the full economic benefits of hydrographic services are to be recognized, it is most important that an appropriate level of resources be provided so that the deficiencies can be rectified.

It is also apparent that a few APEC economies have not progressed far along the path to the production of charts and services in digital media. These new services offer significant benefits for the improvement of safety of navigation and the protection of the environment and coastal economies from the pollution that may result from marine casualties.

We are concerned that some economies that did not participate in the audit, and some small regional economies that are not yet APEC members, may not yet have effective hydrographic services. We hope that this report will provide some guidance and assistance if needed.

Spatial Data Services

We consider that the provision of data and services for administration and sustainable development of the maritime zones, within the national spatial data infrastructure, will be of great economic value in the immediate future. Indeed, based on the very large numbers of potential users, it seems likely that they will be of greater economic benefit than services to navigation. However it is clear that, with a few exceptions, the hydrographic services of the APEC economies have not yet made any significant commitment to the provision of these new services. This is another deficiency that needs to be addressed.

Resource Implications

We suggest that economies should carry out an audit of the status of their hydrographic services, and publish a strategic plan with time frames for completion of high priority requirements. As a result of this process it may be necessary to improve the resources and budgets of the hydrographic services.

Consideration should be given to the potential of introducing a levy on shipping to help pay for improved hydrographic services.

Consideration should also be given to increasing regional co-operation.

4.2.2 Improvement of Effectiveness

We believe that there is some potential to improve the effectiveness of the regional hydrographic services. Improvements could include:

a. Increasing the operational availability of ships by augmenting crew numbers and using crew rotation;
b. Utilising new technology, for example Lidar survey systems, where appropriate;
c. Outsourcing some appropriate functions to the private sector.

The potential for improving outcomes as a result of increased effectiveness deserves attention.

5 ECONOMIC VALUE OF HYDROGRAPHIC SERVICES

5.1 Sector Contribution

The economic benefits to marine transport from sustainable hydrographic services are numerous, including direct navigational improvements to vessel movements in terms of safety and efficiency. Safer, faster and shorter voyages, coupled with increased voyage flexibility, yield sustainable economic benefits not only to individual APEC economies, but also to the APEC region as a whole. Indirectly, hydrographic services also support the use of larger vessels, deeper drafts, and greater load capacity by providing the navigational tools to optimise channel movements.

Most mariners would consider a world without such services unthinkable, with the negative consequences to safety and efficiency, and the corresponding economic, social and environmental impacts.

5.2 Quantifying the Contribution

Quantifying these benefits in economic terms however presents several challenges; firstly the complexities involved in defining and developing appropriate economic assessments; and secondly in obtaining reliable analytical base data. This may explain why few economic assessments have been attempted, and even fewer incorporating accurate, quantitative analysis. Although maritime and oceanographic communities appreciate the tremendous value of hydrographic services, actual quantification of their value remains illusive.

This has ramifications for sector development. Since hydrographic benefits are not quantified, the precise economic value of these services is not known. And if the value is not known, APEC member economies cannot, with reliability and confidence, set appropriate development and investment levels to optimise sector performance. There is a pressing need not only to ascertain economic viability of existing hydrographic services within APEC economies, but also to develop reliable planning tools in order to more accurately define future investment levels.

5.3 Economic Assessment Rationale

This assessment evaluates hydrographic service viability and recommends policy directives for future sector intervention for the APEC region. It focuses on evaluating the navigational impacts of hydrographic service provision on one of the primary beneficiary groups, that of the commercial shipping sector. This is of key interest to the APEC Transportation Working Group and represents one of the major beneficiaries of hydrographic service provision due to the magnitude of maritime trade within the APEC region.

The assessment evaluates potential impacts and costs to commercial vessel voyage duration from variations in hydrographic service provision and expenditure. It is based on the hypothesis that the reduction or cessation of hydrographic service provision within an APEC economy will have a direct navigational impact on commercial vessel voyage duration, due to one or several of the following;

(i) Reduced vessel speed (slowing in “poorly charted” waters and areas of complex navigation);

(ii) Increased voyage distance (taking conservative routings away from complex navigation areas or missing opportunities to develop shorter routes); and

(iii) Reduced sailing flexibility (such as restrictions on night sailings, or during times of poor visibility).

The assessment assumes that increased voyage duration due to hydrographic service degradation will result in corresponding increases in voyage costs encountered both by vessels (vessel-operating costs) and, in the case of passenger vessels, by passengers (passenger-time costs). In addition to increased vessel voyage duration, hydrographic service degradation or cessation may also result in constraints to vessel draft in certain channels, or compromise the manoeuvrability of larger vessels. This may lead to future limitations on the size, draft, and carrying capacity of larger vessels, resulting in the need for more voyages of smaller ships, thereby increasing shipping costs in general.

5.4 Economic Assessment Methodology

5.4.1 Introduction

This assessment considers these impacts in real terms. It directly assesses the relationship between hydrographic service expenditure and the navigational impacts on commercial vessel voyages in terms of vessel-operating costs and passenger-time costs. This is illustrated through evaluation of an example APEC economy, that of the Philippines, which is an archipelagic economy comprising of over 7,000 islands. The Philippines currently spends approximately US$ 3.5 million annually in hydrographic service provision.

The assessment evaluates this cost-benefit relationship by considering two scenarios. The first scenario assumes that hydrographic service expenditure is maintained at the current level, which in the case of the Philippines is approximately US$ 3.5 million per year. As a consequence of this expenditure, the commercial shipping sector benefits from the level of navigational assistance attained from the expenditure. This scenario is referred to as the " tendency

The second scenario assumes, theoretically, that hydrographic service provision ceases immediately and permanently from this day forward. For this scenario, a given APEC economy will therefore receive a "benefit" when compared with the tendency scenario equal to the hydrographic expenditure, which in the Philippine example is US$ 3.5 million annually. In other words, the economy "saves" this amount which otherwise would be spent every year on hydrographic services. As a consequence however, commercial shipping will begin to suffer due primarily to the progressive degradation of hydrographic charts, resulting in increased vessel voyage duration and consequential increases in vessel operating costs and passenger time costs. This scenario is referred to as the "counter-factual scenario".

The assessment evaluates these two scenarios in detail, comparing the costs and benefits of the tendency scenario with the costs and benefits of the counter-factual scenario. It assesses whether the additional vessel-operating and passenger-time costs incurred by commercial shipping as a result of cessation of hydrographic services are greater, equal to, or less than the "savings in expenditure" that would be achieved if hydrographic services cease from this day onwards (US$ 3.5 million annually in the Philippine example).

In this way, current hydrographic expenditure can be justified, or otherwise, since the cost of maintaining hydrographic expenditure (US$ 3.5 million annually) can be compared directly with the cost of not maintaining the expenditure (increased vessel-operating and passenger-time costs). In elementary terms, for the Philippine example, if the costs incurred to commercial shipping by hydrographic cessation are greater than US$ 3.5 million annually, then the current hydrographic expenditure level is justified on the basis of this one benefit alone. However, if the costs incurred by commercial shipping are less than US$ 3.5 million per year, then this benefit alone does not justify the current level of expenditure.

The assessment therefore focuses on the estimation of vessel-operating and passenger-time costs associated with the immediate and permanent cessation of hydrographic services. These estimates are derived through an iterative process, utilizing actual data for a given economy, in this case the Philippine economy, and over a pre-determined planning horizon, which in the Philippine case is 25 years (2003-2028).

5.4.2 Methodological Steps and Results

The methodology detailed in the attached Economic Assessment utilizes the following procedure of eight steps;

- **Step 1 : Defining Potential Commercial Shipping Sector Users**

  Three potential commercial shipping sector users have been identified. These are:
  (i) foreign trade shipping services;
  (ii) domestic trade shipping services;
  (iii) passenger shipping services.

- **Step 2 : Forecasting Future Demand of Potential Users**

  Based on the evaluation of existing national economic data and utilizing economic assessment methods, estimations of existing and future demand for each of the three user classes have been estimated for the 25-year planning horizon (2003-2028). These demand projections are summarized as follows;

Commercial Shipping Demand Projections

Year	Values (P billion at Constant 1985 prices)	Maritime Foreign Trade Volumes (Tons)		Domestic Trade Volumes (Tons)	Maritime Passengers (No)
	GDP	Exports (Tons)	Imports (Tons)		
1993	734	15,037,783	35,486,553	31,933,441	37,873,205
1994	766	14,515,625	38,183,499	35,554,196	40,043,006
1995	802	16,657,559	42,418,302	34,050,327	41,414,647
1996	849	15,687,040	51,829,760	35,776,468	44,141,572
1997	893	16,670,940	51,666,207	38,075,021	43,228,478
1998	888	16,154,116	46,134,026	37,422,615	44,371,866
1999	917	15,270,683	45,307,131	38,704,193	43,463,039
2000	960	15,735,037	50,481,620	38,827,360	45,222,044
2001	994	13,198,770	50,568,107	41,326,709	46,558,062
2002	1,039	13,114,661	52,780,152	42,868,826	48,262,159
2003	1,099	13,223,279	55,694,912	44,790,083	50,385,221
2004	1,165	13,414,684	58,937,443	46,809,568	52,616,828
2005	1,239	13,700,454	62,604,106	48,959,592	54,992,685
2006	1,321	14,774,680	66,623,881	51,174,702	57,440,465
2007	1,379	15,604,307	69,438,500	52,667,058	59,089,575
2008	1,440	16,480,518	72,372,026	54,159,415	60,738,686
2009	1,503	17,405,931	75,429,483	55,651,771	62,387,796
2010	1,569	18,383,308	78,616,106	57,144,128	64,036,907
2011	1,638	19,415,566	81,937,353	58,636,485	65,686,017
2012	1,710	20,505,788	85,398,911	60,128,841	67,335,127
2013	1,771	21,474,676	88,256,459	61,327,823	68,660,048
2014	1,833	22,489,343	91,209,624	62,526,805	69,984,968
2015	1,897	23,551,954	94,261,605	63,725,787	71,309,888
2016	1,964	24,380,982	97,579,613	64,924,769	72,634,808
2017	2,033	25,239,193	101,014,416	66,123,751	73,959,729
2018	2,105	26,127,613	104,570,123	67,322,733	75,284,649
2019	2,164	26,863,366	107,514,818	68,285,214	76,348,226
2020	2,225	27,619,839	110,542,435	69,247,694	77,411,804
2021	2,286	28,376,311	113,570,052	70,184,167	78,446,642
2022	2,347	29,132,783	116,597,669	71,096,000	79,454,252
2023	2,408	29,889,256	119,625,287	71,984,457	80,436,030
2024	2,469	30,645,728	122,652,904	72,850,707	81,393,268
2025	2,530	31,402,201	125,680,521	73,695,832	82,327,164
2026	2,591	32,158,673	128,708,138	74,520,839	83,238,827
2027	2,652	32,915,145	131,735,756	75,326,662	84,129,293
2028	2,713	33,671,618	134,763,373	76,114,175	84,999,524

- **Step 3 : Estimating Existing Vessel Voyages and Shipping Patterns**

Existing shipping data has been utilized to estimate the current pattern of annual shipping movements (vessel voyages) within the Philippine economy. This has included analysis of data provided by the Philippine Ports Authority for approximately 120,000 port calls (vessel movements) within the Philippines, and

extrapolating this data to estimate vessel voyages for the entire economy. The analysis has considered four types of vessels (bulk cargo, break-bulk cargo, containers and passenger vessels), and fourteen vessels size categories of each[2]. The total number of domestic passengers has also been estimated from existing records. This data has then been utilized to estimate the overall shipping pattern of domestic and foreign cargo for the Philippines. This is summarized as follows.

Distribution of Cargo Volume by Vessel Types

Vessel Type	Distribution of Cargo Volume By Vessel Type (Percent)			
	Imports	Exports	Domestic	Total
Bulk	73.78	62.08	48.89	59.60
Break Bulk	17.11	24.12	26.61	22.72
Container	9.11	13.80	24.51	17.68
Total	**100.00**	**100.00**	**100.00**	**100.00**
Total Share (%)	**38.85**	**7.92**	**53.23**	**100.00**

The data has also been utilized to estimate average volumes of cargo and passengers transported by each vessel size category for domestic shipping, and average volumes of cargo for imports and exports, as follows.

Average Cargo and Passengers Transported by Vessel Size

Vessel Size (GRT)	Average Cargo and Passengers Transported Per Vessel By Vessel Size			
	Passengers (Number)	Domestic Trade (Tons)	Imports (Tons)	Exports (Tons)
< 200	95	65	185	160
200 - 400	110	141	281	338
400 - 600	125	509	589	488
600 - 1,000	160	595	971	938
1,000 - 3,000	256	931	1,320	871
3,000 - 5,000	405	1,039	2,545	1,861
5,000 - 10,000	447	638	2,447	1,484
10,000 - 15,000	416	1,145	3,038	1,270
15,000 - 20,000	681	1,764	3,852	1,080
20,000 - 30,000	64	3,850	19,697	9,350
30,000 - 50,000	322	47,410	36,051	9,338
50,000 - 75,000	2,181	7,509	64,483	58,178
75,000 - 100,000	100	81,119	104,681	97,129
> 100,000	3,671	58,272	241,408	11,933
Average	***144***	***362***	***7,281***	***2,284***

[2] Vessel size categories analysed include < 200 GRT; 200-400 GRT; 400-600 GRT; 600-1,000 GRT; 1,000-3,000 GRT; 3,000-5,000 GRT; 5,000-10,000 GRT; 10,000-15,000 GRT; 15,000-20,000 GRT; 20,000-30,000 GRT; 30,000-50,000 GRT; 50,000-75,000 GRT; 75,000-100,000 GRT; and > 100,000 GRT.

- **Step 4 : Estimating Future Vessel Voyages**

Utilizing the demand forecasts (Step 2), existing vessel voyage data (Step 3) and assuming that the shipping patterns (developed in Step 3) remain constant over the 25 year planning period (2003-2028), estimates have then been made of the total annual number of vessel voyages for each of the fourteen size classifications of the four types of vessels analysed (bulk cargo, break-bulk cargo, containers and passenger vessels). These are presented in the attached Economic Assessment and are relatively voluminous. As an illustrative example however, data from a portion of the vessel voyage projections (2003-2006) for bulk cargo vessels is presented as follows.

Bulk Cargo Vessel Projections:
Voyages (Ship Calls) Per Vessel Size (2003-2006)

Vessel Size (GRT)	Voyages Per Vessel Size			
	2003	2004	2005	2006
< 200	9,651	10,088	10,554	11,036
200 - 400	33,261	34,759	36,354	38,002
400 - 600	21,493	22,462	23,494	24,557
600 - 1,000	11,137	11,638	12,173	12,725
1,000 - 3,000	12,347	12,903	13,497	14,118
3,000 - 5,000	5,920	6,184	6,471	6,794
5,000 - 10,000	1,681	1,745	1,819	1,939
10,000 - 15,000	957	999	1,046	1,106
15,000 - 20,000	735	758	786	840
20,000 - 30,000	721	747	779	834
30,000 - 50,000	179	187	197	210
50,000 - 75,000	35	37	39	41
75,000 - 100,000	56	58	61	64
> 100,000	91	96	102	108
TOTAL	**98,264**	**102,662**	**107,372**	**112,376**

The principal outputs of Steps 1 to 4 of the assessment therefore are estimations over the 25 year planning period (2003-2028) of the number of annual vessel voyages for the entire Philippine commercial shipping sector, divided into fourteen size classifications for the four main vessel groups (bulk cargo, break-bulk cargo, containers and passenger vessels). In addition, the number of passengers has been estimated as previously presented in Step 2, in the table entitled “Commercial Shipping Demand Projections”.

- **Step 5 : Estimating Vessel Operating Costs**

Since the benefit analysis utilizes vessel operating costs (as described later), the next step in the analysis has been to estimate vessel operating costs for the fourteen size classifications of the four vessel groups (bulk cargo, break-bulk cargo, containers and passenger vessels). These have been estimated by a

specialist maritime consulting group using proprietary models, and adapted to local Philippine conditions, summarized as follows.

Estimated Hourly Operating Costs Per Vessel Size and Type

Vessel Size (GRT)	Hourly Operating Costs Per Vessel Size and Type (US$ Per Hour)			
	Bulk Cargo	Break Bulk	Container	Passengers
< 200	38	40	40	62
200 - 400	54	57	57	86
400 - 600	68	73	73	130
600 - 1,000	84	87	139	211
1,000 - 3,000	138	152	193	419
3,000 - 5,000	198	190	251	547
5,000 - 10,000	261	284	327	720
10,000 - 15,000	327	320	451	936
15,000 - 20,000	432	423	585	1,260
20,000 - 30,000	541	528	758	1,598
30,000 - 50,000	643	643	985	1,826
50,000 - 75,000	774	774	1,482	2,041
75,000 - 100,000	1,004	1,004	1,505	2,390
> 100,000	1,308	1,308	1,961	3,631

- **Step 6 : Estimating Passenger Time Costs**

Since the benefit analysis also utilizes passenger time costs in the overall assessment (as discussed later), these have also been estimated. Passenger time costs relate to the economic cost of "time loss" for an employed person, in this case for example through time delays to maritime passengers caused by increased maritime voyage duration. These costs are calculated by assuming the annual GDP per employed person (for the Philippines, this is equivalent to approximately US$ 2,642), converting this to an average hourly rate (for the Philippines equating to approximately US$ 1.25 per hour), and expressing the time value as a percentage (assumed as 25 percent, in accordance with generally accepted practice) of the hourly GDP. For the Philippines, the time value of an employed person therefore equates to approximately US$ 0.3127 per hour.

- **Step 7 : Assessing Voyage Duration Increases**

This analysis is based on the hypothesis that hydrographic service cessation will increase average vessel voyage durations (sailing times), due to one or a combination of reduced sailing speed, longer routings and more voyage restrictions. For an entire economy such as the Philippines, there will naturally be a multitude of impact variation relating to this, ranging from zero impact for some voyages to significant impacts to others. For the purposes of this analysis however, assumptions have been made in order to estimate a scenario of impact over the planning period. This includes the following assumptions;

(i) Navigational impacts to commercial shipping from the cessation of hydrographic services will occur incrementally over time. Initially, the impacts would be minimal, as hydrographic charts would have relatively high accuracy and usefulness. Over time however, and without revision, the charts would gradually deteriorate, eventually reaching a point of uselessness; and

(ii) Larger vessels will be impacted sooner and to a greater extent than smaller vessels.

Based on these assumptions, the following estimates have been developed regarding the impacts to average voyage duration over time for various size classifications of vessels. These estimates have been developed from the subjective assessment of both hydrographers and transport economists, and are presented as follows.

Average Voyage Duration Increases Due to
Cessation of Hydrographic Service Provision

Vessel Size (GRT)	Average Voyage Duration Increase (Minutes Per Voyage)				
	Year 5	Year 10	Year 15	Year 20	Year 25
< 1,000	1	2	3	4	5
1,000 – 5,000	3	6	9	12	15
5,000 – 20,000	5	10	15	20	25
20,000 – 100,000	8	16	24	32	40
> 100,000	10	20	30	40	50

As an illustrative example, a 15,000 GRT vessel is estimated to endure an average voyage duration increase of 5 minutes per voyage following 5 years of hydrographic service cessation, increasing to 10 minutes after ten years. In comparison, a larger 75,000 GRT vessel is estimated to endure an average voyage duration increase of 8 minutes after five years, increasing to 16 minutes after ten years.

- **Step 8 : Quantifying The Impact of Hydrographic Service Cessation**

The impacts have ultimately been quantified in terms of actual cost increases for both vessel-operating costs, and passenger-time costs due to the cessation of hydrographic services. For vessel-operating costs, this has included the estimation of vessel-operating cost increases for each of the fourteen individual size categories of the four vessel groups (bulk cargo, break-bulk cargo, containers and passenger vessels) and for each year of the 25 year planning horizon. For each vessel size category of each vessel group and for each year, this has included multiplying the number of vessel voyages (Step 4) by the incremental voyage duration increase (in minutes) for each voyage (Step 7) by the average vessel operating cost (Step 5), thereby equating to the total increase in vessel operating cost for a given size category. This has been computed individually for each of the vessel size categories for each group, and for each year of the 25 year planning period.

A similar process has also been utilized to estimate passenger-time costs. This has included the estimation of passengers for each size classification of passenger vessel for each year of the 25 year planning horizon (2003-2028). Associated costs for each vessel size classification have then been derived by multiplying the number of passengers by the incremental voyage duration increase (in minutes) for each voyage (Step 7) by the average passenger time cost (Step 6), thereby equating to the total passenger-time cost for a given passenger vessel size category. This has then been computed individually for each of the passenger vessel size categories, and for each year of the 25 year planning period.

The results of the assessment are presented in the following table.

Cumulative Costs of Navigational Impacts From Hydrographic Services Cessation on Philippine Commercial Shipping (2003-2028)

Year	Vessel Operating Costs					Passenger Time Costs	Total (US$)
	Bulk	General Cargo	Container	Passengers	TOTAL		
2003	101,717	50,725	52,224	258,609	463,275	78,000	541,275
2004	212,163	105,739	108,759	540,126	966,786	172,684	1,139,470
2005	332,810	165,861	170,437	846,772	1,515,879	288,048	1,803,928
2006	468,452	234,126	240,585	1,179,283	2,122,446	427,636	2,550,082
2007	558,114	279,552	287,288	1,393,532	2,518,487	527,562	3,046,048
2008	664,703	333,710	342,969	1,645,423	2,986,805	650,331	3,637,136
2009	791,398	398,272	409,351	1,941,412	3,540,433	801,079	4,341,512
2010	941,974	475,234	488,488	2,289,046	4,194,742	986,081	5,180,823
2011	1,120,919	566,976	582,828	2,697,137	4,967,860	1,213,002	6,180,862
2012	1,259,001	638,519	656,415	2,998,404	5,552,338	1,407,826	6,960,164
2013	1,404,680	714,038	734,131	3,315,666	6,168,515	1,611,588	7,780,103
2014	1,567,066	798,452	821,013	3,665,132	6,851,664	1,844,154	8,695,817
2015	1,748,081	892,815	918,148	4,049,980	7,609,024	2,109,525	9,718,549
2016	1,946,113	995,892	1,023,953	4,473,693	8,439,651	2,412,249	10,851,900
2017	2,115,897	1,084,926	1,115,278	4,825,079	9,141,181	2,693,300	11,834,481
2018	2,300,258	1,181,842	1,214,665	5,202,395	9,899,160	3,006,130	12,905,290
2019	2,487,719	1,280,265	1,315,608	5,588,350	10,671,942	3,320,082	13,992,024
2020	2,690,309	1,386,839	1,424,890	6,001,773	11,503,811	3,666,110	15,169,921
2021	2,920,280	1,507,842	1,548,967	6,470,319	12,447,408	4,063,612	16,511,021
2022	3,121,346	1,614,136	1,657,911	6,871,057	13,264,451	4,436,810	17,701,261
2023	3,334,683	1,726,992	1,773,573	7,294,897	14,130,144	4,843,141	18,973,286
2024	3,560,990	1,846,786	1,896,339	7,743,112	15,047,228	5,285,478	20,332,706
2025	3,801,009	1,973,919	2,026,617	8,217,045	16,018,590	5,766,935	21,785,525
2026	4,055,519	2,108,809	2,164,836	8,718,109	17,047,273	6,290,895	23,338,168
2027	4,325,344	2,251,899	2,311,451	9,247,794	18,136,488	6,861,025	24,997,513
2028	4,611,350	2,403,659	2,466,939	9,807,669	19,289,617	7,481,304	26,770,921

5.5 Evaluation

The Philippines currently spends approximately US$ 3.5 million annually in hydrographic service provision. It follows that if the hydrographic activity is suspended, the economy will "save" the current hydrographic investment (US$ 3.5 million per year). But for such a scenario, the economy will also progressively suffer additional costs in terms of increased vessel operating costs and passenger time costs. These costs are estimated on the table above, for example US$ 541,275 for the year 2003, rising to US$ 26,770,921 for the year 2028.

Conversely, if the current hydrographic investment (of US$ 3.5 million annually) is maintained, the cost to the economy will be US$ 3.5 million annually when compared to the above scenario. However, the economy will also benefit because it will not incur vessel operating cost and passenger time cost increases as shown on the table, for example, US$ 541,275 for the year 2003, rising to US$ 26,770,921 for the year 2028.

According to this scenario, it is also possible to evaluate the sustainability of hydrographic service annual expenditure for the Philippines. Utilizing these results, the annual expenditure flow of US$ 3.5 million represents a Net Present Value (NPV) at a 12 percent discount rate of US$ 19.2 million, and an Internal Rate of Return (IRR) of 23.6 percent. This means that the investment (of US$ 3.5 million annually) in hydrographic services represents a sound expenditure indeed, with a considerable economic return in terms of vessel operating and passenger time savings.

An analysis has been performed to estimate the level of expenditure in hydrographic services that can be sustained to achieve an IRR of 12 percent for the benefit analysed. An IRR of 12 percent is considered by the international community to represent an acceptable return on this type of investment. The results indicate that hydrographic services expenditure can be increased to approximately US$ 5.9 million, and still maintain an internationally acceptable IRR (12 percent) for the investment made. This represents an increase of nearly 70 percent over and above the current expenditure level. This means that the benefits to commercial shipping from existing hydrographic services in the Philippines are significant enough to allow expenditure to be increased to nearly US$ 6 million, and still return an acceptable IRR.

It is also important to note that the analysis is considered to be conservative, and only assumes relatively small incremental impacts in vessel operating and passenger time costs and savings of a matter of minutes over voyages often of many hours. The scope of the study has been restricted by the limited data available. There appears to be potential for much greater savings in specific cases. For example, international shipping entering the Sulu Sea from the Macassar Strait and traveling north towards Luzon is unable to sail directly north by the shortest route partly because of inadequate hydrographic surveys, but instead must sail west to enter the China Sea south of the Palawan Islands, and then north east to Luzon. This extends the voyage by some 150 miles, or up to 10 hours, probably for thousands of ships each year. Currently, voyage data to assist an analysis of these potentially dramatic improvements to maritime traffic does not exist. This is an aspect of regional hydrographic services that is worthy of further study by APEC, with the intention of identifying areas of regional interest that might benefit from regional co-operation in surveying and charting.

In addition, not all of these benefits from improved efficiency of inter-port voyages will flow to the Philippine economy. Many of the ships will be ships in transit, and the benefits will flow to the economies of the ports of departure and destination within the region. It is suggested that APEC

might research ways to collate data on transit voyages on a regional basis so that these potential benefits can be defined.

It is also important to emphasize that vessel navigation-related benefits only represent a fraction of the cumulative benefits to a given APEC economy from hydrographic services. Other significant benefits relate to the commercial fishing sector, environmental protection, sovereign and economic zone maintenance, national defence, coastal resource management, mineral exploration, emergency response, and recreational fishing and boating.

In summary therefore, the analysis indicates the tremendous economic benefits to the Philippine economy from the current expenditure in hydrographic services. It also indicates that, even by considering only the sole navigation-related benefit analysed, which represents only a fraction of total benefits, that additional hydrographic services expenditure can be justified in order to further improve the hydrographic services.

5.6 Extrapolation To Other APEC Economies

5.6.1 Introduction

The previous section presented the economic impacts from vessel-operating and passenger-time voyage savings as a result of varying investment levels in hydrographic services for the selected APEC economy (the Philippines). It reveals that the impacts are considerable; increased or decreased hydrographic services expenditure greatly affects vessel voyage efficiency and corresponding costs. The analysis of this single benefit alone emphasises the considerable economic viability and importance of hydrographic services to the Philippine economy, and highlights the potential for significant, additional benefits through increased expenditure.

The methodology utilized to develop the economic assessment for the Philippine case is both extensive and complex. It requires significant input data, including; (i) detailed voyage data for a range of vessel categories and size classifications; (ii) vessel operating cost data, which varies for each economy; and (iii) variable economic growth rates.

To complete an analysis in similar detail for other APEC economies would involve individual assessment of each economy, as each possesses markedly variable and unique base parameters. This is beyond the scope of this project, but is a clear recommendation of the assessment. Furthermore, once assessment of individual economies has been completed, then the assessment could consider regional effects.

The objective of the final part of this report is to relate the results of the Philippine example to other APEC economies that responded to the hydrographic questionnaire, in order to assess their relative economic sensitivity to the impact of hydrographic services on their economy. The analysis produced the possibility to group APEC economies responding to the questionnaire into three broad classifications;

(i) Substantial Impact (High sensitivity to increased investment in hydrographic services);

(ii) Moderate Impact (Moderate sensitivity to increased investment in hydrographic services);

(iii) Low Impact (Low sensitivity to increased investment in hydrographic services)

5.6.2 Methodology

The measure of the impact between the different APEC economies that responded to the questionnaire has been accomplished by identifying two sets of key indicators, which are used to estimate the relative economic sensitivity of the impacts benefit-wise for each of the APEC economies. These two parameter sets are; (i) navigational parameters which relate to physical and infrastructure characteristics for each economy; and (ii) economic parameters, which consider the relative impacts to the national economies. These are further described as follows;
Navigation Indicators

As outlined above, the assessment considers the economic impact of reducing or extending the time taken for each voyage due to the quality of hydrographic services. From a navigational sense, this would depend on a number of key factors, but all of which relate to the length of voyage during which hydrographic services influence. For example, for a vessel sailing through open ocean, the impact of hydrographic services would be relatively minimal, whereas for a vessel sailing around the coast, the impact would be greater. Also affecting the voyage and the reliance on hydrographic services is the relative complexity of the seabed, on which the dependency of hydrographic services would increase. From this, therefore, there are a number of key indicators that provide an indication of the length of voyage influenced by hydrographic services, the "navigational complexity", and therefore the reliance on the hydrographic services.

These are summarized as follows;

(i) Length of coastline – coastal waters are generally shallow in nature, and contain hazards to navigation which must be surveyed and published in charts. The longer the coastline, then the greater the task facing the hydrographic services;

(ii) Continental shelf – which is shallow and potentially dangerous to navigation. The greater the width of the continental shelf, the greater the task facing hydrographic services;

(iii) Archi-pelagic Waters – which are waters within island groups, which represent a special case of wide shallow seas and complex coastlines, which increase the task facing hydrographic services and for which good charts are essential; and

(iv) Ports – the production of charts for ports requires a higher degree of accuracy, and therefore an increasing number of ports increases the relative complexity of navigation. The restricted navigation of ports and high volume of traffic requires that surveys and charts be developed to much higher specifications and revised at more frequent intervals, which increases the task of the hydrographic services.

The hydrographic audit provides data about the differing geographic circumstances of the APEC economies. The Philippines has a long coastline, extensive areas of shallow water, an archi-pelagic geography and many ports. By contrast, Singapore has a relatively short coastline, a narrow continental shelf, one major port and practically no archi-pelagic waters. The impact on navigation therefore of increasing hydrographic services investment would be greater from a navigational sense in the Philippines than in Singapore.

Economic Indicators

The economic benefits in this study flow from improved efficiency of shipping, measured in voyage time savings, the number of vessel voyages, vessel cargo values, and passenger movements, represented by the following primary indicators;

(i) Volume of maritime foreign trade – from which is derived an indication of the number of vessel voyages. When these are aggregated, it provides an indication of the total time saved;

(ii) Maritime foreign trade as share of GPD – indicating the relative economic importance of international shipping;

(iii) Per capita GDP – indicating the value of passenger time savings; and

(iv) Volume of maritime domestic trade – indicating the relative economic importance of domestic shipping.

The economic impact can be again illustrated using the example of Singapore and the Philippines. Singapore has a relatively high dependence on foreign trade and high per capita GDP. In comparison, the Philippines has a lower dependence on foreign trade and lower GDP.

Scoring System

In order to infer the relative importance of each indicator to the various economies responding to the questionnaire, each economy has been assessed in terms of each of the navigational and economic indicators. A simplified "scoring system" has been utilized, whereby each economy has been assessed for each elementary indicator according to the following three relative levels;

(i) A score of 3 points is given where there is considered to be a high impact;

(ii) A score of 2 points is given where there is considered to be a medium impact;

(iii) A score of 1 point is given where there is considered to be a low impact.

The process of comparison is completed by summing up the value of all the indicators for each economy to provide an overall "impact score". The results of this are shown on the following table. Where data was lacking, professional judgment was applied.

ELEMENTARY INDICATORS SCORE STRUCTURE

Economy	Economic Factors					Navigational Factors					Overall Impact Indicator
	Foreign Trade	Foreign Trade/GDP	Domestic Trade/GDP	Per Capita GDP	Total	Ports	Coastline	Continental Shelf	Archi-Pelagic Waters	Total	
AUS	M	S	S	L	7	M	L	L	S	9	**16**
CAN	L	M	S	L	9	M	L	L	S	9	**18**
CHL	S	S	S	M	5	M	L	M	S	8	**13**
HKG	L	L	S	L	10	S	S	S	S	4	**14**
IND	M	S	L	S	7	M	L	L	L	11	**18**
JAP	L	S	M	L	9	M	M	M	M	8	**17**
KOR	L	M	S	M	8	M	M	S	S	6	**14**
MEX	M	M	M	M	8	M	M	M	S	7	**15**
NZE	S	S	M	L	7	S	M	M	S	6	**13**
PER	S	S	S	S	4	S	S	S	S	4	**8**
PHI	S	M	L	S	7	L	L	L	L	12	**19**
SIN	L	L	S	L	10	S	S	S	S	4	**14**
USA	L	S	S	L	8	M	L	L	S	9	**17**

Legend: L (Large Impact) = 3 points, M (Medium Impact) = 2 points, S (Small Impact) = 1 point.

Weighting

The overall impact indicators have then been weighted according to the status of hydrographic surveying and charting in each economy, as reported in the hydrographic questionnaire. This weighting represents the size of the outstanding hydrographic task. Thus economies whose surveying and charting is well advanced received a low weighting, and those that have large outstanding areas for surveying and charting receive a high rating. This represents the relative effect of improving hydrographic services, in that economies that still have the bulk of the work to do will benefit more than those whose task is well advanced. The weighting utilized is as follows;

(i) Where little hydrographic services improvement is considered necessary : 1 point;

(ii) Where medium hydrographic service improvement is necessary : 2 points;

(iii) Where large improvements are considered necessary : 3 points.

The following table illustrates the results of the weighting system developed, and the total weighted score for each economy.

RELATIVE IMPACT OF HYDROGRAPHIC SERVICES AMONG APEC ECONOMIES

Economy	Factor Scores			Weighting System	Final Rating
	Economic	Navigational	Total		
PHI	7	12	19	3	57
IND	7	11	18	3	54
MEX	8	7	15	3	45
CAN	9	9	18	2	36
USA	8	9	17	2	34
AUS	7	9	16	2	32
NZE	7	6	13	2	26
CHL	5	8	13	2	26
JAP	9	8	17	1	17
PER	4	4	8	2	16
HKG	10	4	14	1	14
KOR	8	6	14	1	14
SIN	10	4	14	1	14

Other Considerations

Two other matters have been considered in coming to a view about the impact of increased investment in hydrographic services in different economies. These are summarized as follows;

(i) The identification of critical issues and problems in the responses to the questionnaire is to some extent subjective, reflecting the financial realities and service expectations of individual economies. Some well-developed economies have the goal of total hydrographic coverage of the EEZ to the most comprehensive IHO standards, with highly developed navigation

services. Other less well-developed economies have more restricted goals, reflecting the current state of economic development and priorities;

(ii) This means that a certain status of surveying and charting might be regarded as acceptable in a developing economy, but not acceptable in a developed economy;

(iii) We have also observed that some economies with relatively large hydrographic budgets regard the size of the budget as a critical issue, whereas other economies with relatively small hydrographic budgets have not reported the value of the budget as an issue.

These issues have been taken into consideration during the evaluation.

5.6.3 Results

As shown on the above table, the results of the analysis have revealed that the APEC economies that responded to the questionnaire can be broadly classified into the following three groups:

(i) Substantial Impact – This group shows the economies where the benefits associated with increased hydrographic services expenditure are considered to be substantial. Economies: Philippines, Indonesia, and Mexico;

(ii) Medium Impact – Where the impact of increased hydrographic service expenditure is considered to be medium. Economies: Canada, Australia, USA, New Zealand, Chile, Japan and Peru;

(iii) Low Impact – Representing economies in which increased expenditure on hydrographic services would seem to offer relatively less benefit. Economies: Hong Kong, Korea and Singapore.

It must be remembered that the extrapolation process has not taken into account the actual investment that economies presently make in hydrography. Therefore the grouping in itself does not suggest that all members of Group 1 and 2 for example should necessarily increase their present investment in hydrographic services. It rather takes account of the responses (where they were received) of the economies' hydrographic authorities, as to whether in their opinion the present rates of funding are sufficient.

Importantly, when interpreting the implications of these responses, it needs to be remembered that such an opinion is highly dependent on the aspirations and social norms of the economy in question. Consequently the response in investment terms will mean very different things between for example the extremes of a developing economy and a developed economy.

Rather these groupings indicate the importance of hydrography for an economy. In other words they indicate the relative potential within an economy for generating economic gain by increased investment in hydrography.

Countries in Group 1 should see increased investment in hydrographic services as potentially providing major value to their economies. For those in Group 2 the potential benefit of increased investment is smaller. Those in Group 3 should see hydrographic services as important but possibly not as critical an issue for economic development, because their present level of investment seems appropriate to their needs.

The analysis of the Philippines case conducted within this report provides a valuable benchmark for economies to gauge their investment requirement. In the case of the Philippines it is clear from the economic analysis that a minimum investment of the order of US$ 5.9 million per annum is justified based purely on the benefits to shipping efficiency. Additional investment above US$ 6 million per year is clearly justifiable when benefits to ships in transit and non-transport sector benefits of hydrographic services are taken into account.

Other economies of the Group 1 category can use this benchmark to provide an indicative gauge of their needs by considering the length and difficulty of their coastline and economic status of their economy in relation to that of the Philippines. Because of the evident limitations in this extrapolation of the Philippine results, we repeat our recommendation that a full hydrographic audit and economic assessment should be a priority for economies in the top tier grouping, and an important management tool for other economies.

5.7 Conclusions of the Economic Assessment

Conclusions of the economic assessment are summarized as follows:

(i) The economic assessment demonstrates that the provision of hydrographic services has a significant and positive economic impact to the efficient and safe performance of the maritime transport sector in the selected APEC case study economy of the Philippines;

(ii) Based on the economic assessment, the entire national expenditure for hydrographic service provision can be justified from the benefits accruing from only one solitary benefit[3] of hydrographic services. The economic benefits from this single benefit alone when compared with the annual hydrographic services expenditure of US$ 3.5 million, are sufficient to achieve a Net Present Value (NPV) at a 12 percent discount rate of US$ 19.2 million and an Internal Rate of Return (IRR) of 23.6 percent;

(iii) The assessment of this one benefit also indicates that hydrographic service investment can be increased by nearly 70 percent from the current investment level to US$ 5.9 million and still achieve an internationally acceptable Internal Rate of Return (IRR) of 12 percent;

(iv) The cumulative benefits of hydrographic services to the Philippine economy are considerably higher than even this estimate, since the numerous other benefits accruing from hydrographic service provision

[3] Vessel-operating and passenger-time savings / costs accruing from voyage time savings / losses associated with vessel movements.

have not been included in the assessment. These include benefits relating to fisheries, mineral exploration, national defence, delineation and maintenance of sovereign- and economic- zones, search and rescue, environmental protection, sustainable resource management and maritime recreational uses;

(v) There is sound economic justification that the Philippine economy can benefit significantly from progressive and carefully planned additional investments in hydrographic services;

(vi) An initial qualitative assessment performed in order to infer relative economic sensitivity to varying hydrographic service investment levels in economies responding to the questionnaire has resulted in a broad classification of three major groupings. These include APEC economies where the benefits from increased investment are considered to be of; (i) substantial value (Philippines, Indonesia and Mexico); (ii) medium value (Canada, Australia, USA, New Zealand, Chile, Japan and Peru, and; (iii) of lower value (Hong Kong, Korea and Singapore).

6 KEY ISSUES AND RECOMMENDATIONS

6.1 Issues

We have identified a number of key issues facing the hydrographic services of the APEC region. They include;

a. The incomplete status of the surveying and charting of the waters of some of the APEC economies;
b. The incomplete status of the surveying and charting of some important international trade routes, especially in East Asia;
c. The availability of appropriate material, human and financial resources in the hydrographic services of some APEC economies;
d. The availability of easily accessible data on which to base future investment decisions, including data about shipping movements within the EEZ, and data about the current real costs of the hydrographic service;
e. The need for formal institutional and co-ordination arrangements for hydrography in the APEC economies.

6.2 Recommendations

We propose recommendations for individual economies and for APEC.

It is recommended that economies;

Carry out an audit of their individual hydrographic department, in order to define aspects of the hydrographic programme that need attention, and to identify and establish priorities and time frames for completion of outstanding tasks;

Carry out an economic analysis for their individual hydrographic requirements, using the model proposed in this report, in order to derive an optimum level of investment and budget for the hydrographic service;

Ensure that necessary development of the hydrographic department is included in national or ministerial development plans, including development of human, material and financial resources, and administrative arrangements, appropriate to the national survey and charting plans;

Ensure that national five-year plans for survey and charting are in place;

Review the work practices of the hydrographic department in order to identify the potential for improving cost effectiveness;

Review their individual institutional and co-ordination arrangements for hydrographic activities.

We consider that conducting a hyrdographic audit and an economic assessment should be a priority for the economies in Group 1. That process would also be an important management tool for other economies if they wish to take the issue forward.
It is recommended that APEC;

Consider the economic and safety benefits of increasing co-operation in hydrography, especially in the South China Sea, and in the international straits and archipelagic sea-lanes of East Asia.

Consider undertaking research to provide data on the volume and characteristics of international shipping making transit voyages through the international straits and archipelagic sea-lanes of the region.

Consider undertaking research to provide some possible models for navigation levies on ships transiting the archipelagic sea-lanes and international straits.

Consider organising some technical assistance programmes in hydrography for the small island economies of the APEC region.

7 POLICY IMPLICATIONS

The following suggestions are offered for further APEC consideration in order to strengthen existing hydrographic policy;

- Results and conclusions from this assessment should be fully circulated and promoted to relevant policy and sector development entities within APEC and member economies to allow appreciation of the potential economic benefits of current hydrographic services and value of additional investment;

- APEC should further refine the strategies and tools developed in this preliminary assessment and assist interested APEC economies to formulate comprehensive hydrographic evaluation and investment programs, and accurately define optimal investment levels;

- APEC should consider specific evaluation of regional sea-lanes, in order to develop improvement strategies, identify optimal investment levels, and define options for future co-operative hydrographic activity throughout the APEC region.

TPT 02/2001

Analysis of the Economic Benefits of the Provision of Hydrographic Services in the APEC Region

Attachment 1

Hydrographic Audit

July 2002

APP

GlobalWorks
International Project Development

TABLE OF CONTENTS

1 OVERVIEW

1.1 Introduction

This report is the output of Phase 2 of the project "Analysis of the Economic Benefits of the Provision of Hydrographic Services in the APEC Region. The objective of Phase 2 is to provide guidelines for APEC governments on appropriate levels of government investment for the provision of such services. This is to be done by means of an audit of the status of hydrographic services in the region.

The report is broken down into two main parts. The first is a general examination of global arrangements for hydrographic services. The second is a description of the current status of the hydrographic services in the APEC region [the audit].

1.2 Methodology

The audit is based on responses to a questionnaire sent to member economies. It also contains information from published and unpublished material sourced from the International Hydrographic Organisation and public domain hydrographic periodicals. Thirteen (13) of the twenty-one (21) APEC economies participated in the audit.

1.3 Contents

The five main sections of this report are outlined briefly in the paragraphs below.

Global and Regional Hydrographic Systems

The first section describes the fundamental characteristics of a Hydrographic Programme, including the rationale for the programme, the functions of the programme, and the capabilities needed to carry out those functions. These characteristics are independent of the size of the national economy.

The section examines the contribution that the hydrographic programme makes to the achievement of the missions of numerous ministries. It explains the need for an appropriate national institutional framework that will enable the government to realise all the benefits of investment in hydrographic infrastructure, and suggests some options for institutional models. It reviews international and regional treaties and conventions that have hydrographic aspects and requirements, and provides information about national legislation mandating hydrographic services. It also addresses the requirement and potential for co-operative regional activities.

It describes in some detail the empirical resource requirements of the hydrographic service, covering surveying, charting, product maintenance, distribution, data archives, training etc. For the information of readers who are not hydrographic professionals, a technology summary provides an indication of the technology and techniques used in "best practice" and "least cost" scenarios. This is important because the technology has a significant impact on budget, and on the rate of improvement of the national chart inventory.

The section offers some comment on how the empirical resource requirements may be extrapolated, to arrive at an indication of resources required for different nations with specific geographical and economic circumstances. It provides theoretical examples for various sized economies in order to provide some indication of budget requirements.

Finally it addresses some contemporary options for hydrographic service delivery and financing.

APEC Member Hydrographic Systems

The second section provides an audit of the hydrographic programme in each APEC economy, based on the responses to a questionnaire sent to member economies.

It provides a number of comparative tables that summarise the status of various aspects of regional hydrographic services, including institutional arrangements, survey activities, charting activities, resources, and strategic issues and problems. The tables allow for comparison between economies, and a degree of basic benchmarking is possible. There is a commentary on the principal features and issues that are highlighted by the tables.

International Waters

This Section provides a brief description of the status of surveying and charting in international waters [outside national EEZs]. Safe and efficient navigation in international waters is important to the trade and economic well being of regional states, but these waters fall outside the sovereignty and charting responsibility of any single economy.

Improvement Options

Based upon the results of the audit, the third section of the report explores in more detail the hydrographic improvement options that might be appropriate from a regional and national perspective. These include technology and institutional aspects.

Since adequate funding is a prerequisite for success, this section also explores options for funding hydrographic initiatives in the region.

Recommendations

The final section provides recommendations for follow-up action in both the national and regional dimensions. Initiatives that are expected to provide the greatest short to medium term economic and safety benefits are also indicated.

2 GLOBAL AND REGIONAL HYDROGRAPHIC SYSTEMS

2.1 What is a Hydrographic Programme ?

A government hydrographic programme provides for the surveying and charting of coastal and marine areas within national jurisdiction.

2.2 Rationale for a State Hydrographic Programme

The principal function of a hydrographic programme is to publish charts for navigation.

The provision of an adequate coverage of high quality nautical charts is essential for efficient navigation. Without such charts vessels cannot plan and execute the shortest and most convenient voyages between two ports. (For further development of this point see Annex A.) Thus nautical charts are a vital part of the national and international transport infrastructure, since they facilitate the vital economic activity of import and export by sea. Over 95% of international trade by volume is carried by sea.

Charts play an essential part in ensuring the safety of life and property at sea. Without such charts vessels cannot know of or avoid the subsurface dangers that threaten their safety. Charts help to prevent shipwrecks.

The provision of good quality charts makes an important contribution to national programmes for the protection of the marine environment, since safe navigation helps to avoid shipwrecks and the pollution that often results from them. Prevention of pollution has economic as well as environmental benefits, because of the other economic sectors that depend upon clean seas, for example fishing, tourism, and desalination.

So important are the safety and environmental aspects of national charting programmes that the International Maritime Organisation (IMO), in revising the Safety of Life at Sea (SOLAS) Convention, has mandated that all contracting governments should provide hydrographic services. A copy of the proposed Regulation 9 of SOLAS Chapter 5 is attached at Annex B. This measure is in addition to the longstanding SOLAS V Regulation 20, which requires ships to carry charts appropriate to the voyage at hand.

However, there are other economic, social and legislative benefits that flow from a national hydrographic programme. Hydrographic information is a fundamental data set that informs decisions about the delineation, establishment, administration and sustainable development of the national maritime and coastal zones.

It is also important to recall that shipping is an international activity, and that the provision of hydrographic services to support shipping has an essential international dimension. Worldwide delivery of services requires a significant degree of international co-operation. There is much that APEC can do to promote the delivery of high quality hydrographic services on a regional basis.

The hydrographic programme is of great importance to national defence, since comprehensive charts are essential to the successful conduct of maritime military operations.

It should also be noted that, in economic parlance, the national hydrographic programme is regarded as a “Public Good”. That is to say that the necessary services required in the public

interest will not be supplied at optimal levels by market forces alone. In most economies the provision of hydrographic services is a function of central government.

2.3 Principal Functions of the State Hydrographic Programme

The functions and services of the Hydrographic Department may be considered under three headings.

The first priority is the provision of services to support safe and efficient navigation and the protection of the marine environment. These services are a requirement of international convention, to which most APEC member economies are signatories. They may be summarised as:

1 Provision of a comprehensive national chart series
2 Promulgation of maritime safety information
3 International distribution arrangements for these services
4 Data management and custodianship arrangements
5 Production of other nautical documents for the information of mariners

We examine each of these items in more detail in Section 2.4

The second group of services are those that support the national spatial data infrastructure, oceanographic research, management and development of the national oceanic zone, and other functions. The main requirement here is the development of accessible databases that may be used in Geographic Information Systems [GIS], together with specific digital and analogue products such as bathymetric maps. The requirement for such services is at present small in most economies, but demand is expected to grow, and may eventually exceed the demand for statutory services for navigation. [For further information on this important subject we refer readers to The International Hydrographic Review, December 2001, listed in the bibliography].

The third group of services is for military applications. It is not proposed to deal with these in detail in this report. However the hydrographic department should be capable of delivering data and services that meet both civil and military international standards.

2.4 Principal Capabilities of the State Hydrographic Services

2.4.1 Cartography

The principal service offered by the hydrographic department is the national chart series. The hydrographic programme should therefore have access to a production facility. A production facility has a number of key features, including facilities for the;

i. Compilation of new charts, including cartographers and computing equipment,
ii. Maintenance and updating of charts on a continuous basis,
iii. Publication of charts in digital and analogue form,
iv. Compilation and publishing supporting texts such as Sailing Directions and Tide Tables, and
v. Provision of facilities for distribution of services to users around the world.

These facilities meet the requirement of Regulation 9 of the revised Chapter V of the SOLAS Convention that Contracting Governments undertake " to prepare and to issue official nautical c

2.4.2 Maritime Safety Information

The national charts series must be supported by a means of supplying mariners with immediate advice about new dangers to navigation and other information such as failure of navigation aids, temporary obstructions etc.

It is necessary to have a means of obtaining and examining information about potential dangers to navigation in national waters. Subsequently these can be promulgated by Notice to Mariners, or if of an urgent nature by radio through the Global Maritime Distress and Safety System (GMDSS).

This meets the requirement of Regulation 9 that Contracting Governments will " promulgate

2.4.3 Data Management Arrangements

A high quality nautical charting service must be underpinned by an appropriate data management system, so that all necessary information may be easily accessed for compilation of products and services, and for quality assurance processes. Databases must also be able to provide data into the national spatial data infrastructure for research, administration and development.

Regulation 9 requires contracting governments "to provide data management arrangements ", recognising this to be a fundamental activity of any hydrographic department.

2.4.4 Hydrographic Surveying

In order to produce high quality nautical charts it is necessary to carry out hydrographic surveys to acquire the information on which the charts are based. The facilities required for hydrographic surveys include research vessels or aircraft, suitable survey equipment, and expert surveying personnel. It should be noted that hydrographic surveying is very time consuming and expensive. [A note about hydrographic surveying for the lay reader is given in Annex A.]

Regulation 9 requires contracting governments " to ensure that hydrographic surveying is carried out ".

2.4.5 Training

It is necessary to make provision for the education and training of surveyors and cartographers. In some APEC economies training facilities exist within the hydrographic department. Training is also available in a number of educational institutions around the world, and is offered by the major equipment suppliers in association with capital purchases. Training may be a significant cost centre in the budget of the hydrographic department.

2.4.6 Budget

To provide these capabilities it is necessary to allocate a realistic budget for the hydrographic programme. The budget has two parts. The first part provides funds for annual operations including salaries, and the second [larger] part provides capital money for investment in facilities, equipment and survey platforms. Because of the cost of buying, operating and depreciating ships, the survey component of the activity may be expected to absorb between 60% and 80% of the total budget.

2.5 Organisational, Institutional and Regulatory Frameworks for Hydrography

2.5.1 The National Institutional Framework

The work of the hydrographic programme generally affects a number of government ministries including Defence, Transport or Communications, Foreign Affairs, Environment, Law, Mineral Resources, and Oceans or Fisheries.

Whilst the national hydrographic programme should properly be the responsibility of one Ministry, it is important to establish an effective consultative institutional framework, so that national priorities may be decided and reflected in the work of the programme. It is therefore recommended that a Ministerial or Senior Officials Committee be formed, named the "National Hydrographic Committee", or with some other suitable title.

It may also be convenient to consider the establishment of a national technical committee that can research and make proposals on matters referred to it by the Ministerial Committee.

The responsible Ministry should establish a Hydrographic Authority, which will ensure that the necessary services are provided. We recommend that the budget for this Authority should be identified as a specific item within the budget of the responsible Ministry.

2.5.2 The Regulatory Framework

In meeting their obligations to provide navigation services to domestic and international shipping, hydrographic services are responding to the regulatory requirements of the Convention on the Safety of Life at Sea [SOLAS], which is administered by the International Maritime Organisation.

The text of the relevant regulations of SOLAS Chapter V is reproduced in Annex B.
National regulatory frameworks differ widely. Where regulatory powers exist they are usually mandated in legislation. Sometimes they are provided in executive government decisions.

2.5.3 International Treaties, Conventions and Resolutions

There are several international conventions that encourage the provision of hydrographic services.

<u>The International Convention for the Safety of Life at Sea 1974 [SOLAS]</u>

This is the most important international convention affecting hydrography. Essentially this Convention encourages and regulates international maritime safety. The relevant provisions of the SOLAS Convention are described in Annex B.

The United Nations Convention on the Law of the Sea 1982 [UNCLOS]

This Convention establishes the concept of the maritime exclusive economic zone, which extends to 200 nautical miles from the national baselines. The position of the baselines depends upon an accurate knowledge of all the coastline and outlying reef areas that are dry at low tide. Sovereignty claims based upon these features must be supported by comprehensive hydrographic data.

UNCLOS also provides certain circumstances under which an extension to the maritime zone may be claimed. Such claims require comprehensive hydrographic and geophysical data about the continental shelf and the continental slope.

In 2002 the surveying of national maritime zones has become a high priority activity, especially for the smaller developing nations, and is likely to be raised at the World Summit on Sustainable Development. [See under UNCED below].

The United Nations Conference on the Environment and Development 1992 [UNCED]

This inter-governmental Conference was concerned with establishing international protocols and programmes to ensure sustainable development of the world's natural resources. The report of the Conference is a document called Agenda 21. Chapter 17 of Agenda 21 deals with protection of the oceans, and paragraphs 13 and 102 emphasise the importance of adequate scientific data in ensuring sustainable development of the maritime exclusive economic zone. Hydrographic data is one of several fundamental data sets that inform decisions on sustainable development.

The recommendations of Agenda 21 Chapter 17 were re-affirmed in 1999 by the 7th Session of the UN Commission on Sustainable Development, during its deliberations on Oceans and Seas. They will be reviewed in 2002 at the World Summit on Sustainable Development.

The United Nations General Assembly, Resolution A 53/32, November 1998

This resolution resulted from a General Assembly debate on the subject of Oceans and the Law of the Sea. Paragraph 21 of the resolution encourages states to co-operate in the provision of hydrographic services to improve safety of navigation and to make hydrographic data widely available for national development purposes.

The Scientific Committee on Oceanic Research [SCOR], 1995 Report "Improved Global

This report from the international scientific establishment highlighted the critical importance of seabed topography as a controlling parameter in ocean dynamics, and identified a pressing scientific and economic need to improve knowledge of the topography of the seabed.

2.5.4 Global and Regional Co-operation and Co-ordination

Global Co-operation and Co-ordination

Global co-operation and co-ordination between national hydrographic agencies is necessary in order to provide the international mariner with convenient access to charts and navigation information on a global basis.

Global co-operation and co-ordination for hydrography is achieved through the International Hydrographic Organisation [IHO]. The objective of the Organisation, which was established in 1921, is to bring about;

i. The co-ordination of the activities of the national hydrographic offices;
ii. The greatest possible uniformity in nautical charts and documents;
iii. The adoption of reliable and efficient methods for conducting hydrographic surveys;
iv. The development of the sciences in the field of hydrography.

The Organisation has three principal programmes;

i. International co-operation and co-ordination;
ii. Capacity building, especially in developing economies; and
iii. Establishment and maintenance of technical and competency standards.

The Organisation undertakes regional co-ordination and co-operation through its Regional Hydrographic Commissions. In the APEC Region there are four IHO regional commissions;

i. The East Asia Hydrographic Commission;
ii. The North America Hydrographic Commission;
iii. The South East Pacific Hydrographic Commission;
iv. The South West Pacific Hydrographic Commission.

The Organisation co-operates with inter-governmental and other organisations, for example the International Maritime Organisation, the Inter-governmental Oceanographic Commission, the UN Office of the Law of the Sea, the Global Spatial Data Infrastructure, the International Federation of Surveyors, the International Cartographic Association, etc, etc.

Some 70 maritime states are members of the IHO. All the APEC economies are members, with the exception of Brunei, Mexico and Viet Nam. Membership of the Organisation enables national hydrographic agencies to participate in international and regional development of standards and expertise, in arrangements for global distribution of data and services, and in the co-ordination of activities on a worldwide scale that ensure that high quality charts and navigation services are conveniently available to the mariner in all parts of the world.

Regional Co-ordination and Co-operation

At a regional level there is active co-operation between hydrographic agencies through the work of the IHO regional commissions, which meet at intervals of two years, and which progress co-operative projects between meetings. Standard agenda items for these meetings include, for example, the regional progress of the IHO Scheme of International Charts, exchange of information about new services, technology, techniques and training, and opportunities for regional co-operation and co-ordination.

There is also active bi-lateral co-operation between economies, both within the region and globally. This co-operation includes training, conduct of surveys, provision of equipment, compilation of electronic charts, provision of funds, and project management.

Funds for capacity building in developing economies are provided by national and international development aid agencies.

2.6 Empirical Resource Requirements

2.6.1 Optimal Level of Resources

It is very important to understand the optimal level of resources required for a hydrographic service. This is a level of resources which offers the possibility of completing all outstanding surveying and charting tasks in a reasonable period of time, possibly about 20 years depending upon the current status. The optimum level of resources will allow an appropriate rate of effort in the plans and programmes for surveying and charting.

It is important to ensure that the resources are sufficient to avoid decay in the service. Application of insufficient resources will prevent the achievement of the required rate of effort in new work and revision work, and the services provided to users will slowly decay to a point where safety and economic benefits are compromised.

If all surveys and charts are substantially complete, the resources required would be only those needed to ensure that new surveys can be undertaken and new charts can be produced as required by natural and developmental changes to the seabed and the coastline.

2.6.2 National Surveying Requirements

It is general practice for national hydrographic agencies to have a 5 or 10-year national survey plan, which identifies areas requiring survey or re-survey, with an allocation of priorities.

Because of the high cost and time-consuming nature of hydrographic surveying, many nations have significant areas of their coasts and EEZ that are inadequately surveyed or require re-survey. The percentage of the coast that is inadequately surveyed or in need of re-survey is a very important indicator in assessing the adequacy of national surveying arrangements and resources.

If adequate resources are not applied to survey programmes it will not be possible to make progress in surveying areas which are at presently inadequately surveyed or charted. At the same time, inadequate resources will result in a decay of the present service, as surveys become out of date and inaccurate/unsafe over time.

2.6.3 Hydrographic Survey (Ships and Equipment)

The facilities for hydrographic surveying are the most expensive facilities in the hydrographic department, since they involve the use of research vessels that have high capital and operating costs.

Generally it is necessary to have, or to have access to, vessels that are capable of operating for long periods in the national offshore areas, and in shallow coastal waters. A combination of ocean going ships and inshore vessels is effective, or ocean-going ships fitted with embarked survey launches. A wide variety of vessels are described in the book “Jane’s Survey Vessels”. Aircraft fitted with lidar (laser) systems may also be used.

The survey vessels should be fitted with the equipment necessary for them to execute surveys to the standards laid down in IHO Publication S-44, IHO Standards for Hydrographic Surveys. The duty of care imposed on the hydrographic department requires the use of appropriate modern

equipment. Further details of contemporary technology requirements and costs are given in Annex E.

The duty of care imposed on the hydrographic department requires that the hydrographic surveyors should be educated to the standards laid down in IHO Publication M-5, Standards of Competence for Hydrographic Surveyors.

2.6.4 National Charting Requirements

It is the general practice of hydrographic offices to publish their charts in three principal groups.

Small Scale charts are provided for passage planning and for navigation out of sight of land. These charts are typically of a scale between 1:10 million and 1:1 million.

Medium Scale charts are provided for making landfall and for passage along the coast. These charts are typically at a scale of 1:300,000 or 1:150,000.

Large Scale charts are provided for the approaches to ports, internal waters of ports, and other areas where navigation is constrained by land formations, navigational hazards, traffic density etc. The scale of these charts is usually between 1:75,000 and 1:5,000.

The number of charts in the national chart series will depend upon the length of the national coastline and the extent of the national EEZ. Often the national chart scheme will be linked to the international chart scheme of the region, compiled by the IHO. The purpose of the international chart scheme is to ensure that the needs of international shipping are met in an economical and efficient way, through co-ordination of the chart schemes of neighbouring regional states.

Charts are compiled according to the standards laid down in the Chart Specifications of the IHO (IHO publication M-4).

From time to time charts must be completely revised in order to ensure that they contain all appropriate information. New editions of medium scale charts should be prepared at intervals of about ten years. Large-scale charts should generally be revised at more frequent intervals. If charts are not regularly revised their utility will decay with age. It is estimated that after about 50 years without revision, the utility of large and medium scale charts will decay to a point at which they will no longer be a safe aid to navigation due to the risk of inaccuracies and omissions.

In our experience there is often a mismatch between the number of charts that are required by the national chart scheme and the number of charts that are available. This ratio is a very important indicator in assessing the adequacy of national charting arrangements and resources.

If adequate resources are not applied to charting programmes it will not be possible to make progress in providing quality charts of areas, which are at presently inadequately charted. At the same time, inadequate resources will result in a decay of the present service, as charts become out of date and inaccurate/unsafe over time.

2.6.5 Compilation of Charts

An important component in any chart compilation facility is the availability of experienced compilers. These compilers have to be capable of ensuring that the correct information is included in the chart, by making a skilled selection from a diversity of sources. This requires the exercise of important judgement based upon an understanding of the needs of the mariner. The compilers must also have the skills to operate the advanced computer systems that are used for the operation of hydrographic databases and for the compilation of charts in electronic media.

The number of compilers to be employed will depend upon the size of the national chart series. It is an accepted approximation among IHO Member States that a skilled compiler will require 6 months to compile a new chart, or to prepare a major revision of an existing chart. This figure is likely to reduce in the future with the introduction of new compilation and database technology. It is also a generally accepted approximation that charts will require replacement or major revision at intervals of about ten years.

The work of compilation is undertaken in a workstation environment, using a computer system designed for such applications. Several proprietary systems are available in the market place. Such systems are often linked to a database or archive containing fundamental data from which specific compilations are derived. They may also be linked to some output devices that enable the compilation to be customised to a variety of products, for example paper charts, electronic navigation charts, military products etc.

2.6.6 Compilation of Supporting Publications

The mariner requires a number of publications in addition to the chart. These include the Sailing Directions, which are a textual description of the coast containing essential information about sea and weather conditions, port regulations, and other matters that may improve the safety and efficiency of navigation. Tide Tables are also required, as well as other publications such as Chart Catalogues and Lists of Lights.

The compilation and maintenance of these publications requires staff with experience in navigation, and provision of computer systems and office space.

2.6.7 Maintenance of Products and Databases

It is vital for the safety of navigation that charts and other products be kept up to date and amended to incorporate new information. It has been found necessary to have a dedicated facility for this work. The three principal functions that must be catered for are the examination of all new material, updating of databases and the updating of products and services.

Exactly how these functions are organised will depend upon the systems environment that has been chosen, but the facility must be staffed by the necessary number of skilled staff, to enable new data to be processed and promulgated within the short time frames demanded for navigational safety.

2.6.8 Provision of Maritime Safety Information

It is necessary to provide a means by which mariners may immediately be informed of changes to charted information and other dangers to navigation. This is routinely achieved through the system of “Notices to Mariners”, which are published regularly (weekly, fortnightly or monthly

depending upon volume). The usual form of publication is a booklet, but a "WEB" page or other means of communications can supplement this.

Because "Notices to Mariners" may take several days or weeks to reach subscribers, it is also necessary to promulgate urgent maritime safety information (MSI) to ships at sea by radio. This is a requirement of SOLAS Chapter V Regulation 2b. (See also IHO Special Publication S-53, Manual on Maritime Safety Information).

It is necessary to have a desk responsible for promulgating maritime safety information. The task involves examination of new material, preparation of Notices to Mariners, and preparation of radio navigation warnings. Skilled personnel are required, and appropriate national administrative arrangements, for which the hydrographic department may be the co-ordinator.

There must be an effective arrangement for the timely broadcast of warnings. This is not necessarily a function of the hydrographic department, but may be carried out by another government department such as the Ministry of Communications.

2.6.9 Data Management

It is necessary to have a means of archiving all incoming information.

Much existing information will be in manuscript form, requiring facilities for cataloguing and storing large volumes of plans, surveys sheets, reports and note books. It is desirable to have a person trained as an archivist to manage this collection.

It is likely that much new survey information will be received in digital form, and this should be managed in a database environment. The effective operation of such an environment requires specially trained personnel.

2.6.10 Printing

It is necessary to have access to facilities capable of printing charts to the standards of the IHO, and in the volumes needed to meet demand. Because volumes are often small, many hydrographic offices find that maintenance of in-house printing facilities is not economical, and they outsource this activity to another government department or commercial organisation that operates printing facilities. Modern technology allows printing on-demand, which has been adopted by a few hydrographic offices to date, especially as a complement to electronic chart services.

2.6.11 Distribution of Products and Services for Navigation

Effective distribution arrangements are required to ensure that mariners may easily and conveniently access the services provided by the Hydrographic Office. Distribution has national and international components.

To achieve national (domestic) distribution, hydrographic offices have traditionally acted as wholesalers, carrying bulk stocks of charts and publications for distribution to retail chart agents, such as ship chandlers and bookshops. This wholesaling activity requires a simple system for stock control and maintenance of accounts. A small staff will process and dispatch orders. The chosen arrangement should ensure that the required product is delivered to the mariner quickly. A normal service target requires that product delivery should occur within 48 – 72 hours from receipt of order.

It is also most important to ensure that chart products are conveniently available in all parts of the world (global distribution). It is difficult for an individual hydrographic office to achieve this without great expense. A convenient solution for global distribution, which has been adopted by many economies, is to formalise arrangements with one of the major chart producers that has a worldwide chart series, for example the UK Hydrographic Department, or the US National Image and Mapping Agency. Such arrangements will allow national charts to be obtained by international shipping anywhere in the world in a most economical and convenient way.

2.6.12 Support of the National Spatial Data Infrastructure

An increasingly important function of the hydrographic department is to ensure that hydrographic data are available in the national interest to researchers, administrators and producers working in the national exclusive economic zone and the coastal zone, who require comprehensive data to support complex decisions. Increasingly this is being achieved through the contribution of meta-data to the national spatial data infrastructure. This procedure allows users to discover the availability of data sets, whilst allowing government agencies to retain control of access and distribution.

Many advanced hydrographic agencies are restructuring themselves and their priorities in order to provide more effective service to this new and very large community of users.

On a regional and global scale, economies are co-operating and co-ordinating their activities to provide regional and global spatial data infrastructures.

2.6.13 Education and Training

Provision must be made for the initial training of personnel and for their continuous professional education and development. Education and training is another specialised activity that may be outsourced with advantage, in cases where the throughput of trainees is small. An appropriate budget provision is required.

2.6.14 Research and Development

The technologies and techniques used in hydrographic surveying and in production of the national nautical chart series are changing rapidly. In these circumstances it is worth considering the establishment of a small research and development cell to maintain a body of corporate knowledge about new developments, and to advise management about strategic technology decisions.

2.7 Examples of Resource Needs for Various Economies

2.7.1 Introduction

The preceding text has described the resources needed to effectively execute the mission of a typical hydrographic programme. This section will offer some theoretical examples of the extrapolation of those requirements and their application to small and medium sized economies. Larger economies and archipelagic states have such individual situations and requirements that it is not possible to offer theoretical examples.

It must be emphasised that these examples are intended only to provide indicative figures. The requirements of each individual economy will vary significantly, according to the geography of

the coast, the port infrastructure, and the pattern of trade. These examples are not a substitute for thorough assessments by individual economies.

2.7.2 The Small Economy

The first theoretical example illustrates the requirements of a typical small economy, which has a simple coastline of 600 km, 3 major trading ports, one area of restricted navigation, and a standard 200 nautical miles EEZ.

Chart Scheme and Navigation Publications

The chart scheme for this economy would typically contain

Chart Scheme	
Small-scale charts [1:750,000] for navigation planning	1
Medium-scale charts [1:150,000] for coastal navigation	4
Large-scale charts for precise navigation in ports, port approaches, and areas of restricted navigation	8
Allowance for future requirements	4
Estimated total number of charts	17
Minimum Supporting Publications	
Sailing Directions	1
Tide Tables	1
Monthly Maritime Safety Information	1
Resources for Cartography	
Cartographic Staff	
Management, planning and QA	2
New charts/major revisions	3
Maintenance of current charts	2
Maritime Safety Information	1
Publications	2
Data Management	1
Printing	0
Chart Sales and Distribution	3
Margin for training, holidays, sick leave etc [25%]	3
Total Cartographic Staff	15
Cartographic Equipment	
Workstations and tables	15
Archive Equipment	
Workstation, server and software	1

Hydrographic Survey

Assuming that the coast has been surveyed to some extent in the past, three months of survey work every year should be sufficient for the general maintenance and improvement of the coastal chart detail, in order to keep the chart series in an up-to-date state. If special new work or improvement is required, that work should be the objective of special projects with additional funding.

If an in-house capability is required, the following resources should be applied;

Survey Resources	
Small coastal survey ship, with embarked survey boat [Fully equipped]	1
Ship's crew	14
Survey manager	1
Professional surveyors	2
Survey technicians	2
Trainee	1
Total personnel for survey	20

Contracting Out Options

Provision of these resources can be achieved by contracting out some or all of the functions, which may be cost effective if the annual survey programme is less than six months.

2.7.3 The Medium Economy

The second theoretical example concerns a typical medium sized economy, which has a coastline of 3000 km, 12 major trading ports, 20 minor ports, four areas of islands and shoals, and a standard 200 nautical miles EEZ.

The Chart Scheme and Navigation Publications

The chart scheme for this economy would typically contain

Chart Scheme	
Small-scale charts [1:750,000] for navigation planning	5
Medium-scale charts [1:150,000] for coastal navigation	15
Large-scale charts for precise navigation in ports, port approaches, and areas of restricted navigation	50
Allowance for future requirements	10
Estimated total number of charts	80
Minimum Supporting Publications	
Sailing Directions	2
Tide Tables	1
Monthly Maritime Safety Information	1
Resources for Cartography	
Cartographic Staff	
Management, planning and QA	2
New charts/major revisions	12
Maintenance of current charts	8
Maritime Safety Information	1
Publications	2
Data Management	2
Printing	0
Chart Sales and Distribution	3
Margin for training, holidays, sick leave etc [25%]	8
Total Cartographic Staff	38

Resources for Cartography cont.	
Cartographic Equipment	
Workstations and tables	38
Archive Equipment	
Workstation, server and software	2
Compactus Storage	1

Hydrographic Survey

Assuming that the coast has been surveyed to some extent in the past, and if it is reasonably stable, twelve ship months of survey work every year should be sufficient for the general maintenance and improvement of the coastal chart detail, in order to keep the chart series in an up-to-date state. If special new work or improvement is required, that work should be the objective of discrete projects with additional funding.

If an in-house capability is required, the following resources should be applied;

Survey Resources	
Coastal/ocean survey ship, with embarked survey boat [Fully equipped]	1
Ship's crew	30
Survey manager	1
Professional surveyors	6
Survey technicians	6
Trainees	2
Total personnel for survey	45

Contracting Out Options

Provision of these resources can again be achieved by contracting out some or all of the functions.

2.8 Contemporary Options for the Provision of Hydrographic Services

2.8.1 Outsourcing

Hydrographic surveying and nautical charting have always been very specialised subjects and, because of the public good nature of the enterprise, the work has in the past been done in many countries by government departments. It remains the case that in most economies the work described above is carried out by government employees.

However in recent years many private sector companies have entered the market, offering to undertake both hydrographic surveys and compilation of charts. A number of hydrographic departments are taking advantage of this trend, and realising the benefits of utilising private sector expertise by outsourcing surveying and cartographic work. These benefits include leveraging on private sector expertise, flexibility in programme management, reduction of government investment in infrastructure and personnel and improved cost effectiveness of operations (better utilisation of assets and reduced costs).

In both of these options the government finances and retains control of the work.

The decision on which option to follow will depend upon national policy. Some nations appear to have embraced the process of outsourcing government funded work as a means of encouraging economic growth through industry development. Others have embraced outsourcing as a means of reducing government operating and investment costs. Others have elected to continue to provide solutions through government activities.

It is sometimes difficult for governments to measure the potential cost benefits of outsourcing, because capital and personnel budgets are held quite separately from operating budgets. In that case the costs of capital and personnel are invisible to the operating agency. As governments move towards the use of commercial accounting standards, it will be easier to assess the financial benefits of outsourcing options.

2.8.2 Cost Recovery

We have mentioned earlier that the provision of hydrographic services is regarded as a public good. The services required will not be supplied at optimum levels by market forces alone. In global terms, the hydrographic services in most maritime nations are fully funded by government appropriation, with some minor income derived from the sale of charts and nautical publications. However, it is increasingly clear that governments are experiencing difficulty in the provision of funds, and are looking at alternatives.

One possible alternative is the imposition of a levy on shipping to recover all or part of the costs of the service. Many nations have traditionally paid for their lighthouse services and port infrastructures through the levy mechanism, which seems equally applicable to the provision of charts. A few maritime states currently use this mechanism for funding the work of the hydrographic service, and it is an option worthy of consideration.

A levy system should include a mechanism for administration on a regional basis, in order to include both ships making port calls and ships in transit on major sea-lanes.

We suggest that APEC may wish to conduct a study of the benefits of funding hydrographic services through a regional levy system.

3 APEC MEMBER HYDROGRAPHIC SYSTEMS

3.1 Introduction

This section of the report summarises the responses to the questionnaire that was sent out to the hydrographic agencies of APEC member economies in August 2001.

Thirteen APEC economies provided responses to the questionnaire. The information in these responses has been compiled into a number of comparative tables. Eight member economies did not participate in the audit. A copy of the questionnaire is attached at Annex H.

Tables have been compiled to cover the following topics;

	Background Information
Table 1	Geographic Data and Trading Partners
Table 2	Principal Sectors of the Maritime Economy
Table 3	Responsibilities of the Hydrographic Service
	Status of Activities
Table 4	Status of Surveys
Table 5	Status of Charts
Table 6	Status of Publications and Sales Figures
Table 7	Status of Non-Navigation Services
	Status of Resources
Table 8	Survey Resources
Table 9	Charting Resources
Table 10	Resources for Non-Navigation Services
Table 11	Financial Resources and Sources of Funds
Table 12	Outsourcing
Table 13	Personnel - Training and Gender
	Status of Institutional Arrangements
Table 14	Ministerial Responsibility and Legislation
Table 15	Institutional and Co-ordination Arrangements
Table 16	Regional Co-operation
	Strategic Issues
Table 17	Strategic Issues and Problems

The following summarises the key points that have emerged from the tables.

3.2 Results of Audit

3.2.1 Background Information

Geographic Data and Trading Partners

The information in Table 1 on coastline and EEZ emphasises the very significant length and size of the coastlines and EEZs of the APEC member economies, and the enormous economic resources and administrative responsibilities that these areas represent. [It is noted that the Atlantic and Arctic seaboards are included for some economies.]

The information regarding Major Trading Partners is important because it illustrates the major trade routes within the region. In particular it emphasises the major trade to Europe and the Middle East, much of which pass through the Singapore and Malacca Straits. It also highlights the heavy volume of trade to North America, much of this being to West Coast ports, passing through Luzon Strait. Lastly it illustrates the importance of trade within East and South East Asia.

Principal sectors of the Maritime Economy

Table 2 illustrates the wide spectrum of maritime economic interests. It underlines the particular importance of shipping and fisheries, and the emergence of tourism as a major sector. The responses do not seem to reflect expected growth in non-shipping economic activities resulting from development of the EEZ and coastal zone.

Responsibilities and Activities of the Hydrographic Service

Table 3 shows that within APEC the activities and responsibilities of the hydrographic services are still primarily for transportation and defence. It suggests that the responsibilities and the services provided do not yet reflect the emerging demand for hydrographic information from other sectors of the maritime economy.

3.2.2 Status of Activities

Status of Surveys

Table 4 regarding status of surveys illustrates a point of fundamental importance. Only a few economies reported that their maritime zones are adequately surveyed. In many parts of the region, in both developed and developing economies, large parts of the marine areas are not yet surveyed to an adequate standard to assure the safe and efficient navigation of modern ships, and to support the growth of the regional and national maritime economies.

The status of surveys is a matter that should be of concern to APEC and to individual governments. It needs to be addressed in future regional and national development plans and budgets.

Status of Charts

Table 5 regarding the status of charts illustrates another point of fundamental importance. Only a few economies reported that their maritime zones have an adequate coverage of charts. In many parts of the region, in both developed and developing economies, charts of an adequate standard to assure the safe and efficient navigation of modern ships are not yet available for some parts of the marine areas.

In addition, some of the developing economies are not yet marketing digital charts in raster or vector form, and are thus denying mariners and the wider community the significant safety improvements which accrue to the use of digital charts. To some extent this omission is probably filled by the raster chart services of the major international chart producers, but that arrangement is not evident from the responses to the survey.

The status of charting is another matter that should be of concern to governments and regional organisations, and which needs to be addressed in future regional and national development plans and budgets.

Status of Publications and Sales Figures

Table 6 concerning the status of publications suggests that the provision of textual navigational publications to complement charts is satisfactory within the region.

The table of chart sales is an important measure of the uptake of hydrographic services within the community. Unfortunately the figures in this table may not truly illustrate the number of charts in circulation. This is because the number of charts sold by the major global sales agencies in UK and USA cannot always be identified by the hydrographic agencies in individual economies. It is therefore doubtful that the table reflects the true extent of demand for charts and hydrographic products.

Because of the importance of the sales figures as an indicator of the usage of hydrographic services, it is recommended that all hydrographic agencies establish formal distribution arrangements with the international producers, in order to ensure that these important statistics are available, and to ensure receipt of royalty revenue. This may be done through the international chart publishing protocols of the IHO.

Status of Non-Navigation Services

Table 7 shows that the hydrographic offices provide a very broad spectrum of services that are not for navigation. It illustrates a growing demand for these services, but it also confirms that the provision of such services is not widely developed, supporting the comments made in relation to Tables 2 and 3 above. Some important national policy requirements are visible, including delimitation of maritime boundaries, marine environment protection, sustainable coastal development, and sustainable development of living and non-living marine resources.

We believe that hydrographic services within the APEC region should actively promote these services in the interests of economic growth, and should if necessary seek additional funding. APEC specialised groups outside the transportation sector should be asked to support such an initiative, for example the APEC groups responsible for promoting sustainable development and protection of the environment in the oceans and seas [Marine Resource Conservation Working Group, Senior Environment Officials Group], and the group responsible for promoting a regional spatial data infrastructure.

3.2.3 Status of Resources – Material, Human and Financial

Survey Resources

The survey resources listed in Table 8 must be considered in conjunction with the status of surveys portrayed in Table 4.

With some exceptions, the table on surveying resources shows a relatively small number of ships employed for a very significant surveying task. This is a cause for concern.

From the perspective of improving cost-effectiveness, a few economies are employing a rotating crew arrangement for their surveying ships, in order to increase the availability of these assets by up to 80 % per annum. If depreciation and the cost of capital are applied in accounting procedures, survey ships will take up some 80 % of the annual budget allocation of the hydrographic department, and it makes very good sense to ensure that these assets are tied up in port for the minimum amount of time commensurate with maintenance requirements.

This can only be achieved in a socially acceptable way by having a rotation of the crew at frequent intervals.

Some economies are supplementing their resources by contracting commercial assets.

The table shows an almost universal use of modern technology, which is a prerequisite to achieving an acceptable standard of surveys. However it appears that there is still scope for improving cost effectiveness through technology advances, especially through the use of lidar survey equipment when circumstances permit, and through the use of remotely operated survey platforms. It is encouraging to see that some economies have plans for significant investments in new equipment, for which dollar values are shown in Annex D.

The Table suggests that there is an adequate number of surveyors in some economies, but only a small number in others. In general the numbers of surveyors do not seem large in the context of the lengths of coastline, size of EEZ and the status of the surveys reported in Table 4. [To some extent this may reflect a preference for outsourcing. Some correlation may be seen between these figures and the figures in Table 12, for example with the USA].

As mentioned in paragraph 2.6.2, if adequate resources are not applied to hydrographic programmes it will not be possible to make progress in surveying those areas which are at presently inadequately surveyed. At the same time, inadequate resources will result in a decay of the present service, as surveys become out of date and inaccurate/unsafe over time.

It is suggested that economies should carefully review the adequacy of their survey resources.

Charting Resources

The charting resources listed in Table 9 must be considered in conjunction with the status of charts portrayed in Table 5.

Again, with several exceptions, the table on charting resources shows a relatively small number of resources employed for a very significant task. This is a cause for concern. As mentioned in paragraph 2.6.4, failure to apply adequate resources to charting will result in decay in the utility of the national chart series, and will also prevent the publication of new charts to service new requirements and to fill gaps in the chart coverage.

Equipment to provide basic cartographic services is widely available, and some significant investments are planned. A list of projects is contained in Annex D. [Only Mexico reported a planned reduction in resources.] It is also pleasing to note the high level of digital compilation equipment in use. However the general lack of digital products is disappointing, because the use of electronic charts systems offers significant safety benefits through the reduction of human error in navigation.

With two exceptions, the number of cartographers employed seems to be insufficient for the task at hand and to address the significant number of new charts required by many economies.
It is suggested that economies should carefully review the adequacy of their charting resources.

Resources for Non-Navigation Services

It can be seen from Table 10 that very few resources have been allocated to the provision of non-navigation products and services. This demonstrates the high priority given to nautical

charting programmes, and a degree of difficulty in re-allocation of resources to meet demand for new non-navigational products. See also the comments in relation to Table 7 above.

We consider that provision of hydrographic information to the wider maritime economy is vital for efficient national development, and we suggest that economies should carefully review the adequacy of the resources allocated to non-navigation products and services.

Financial Resources

Table 11 contains details of financial resources. Some caution should be exercised in comparing the value of the budget for different economies, recognising variations in the cost of labour and the artificiality of currency exchange rates.

The value of the annual hydrographic budget for comparable regional economies seems to be similar, with one or two exceptions. However the accuracy of these figures must be questioned, because on the surveying side there is no indication that the cost of capital or the depreciation of ships has been taken into account. In addition, in some economies the responsibility for surveying of ports lies with the port operating companies rather than the government. It seems likely that the true cost of running the hydrographic programme may have been significantly understated in some responses.

[For example, the Philippines response to the questionnaire reported an annual budget figure of $ US 1M, but in the Economic Analysis a figure of $ US 3.5M has been used, in order to reflect the depreciation of capital items, principally new ships. Australia's response to the questionnaire reported a budget of $ US 20M, but in its Annual Report for 2000-2001 the Australian Hydrographic Service indicates a budget estimate for 2001-2002 of $ US 90M, of which $ 20M is for depreciation and capital use charges. In addition, within Australia's federal system of government, each provincial government has a hydrographic department, but the costs of these subsidiary government programmes is not reflected in the Australian response.]

Most economies indicated that a continuation of current funding levels would equate to a real reduction in annual budget. This would result in a slow decay of service, and current goals would not be achieved. If goals are to be achieved it will be necessary to increase the budget in order to maintain the real value of the budget.

One or two economies have reported that they expect a reduction in the current dollar value of their hydrographic budget. This is a matter of concern, given the significant outstanding tasks reported by those economies.

The source of funds for most hydrographic programmes is from central government allocations. Only one economy reported a significant element of user-pays funding. [See paragraph 2.8.2 above]. Because of the regional nature of shipping, and the high numbers of ships in transit passage, we consider that APEC should consider the merits of introducing a regional levy on shipping. [See comments in section 4.3].

The optimum value of financial resources required will vary from economy to economy. It is principally related to the geography, and to the level of past activity and investment in hydrography. However there is a correlation between the value of seaborn trade and the value of investment in hydrographic infrastructure. Recognition of this correlation is evident in some economies but not in others, but it should always be a factor in determining an appropriate hydrographic budget. This has been addressed in the accompanying report on Economic Benefits.

The annual operating and capital budgets should in all cases be sufficient for the tasks at hand. We have commented in relation to surveying and charting resources [Table 8 and 9] that the physical and human resources available in many cases do not seem to be sufficient. This comment extends also to the financial resources.

We recommend that APEC members review the adequacy of the budget allocation for their individual hydrographic programmes.

Outsourcing

As mentioned in Section 2.8 of this report, outsourcing or contracting-out is widely used by governments for the provision of government services. Table 12 shows that a significant percentage of the work of some APEC hydrographic departments is now outsourced, covering many aspects of their work. This may be regarded as a sign that regional hydrographic agencies are seeking to improve cost effectiveness.

Training and Gender

We live in a time when the expertise of staff is considered to be critical to the effectiveness of an organisation. It is therefore surprising that the figures in Table 13 show a relatively low level of education and training activity. The figures probably reflect the small numbers of surveying and cartographic personnel reported in Table 8 and 9. They may also reflect the tendency to recruit personnel who hold first degrees in appropriate disciplines, which significantly reduces the training burden. In cases where activities are outsourced, the contractors provide trained staff.

Participation in the workforce by gender is one of the wider socio-economic issues of interest to APEC. The participation rates shown in this table should be compared to overall APEC participation rates.

3.2.4 Status of Institutional Arrangements

Ministerial Responsibility and Legislation

Table 14 shows that responsibility for provision of hydrographic services is spread across a wide number of government ministries, with Transport and Defence predominating.

The table also shows that almost all economies have recent legislation to provide the mandate for the work of the hydrographic service. A more detailed list of legislation is contained in Annex C.

Institutional and Co-ordination arrangements

Table 15 illustrates the wide spectrum of government ministries whose work is supported by the hydrographic service. It also illustrates an emerging trend for the hydrographic agencies to support wider economic and administrative activity. Until recently Defence and Transport have been the predominant users of hydrographic data, but a much greater draw-down of services by other economic sectors is expected to be the norm within 50 years.

Only two economies indicated the existence of legislation mandating high-level co-ordinating arrangements between ministries. Several economies indicated co-ordination between ministries through official memorandum of agreement or memorandum of understanding. Several indicated additional co-ordination through inter-departmental committees. Some have

advisory committees comprised of users of hydrographic services. Some indicated that co-ordination arrangements were informal. There was no indication of the existence of a national hydrographic committee, of the sort advocated in Section 2.5.1

In view of the many stakeholders, we consider that APEC economies should ensure that effective internal co-ordinating arrangements are in place.

Regional co-ordination arrangements seem adequate, principally through the regional arrangements of the IHO.

Regional Co-operation

Table 16 shows that the current major regional co-operation effort is between the littoral nations of the Malacca Strait, working with Japan to resurvey this important sea lane prior to the production of electronic charts. Japan is also involved with the Philippines in an electronic chart project. There is co-operation in the Americas in the vicinity of national boundaries. Australia and the Asia Development Bank provide support for Papua New Guinea.

It is also known that there are a considerable number of bi-lateral co-operation and technical assistance projects, involving the development aid agencies of donor economies such as Canada, Japan, Korea and Norway, working with hydrographic agencies in recipient economies such as Indonesia, Malaysia, Philippines and Vietnam.

There is evidently some scope for increased regional co-operation in the navigationally significant international waters and sea-lanes in East Asia [see also comments in Section 4].

There is also significant scope for increasing co-operation with developing regional economies that are not members of IHO or APEC, notably Cambodia, North Korea, and the small island economies of the Pacific Ocean. Many of these economies have little or no hydrographic capacity, but they depend significantly on the maritime sectors for their economic wellbeing.

One economy suggested the creation of an APEC technical committee for hydrography to encourage and co-ordinate co-operative regional programmes, and this suggestion should be followed up.

3.2.5 Strategic Issues and Problems

The responses to the questionnaire exposed a large number of strategic issues and concerns. The most often repeated include:

1. Value of the budget;
2. Surveying capacity;
3. Surveying expertise;
4. ENC production capacity;
5. ENC compilation expertise.

Given the responses concerning the status of the national chart series, it is surprising that chart production capacity and expertise were not so widely mentioned.

We think that the identification of critical issues and problems reflects, to some extent, the financial realities and service expectations of individual economies.

Some well-developed economies have the goal of total hydrographic coverage of the EEZ to the most comprehensive IHO standards with highly developed navigation services. Other less well-developed economies have more restricted goals, reflecting the current state of economic development and priorities.

We have also observed that some economies have quite substantial hydrographic budgets, but regard the size of the budget as a critical issue, whereas some economies with small hydrographic budgets have not reported the value of the budget as an issue.

APEC member economies should review these important issues and take action to ensure that they do not compromise the safety and efficiency of navigation. We believe that it important for governments to understand the need for adequate resourcing of hydrographic services, and to accept the high level of financial commitment that is required.

Several developing economies suggested that some common issues and difficulties could be resolved through international and regional co-operation.

3.3 Conclusions of Hydrographic Audit

1. Most of the APEC member economies have long coastlines and extensive EEZs. They have significant economic dependence on maritime trade, and extensive offshore economic interests in fisheries, minerals and oil, tourism, etc.

2. However a significant number of them have not yet completed the surveying and charting of their coastlines to an adequate standard to support the safe navigation of modern ships, or the sustainable development of their EEZs. In the case of navigation some economies are not yet fully compliant with the requirements of the SOLAS Convention. This is the most important conclusion of this audit, and should be a matter of concern to governments.

3. Incomplete surveying and charting of the national maritime areas results in inefficiencies in ship operations, affecting the competitiveness of trade. It inhibits decision making for national development in maritime zones. It also exposes the economy to risks of pollution from accidents that could cause significant damage to the coastal environment and the coastal economy.

4. The hydrographic agencies in several economies are extending their services to provide information to the many users who are not navigators, through the national spatial data infrastructure. However several economies continue to confine their hydrographic activities to support of the traditional transport and defence sectors. If the full economic benefit of investment in hydrographic services is to be realised, it is important to extend the provision of services across as many economic sectors as possible. This is another important conclusion of this audit.

5. The situation in many economies described above is the result of the generally low level of annual hydrographic budget allocations in relation to the high cost and lengthy time requirements to complete hydrographic surveys and to publish charts. This is the third important conclusion of this audit.

6. The principle strategic concerns of the agencies that responded to the questionnaire were the size of the budget and the consequent limitations on capacity and expertise to adequately discharge the agencies' responsibilities. One major economy has recognised

this situation and has recently doubled the budget allocation of the hydrographic programme [USA].

7. One economy provides the majority of its hydrographic budget from shipping charges [Peru]. Such user pays regimes are an appropriate contemporary means of increasing the hydrographic budget.

8. The budget is used to purchase material and human resources. In many economies the quantity of these resources is small in relation to the unfinished tasks. However in most economies these resources are of high quality.

9. The majority of economies are using modern equipment appropriate to the achievement of international standards for hydrographic surveying and nautical charting. Most economies are making the difficult transition to electronic media for the management of data and the provision of navigation services.

10. Some economies are improving cost effectiveness via technology development, for example by using lidar survey techniques in appropriate circumstances. Some economies are also improving cost effectiveness via greater utilisation of assets, particularly by introducing dual or rotating crew arrangements for their survey ships.

11. Most economies have small numbers of skilled and experienced survey and cartographic personnel to undertake the tasks. It is clear that such expertise is in short supply, and much sought after. The shortage of expertise is a threat to the ability of hydrographic agencies to complete their tasks on schedule. In seeking to meet their responsibilities many economies will require to make a significant investment in personnel training and development.

12. Outsourcing is an avenue to improve performance without major capital expenditure and without increases in staff. A few economies are using outsourcing to good effect for the provision of equipment and expertise, and this practice is worthy of consideration by all economies.

13. In order to obtain optimum economic value from the hydrographic service, it is desirable to have some formal co-ordination arrangements across government departments that utilise the products of the service. These formal arrangements exist at present in some of the economies that responded to the questionnaire, and it would seem useful to create them in others.

14. Most economies have legislation or statutory instruments in place to mandate the activities of the hydrographic service.

15. There is useful international co-operation and co-ordination within the region aimed at overcoming problems of surveying capacity and training. It would be advantageous to increase the amount of co-operation and development aid to hydrographic programmes in the APEC region, including extension to those economies that are not yet APEC members.

16. Increased regional co-operation to advance the surveying and charting of the international straits and sea-lanes in East Asia and the South China Sea is regarded as particularly important.

3.4 Tables Summarising Audit Results

Table 1 Geographic Information and Trading Partners

Country	Coastline [km]	EEZ km^2	Major Ports	Major Trading Partners								
				North East Asia	South East Asia	West Asia	Middle East	Africa	Europe	North America	South America	Austral-Asia
Australia	59,736	8,941,759	12	Yes	Yes		Yes		Yes	Yes		Yes
Canada	244,000 [1]	6,500,000 [1]	9 [1]	Yes					Yes	Yes		
Chile	84,000	1,576,886	8	Yes					Yes	Yes		
Hong Kong	1140		-	Yes				Yes	Yes			
Indonesia	80,570	2,692,762	4	Yes	Yes			Yes	Yes		Yes	
Japan	-	-	-	Yes	Yes		Yes		Yes	Yes		Yes
Korea	11,542	376,000	27	Yes						Yes		
Mexico	11,208 [1]	3,150,000 [1]	17 [1]						Yes	Yes	Yes	
New Zealand	18,252	4,000,000	-									
Peru	3,080	800,000	6									
Philippines	31,800	1,993,000	21	Yes	Yes				Yes	Yes		
Singapore	495	-	6	Yes	Yes			Yes	Yes			
USA	152,950 [1]	11,533,395 [1]	9 [1]	Yes					Yes	Yes		

Note: Includes Atlantic and Arctic seaboards.

Table 2 Principal sectors of the Maritime Economy

Country	Mining	Oil + Gas	Fishing	Mari-culture	Shipping	Ship-building	Ocean Services	Tourism / Recreation	Port Operation	Defence
Australia		Yes	Yes					Yes		
Canada		Yes	Yes		Yes	Yes	Yes			
Chile	Yes		Yes	Yes	Yes					
Hong Kong					Yes					
Indonesia	Yes	Yes	Yes					Yes		
Japan			Yes		Yes			Yes		
Korea	Yes		Yes		Yes					
Mexico			Yes		Yes			Yes		
New Zealand			Yes		Yes			Yes		
Peru	Yes		Yes		Yes					
Philippines		Yes	Yes		Yes					
Singapore					Yes	Yes			Yes	
USA		Yes			Yes			Yes		

Table 3 Responsibilities of the Hydrographic Service

Country	Survey	Charts	Tides	Navaid	Geodesy	Geo-science Support	Coastal Monitoring	Fishery Support	Ocean-ography	Tsunamis	Meteo-rology	Inland Waters	Maritime Boundary	Defence Support
Australia	Yes	Yes	Yes						Yes					Yes
Canada	Yes	Yes	Yes					Yes				Yes		Yes
Chile	Yes	Yes	Yes						Yes	Yes				Yes
Hong Kong	Yes	Yes	Yes											
Indonesia	Yes	Yes	Yes											Yes
Japan	Yes	Yes	Yes						Yes					
Korea	Yes	Yes	Yes			Yes							Yes	
Mexico	Yes	Yes	Yes											Yes
New Zealand	Yes	Yes	Yes											Yes
Peru	Yes	Yes	Yes						Yes		Yes	Yes		Yes
Philippines	Yes	Yes	Yes		Yes				Yes					
Singapore	Yes	Yes	Yes	Yes			Yes							
USA	Yes	Yes	Yes		Yes									

Table 4 Status of Surveys

Country	Status of Surveys d<50m			Status of Surveys 50m<d<200m			Status of Surveys d>200m		
	% adequate	% resurvey	% unsurveyed	% adequate	% resurvey	% unsurveyed	% adequate	% resurvey	% unsurveyed
Australia	32	44	24	15	45	40	10	0	90
Canada	45	30	25	45	30	25	45	30	25
Chile	No information provided								
Hong Kong	100	0	0	100	0	0	NA	NA	NA
Indonesia	25	60	15	25	60	15	35	50	15
Japan	100	0	0	100	0	0	100	0	0
Korea	60	40	0	50	50	0	100	0	0
Mexico	23	2	75	4	4	92	10	0	90
New Zealand	No information provided								
Peru	80	10	10	80	10	10	75	25	0
Philippines	20	55	25	25	45	30	30	0	70
Singapore	100			100					
USA	Statistics given in another form								

Note: The adequacy of surveys is assessed according to the IHO Standards for Hydrographic Surveys, which sets out parameters and procedures to ensure that surveys and charts are of sufficient quality to ensure the safe navigation of large modern vessels carrying valuable and/or hazardous cargoes.

Table 5 Status of Charts

Country	<300,000		101,000 to 300,000		25,000 to 100,000		>25,000		% on Geocentric datum	ENC Sch	Cells On Market	Raster Charts		ISO 9000 Accred.'
	Sch	Pub	Sch	Pub	Sch	Pub	Sch	Pub				Sch	Pub	
Australia	78	40	362	181	195	103	117	62	38	-	-	-	-	No
Canada	43	79	136	49	334	43	123	270	33	574	528	650	650	Yes
Chile	33	25	48	34	201	173	439	312	-	202	69	0	0	No
Hong Kong	NA	NA	NA	NA	5	2	7	6	100	16	1	0	0	No
Indonesia	82	79	257	248	142	120	39	18	30	53	0	0	0	No
Japan	270	270	140	140	180	180	460	460	35	22	0	0	0	No
Korea	42	42	48	48	116	116	52	52	100	184	184	0	0	Not Yet
Mexico	15	15	30	3	100	8	261	63	90	96	0	0	0	No
New Zealand	15	15	52	50	866	80	22	20	95	14	0	0	0	NA
Peru	19	13	36	34	88	24	62	48	32	91	0	0	0	No
Philippines	12	12	55	55	91	91	54	54	0	0	0	0	0	No
Singapore	0	0	3	3	11	11	10	10	100	15	15	0	0	Yes
USA	67	67	77	77	498	498	383	383	100	1000	134	1025	1025	Yes

Notes:

1. The number of charts schemed is the number identified as being required to ensure safe and efficient navigation of shipping
2. The number of charts published is the number currently available for the use of mariners.

Table 6 Status of Publications and Sales Figures

Country	Publications							Sales by Volume1		
	Catalogue of Charts	Notices to Mariners	Navigation Warnings	Sailing Directions	List of Lights	List of Radio Signal	Tide Tables	Paper Charts	Digital Charts	Publications
Australia	Yes	Yes	Yes	No2	No[2]	No[2]	Yes	162,000	-	-
Canada	Yes	Yes	Yes	Yes	Yes	Yes	Yes	220,000	10,000	110,000
Chile	Yes	Yes	Yes	Yes	Yes	Yes	Yes	23,100	265	6100
Hong Kong	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Indonesia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	36,000	0	6,000
Japan	Yes	Yes	Yes	Yes	Yes	Yes	Yes	170,000	700	2,300
Korea	Yes	Yes	Yes	Yes	Yes	Yes	Yes	59,000	2,500	10,200
Mexico	Yes	Yes	No	Yes	Yes3	Yes[3]	Yes	5,000	-	3,800
New Zealand	Yes	Yes	Yes	No	Yes	Yes	Yes	50,700	0	7,700
Peru	Yes	Yes	Yes	Yes	Yes	Yes	Yes	24,000	-	8,000
Philippines	Yes	Yes	Yes	Yes	Yes	No	Yes	15,000	0	2,000
Singapore	No[2]	Yes	No	No[2]	No[2]	No[2]	Yes	1,100	50	6,400
USA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	760,000	960,000	25,000

Notes:

1. Includes volume sold by licensees and international producers.
2. This information is published by UKHO, NIMA and others.
3. Published by another national ministry

Table 7 Status of Non-Navigation Services

Country	Bathymetry Charts	Boundary Charts	EEZ Charts	Base Point Charts	Geoscience Maps	Gravity Charts	Magnetic Charts	Environment Maps	Coastal Management Maps	Ocean Thematic Maps	Ocean Publication	Tsunami Services	Tidal Data
Australia	Yes												
Canada		Yes			Yes								
Chile										Yes	Yes	Yes	
Hong Kong													
Indonesia			Yes	Yes			Yes	Yes					
Japan	Yes												
Korea	Yes					Yes	Yes						
Mexico										Yes	Yes		Yes
New Zealand		Yes											
Peru		Yes											
Philippines													
Singapore													
USA									Yes				

Table 8 Survey Resources

Country	Hydrographic Surveying Vessels					Hydrographic Equipment						Hydrographic Staff	
	>100m	50m-100m	25m-50m	<25m	Lidar	DGPS	Other Navigation	SBES	MBES	SSS	Data Processing	Surveyors	Assistants
Australia	2	0	4	10	1	Yes	Yes	Yes	Yes	Yes	Yes	56	130
Canada	0	2	2	50	0	Yes	Yes	Yes	Yes	Yes	Yes	100	0
Chile	1	0	0	1	0	Yes	Yes	Yes	Yes	Yes	Yes	21	29
Hong Kong	0	0	0	3	0	Yes	Yes	Yes	Yes	Yes	Yes	20	29
Indonesia	0	7	0	1	0	Yes	Yes	Yes	No	Yes	Yes	242	237
Japan	0	5	0	7	0	Yes	Yes	Yes	Yes	Yes	Yes	90	60
Korea	2	2	2	0	0	Yes	Yes	Yes	Yes	Yes	Yes	4	26
Mexico	0	4	SoP	2	0	Yes	Yes	Yes	No	No	Yes	11	22
New Zealand	-	os	os	os	-	-	-	-	-	-	-	os	os
Peru	0	0	3	1	0	Yes	Yes	Yes	Yes	Yes	Yes	58	190
Philippines	0	4	0	4		Yes	Yes	Yes	Yes	Yes	Yes	12	24
Singapore	0	0	1	4	0	Yes	Yes	Yes	Yes	Yes	Yes	12	8
USA	0	2	5	0	0	Yes	Yes	Yes	Yes	Yes	Yes	28	4

Note:

1. SoP Ships of opportunity
2. OS Function Outsourced

Table 9 Charting Resources

Country	Cartographic Equipment					Compilation		Cartographic Staff					
	Printing Equip	Manual Compilation	Digital Compilation	Paper Archives	Digital Databases	% Digital	% Manual	Cartogr-aphers	Drafts-persons	Printers	IT Specialists	Navigators	Other
Australia	Yes	Yes	Yes	Yes	Yes	95	5	35	na	na	4	na	26
Canada	Yes	Yes	Yes	Yes	Yes	98	2	100	na	na	20	5	75
Chile	Yes	No	Yes	Yes	Yes	90	10	10	9	5	3	0	0
Hong Kong	No information provided												
Indonesia	Yes	Yes	Yes	Yes	Yes	60	40	10	25	5	2	15	3
Japan	Yes	Yes	Yes	Yes	Yes	50	50	30	15	20	30	0	50
Korea	No Information Provided												
Mexico	Yes	Yes	Yes	Yes	No	90	10	5	6	10	0	3	12
New Zealand	os	os	os	os	-	-	-	os	os	os	-	-	-
Peru	No Information Provided												
Philippines	Yes	Yes	Yes	Yes	Yes	60	40	10	2	6	8	12	50
Singapore	os	Yes	Yes	Yes	Yes	90	10	1	9	0	4	1	0
USA	Yes	Yes	Yes	Yes	Yes	100	0	107	0	0	6	0	0

Note: OS indicates that this function is outsourced

Table 10 Resources for Non-Navigation Services

Country	Cartographic Equipment					Cartographic Staff			
	Printing Equipment	Manual Compilation	Digital Compilation	Paper Archives	Digital Databases	Cartogr-aphers	Drafts-persons	Printers	IT Specialists
Australia	Yes	Yes	Yes	Yes	Yes	0	0	0	1
Canada	Yes	Yes	Yes	Yes	Yes	5	0	0	0
Chile	Yes	No	Yes	Yes	Yes	0	0	0	0
Hong Kong	No Information Provided								
Indonesia	Yes	Yes	Yes	Yes	Yes	0	10	2	1
Japan	No Information Provided								
Korea	Yes	No	Yes	Yes	Yes	2	2	1	2
Mexico	Resources in Table 9 used when needed								
New Zealand	No Information Provided								
Peru	Yes	Yes	Yes	Yes	Yes	0	0	0	0
Philippines	Yes	Yes	Yes	Yes	Yes	1	1	0	2
Singapore	Nil								
USA	Yes	No	No	No	No	4	0	0	0

Table 11 Financial Resources

Country	Budget Value $ US M				Investments Planned $US M	Budget Trend [Real]	Source of Funds %			
	Survey	Navigation Services	Other Services	Total			Central Govt	Levies or Taxes	Sales	Other
Australia	13.6	1.5	4.9	20	50	Reduce	99	0	1	0
Canada	30	7.5	0.7	38.2	10	Increase	85	5	10	0
Chile	No Information				4.7	No Change	100	0	0	0
Hong Kong	No Information				No Info.	No Info.	No Information			
Indonesia				2.2	No Info.	No Change	40	0 30		30
Japan	20	5	2.5	27.5	4.1	Reduce	No Information			
Korea	1.0	-	-	1.0	No Info.	Increase	100	0	0	0
Mexico	No Information					Increase	No Information			
New Zealand	No Information									
Peru	0.3	0.3	0.4	1	No Info.	No Info.	0	90	10	0
Philippines	0.9	0.1	0.02	3.5	6.4	Increase	100	0	0	0
Singapore	2.8	3.1	0	5.9	0.6	Increase	67	3	40	0
USA	33.2	38.3	0	71.5	Large	Unknown	100	0	0	0

Caution; With regard to budget values, see cautionary comments in section 3.2.3.4.

Table 12 Outsourcing

Country	Percentage of work outsourced by volume				Type of work outsourced							
	Surveying	Chart Production & N to M	Non Navigation Services	Other	Ship Survey	Lidar Survey	Chart Compilation	Chart Printing	ENC Production	ECS Production	Chart Distribution	Air Photo
Australia	5	10	0	0		yes				yes	yes	
Canada	20	40	0	0			Yes		Yes	Yes		
Chile	0	0	0	0								
Hong Kong												
Indonesia	0	0	0	0								
Japan	10	30	100				yes	yes				
Korea	50											
Mexico	20	0	5	0								yes
New Zealand	90	90	90		yes	yes	yes	yes				
Peru	0	0	5	0								yes
Philippines	0	0	0	0								
Singapore	30	30	0	0	yes			yes				
USA	65	10			yes		yes					

Table 13 Training and Staff Gender

Country	Survey Courses				Cartographic Courses				Workforce Gender			
									Surveyors		Cartographers	
	Cat A	Cat B	Cat C	Other	Post Graduate	Graduate	Technical Certificate	Other	% Male	% Female	% Male	% Female
Australia	2	4	19			1	6	ih	75	25	80	20
Canada									Not Available		Not Available	
Chile	1	1				1		ih	90	10	60	40
Hong Kong				ih				ih	80	20		
Indonesia	15	15	15						90	10	75	25
Japan	3	10				10						
Korea		4					6		100	0	100	0
Mexico	1	2	6						100	0	40	60
New Zealand	os	os				os	os					
Peru									100	0		
Philippines		1				1			100		70	30
Singapore	2	1							100	0	30	70
USA				ih				ih	Not Available		Not Available	

Note;

1. os indicates that training is outsourced.
2. Ih indicates that training is in-house on-the-job training

Table 14 Responsible Ministry and Legislation

Country	Responsible Ministry	Legislation or Decree 1	Date	Legislation or Decree 2	Date
Australia	Defence	Cabinet Decision 1169	1946	Cabinet Decision 17026	1981
Canada	Oceans	Oceans Act	1996	Shipping Act	1995
Chile	Defence	Law 16771	1968	Decree 192	1969
Hong Kong	Planning	SOLAS Convention	2001		
Indonesia	Defence	Presidential Decree 164	1960	Government Regulation 23	1951
Japan	Transport	Hydrographic Law	1950		
Korea	Maritime	Hydrographic Law			
Mexico	Navy	Administrative Law			
New Zealand	Land Information	Survey Act	1986		
Peru	Defence	Decree	1903		
Philippines	Environment	Republic Act No. 2057	1958	Executive Order No. 94	1988
Singapore	Communication	Marine & Port Authority Act	1996		
USA	Commerce	Coast and Geodetic Survey Act	1947	Hydrographic Service Improvement Act	1998

Table 15 Institutional and co-ordination arrangements

This table indicates the government departments that are regularly consulted in relation to the work of the hydrographic programme.

Country	Defence	Economy	Education	Environ-ment	Fisheries	Foreign Affairs	Interior	Law	Resources	Science	Tourism	Transport
Australia	yes			yes	yes	yes		yes				yes
Canada	yes			yes	yes	yes		yes				yes
Chile	yes	yes	yes			yes	yes					
Hong Kong		yes										
Indonesia	yes				yes	yes	yes	yes				yes
Japan	No Information Provided											
Korea						yes				yes		
Mexico	yes			yes			yes				yes	yes
New Zealand	yes				yes	yes						yes
Peru	yes											
Philippines	yes					yes			yes			yes
Singapore	yes											
USA	Yes											Yes

Table 16 Regional Co-operation

Country	Abbr	Au	Bn	Ca	Cl	Cn	Tp	HK	Id	Jp	Kr	My	Mx	NZ	PNG	Pe	Ph	Ru	Sg	Th	US	VN	Aid Funding
Australia	Au														S,C								
Canada	Ca																				C		
Chile	Cl																						
Hong Kong	HK																						
Indonesia	Id									S,E		S,E							S,E				Jp
Japan	Jp								S,E			S,E					E		S,E				
Korea	Kr																						
Mexico	Mx																				S		US
New Zealand	NZ																						
Peru	Pe																						WB
Philippines	Ph									E													Jp
Singapore	Sg	T							S,E,T	S,E		S,E,T					T						Jp
USA	USA																						

Legend:
S Surveying
C Charting
E ENC
T Tides
WB World Bank

Table 17 Strategic Issues and Problems

Country	Budget Value	Staff Numbers	Survey out of date	Charts out of date	Chart Datums	Data Quality	Data Bases	Survey Cap.	Carto Cap.	ENC Cap.	Survey Exp.	Carto Exp.	ENC Exp.	Survey Train	Carto Train	ENC Train	National Visibility	Private Sector Capacity
Australia				Yes					Yes			Yes	Yes					
Canada			Yes	Yes				Yes			Yes	Yes	Yes					Yes
Chile	Yes													Yes				
Hong Kong	No information provided																	
Indonesia					Yes					Yes			Yes					
Japan		Yes			Yes					Yes			Yes					
Korea						Yes	Yes											
Mexico	Yes							Yes	Yes	Yes				Yes				
New Zealand											Yes	Yes						
Peru	No information provided																	
Philippines	No information provided																	
Singapore																		
USA	Yes		Yes	Yes				Yes		Yes	Yes	Yes	Yes				Yes	

4 INTERNATIONAL WATERS AND SEA LANES FOR INTERNATIONAL TRAFFIC

4.1 Introduction

International waters are those waters that lie outside the jurisdiction of any nation. For the purposes of this study they are taken to be waters beyond the 200 nautical mile Exclusive Economic Zone [EEZ]. They are important to this study because a large percentage of shipping trading to APEC member economies must pass through them. Of particular concern are the international waters in East Asia.

There are also a number of key international shipping routes that pass through the shallow waters of East Asia within the EEZs of regional nations. These routes use several international straits and archipelagic sea-lanes. These straits and sea-lanes are critical to the efficient movement of very significant volumes of international trade and passenger traffic. There are also important issues of safety of life and property and the protection of the marine and coastal environment. It is therefore essential that the surveying and charting of these routes be of the highest standard.

4.2 International Waters

The majority of the international waters in the APEC region are deep oceanic waters, and the risks to safe and efficient navigation are not of major concern to hydrographers. However a large percentage of ships serving the APEC economies pass through the shallow waters of the South China Sea. Significant parts of the South China Sea lie outside any national EEZ, most parts of these waters are not surveyed, and where surveys do exist few are to modern standards. This situation has adverse implications for safe and efficient navigation.

In 1994 the International Hydrographic Organisation commissioned Captain H.F.Ohlsen to research the status of navigation in the international waters of the South China Sea.

The Ohlsen Report contains an excellent executive summary, and the comments that follow are quoted from this.

> *"The South China Sea lies across the most direct route between the Pacific and Indian Oceans. Through it passes almost all of the marine traffic between the Far East and Europe, Africa, the Middle East, and South Asia. It also carries traffic between South Asia and Pacific ports of North and Central America and Australasia. [The main shipping routes in the South China Sea are shown in Figure 1.]*
>
> *Much of the South China Sea is poorly represented on nautical charts, the result of cursory, inaccurate, or non-existent surveys. Much of what is charted may be shown or described as being in different locations in different references, creating confusion and uncertainty on the part of the mariner. Numerous reefs, shoals, banks, and other hazards abound throughout much of the area. [The areas of the South China Sea which have been surveyed are shown in Figure 2]*
>
> *More than 10,000 vessels of greater than 10,000 dwt move southward through the South China Sea annually, with [a similar number] proceeding in the opposite direction.*

Numbers and tonnages of vessels transiting the South China Sea, increases in port traffic, increases in sizes of regional fleets, and the presence of many natural physical hazards to shipping indicate a need for up to date charts based on accurate hydrographic information."

In addition to commenting on the state of surveying and charting, the Ohlsen report analysed regional shipping trends. Almost all of the factors considered show a consistent upward trend - in port traffic, in the size of the shipping fleets of the littoral states by number and tonnage, and as a percentage of the total world fleet.

The IHO acted on the Ohlsen Report by establishing a further research project called the South China Sea Project. In 1995 the United Kingdom Hydrographic Office [UKHO] was requested by the IHO to prepare a status report on the quality of surveys in the South China Sea to complement the Ohlsen Report on 'Marine Traffic in the South China Sea'. The IHO Regional Hydrographic Commission for East Asia proposed that the IHO should use this information to stress to IMO and other appropriate international organizations its concern for the safety of navigation in the South China Sea, and the urgent need for remedial action.

In 1996 the UKHO commissioned a desktop study of the availability of hydrographic data from oil and gas exploration companies, which might be used to improve the charts of the South China Sea. This study concluded that considerable quantities of data for critical navigational areas were held by a number of companies. However it also reported difficulties of access to data arising from commercial confidentiality, certain data quality problems arising from the purposes for which the data was obtained [i.e. not for navigation], and consequent difficulties of meeting IHO standards for the compilation of nautical charts.

It is understood that the South China Sea Project was placed in abeyance in 2001 due to other priorities of the IHO and the UKHO.

4.3 Straits used by International Shipping

There are a number of straits in the region that are of great importance to international shipping. Many of these, for example the Sunda Strait, are entirely within the jurisdiction of regional economies. A few, for example the Malacca Strait, are within waters under the jurisdiction of several states.

The surveying and charting of the Malacca Strait is a good example of co-operation and co-ordination between the littoral states, and other regional economies whose shipping interests pass through these waters.

Such co-operation is important because, although the littoral states have sovereignty over these waters, they are not the main economic beneficiaries of the very significant volumes of traffic in transit. They cannot always afford an appropriate effort for the surveying and charting of these sea-lanes, but their coastal economies are at risk from marine accidents and consequent pollution. However their rights to control or regulate the transit traffic are constrained by the UNCLOS Convention.

4.4 Archipelagic Sea Lanes

There are a number of important archipelagic sea-lanes in the region, notably in Indonesia, Papua New Guinea, and the Philippines. There is some on-going regional co-operation to re-

survey and produce new charts of the Indonesian sea-lanes. It appears that there may be some scope for regional co-operation in surveying potential archipelagic sea-lanes in other economies.

As mentioned in the Economic Analysis section of this report, the surveying, charting and establishment of new sea-lanes appears to have the potential to realise significant safety improvements, and significant reductions in the length and duration of international voyages, benefiting many regional nations. This subject is worthy of further study by APEC.

4.5 Funding for Regional Hydrographic Initiatives

Funding for co-operative surveys in areas that are important to regional shipping has come in the past from donor agencies such as JIACA, CIDA, AUSAID and NORAD. Recently some funds have been provided by ADB.

These sources of funds are most valuable, and it may be possible to extend funding proposals to other agencies such as UNDP and GEF.

However we believe that it would also be possible to provide some funds through a regional levy on shipping. This would help to ensure that ships in transit through major straits and sea-lanes provide some financial assistance to littoral and archipelagic states for improvement and maintenance of good quality charts and services. We believe that APEC should investigate this idea.

4.6 Audit Conclusions relating to International Waters.

In providing audit comment on the hydrographic situation in international waters we can only agree with Captain Ohlsen's conclusions, which, although written about the South China Sea, apply equally to the situation in the straits used by international shipping and in the archipelagic sea lanes. Captain Ohlsen's comments were as follows;

> *"There is an immense, and growing, volume of marine traffic in the (region). Annual through traffic alone totals thousands of vessels larger than 10,000 dwt, and hundreds of thousands in aggregate tonnage. Intra-regional traffic is expanding, as indicated by port traffic data and economic growth.*
>
> *Marine casualties can be expected to increase in number and severity simply because of increased density of traffic. A greater impact on the resources of the marine environment may be anticipated.*
>
> *Traffic growth and the consequences of marine casualties, human and otherwise, indicate a need for the most accurate information possible to insure safe navigation in this "hydrographically neglected" region. Whether or not vessels themselves are equipped with the most sophisticated navigation equipment, accurate charts can provide the greater margin of safety that will be needed for their safe passage."*

It is our opinion that the APEC economies on the littoral of the South China Sea should give a high priority to the improvement of surveys in the South China Sea, and in the straits and sea-lanes used by international traffic.

APEC should actively support the IHO South China Sea Project. The hydrographic agencies of the littoral economies should initiate a co-operative programme to undertake surveys in those areas of the South China Sea that are critical to navigation. Such a programme would involve data archaeology, identification of areas requiring survey, commitment of ship time for data acquisition by each littoral economy, and commitment of cartographic resources to compile the necessary charts and publications. One of the littoral states should act as co-ordinator.

The present regional co-operative programmes for the surveying and charting of straits and sea-lanes used for international navigation should continue, and perhaps be extended. APEC should conduct a review to establish priorities, based on safety and efficiency, and to identify sources of funds. IHO assistance could be sought for this activity.

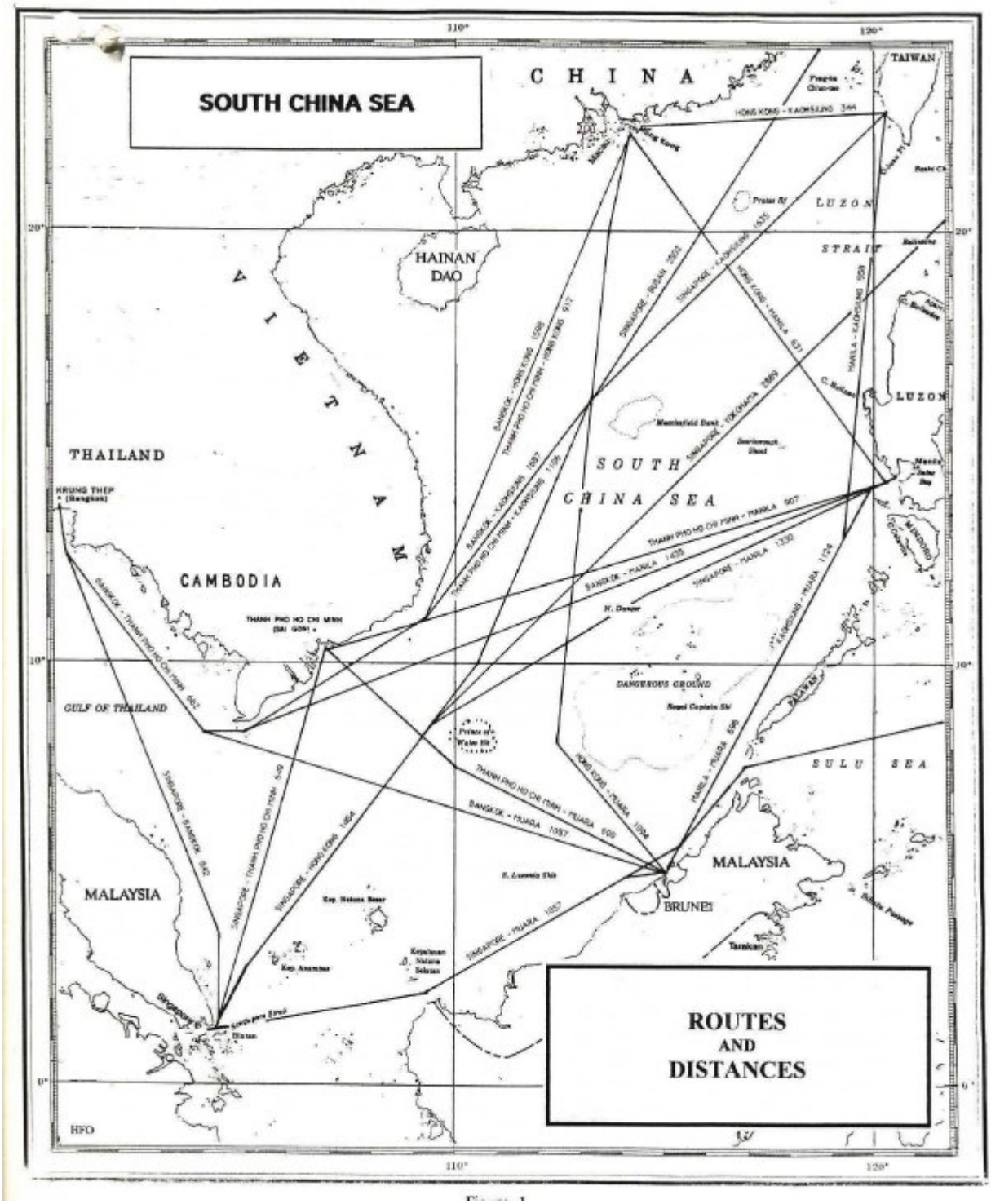

Figure 1 - South China Sea - Routes and Distances

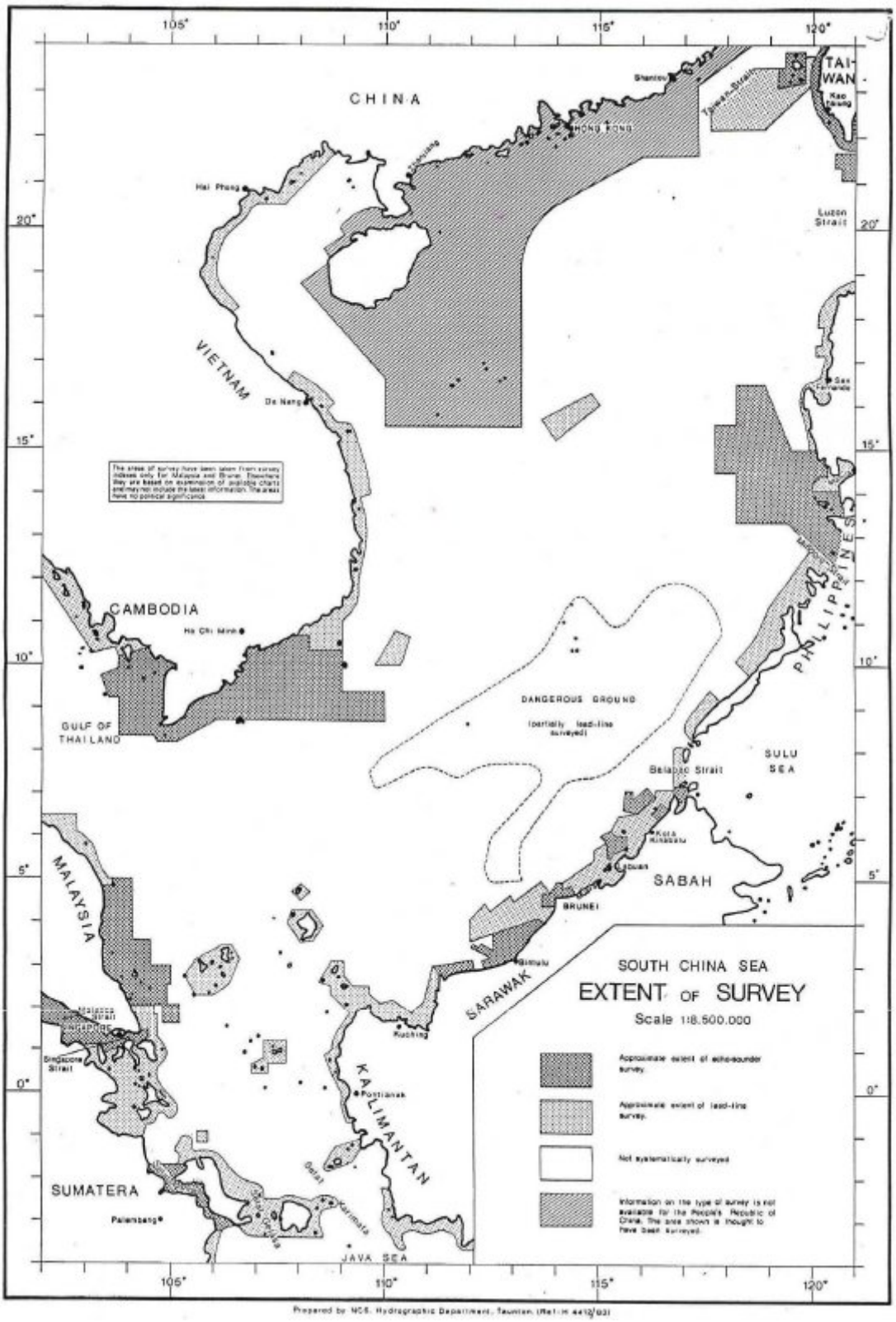

Figure 2 - South of China Sea - Extent of Survey

5 IMPROVEMENT OPTIONS

As mentioned in the audit conclusions, it is essential that the budget of the hydrographic agency be appropriate to its tasks, and to the current status of surveying and charting. As noted, many economies have a significant backlog of work to complete before the status of surveying and charting can be considered to be satisfactory. There are a number of improvement options that APEC Member Economies may wish to consider in order to rectify the situation.

1. The first option is to ensure that the annual hydrographic budget is set at a level appropriate to the task at hand. Determination of an appropriate budget figure can be made in two stages. Stage one is to conduct an economic analysis in order to identify an optimum investment figure. Stage two is to conduct a hydrographic audit in order to identify the status of surveying and charting and the optimum time frame for the completion of any backlog of tasks. Stage three is to integrate the first two stages to arrive at an appropriate annual budget.

2. If it is decided to increase the budget, the introduction of user-pays charges might be considered as a means of achieving the increase.

3. Improvements may also be achieved by optimising the use of existing resources. The following might be considered;
    a. Maximise the use of surveying assets by introducing double crewing of ships to increase available time on task by 80 to 100 percent. This practice significantly reduces the cost of survey per square kilometre.
    b. Maximise the use of cartographic assets by introducing shift work for chart compilation.

4. Economies should take advantage of the cost effectiveness benefits of emerging technologies. The following could be considered;
    a. Use lidar survey systems where appropriate, in order to significantly reduce the costs of survey per square kilometre.
    b. Use automatic or remotely operated systems when appropriate in order to reduce personnel costs and to make the best use of scarce skilled manpower resources. ROVs are also less costly to construct than manned vehicles.
    c. Most economies are utilising modern equipment, and the opportunities for using new technology at the equipment level are limited. However the use of a totally digital environment for data acquisition, management and distribution would in due course offer further cost effectiveness benefits in some economies.

5. Consideration should be given to the advantages of outsourcing when appropriate, in order to harness the skills and lower costs of the private sector. Outsourcing is a cost effective strategy where capital or skills are in short supply, operational costs are often lower than costs of in-house activity, and the value of contracts can be conveniently varied to suit annual budget targets. The lead-time for the introduction of new initiatives is often shorter.

6. Economies should also consider the potential economic benefits of providing hydrographic services to all sectors of the maritime economy, and should review the range of products and services currently offered.

6 RECOMMENDATIONS

We propose recommendations for individual economies and for APEC.

It is recommended that economies;

1. Carry out an economic analysis for their individual hydrographic requirements, in order to derive an optimum level of investment and budget for the hydrographic service.
2. Carry out an audit of their individual hydrographic department, in order to identify aspects of the hydrographic programme that need attention, and to define and establish resources, priorities and time frames for completion of outstanding tasks.
3. Ensure that national five-year plans for survey and charting are in place.
4. Ensure that development of the hydrographic department is included in national or ministerial development plans, including development of human, material and financial resources, and administrative arrangements, appropriate to the national survey and charting plans.
5. Review the work practices of the hydrographic department in order to identify the potential for improving cost effectiveness.
6. Review the institutional and co-ordination arrangements for hydrographic activities, and consider the benefits of establishing formal high-level arrangements.

It is recommended that APEC;

7. Consider the economic and safety benefits of increasing co-operative activity in hydrography, especially in the South China Sea, and in the international straits and archipelagic sea-lanes of East Asia.
8. Consider undertaking research to provide data on the volume and characteristics of international shipping making transit voyages through the international straits and archipelagic sea-lanes of the region, together with research into marine incidents and their nature, in order to inform risk assessment and subsequent prioritisation of work.
9. Consider undertaking research to establish the feasibility of, and provide some possible models for, navigation levies on ships transiting the archipelagic sea-lanes and international straits.

7 ANNEXES

Annex A Notes on Navigation and Surveying

Note on Navigation

This note offers a few words about the role of the chart for those readers who are not familiar with the practice of navigation at sea.

Marine navigation is not like land navigation, since the navigator cannot see with his own eyes the hazards that lie below the surface of the sea. He must rely on the chart to provide this information. Navigating without a good quality chart can be compared to walking around a town with your eyes shut. You are unlikely to reach your destination, and you are likely to suffer an accident. Whilst one can navigate safely and often efficiently without a map on land, a chart is essential at sea.

This is why ships are required by law to carry charts (SOLAS Chapter V, Regulation 20), whereas road users are not required by law to carry maps.

Note on Hydrographic Surveying

Readers may ask why hydrographic surveying is such an expensive and time consuming activity. People are becoming more and more used to the widespread availability of data obtained quickly and cheaply from satellite imagery.

The availability of hydrographic data is limited by the technology for gathering data. The present technology for imaging the seafloor relies on the use of sound, since light will not penetrate the sea for any great distance. The sonar sensors used in this work must be mounted in ships, which move slowly, and the sensors are only able to image very small areas at any one time (just as a vacuum cleaner can only clean a very small area of floor in one sweep). The effectiveness of sensors is limited by weather and seasonal phenomena such as ice, which reduce the opportunities for gathering data.

The speed of acquisition of data is also affected by the duty of care placed upon the hydrographic surveyor, who, in the interests of safety of life at sea, is obliged to ensure that all dangers to navigation are identified. The certain detection of small features is very time consuming, but it is increasingly important as the size and draught of vessels increases, and as under keel clearances in harbours and passages are being reduced in the effort to maximise the operational efficiency and the commercial performance of ships.

It is also necessary to re-survey areas from time to time, particularly in places where there are shifting sandbanks or siltation, or where new infrastructure developments cause changes in transportation patterns.

The hydrographic and scientific communities are constantly searching for and developing new and more effective means of acquiring hydrographic data to the required standard. Modern developments include the use of lasers mounted in aircraft, and the use of synthetic aperture radar, but even these promising techniques have, at present, some major limitations.

Annex B Safety of Life at Sea Convention - Chapter V

Text of Amendments Approved by the IMO Maritime Safety Committee, December 2000.

Regulation 2.2 Definitions

Nautical chart or nautical publication is a special-purpose map or book, or a specially compiled database from which such a map or book is derived, that is issued officially by or on the authority of a Government, authorized Hydrographic office or other relevant government institution and is designed to meet the requirements of marine navigation.[1]

Regulation 9 Hydrographic Services

1 Contracting Governments undertake to arrange for the collection and compilation of hydrographic data and the publication, dissemination and keeping up to date of all nautical information necessary for safe navigation.

2 In particular, Contracting Governments undertake to co-operate in carrying out, as far as possible, the following nautical and hydrographic services, in the manner most suitable for the purpose of aiding navigation:

2.1 to ensure that hydrographic surveying is carried out, as far as possible, adequate to the requirements of safe navigation;

2.2 to prepare and issue nautical charts, sailing directions, lists of lights, tide tables and other nautical publications, where applicable, satisfying the needs of safe navigation;

2.3 to promulgate notices to mariners in order that nautical charts and publications are kept, as far as possible, up to date;

2.4 to provide data management arrangements to support these services.

3. Contracting Governments undertake to ensure the greatest possible uniformity in charts and nautical publications and to take into account, whenever possible, relevant international resolutions and recommendations. [2]

4. Contracting Governments undertake to co-ordinate their activities to the greatest possible degree in order to ensure that hydrographic and nautical information is made available on a worldwide scale as timely, reliably, and unambiguously as possible.

1 Refer to appropriate resolutions and recommendations of the International Hydrographic Organization concerning the authority and responsibilities of coastal States in the provision of charting in accordance with regulation 9.

2 Refer to the appropriate resolutions and recommendations adopted by the International Hydrographic Organization.

Annex C Details of National Legislation

Table lists the economies that have legislation or decrees mandating the work of hydrographic service. The titles of these mandates are considered to be of interest and are reproduced below.

Economy	Legislation	Year
Australia	Cabinet Decision No. 1169	1946
	Cabinet Decision No. 1702	1981
Canada	Oceans Act	1996
	Canada Shipping Act	1995
	Order In Council No. 461	1904
	British North America Act	1867
Chile	Supreme Decree Nº 192	1969
	Law Nº 16,771	1968
Hong Kong	Nil	
Indonesia	Supreme Decree Nº 192	1960
	Government Regulation No.23	1951
Japan	Law for Hydrographic Activities	1950
Korea	The Law of Hydrographic Affairs	
	The law of Ocean Science Research	
Mexico	Public Administration Law	
New Zealand	Survey Act	1986
Peru	Supreme Decree	1903
Singapore	Marine and Port Authority Act	1996
U S A	Hydrographic Services Improvement Act	1998
	Coast and Geodetic Survey Act	1947

Annex D List of Major Equipment Projects

Section 3.2.3 refers to some major new initiatives and projects being planned by various economies. This Annex provides further details of the projects.

Country	Project	Cost
Australia	Upgrade Small Ship Survey Systems	A$ 50M - A$ 70M
	Digital Hydrographic Data Base	A$ 33M
	[2 Ocean going survey ships were constructed in 2000]	Not Known
Canada	Creation of source data base	$ 10M
Chile	New Oceanographic Equipment	$ US 2.8M
	Digital nautical publications	$ US 0.7M
	New hydrographic equipment	$ US 0.3 M
	Aerial photography	$ US 0.2M
	Corporate database	$ US 0.2M
	Upgrade computer network	$ US 0.1M
	Upgrade oceanographic data centre	$ US 0.1M
	Upgrade time signal station	$ US 0.1M
	Tsunami inundation charts	$ US 0.06M
	Electronic commerce	$ US 0.02M
Japan	Lidar System	Y 400M
	Radar for surface current measurement	Y 100M
	[Several large ship replacements have occurred recently]	Not Known
New Zealand	Raster and Vector charts, Internet access, Print-on-Demand	Not Known
Korea	Basic Map of Coastal areas	100M
Singapore	Multi-beam System	SGD $ 900, 000
	ROV System	SGD $90, 000
	Electronic Archive	SGD $70, 000
USA	Full ENC coverage of U.S.	Not Known
	Fleet Replacement	Not Known
	Topographic / Bathymetric Project	Not Known
	Digital Elevation Models	Not Known

Annex E Technology Requirements of the Hydrographic Department

Hydrographic Surveying

Best Practice in Surveying

Best practice in hydrographic survey for navigation requires that the surveyor identifies and precisely positions all dangers to navigation. The precise requirements are set down in IHO Publication S-44, Standards for Hydrographic Surveys. The choice of technology must respond to this best practice requirement.

Surveying Equipment

For navigation, the universally accepted solution is the satellite based Global Positioning System [GPS]. A more precise variant is the Differential GPS, which uses calibration techniques to ensure the highest precision in a localised situation. Using DGPS it is possible to establish the position of any subsurface feature to an accuracy of +/- 1 metre.

The measurement of depth is generally achieved by the use of an echo sounder mounted in a ship or boat. The vessel moves up and down parallel lines, which have a regular spacing, thus enabling systematic measurement of depth. There are two types of echo sounders. Single beam echo sounders [SBES] measure the depth of water immediately below the sounding platform. Use of a SBES results in a survey consisting of a number of depth profiles where depth is measured precisely, but no measurement is made between the profiles. Multi beam echo sounders [MBES] are able to spread out the sound rays so that there is a continuous coverage of the seabed between the sounding lines. MBES are preferred for contemporary surveys because they provide the ability to obtain a complete description of the seabed, and a reasonable certainty of detecting all dangers to navigation.

In cases where greater certainty of feature detection is required, surveyors use an instrument called Side Scanning Sonar [SSS], which projects a sideways sonar beam between the lines of soundings, giving an alternative view of objects rising from the seabed. SSS is frequently used in conjunction with SBES to obtain a complete picture of the seabed.

The navigation and depth measuring systems produce large volumes of digital data that are stored in a data logging system. Such systems also have a data processing capability, to enable the data to be checked and edited for quality assurance, variations in water level, etc. The cleaned and adjusted data are stored on disc and transferred from the field to a shore-based archive.

The preparation of accurate maps and charts requires that the echo sounder data must be corrected for the continuous variations in sea level caused by tides. These tidal variations are measured by tide gauges placed on the seabed in the survey area. The tide gauges are automatic instruments that store the tidal data and transmit it to the survey ship at predetermined intervals for inclusion in the data logging system.

For safe navigation and other purposes it is important to know the strength and direction of currents and tidal streams. Current meters are placed in the survey area to gather these data.

It is also important to know the nature of the seabed, whether it is sandy, muddy, rocky or weedy. To obtain information about the nature of the seabed it is necessary to have instruments that can take samples of seabed material.

The objective of any survey is to obtain the most accurate data. This is assisted by the use of appropriate peripherals. Heave compensators remove deviations in depth measurement caused by the movement of the survey boat in the waves. Automatic pilots ensure that the survey boat adheres to planned tracks to provide total and systematic coverage of echo sounder measurements.

Lidar Equipment

The most recent technology innovation in hydrographic survey is the airborne laser sounder or lidar system. In this system an aircraft fitted with a laser depth-measuring device replaces the ship or boat. This is a very cost effective means of surveying in the right circumstances. It brings the cost of hydrographic surveys into the same price range as surveys by aerial photography, and it offers significant logistic advantages compared to ship operations in remote areas.

It has been estimated that in open coastal waters in the right conditions the cost per square kilometre of survey using an airborne lidar is about 25% of the cost of survey using a small ship. The survey can also be completed 10 or 20 times more quickly, and sometimes more safely, using the airborne lidar. The reasons for the cost savings are threefold. First, the purchase price of an aircraft is less than the price of a small ship, so that annual amortisation costs of capital are reduced. Second, the number of people required to operate an aircraft is much smaller than the number required to run a ship, so personnel costs are significantly reduced. Third, an aircraft is much faster and more productive than a ship, so that a survey operation takes significantly less time and total operating costs are reduced.

The main limitations of the lidar system relate to the ability of the laser beam to penetrate to the seabed to achieve a measurement. Depths in excess of 50 metres may be measured in clear water, but in muddy water the system is not usually effective.

Ships and Boats

Ships and boats are a major element of hydrographic surveying. They are also very expensive. The choice of platforms will depend on the typical environmental conditions in national waters. Nations usually operate a number of vessels of differing sizes, to cover the varying coastal environment.

An indication of the different types of ships and boats used for survey, and their cost, may be obtained by reference to the book “Jane’s Survey Vessels”.

The principal costs of running a ship are the opportunity cost of capital, and the cost of personnel. Crew costs may be significantly reduced by good ship design. Running the ship for ten months of the year, using crew rotation arrangements, may significantly reduce capital costs per mile surveyed.

The use of Remotely Operated Vehicles [ROVs] is another way of improving cost effectiveness in some circumstances, since they cost less to build and operate, and do not need a crew.

We take the opportunity to observe that in a global sense there are insufficient research ships employed in hydrographic surveys for safety of navigation. The problem is especially significant in developing countries.

Surveying Personnel

The achievement of best practice in surveying requires that qualified and experienced surveyors execute the surveys. These personnel are normally educated at degree level, and undertake continuous professional development throughout their careers. Standards of Competence for Hydrographic Surveyors are described in IHO Publication M-5.

Cartography

Best Practice in Cartography

Best practice in the publication of charts and the provision of other services requires that charts and services be produced in accordance with IHO standards, in order to ensure accuracy, completeness and uniformity. The precise requirements are set down in IHO Publications M-4, Chart Specifications of the IHO, and S-52, Specifications for Electronic Charts. The choice of technology must respond to these best practice requirements.

Cartographic Equipment

Modern hydrographic survey data is handled and stored in large digital files. Because of this a modern chart production facility should be organised as a digital environment, even if the end products such as charts and books are printed documents. It is likely that future products for navigational and GIS applications will themselves be digital.
Each chart compiler requires a graphics workstation with appropriate application software and peripherals such as plotters. These workstations and software are available as commercial off-the-shelf [COTS] items.

Data Bases, Archives, and Information Management Systems

The individual cartographic workstations are connected via a network to a central digital data archive and information management system. Archive and information management facilities and software are available as commercial off-the-shelf [COTS] items.

It is also necessary to have facilities for archiving and handling paper records from the past. This requires appropriate physical storage, and some climate control for the long-term protection of the material.

Printing

As noted elsewhere in this report, it is probably not economical for smaller hydrographic offices to install in-house printing facilities, because of the high capital and maintenance cost of this equipment. Outsourcing should be a cost effective means of providing for printing requirements.

Indicative Costs of Equipment

The following is a list of the major items of equipment required for a hydrographic programme, with an indication of typical unit prices in $ US, sourced from equipment manufacturers.

Hydrographic Survey

Item	Cost [$ 000s]
DGPS navigation equipment	$10
Multi-beam echo sounder	$125-250
Single beam echo sounder	$15
Side scanning sonar system	$70-130
Data logging and processing system	$25-100
Digital remote tide gauges	$80 - 100
Digital remote current meters	$50 -80

Notes;

1. Each boat or ship will require a suite of this equipment.
2. The cost of equipment varies significantly between harbour survey launches and ocean-going survey ships.

Chart Production

Item	Cost
Cartographic Equipment	$10-20
Peripherals	$50

Archives

Item	Cost
Data management and storage system	$250 - 500

Annex F List of Apec Hydrographic Agencies

Australia

The Hydrographer,
Royal Australian Navy Hydrographic Service,
Locked Bag 8801,
South Coast Mail Centre,
NSW 2521,
Australia

Telephone: +61 2 4221 8500
Fax: +61 2 4221 8599
E-mail: Bruce.Kafer@defence.gov.au
Web Site: www.hydro.navy.gov.au

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Note; The details of the agency responsible for hydrography in Vietnam may not be correct.

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The Scientific Committee on Oceanic Research, Proceedings of SCOR 1995. See also www.jhu.edu/~scor/wg107front

Jane's Survey Vessels 2001 – 2002, Janes, London, 2001. [ISBN 0 7106 2331 3]. See also www.janes.co.uk

Annex H Questionnaire used in the Study

HYDROGRAPHIC QUESTIONNAIRE

SECTION 1. GENERAL QUESTIONS

1. What is the Length of the Coastline in km?

2. What is the Area of the EEZ in sq.km?

3. What are the principal sectors in the maritime economy?
   for example; shipping, fishing, mining, etc]

4. Which are the major international trading partners?

SECTION 2. NAVIGATION INFRASTRUCTURE

5. Please provide a graphic showing the following;
   Major international shipping routes;
   Major domestic shipping routes;
   Archipelagic sea-lanes;
   Principal ports.

This information will facilitate a general understanding of the hydrographic infrastructure required to support the navigation infrastructure in each APEC economy.

SECTION 3. HYDROGRAPHIC INFRASTRUCTURE

Institutional Arrangements

6. What are the principal responsibilities of the hydrographic service?

7. Which is the responsible ministry?

8. Which other ministries or agencies have responsibilities that are supported by the hydrographic service? What services do they need?

Ministry	Service 1	Service 2	Service 3	Service 4

9. By what institutional means [formal or informal] does the government co-ordinate these activities?

10. What are the principal arrangements for international and regional co-ordination and co-operation?

11. Is the work of the hydrographic service mandated in legislation?

Yes / No	Title of Legislation	Date

Status of Hydrographic Surveys

12. What is the status of hydrographic surveys of the coast and EEZ described in terms of IHO survey standards? [IHO Special Publications S 44 and S 55 refer.]
Please also provide a graphic if available.

State of Hydrography d < 50m

% adequate	% needing resurvey	% unsurveyed

State of Hydrography d = 50m - 200m

% adequate	% needing resurvey	% unsurveyed

State of Hydrography d > 200m

% adequate	% needing resurvey	% unsurveyed

Status of Nautical Charting and other Services for Navigation

13. Does a national paper chart scheme exist?
Yes / No __
Please provide a graphic if available.

14. How many paper charts are schemed and published, indicating numbers in principal scale bands?

< 300,000		101,000 to 300,000		25,000 to 100,000		> 25,000	
Schemed	Published	Schemed	Published	Schemed	Published	Schemed	Published

15. What percentage of charts is published using a geocentric datum suitable for GPS navigation?
____%

16. Does a national Electronic Navigation Chart [ENC] scheme exist?
Yes / No __

17. How many ENCs are schemed and published?

Usage Band	ENC Cells Schemed	ENC Cells Produced	ENCs on the market (with updating service)
Berthing			
Harbour			
Approach			
Coastal			
General			

Please provide a graphic showing the geographical location of ENCs schemed and produced.

18. How many raster charts for use in ECS are schemed and published?

< 300,000		101,000 to 300,000		25,000 to 100,000		> 25,000	
Schemed	Published	Schemed	Published	Schemed	Published	Schemed	Published

Please provide a graphic showing the geographical location of ECS schemed and produced.

19. What nautical publications are available?

Charts	**Catalogue**	**Notices to Mariners**	**Navigation Warnings**	**Sailing Directions**	**List of Lights**	**List of Radio Signals**	**Tide Table**
Yes / No	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No

20. How many charts and publications are distributed each year?
Please include those distributed directly, and those distributed by licensees [e.g. UKHO / NIMA / CMAP / etc.].

Paper Charts	Digital Charts	Publications

21. Does the hydrographic agency have ISO 9000 accreditation for production of charts and provision of navigation services?

Yes / No / Expected Date___

Products and Services that are not for navigation

22. What products and services are provided which are not primarily used for navigation? Please list the products and services and the principal users in the table below, eg. Fisheries, geo-science, maritime boundaries, etc. Please also indicate the medium used for each product or service, e.g. paper, digital file, web site, etc., and the annual distribution. If significant quantities of data are provided to other publishers for compiling products and services, please include those products in the list and mark with an asterisk.

Please provide graphics if available indicating geographical coverage of each service.

Product or Service	Users	Medium	Annual Distribution

Budget and Resources

23. What is the value of the annual hydrographic service budget in local currency and $ US, and how is it divided operationally and regionally?

	Surveying	Services for navigation	Services not for navigation	Total
Local currency				
$ US				

	Region 1	Region 2	Region 3	Region 4
Local currency				
$ US				

Please use units of 1 million, eg $US 123.4

24. What is the projected budget in 5 and 10 years time?

5 Years ___ 10 Years__

25. What are the human and material resources allocated to survey activity?

Hydrographic Survey Vessels [Please indicate number of platforms]

>100m	50m – 100m	25m – 50m	< 25m	Lidar

Hydrographic Staff [Please indicate number of staff]

Specialists	Assistants

Hydrographic Equipment [Please indicate generic types of equipment in service]

DGPS	Other Navigation	SBES	MBES	SSS	Digital Data Processing
Yes/No	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No

26. What are the human and material resources allocated to nautical charting and navigation service activity?

Number of Staff [Please indicate number of staff in each category]

Cartographers	Draftspersons	Printers	IT Specialists	Navigators	Other

Equipment [please indicate generic types of equipment in service]

Printing Equipment	Manual Compilation	Digital Compilation	Paper Archives	Digital Data Bases
Yes / No	Yes / No	Yes / No	Yes / No	Yes / No

Allocation of Staff [Please indicate % of staff using manual and digital techniques]

	%
Digital	
Manual	

27. What are the human and material resources allocated to provision of services that are not for navigation?

Staff [Please indicate number of staff in each category]

Cartographers	Draftspersons	Printers	IT Specialists

Equipment [please indicate generic types of equipment in service]

Printing Equipment	Manual Compilation	Digital Compilation	Paper Archives	Digital Data Bases
Yes / No	Yes / No	Yes / No	Yes / No	Yes / No

28. What is the division of human resources by gender?
Please indicate percentage.

	Male %	Female %
Surveying		
Cartography		

29. What major new projects are being planned for the improvement of the hydrographic infrastructure?

Please list projects and cost. Please indicate any associated change in human resources.

Project	Estimated Cost	Change in Staff + / -

30. What major facilities or products are expected to be terminated?

Please list facilities or products, and expected changes in financial and human resources.

Facility or Product	Estimated saving in cost	Estimated saving in staff

31. To what extent is work outsourced [done by contractors]?

Please divide your answer into the three categories; survey, nautical charts and navigation services, products and services not for navigation, and indicate volume outsourced as a percentage of all work in that category. e.g. survey 30%.

Category	Hydrographic Survey	Nautical Charts & Navigation Services	Products & Services not for navigation	Other
% Outsourced				

32. What major facilities are regularly provided by contractors?
For example, ships, production facilities, staff

33. Please indicate the sources of budget funds as a % of total funding

Source of funds	**%**
Central Government allocations	
Sales of products and services	
Navigation Levies	
Other [please specify]	

Education and Training

34. What are the principal arrangements for education and training of hydrographic and cartographic staff?

Please indicate principal courses in use and annual number of students by gender.

Survey Courses

MSc	BSc	Cat A	Cat B	Technical	Technical	Other	Other
				Certificate	Certificate	(Insert	Name)
				(Advanced)	(Basic)		

Cartographic Courses

MSc	BSc	Diploma		Technical	Technical	Other	Other
				Certificate	Certificate	(Insert	Name)
				(Advanced)	(Basic)		

35. What skills, if any, are difficult to obtain?

Regional Co-operation and Technical Assistance

36. Is the hydrographic agency involved in regional co-operative hydrographic projects?

Please provide details.

Name of Project	Brief description

37. Is the hydrographic agency in receipt of international or bilateral aid funding or technical assistance?

Please provide details.

Name of Project	Brief description

Issues and difficulties

38. What are the major strategic issues facing the hydrographic service?

39. What are the major problems faced in achieving the objectives of the hydrographic service, and how will they be resolved?

Problem	Proposed solution

40. Can any of these issues be resolved on a regional basis?

Development Scenarios

41. What is likely to be the effect of the following future hydrographic service investment scenarios?

no budget

reduced budget

continuation of current level of budget

increased budget

42. Which is the most likely scenario for the next 5 year period?

SECTION 4. ECONOMIC INFRASTRUCTURE

43. Please provide information about the major ports by completing the table below; This response will provide important data for the economic analysis.

Please use additional sheets of paper if necessary.

Port Name	Port Type[1]	Max draft[2]	Max length[2]	Max tonnage[2]	Cargo type [3]	Cargo type [3]	Cargo type [3]

Notes; 1. Please indicate type of port from the following choices; Bulk Liquid [BL], Bulk Solid [BS], Containers [C], Unspecified [U].

Please indicate maximum size of vessel that can use the port.

Please indicate the types of cargo applicable to ships using the port [use more than 1 column if necessary]

Please provide the name and contact of a relevant government department who can provide additional information on the shipping sector if required.

SECTION 5. OTHER MATTERS AND COMMENTS

44. Are there any other matters that you would like to mention, or comments you would like to make, in order to provide a complete picture of the activities, resources and issues facing the hydrographic service?

    Please use the space provided below, or use additional sheets of paper.

45. Please advise the preferred e-mail address for subsequent messages and interaction.

Annex I Glossary of Abbreviations

ADB	Asia Development Bank
AUSAID	Australian International Development Aid Agency
CIDA	Canadian International Development Aid Agency
CMAP	CMAP is a private sector publisher of electronic charts
COTS	Commercial off-the-shelf [software]
DGPS	Differential Global Positioning System [a satellite based navigation system]
EEZ	Exclusive Economic Zone
ENC	[Vector] Electronic Navigation Chart
ECS	Electronic Chart System
GEF	Global Environment Facility [of the World Bank]
GIS	Geographic Information System
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
IHO	International Hydrographic Organisation
IMO	International Maritime Organisation
ISO	International Standards Organisation
ISO 9000	An International Standard for Quality Assurance
IT	Information Technology
Lidar	Laser system for measurement of water depth
NIMA	National Imaging and Mapping Agency of the USA [formerly Defence Mapping Agency]
NORAD	Norwegian International Development Aid Agency
MBES	Multi Beam Echo Sounder [For depth measurement]
ROV	Remotely Operated Vehicle
SBES	Single Beam Echo Sounder

SCOR	Scientific Committee on Ocean Research
SOLAS	Safety of life at sea Convention of the IMO
SSS	Side Scanning Sonar [for detection of sub-surface obstructions]
UKHO	United Kingdom Hydrographic Office [publisher of the Admiralty worldwide chart series
UNCED	United Nations Conference on the Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme

TPT 02/2001

Analysis of the Economic Benefits of the Provision of Hydrographic Services in the APEC Region

Attachment 2

Economic Analysis

July 2002

APP

GlobalWorks
International Project Development

TABLE OF CONTENTS

1 OVERVIEW

1.1 Introduction

Most maritime stakeholders worldwide recognize the invaluable contribution of hydrographic services to the maritime sector. Furthermore, most would consider unthinkable a world without such services - the catastrophic impacts to sector safety and efficiency, and the gravity of economic, social and environmental consequences. Sustainable hydrographic services are, and have been, a cornerstone of the maritime sector throughout the ages. Not only do they facilitate safe and efficient vessel passage, they also contribute significantly to overall economic and social wellbeing through the provision of a range of other useful and varied services.

Few studies have been performed however to attempt to identify and evaluate the overall benefits of hydrographic services, and even fewer have attempted to quantify these benefits in economic terms. A primary reason for this is the fact that the benefits are difficult to quantify in real terms, and even more difficult to evaluate through rigorous economic analysis. The situation exists therefore, that although there is general agreement that hydrographic services contribute significantly to the maritime sector, little has been done to actually provide quantification of these benefits.

This report summarizes work performed in order to identify and evaluate the benefits of hydrographic services in economic terms, focusing on the APEC economies. It provides discussion of previous evaluations, identifies and describes principal benefits, and presents an economic model, which has been developed specifically to allow evaluation of certain target benefits for a selected APEC member economy, the Philippines.

1.2 Background and Rationale

National and regional hydrographic institutions produce three principal outputs: (i) *hydrographic charts and services*, which are primarily utilized for navigation; (ii) *bathymetric maps* of the ocean sub-surface, principally for resource development purposes; and (iii) *oceanographic charts*, which provide current and water temperature data to submariners, the fishing industry and other users[1]. These outputs, in the form of paper and electronic charts, are sold on to consumers often at no more than the cost of chart production itself. Direct revenues from chart sales often do not appear to cover the overall costs associated with hydrographic service provision, with supplementary costs being met from additional Government budgetary allocations.

Hydrographic services are often viewed therefore as a direct cost, where consumer cost recovery does not meet the total cost of required service provision. In this regard, hydrographic services have been justified on the basis of (i) fulfilling national and international statutory obligations; (ii) providing a “public good”; (iii) contributing to overall economic development and well-being; and (iv) being of vital strategic importance, particularly with regard to national defence.

With regard to previous studies reviewed as part of this evaluation, only one study has attempted to quantify the benefits of hydrographic services in economic terms. The study, completed for

[1] Other hydrographic publications and related services include sailing directions, small craft guides, water level publications, territorial sea and fishing zone charts, and other natural resource maps (including gravity and magnetic maps).

the Canadian Hydrographic Service[2], identified and evaluated hydrographic benefits based on the comparison of the (then) current situation (with hydrographic services) with a "counter-factual scenario" that assumed that hydrographic services had never been formally implemented throughout the nation. On this basis, and utilizing a consumer-surplus and producer-surplus analytical approach, the study determined significantly high benefit-cost ratios for the provision of hydrographic services.

This previous study assumed that the two scenarios of; (i) the "existence" of hydrographic services, compared with; (ii) the "non-existence" of hydrographic services, will directly affect demand, particularly in relation to foreign trade (through the use of producer-surplus and consumer-surplus approaches), an assumption which is often over-stated. In addition, the assumption and comparison of the "existence" and "non-existence" scenarios of hydrographic services is also considered by certain hydrographers as being too far from reality. The resulting effect therefore is that although the study reached quantitative results and conclusions, these results are subject to considerable debate and discussion, especially in relation to the assumptions made. Other studies have also provided valuable insights into the benefits of hydrographic services[3], although they do not provide quantitative analysis of economic benefits.

1.3 Benefits and Beneficiaries

Table 1 summarizes key benefits and beneficiaries of hydrographic services. As can be seen, they are substantial and wide ranging. Of primary value are the direct improvements to vessel movements in terms of efficiency and safety. Safer, faster and shorter voyages, coupled with increased flexibility and ability to sail at night and during poor visibility, yield substantial economic benefits, not only to individual APEC economies, but also to the APEC region as a whole. Benefits also accrue from the overall tendency in certain cases to support an increase in vessel size, deeper draft and optimisation of load capacity. Improved safety is also substantial, not only in direct economic terms, but also in terms of environmental and social protection.

For the fisheries sector, hydrographic services facilitate efficient sector management, and are invaluable in regulation and enforcement, and in the delineation of national and international fishing zones. They also assist commercial fleets to identify and locate fish resources, and reduce net groundings. Hydrographic services also play a key role in mineral exploration, in national defence, and provide products and services to recreational boating and fishing consumers throughout the APEC region. Hydrographic services are invaluable for emergency response, including search and rescue. And they provide the basis for the delineation and maintenance of sovereign and economic zones throughout the region.

Although difficult to quantify, hydrographic services also contribute considerably to the protection and management of the environment, not only through maritime safety improvements, but also by supporting sustainable resource management, particularly for coastal zones. As historical events indicate, environmental impacts from maritime accidents are often significant and lasting, and environmental damage sometimes irreparable. Hydrographic services therefore play a key role in reducing the number and severity of these impacts.

---

2 *Benefit Cost Assessment of the Canadian Hydrographic Service*, Brinkman G, and Calverley S., 1992

3 Including (i) *An Economic Analysis of the Benefits of the RAN Hydrographic Programme*, Leech, J., and Coochey, J., 1992; (ii) *An Economic Evaluation of Hydrographic Charting With Special Emphasis on the Australian Case*, Coochey, J., 1993; (iii) *Hydrographic Charts and the Economy*, Cowan, E, 1993; and (iv) *The Case for Using Cost Benefit Analysis to Evaluate the Supply of Public Goods in the Maritime Industry*, John, M., 1996.

Table 1 - **Benefits and Beneficiaries of Improved Hydrographic Services**

Beneficiary	**Benefit**
(i) General Cargo, Passenger, Other Vessels	Faster voyages, reduced voyage duration Shorter voyages, reduced voyage duration Safer voyages, fewer accidents Improved voyage flexibility (night, restricted-visibility sailings) Reduced insurance cost Larger vessels, deeper draft, less load restrictions Less reliance on pilots
(ii) Commercial Fishing	As per (i) above Enhanced fisheries sector management, regulation and enforcement Improved economic and fishing zone delineation and maintenance Enhanced capacity to locate fish and select species Reduced net and equipment losses
(iii) Environmental Protection	Decrease in number and severity of accidents and related environmental impacts
(iv) Economic Zone Maintenance	Definition and maintenance of economic zones
(v) National Defence	As (i) above for vessels, and several benefits in (i) for submarines
(vi) Sovereign Zone Maintenance	Enhanced identification, definition and maintenance of sovereign zones
(vii) Coastal Resource Management	Improved identification, management and protection of coastal resources
(viii) Mineral Exploration	As per (i) above Improved mineral exploration and management (oil, gas, aggregates and others)
(ix) Recreational Fishing and Boating	As per (i) above Safer yachting and recreational fishing
(x) Emergency Response	As per (i) above Improved search and rescue services

2 ECONOMIC ASSESSMENT

2.1 Introduction

This section presents key aspects and results of the analysis, and draws conclusions regarding economic benefits of hydrographic services. Due to both the relative complexity of analysis and the limitations of this assessment, this economic analysis has focused on the detailed assessment of one of the predominant economic benefits accruing to an economy from the provision of hydrographic services, the benefit to the shipping sector. In addition, because of the difficulty in obtaining data, and the complexity of the work, the analysis of this benefit has been restricted to one selected APEC economy, that of the Philippines.

The benefit analysed relates to the potential cost impacts to voyage sailing times of the commercial shipping sector operating in the Philippines due to variations in hydrographic service provision and investment. It is based on the assumption that should hydrographic service provision cease, existing navigation will begin to suffer, and that the duration of vessel voyages will progressively increase over time as a result of this. This will have the effect of increasing the operating costs of vessels, and also impacting on passengers through passenger time loss, since each voyage will progressively take longer.

It is also important to emphasize that the analysed benefit forms only a portion of the overall benefits to the "General Cargo, Passenger and Other Vessels" beneficiary classification, as shown on Table 1. In addition to this, there are numerous other benefits accruing to beneficiaries from the provision of hydrographic services, and the analysed benefit only represents a small portion of the cumulative benefits.

The general methodological framework adopted has the following progression:

(i) Elaboration of foreign trade, domestic trade and passenger services, including specific demand forecasts for imports, exports, domestic trade and passengers for a 25-year planning horizon;

(ii) Evaluation of shipping services in terms of shipping patterns and projections of shipping traffic and of passenger voyages;

(iii) Assessment of benefits, in terms of vessel operating costs and passenger time savings;

(iv) Evaluation and sustainability analysis comparing costs and benefits of different scenarios; and

(v) Extrapolation of the analysis to other APEC economies.

2.2 Philippine Hydrographic Sector

Government funded Philippine national hydrographic services cover the entire archipelago of over 7,000 islands. Principally through two hydrographic service vessels, they survey up to 400,000 square km of oceanic waters per year. Each of the vessels has a crew of 48 personnel, and each perform tours of up to 20 days duration. There are no private sector survey operations performed for the Government, and practically no airborne survey work is performed.

The hydrographic surveys are carefully planned to optimise vessel use and maximize output. Generally, the major ports of the Philippines are re-surveyed every two years; secondary ports every five years and smaller ports and routes every ten years. Notable exceptions include the heavily trafficked ports of Manila and Batangas, which are subject to severe siltation. In addition to navigation-related duties, hydrographic services are provided for (i) marine resource surveys; (ii) United Nations related submarine and continental shelf mapping; (iii) regulation of the mining sector; and (iv) economic zone "fencing". In conjunction with Japanese assistance, the Philippines has recently initiated an electronic charting program, which is focusing on the mapping of major international cargo routes around Manila and the western coastline.

General observations of Philippine hydrographic specialists are that; (i) there is an overall tendency towards ever-increasing vessel size; (ii) there is a need to identify and chart new sea lanes, as many uncharted lanes are used frequently by commercial vessels; and (iii) a considerable portion of surveys are performed for non-navigation related activities. The estimated annual expenditure in Philippine hydrographic services is US$ 3.5 million.

2.3 General Methodological Framework

2.3.1 Scope

This assessment is related to the potential impact of varying the quality of hydrographic services on different user classes. In summary, the methodology includes;

(i) Forecasting future demand of potential users;

(ii) Elaborating different development scenarios for the hydrographic services;

(iii) Elaborating unit benefits and costs associated with each specific user;

(iv) Evaluating, over time, each scenario with respect to the tendency scenario;

(v) Extrapolating the analysis to other APEC economies.

Potential User Assessment

Time and resources available for this study do not allow analysing in detail the impact of hydrographic services over all users. The analysis concentrates on the commercial shipping (cargo and passengers) users. Even considering only this sub-set of users, the benefits of hydrographic services associated with these users can, largely, justify investment actions necessary to maintain and/or to improve the service.

Shipping Service Demand

Present and projected demand of commercial shipping has been analysed considering the following demand segments:

(i) Foreign Trade Shipping Services;

(ii) Domestic Trade Shipping Services;

(iii) Passenger Shipping Services;

The method used to elaborate present and future foreign trade using the maritime mode of transportation has included projections of the following;

(i) Foreign trade (e.g. imports and exports) shares over GDP in time series;
(ii) Foreign trade shares to GDP;
(iii) Maritime shares of foreign trade over total trade;
(iv) GDP;
(v) Maritime foreign trade in value;
(vi) Value to volume ratios for exports and imports;
(vii) Foreign trade volumes (tons);
(viii) Existing distribution of cargo transported by vessel type and size;
(ix) Cargo distribution by vessel type and size;
(x) Existing average cargo transported by vessel type and size;
(xi) Average cargo transported by vessel type and size;
(xii) Maritime traffic (e.g. number of ships) by vessel type and size for foreign trade.

Domestic trade forecasts are elaborated using a procedure, which has considered:

(i) Development of a relationship between domestic trade volumes and GDP;
(ii) Projections of domestic trade volumes in relation to GDP;
(iii) Calculation of existing average volumes transported by vessel type and size;
(iv) Projection of volumes transported by vessel type and size;
(v) Calculation of distribution of volumes transported by vessel type and size;
(vi) Projection of distribution of volumes transported by vessel type and size;
(vii) Projection of maritime traffic (e.g. number of ships) by vessel size and type for domestic trade.

A similar procedure is used to forecast the number of vessels used for passenger transport:

(i) Identification of a relationship between passenger traffic and GDP;
(ii) Projections of passenger traffic related to GDP;
(iii) Calculation of existing average number of passengers transported by vessel size;
(iv) Projections of average number of passengers by vessel size;
(v) Projections of passenger traffic distribution by vessel size;
(vi) Projections of maritime traffic by vessel size for passenger transportation.

Benefit Assessment

The existence of the hydrographic services provides a navigation tool, which minimizes the time spent by vessels during both open sea navigation and approaching ports. This impacts on cost,

since the extra time saved because of hydrographic services can be transformed into vessel operating cost reductions. Costs reductions, in turn, are transferred to final users (passengers, importers, exporters and traders) making goods and passenger mobilization cheaper. Benefits associated to commercial shipping considered are of two types;

(i) Vessel operating costs, which are assumed to increase or decrease according to the condition of hydrographic services and related maps. If hydrographic services improve, vessel voyage time will reduce with consequential reduction in vessel operating costs. Should hydrographic service provision reduce however, then vessel voyage time and associated vessel operating costs will increase;

(ii) Passenger time costs, which are also assumed to increase or decrease in relation to vessel voyage time increases or decreases as a result of variations in hydrographic service provision.

The method used for identifying benefit flows consists of the following procedures;

(i) Development for each vessel size an average unit operating cost related to time (e.g. US$ per hour per vessel type);

(ii) Identification of a pattern of time loss (saved) because of hydrographic services by vessel size (e.g. 10 minutes for each vessel larger than 50,000 tons, 1 minute for vessels smaller than 1,000 tons, etc.);

(iii) Development of two scenarios; (i) a tendency scenario in which hydrographic services continue to operate in accordance with the existing situation, with similar levels of expenditure; and (ii) a counter-factual scenario, whereby hydrographic services immediately and permanently cease to be provided.

(iv) Calculation of each benefit scenario the total cost savings using demand projections elaborated in the previous section.

The result of benefit assessment is a set of benefit flows associated to each scenario. This simplistic method conservatively underestimates benefit flows. Benefit underestimation is due to two main factors:

(i) Increase of unit costs due mainly to insurance premiums. If hydrographic services are not delivered, the statistical occurrence of vessel accidents increases and so the insurance premiums. The analysis performed does not consider increases on unit costs;

(ii) Relative reduction of vessel size. The general tendency of increasing the vessel size for cost reduction purposes could be offset. Shipping operators, in the absence of proper hydrographic services could choose to use reduced vessel size to reduce accident risks. This will impact on cost increases since the same transport demand will be satisfied by vessels of reduced size, which shows larger costs for ton and/or passenger transported. The analysis does not consider vessel pattern modification.

Scenario Identification and Evaluation

Two scenarios have been identified:

(i) Tendency Scenario; Hydrographic services will continue to be provided, with the same characteristics as those of the existing situation;

(ii) Counter Factual Scenario. Hydrographic services will stop being provided.

A counter-factual scenario (where hydrographic services cease activity) has been developed in order to evaluate the existing hydrographic services expenditure. The evaluation also identifies a level of sustainable development for hydrographic services, in terms of increased annual expenditure.

2.3.2 Foreign Trade

Scope

This section's main objective is to determine the projection of the number of vessels (by vessel size) transporting foreign trade cargos.
The following sub-sections are dedicated to:

(i) Estimation of the projections of total foreign trade in value;

(ii) Estimation of the projections of foreign trade transported by maritime mode in volume;

(iii) Estimation of the number of vessels by vessel type and size transporting foreign trade cargos.

Foreign trade forecasts have been performed regressing observed shares of imports and exports over GDP with respect to time. The functional relationship used is:

$$\text{Shares} = a + b \ln(\text{Years})$$

Where a and b are regression parameters and Ln (Years) is the natural logarithm of time (years). Using data at constant 1985 prices from 1980 to 2000, the results of the regression estimates are illustrated on Table 2.

Table 2 - **Regression Results (Shares = a + b Ln (Years))**

Statistics	Export Shares	Import Shares
Adjusted R square	0.828	0.796
F	97.6	79.1
a value	- 19,418	- 28,018
b value	2,561	3,694
t(a)	- 9.9	- 8.9
t(b)	9.8	8.9

Source: Consultant's estimates using data from *The National Accounts of the Philippines, National Statistical Coordination Board, Various Years*.

Using the regression results it is possible to elaborate foreign trade projections in terms of shares over GDP. Figure 1 illustrates the projections of the import and export shares with respect to GDP over time.

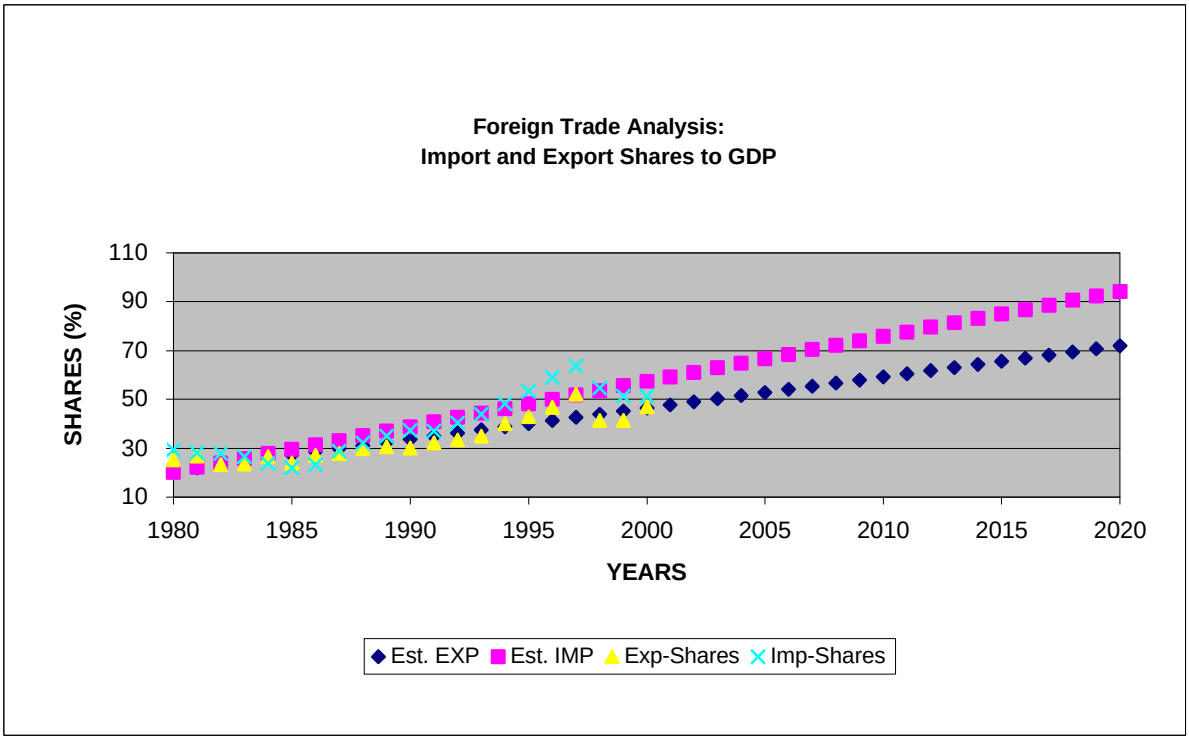

Figure 1 - **Foreign Trade Analysis: Import and Export Shares to GDP**

The projections obtained with this method imply that the Philippines is over relying on external demand. In year 2020, imports will reach 94% of GDP and exports 72%. Even if the globalisation process is going to achieve its main effects in the next 4-5 years it is reasonable to assume that, in the medium–long term, the economy will rely upon a faster increase of domestic demand.

The hypothesis that can be made is that foreign trade share will follow the trend (e.g. the regression results) until year 2005. Using this hypothesis, exports in that year will reach 53% of GDP and imports 67%.

Successively, the faster growth of internal demand will reduce the shares to GDP of both imports and exports. Setting future share value of foreign trade is, certainly, not an easy task. Tentatively it can be assumed that the shares to GDP of both imports and exports will decrease steadily to 50% by the years 2020. In that year it is also assumed a foreign trade balance. Figure 2 illustrates the assumed behaviour over time of Philippine foreign trade.

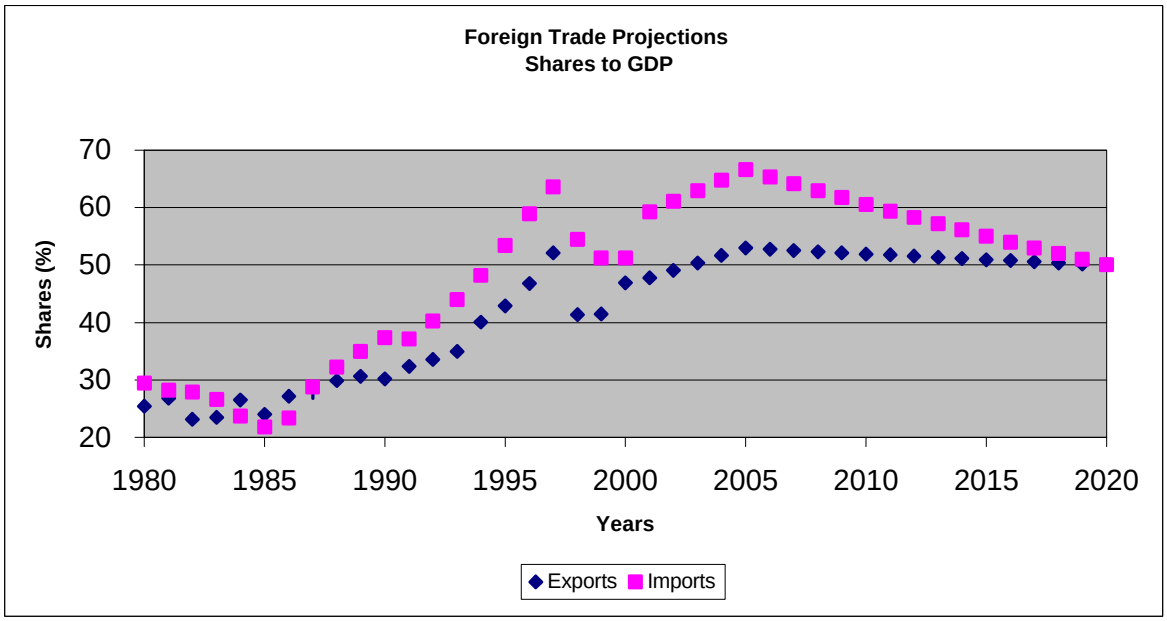

Figure 2 - **Foreign Trade Projections: Shares to GDP**

In order to project foreign trade values it is necessary to identify the projections of GDP. This allows elaborating foreign trade projections in value using the projections of the shares to GDP previously identified.

The National Economic Development Agency (NEDA) publishes yearly the projections in terms of growth rates for GDP. Published GDP expected growth rates are produced for 6 years (e.g. until 2006). The project team assumes that after 2006 and until 2012 the growth rate will be the 80% of the average expected for the 2001-2006 period, and that for the period 20013-2020 GDP yearly growth rate will be, again, the 80% of that of the previous period.

Table 3 illustrates the growth rates used in this study.

Table 3 - **GDP Yearly Growth**

Year	High	Low	Average
2001	3.30	3.80	3.55
2002	4.30	4.80	4.55
2003	5.40	6.00	5.70
2004	5.70	6.30	6.00
2005	6.10	6.70	6.40
2006	6.30	6.90	6.60
2001-2006	5.80	5.20	5.50
2007-2012	4.64	4.16	4.40
2013-2020	3.71	3.33	3.52

Source: NEDA and Consultant Estimates

Maritime International Trade

Figure 3 illustrates the shares of merchandise trade over total imports and exports for the years 1980-2000. Although the data does not show relevant trends of merchandise shares for both imports and exports, the project team considered that the shares of merchandise trade, respectively for imports and exports, will remain unchanged for the whole period (e.g. 2001-2020) and equal to the average of that observed during the period 1995-2000: 72.1% for exports and 87.3% for imports.

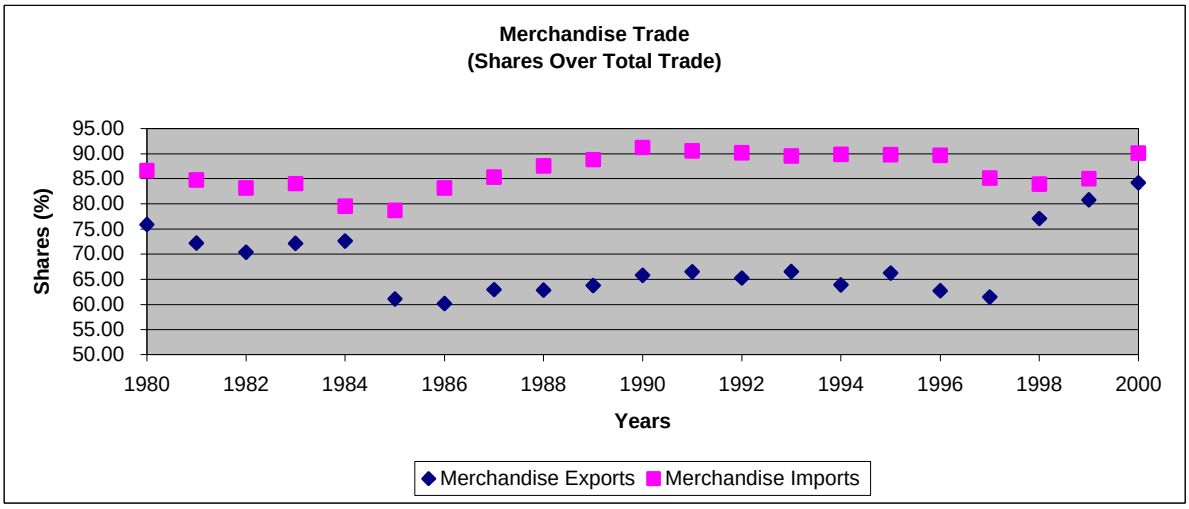

Figure 3 - **Merchandise Trade (Shares over Total Trade)**

Foreign Trade statistics report the values traded by mode of transportation (e.g. air and maritime). Figure 4 illustrates maritime shares over total merchandise trade.

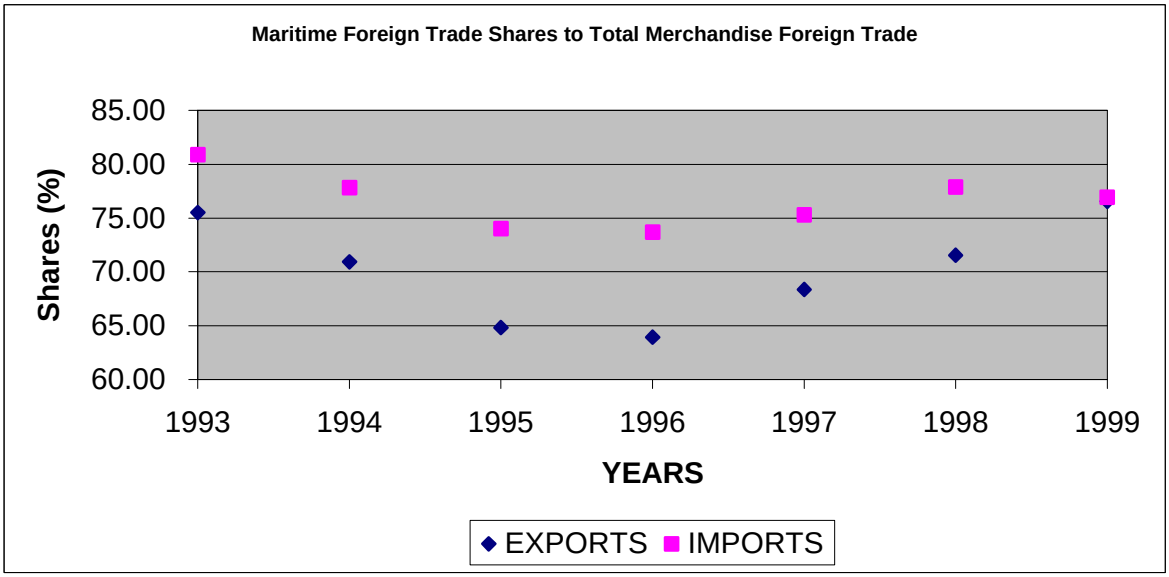

Figure 4 - **Maritime Foreign Trade Shares to Total Merchandise Foreign Trade**

Available data do not allow estimating the share projections for maritime shares of merchandise foreign trade. The project team adopted share average values between 1993 and 1999 as reference value and maintained it constant for the whole projection period. The average shares adopted are of 70.24% for exports and 76.65% for imports.

The analysis carried out allows forecasting maritime international trade in values at constant prices.

Finally, unit ratios Values to Volumes have been analysed. This ratio and its behaviour over time are necessary for transforming maritime foreign trade values into volumes (tons). The available data (1993-1999) are illustrated on Figure 5. Regression analysis was carried out for both import and export value to volume ratios. Reliable results are obtained only for exports:

Exports Value to Volume Ratios = a + b Ln(Years)

(i) Adjusted R square = 0.863

(ii) F = 31.4

(iii) a value = - 15,889,375

(iv) b value = 2,092,455

(v) t(a) = - 5.6

(vi) t(b) = 5.6

Export value to volume ratios are assumed to follow the regression results until year 2005 (in that year the ratio is of 20,399 Pesos per ton) and remaining constant thereafter. As far as import ratios are concerned, the average value between 1993 and 1999 has considered (e.g. 6,735 Pesos per ton) and maintained this for the whole projection horizon.

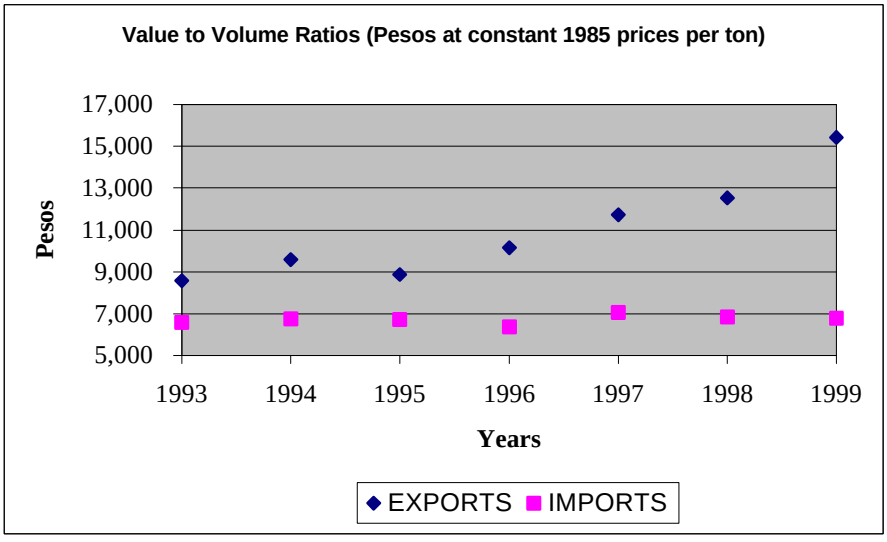

Figure 5 - **Value to Volume Ratios (Pesos at constant 1985 prices per ton)**

Projections of Foreign Trade Volumes

The analysis allows elaboration of the projections of maritime foreign trade in volume (tons). Table 9 presented later in the report illustrates the foreign trade projections.

2.3.3 Domestic Trade

Philippine Port Authority (PPA) collects, at port level, information on domestic trade volumes inbound and outbound. This information is consolidated at national level in the PPA Annual Report.

Domestic Trade Shipping Forecasts

Domestic trade forecasts have been elaborated using a relationship relating domestic trade volumes (Tons) to GDP. This relationship is used to project domestic trade volumes using GDP projections.

PPA information contains inbound and outbound trade flows volumes. These two sets of data are slightly different due to the statistical reporting system and to errors. It is reasonable to assume that inbound traffic volumes should match with outbound volumes; an average value has been used for estimation purposes.

The previous ten years of data are used for estimating the relationship:

Tons Traded = a + b Ln(GDP)

The regression results show the following statistics:

(i) Adjusted R square = 0.804

(ii) F = 42.0

(iii) a value = - 197.9

(iv) b value = 34.7

(v) t(a) = - 5.5

(vi) t(b) = 6.5

Figure 6 shows the results of the estimation.

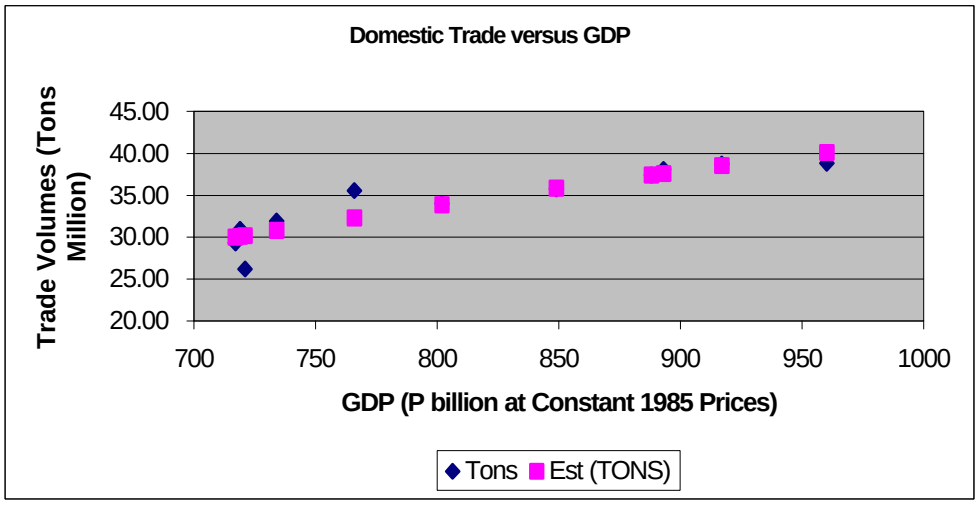

Figure 6 - **Domestic Trade versus GDP**

2.3.4 Maritime Passenger Services

The PPA produces, in its annual report, information related to passenger traffic for ports. The information is associated to each port and consolidated at national level as inbound and out bound passenger traffic.

Passenger Voyage Forecasts

Inbound and outbound data do not match and average values have been used for carrying out the analysis. Also in this case, an econometric logarithmic relationship between passenger flows and GDP has been estimated [e.g. Passengers = a + b Ln(GDP)] considering the last ten years data.
The statistics of the regression are:

(i) Adjusted R square = 0.811

(ii) F = 35.4

(iii) a value = - 217.8

(iv) b value = 38.3

(v) t(a) = - 5.0

(vi) t(b) = 5.9

Figure 7 illustrates the estimation results.

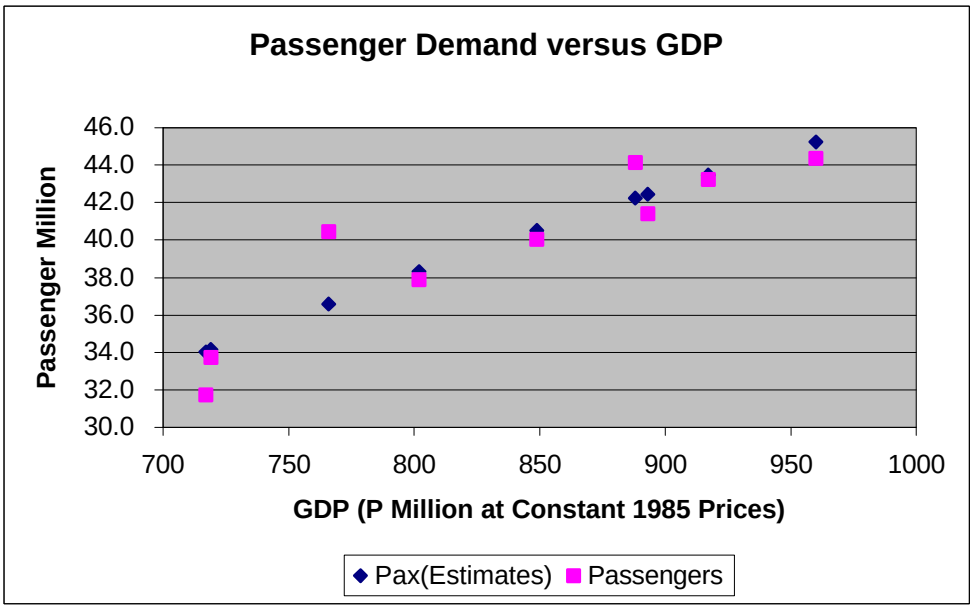

Figure 7 - **Passenger Demand versus GDP**

2.3.5 Demand Forecasts

Summarises demand projections. The following table shows the projections for:

(i) Maritime Imports (Tons);

(ii) Maritime Export (Tons);

(iii) Maritime Domestic Trade (Tons);

(iv) Number of Passenger using Shipping Services.

Table 4 - **Demand Projections**

Year	Values (P billion at Constant 1985 prices)	Maritime Foreign Trade Volumes (Tons)		Domestic Trade Volumes (Tons)	Maritime Passengers (No)
	GDP	Exports (Tons)	Imports (Tons)		
1993	734	15,037,783	35,486,553	31,933,441	37,873,205
1994	766	14,515,625	38,183,499	35,554,196	40,043,006
1995	802	16,657,559	42,418,302	34,050,327	41,414,647
1996	849	15,687,040	51,829,760	35,776,468	44,141,572
1997	893	16,670,940	51,666,207	38,075,021	43,228,478
1998	888	16,154,116	46,134,026	37,422,615	44,371,866
1999	917	15,270,683	45,307,131	38,704,193	43,463,039
2000	960	15,735,037	50,481,620	38,827,360	45,222,044
2001	994	13,198,770	50,568,107	41,326,709	46,558,062
2002	1,039	13,114,661	52,780,152	42,868,826	48,262,159
2003	1,099	13,223,279	55,694,912	44,790,083	50,385,221
2004	1,165	13,414,684	58,937,443	46,809,568	52,616,828
2005	1,239	13,700,454	62,604,106	48,959,592	54,992,685
2006	1,321	14,774,680	66,623,881	51,174,702	57,440,465
2007	1,379	15,604,307	69,438,500	52,667,058	59,089,575
2008	1,440	16,480,518	72,372,026	54,159,415	60,738,686
2009	1,503	17,405,931	75,429,483	55,651,771	62,387,796
2010	1,569	18,383,308	78,616,106	57,144,128	64,036,907
2011	1,638	19,415,566	81,937,353	58,636,485	65,686,017
2012	1,710	20,505,788	85,398,911	60,128,841	67,335,127
2013	1,771	21,474,676	88,256,459	61,327,823	68,660,048
2014	1,833	22,489,343	91,209,624	62,526,805	69,984,968
2015	1,897	23,551,954	94,261,605	63,725,787	71,309,888
2016	1,964	24,380,982	97,579,613	64,924,769	72,634,808
2017	2,033	25,239,193	101,014,416	66,123,751	73,959,729
2018	2,105	26,127,613	104,570,123	67,322,733	75,284,649
2019	2,164	26,863,366	107,514,818	68,285,214	76,348,226
2020	2,225	27,619,839	110,542,435	69,247,694	77,411,804
2021	2,286	28,376,311	113,570,052	70,184,167	78,446,642
2022	2,347	29,132,783	116,597,669	71,096,000	79,454,252
2023	2,408	29,889,256	119,625,287	71,984,457	80,436,030
2024	2,469	30,645,728	122,652,904	72,850,707	81,393,268
2025	2,530	31,402,201	125,680,521	73,695,832	82,327,164
2026	2,591	32,158,673	128,708,138	74,520,839	83,238,827
2027	2,652	32,915,145	131,735,756	75,326,662	84,129,293
2028	2,713	33,671,618	134,763,373	76,114,175	84,999,524

2.3.6 Shipping Services

The PPA provided the project with the data of ship calls to PPA ports for the year 2000. The amount of information processed has been excessive, including over 120,000 vessel movement records which is still only a representative sample of vessel movements for the nation.

Patterns of Shipping Services

Table 5 illustrates the shares of the analysed data over total Philippine shipping services as reported for year 2000 by the PPA Annual Statistical Report.

Table 5 - **Ratios Between Sampled Data and Total Shipping Services**

Ship Calls	**Total**	**Domestic**	**Foreign**
SAMPLE			
Ship Calls	122,725	116,029	6,696
Cargo Throughput	76,067,342	40,490,944	35,576,398
Passenger Traffic	20,748,758		
PPA REPORT 2000			
Ship Calls	369,767	357,745	12,022
Cargo Throughput	170,527,566	92,521,847	78,005,719
Passenger Traffic	56,615,787		
Sample/Universe Ratio (%)			
Ship Calls	33.19	32.43	55.70
Cargo Throughput	44.61	43.76	45.61
Passenger Traffic	36.65		

Source: PPA Annual Statistical Report

Considerable problems were encountered in the conduct of data processing activities. One of the most notable is the volume of the data contained in the two CD-ROMs PPA provided to the project. The data for each port was tabulated and analysed for existence of formulas or reference expressions, these expressions were then replaced with the actual values as contained in each sheet. Afterwards the data for each month was merged[4].

[4] The primary problem with the data for all the ports is that there is no primary key or common coding system for all ports that assigns a unique value to each record of ship visit. Further, the methodology initially included the use of the ship voyage or trip control number, but this proved to be difficult since this number is not in series and sometimes inconsistent in format. So, at the point of merging the data, a primary key was assigned which is a combination of some data already available, such as using the filename as the date then adding the following: port name, pier name, and other relational data. At the end of this key, a series number was assigned for each record starting from 1 to the expected end of the volume (initially estimated as around 240,000 port calls, ship records or other name).

A number of results tables were produced. These data tables are basically the result of analysing the one-year data of the Port Management Offices shown on Table 6.

Table 6 - **Processed Data by Port**

Processed PMOs	**Vessel Port Calls**
PMO Batangas	23,874
PMO Calapan	4,137
PMO Cagayan de Oro	12,535
PMO Cotabato	2,010
PMO Dumaguete	14,746
PMO Davao	11,879
PMO Iligan	10,599
PMO General Santos	4,386
PMO Limay	6,854
PMO MICT	1,849
PMO Nasipit	1,073
PMO North Harbour	6,431
PMO Ozamis	11,350
PMO South Harbour	11,002
Total	**122,725**

Records processed reported the following fields:

(v) Port Name;

(vi) Vessel Size (GRT);

(vii) Vessel Type;

(viii) Import Volumes;

(ix) Export Volumes

(x) Domestic Trade Inbound Volumes;

(xi) Domestic Trade Outbound Volumes;

(xii) Number of Inbound Passengers;

(xiii) Number of Outbound Passengers.

Following the data processing for all ports, the data tables have been produced individually by port, and the master database provided. According to the assumptions made, data have been processed with the aim of producing the pattern of shipping services by vessel type and by vessel size for each class of service.

Four shipping services have been considered:

(i) Cargo imports;

(ii) Cargo exports;

(iii) Cargo traded domestically;

(iv) Passenger Services.

Three vessel types for cargo have been also identified:

(i) Bulk Cargo;

(ii) Break bulk cargo;

(iii) Containerised cargo.

The following fourteen vessel size classes were analysed in terms of Gross Registered Tonnage (GRT):

1.	< 200	8.	10,000 - 15,000
2.	200 - 400	9.	15,000 - 20,000
3.	400 - 600	10.	20,000 - 30,000
4.	600 - 1,000	11.	30,000 - 50,000
5.	1,000 - 3,000	12.	50,000 - 75,000
6.	3,000 - 5,000	13.	75,000 - 100,000
7.	5,000 - 10,000	14.	> 100,000

Table 7 illustrates the distribution of cargo volumes (tons) among the various shipping services by vessel type.

Table 7 - **Distribution of Cargo Volumes by Vessel Types**

Vessel Type	**Distribution of Cargo Volumes By Vessel Type (Percent)**			
	Imports	**Exports**	**Domestic**	**Total**
Bulk	73.78	62.08	48.89	59.60
Break Bulk	17.11	24.12	26.61	22.72
Container	9.11	13.80	24.51	17.68
Total	*100.00*	*100.00*	*100.00*	*100.00*
Total Share (%)	*38.85*	*7.92*	*53.23*	*100.00*

Data analysed allowed elaboration of average volumes of cargo and passengers transported by each vessel class in each shipping service. Table 8 illustrates the average volumes of cargo (tons loaded and/or unloaded) and passengers (number of passengers embarked and/or disembarked) for each vessel size.

Table 8 - **Average Cargo and Passengers Transported by Vessel Size**

Vessel Size (GRT)	Average Volumes (No. of Pass. and Tons) per Vessel			
	Passengers	**Domestic Trade**	**Imports**	**Exports**
< 200	95	65	185	160
200 - 400	110	141	281	338
400 - 600	125	509	589	488
600 - 1,000	160	595	971	938
1,000 - 3,000	256	931	1,320	871
3,000 - 5,000	405	1,039	2,545	1,861
5,000 - 10,000	447	638	2,447	1,484
10,000 - 15,000	416	1,145	3,038	1,270
15,000 - 20,000	681	1,764	3,852	1,080
20,000 - 30,000	64	3,850	19,697	9,350
30,000 - 50,000	322	47,410	36,051	9,338
50,000 - 75,000	2,181	7,509	64,483	58,178
75,000 - 100,000	100	81,119	104,681	97,129
> 100,000	3,671	58,272	241,408	11,933
Total Average	*144*	*362*	*7,281*	*2,284*

Table 9 presents the maritime foreign trade forecasts, and Table 10 illustrates the sample distribution of cargo volumes for imports, exports and domestic trade for the vessel types.

Table 9 **- Maritime Foreign Trade Forecasts**

YEARS	Shares to GDP (%)		Values (P billion at Constant 1985 prices)			Merchandise Shares over Total Trade (%)		Maritime Value Shares to Total Merchandise Trade (%)		Value to Volume Ratios (P per ton)		Maritime Foreign Trade Volumes (Tons)	
	EXPORTS	IMPORTS	GDP	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS
1986	27.24	23.35	591	161	138	60.2	83.2						
1987	27.88	28.85	617	172	178	62.9	85.3						
1988	29.74	32.17	659	196	212	62.8	87.5						
1989	30.62	35.05	699	214	245	63.8	88.8						
1990	30.24	37.31	721	218	269	65.8	91.2						
1991	32.36	37.10	717	232	266	66.5	90.5						
1992	33.52	40.19	719	241	289	65.3	90.2						
1993	34.88	44.01	734	256	323	66.5	89.6	75.50	80.88	8,565	6,584	15,037,783	35,486,553
1994	40.08	48.17	766	307	369	63.9	89.9	70.93	77.82	9,589	6,764	14,515,625	38,183,499
1995	42.89	53.37	802	344	428	66.3	89.8	64.83	74.03	8,876	6,715	16,657,559	42,418,302
1996	46.76	58.89	849	397	500	62.7	89.7	63.93	73.68	10,154	6,376	15,687,040	51,829,760
1997	52.07	63.61	893	465	568	61.5	85.2	68.37	75.31	11,734	7,047	16,670,940	51,666,207
1998	41.33	54.50	888	367	484	77.1	83.9	71.55	77.89	12,543	6,860	16,154,116	46,134,026
1999	41.55	51.36	917	381	471	80.8	85.0	76.57	76.93	15,428	6,795	15,270,683	45,307,131
2000	42.03	51.28	960	404	492	84.2	90.1	70.24	76.65	15,174	6,735	15,735,037	50,481,620
2001	42.52	51.19	994	423	509	72.1	87.3	70.24	76.65	16,220	6,735	13,198,770	50,568,107
2002	43.02	51.10	1,039	447	531	72.1	87.3	70.24	76.65	17,266	6,735	13,114,661	52,780,152
2003	43.52	51.02	1,099	478	561	72.1	87.3	70.24	76.65	18,311	6,735	13,223,279	55,694,912
2004	44.02	50.93	1,165	513	593	72.1	87.3	70.24	76.65	19,355	6,735	13,414,684	58,937,443
2005	44.54	50.85	1,239	552	630	72.1	87.3	70.24	76.65	20,399	6,735	13,700,454	62,604,106

Table 9 Cont.

YEARS	Shares to GDP (%)		Values (P billion at Constant 1985 prices)			Merchandise Shares over Total Trade (%)		Maritime Value Shares to Total Merchandise Trade (%)		Value to Volume Ratios (P per ton)		Maritime Foreign Trade Volumes (Tons)	
	EXPORTS	IMPORTS	GDP	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS
2006	45.05	50.76	1,321	595	671	72.1	87.3	70.24	76.65	20,399	6,735	14,774,680	66,623,881
2007	45.58	50.68	1,379	629	699	72.1	87.3	70.24	76.65	20,399	6,735	15,604,307	69,438,500
2008	46.11	50.59	1,440	664	728	72.1	87.3	70.24	76.65	20,399	6,735	16,480,518	72,372,026
2009	46.65	50.51	1,503	701	759	72.1	87.3	70.24	76.65	20,399	6,735	17,405,931	75,429,483
2010	47.19	50.42	1,569	740	791	72.1	87.3	70.24	76.65	20,399	6,735	18,383,308	78,616,106
2011	47.74	50.34	1,638	782	825	72.1	87.3	70.24	76.65	20,399	6,735	19,415,566	81,937,353
2012	48.29	50.25	1,710	826	859	72.1	87.3	70.24	76.65	20,399	6,735	20,505,788	85,398,911
2013	48.86	50.17	1,771	865	888	72.1	87.3	70.24	76.65	20,399	6,735	21,474,676	88,256,459
2014	49.42	50.08	1,833	906	918	72.1	87.3	70.24	76.65	20,399	6,735	22,489,343	91,209,624
2015	50.00	50.00	1,897	949	949	72.1	87.3	70.24	76.65	20,399	6,735	23,551,954	94,261,605
2016	50.00	50.00	1,964	982	982	72.1	87.3	70.24	76.65	20,399	6,735	24,380,982	97,579,613
2017	50.00	50.00	2,033	1,017	1,017	72.1	87.3	70.24	76.65	20,399	6,735	25,239,193	101,014,416
2018	50.00	50.00	2,105	1,052	1,052	72.1	87.3	70.24	76.65	20,399	6,735	26,127,613	104,570,123
2019	50.00	50.00	2,164	1,082	1,082	72.1	87.3	70.24	76.65	20,399	6,735	26,863,366	107,514,818
2020	50.00	50.00	2,225	1,113	1,113	72.1	87.3	70.24	76.65	20,399	6,735	27,619,839	110,542,435
2021	50.00	50.00	2,286	1,143	1,143	72.1	87.3	70.24	76.65	20,399	6,735	28,376,311	113,570,052
2022	50.00	50.00	2,347	1,173	1,173	72.1	87.3	70.24	76.65	20,399	6,735	29,132,783	116,597,669
2023	50.00	50.00	2,408	1,204	1,204	72.1	87.3	70.24	76.65	20,399	6,735	29,889,256	119,625,287
2024	50.00	50.00	2,469	1,234	1,234	72.1	87.3	70.24	76.65	20,399	6,735	30,645,728	122,652,904
2025	50.00	50.00	2,530	1,265	1,265	72.1	87.3	70.24	76.65	20,399	6,735	31,402,201	125,680,521
2026	50.00	50.00	2,591	1,295	1,295	72.1	87.3	70.24	76.65	20,399	6,735	32,158,673	128,708,138
2027	50.00	50.00	2,652	1,326	1,326	72.1	87.3	70.24	76.65	20,399	6,735	32,915,145	131,735,756
2028	50.00	50.00	2,713	1,356	1,356	72.1	87.3	70.24	76.65	20,399	6,735	33,671,618	134,763,373

Table 10 - **Volume Distribution Among Vessel Types By Vessel Size (1 of 3)**

Vessel Size	BULK CARGO			
GRT	IMPORTS	EXPORTS	DOMESTIC	TOTAL
< 200	0.08	0.02	1.46	0.68
200 - 400	0.01	0.24	11.04	4.85
400 - 600	0.01	-	25.79	11.26
600 - 1,000	0.05	0.29	15.56	6.84
1,000 - 3,000	0.86	1.56	26.19	11.98
3,000 - 5,000	4.77	9.64	11.56	8.14
5,000 - 10,000	3.93	12.39	0.5	3.13
10,000 - 15,000	2.37	2.8	1.23	1.91
15,000 - 20,000	1.87	5.39	0.52	1.57
20,000 - 30,000	17.36	40.77	0.01	11.71
30,000 - 50,000	11.66	3.93	1.25	6.48
50,000 - 75,000	5.1	1.56		2.58
75,000 - 100,000	4.32	20.78	4.1	5.58
> 100,000	47.61	0.64	0.8	23.3
TOTAL	**100**	**100**	**100**	**100**

Table 10 - **Volume Distribution Among Vessel Types By Vessel Size (2 of 3)**

Vessel Size	BREAK BULK CARGO			
GRT	IMPORTS	EXPORTS	DOMESTIC	TOTAL
< 200	0.04	-	15.21	9.49
200 - 400	0.4	0.15	25.96	16.31
400 - 600	1.14	0.43	23.85	15.24
600 - 1,000	0.97	0.03	10.85	7.05
1,000 - 3,000	4.44	0.41	9.46	7.23
3,000 - 5,000	16.37	23.47	5.38	10.12
5,000 - 10,000	30.08	67.39	3.52	16.66
10,000 - 15,000	12.65	6.34	3.57	6.46
15,000 - 20,000	12.62	0.52	0.42	4
20,000 - 30,000	15.88	1.07	0.13	4.82
30,000 - 50,000	5.31	0.18	1.22	2.33
50,000 - 75,000	0.1	-	0.28	0.2
75,000 - 100,000	-	-	-	-
> 100,000	-	-	0.16	0.1
TOTAL	**100**	**100**	**100**	**100**

Table 10 - **Volume Distribution Among Vessel Types By Vessel Size (3 of 3)**

Vessel Size	CONTAINERISED CARGO			
GRT	IMPORTS	EXPORTS	DOMESTIC	TOTAL
< 200	-	-	1.27	0.94
200 - 400	-	0.01	0.74	0.55
400 - 600	0.00	0.31	1.44	1.08
600 - 1,000	-	-	2.46	1.81
1,000 - 3,000	0.14	0.95	12.41	9.25
3,000 - 5,000	0.98	0.71	22.58	16.90
5,000 - 10,000	29.91	34.12	37.46	35.74
10,000 - 15,000	29.01	41.30	17.07	20.96
15,000 - 20,000	36.98	21.09	4.58	12.09
20,000 - 30,000	2.96	1.51	-	0.69
30,000 - 50,000	-	-	-	-
50,000 - 75,000	0.00	-	-	0.00
75,000 - 100,000	-	-	-	-
> 100,000	-	-	-	-
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**

Projection of Shipping Traffic

Shipping traffic projections have been carried out according to two main assumptions that can be relaxed after conducting a more detailed study of the sector, which is a task that goes beyond the scope of this study. The two assumption made are:

(i) Shipping traffic distribution among different vessel types remain unchanged for the whole projection time horizon considered (e.g. until 2020);

(ii) Distribution of cargo among different vessel sizes within the same vessel type remains unchanged for the whole projection time horizon.

Assuming the patterns shown, future volumes of cargo and passengers have been transformed in ship calls. Shipping traffic projections are reported, by vessel size, on:

(i) Table 11 : Bulk Vessel Traffic;

(ii) Table 12 : Break Bulk Vessel Traffic;

(iii) Table 13 : Container Vessel Traffic;

(iv) Table 14 : Passenger Vessel Traffic;

(v) Table 15 : Total Vessel Traffic.

Table 11 - **Bulk Cargo Vessel Projections: Ship Calls Per Vessel Size (1 of 4)**

GRT	2000	2001	2002	2003	2004	2005	2006
< 200	8,376	8,903	9,236	9,651	10,088	10,554	11,036
200 - 400	28,853	30,693	31,836	33,261	34,759	36,354	38,002
400 - 600	18,632	19,831	20,571	21,493	22,462	23,494	24,557
600 - 1,000	9,663	10,277	10,660	11,137	11,638	12,173	12,725
1,000 - 3,000	10,762	11,400	11,820	12,347	12,903	13,497	14,118
3,000 - 5,000	5,300	5,483	5,673	5,920	6,184	6,471	6,794
5,000 - 10,000	1,705	1,593	1,627	1,681	1,745	1,819	1,939
10,000 - 15,000	901	892	919	957	999	1,046	1,106
15,000 - 20,000	777	706	716	735	758	786	840
20,000 - 30,000	755	687	699	721	747	779	834
30,000 - 50,000	171	166	171	179	187	197	210
50,000 - 75,000	32	32	33	35	37	39	41
75,000 - 100,000	55	53	54	56	58	61	64
> 100,000	84	83	87	91	96	102	108
TOTAL	**86,065**	**90,798**	**94,101**	**98,264**	**102,662**	**107,372**	**112,376**

Table 11 - **Bulk Cargo Vessel Projections: Ship Calls Per Vessel Size (2 of 4)**

GRT	2007	2008	2009	2010	2011	2012	2013
< 200	11,361	11,686	12,012	12,338	12,664	12,992	13,255
200 - 400	39,112	40,222	41,333	42,444	43,556	44,667	45,561
400 - 600	25,273	25,990	26,706	27,422	28,138	28,855	29,430
600 - 1,000	13,097	13,469	13,842	14,215	14,587	14,960	15,260
1,000 - 3,000	14,538	14,960	15,382	15,806	16,231	16,657	17,001
3,000 - 5,000	7,017	7,243	7,473	7,706	7,942	8,183	8,380
5,000 - 10,000	2,027	2,118	2,213	2,313	2,417	2,526	2,619
10,000 - 15,000	1,149	1,193	1,239	1,285	1,334	1,384	1,426
15,000 - 20,000	880	922	966	1,011	1,060	1,110	1,154
20,000 - 30,000	875	918	963	1,010	1,060	1,112	1,156
30,000 - 50,000	220	229	239	250	261	272	282
50,000 - 75,000	43	45	47	49	51	53	55
75,000 - 100,000	67	70	73	76	79	82	85
> 100,000	113	118	123	128	133	139	143
TOTAL	**115,772**	**119,183**	**122,610**	**126,053**	**129,513**	**132,992**	**135,807**

Table 11 - **Bulk Cargo Vessel Projections: Ship Calls Per Vessel Size (3 of 4)**

GRT	2014	2015	2016	2017	2018	2019	2020
< 200	13,518	13,782	14,046	14,311	14,576	14,790	15,003
200 - 400	46,455	47,349	48,242	49,135	50,029	50,746	51,464
400 - 600	30,005	30,581	31,156	31,732	32,307	32,769	33,231
600 - 1,000	15,560	15,860	16,160	16,460	16,760	17,001	17,242
1,000 - 3,000	17,346	17,692	18,037	18,382	18,729	19,007	19,287
3,000 - 5,000	8,580	8,782	8,981	9,183	9,387	9,553	9,721
5,000 - 10,000	2,715	2,816	2,907	3,001	3,098	3,179	3,261
10,000 - 15,000	1,469	1,513	1,556	1,599	1,644	1,681	1,719
15,000 - 20,000	1,199	1,246	1,287	1,329	1,373	1,409	1,446
20,000 - 30,000	1,203	1,252	1,296	1,341	1,389	1,428	1,468
30,000 - 50,000	292	302	313	324	335	344	353
50,000 - 75,000	57	59	61	63	65	67	69
75,000 - 100,000	88	90	93	96	99	101	104
> 100,000	148	153	158	164	170	174	179
TOTAL	**138,636**	**141,478**	**144,294**	**147,121**	**149,961**	**152,249**	**154,546**

Table 11 - **Bulk Cargo Vessel Projections: Ship Calls Per Vessel Size (4 of 4)**

GRT	2021	2022	2023	2024	2025	2026	2027	2028
< 200	15,278	15,524	15,770	16,016	16,261	16,507	16,753	16,999
200 - 400	52,392	53,220	54,048	54,876	55,704	56,532	57,360	58,188
400 - 600	33,830	34,363	34,896	35,430	35,963	36,496	37,030	37,563
600 - 1,000	17,554	17,832	18,110	18,388	18,666	18,944	19,222	19,500
1,000 - 3,000	19,645	19,966	20,287	20,608	20,929	21,250	21,571	21,892
3,000 - 5,000	9,929	10,118	10,307	10,496	10,684	10,873	11,062	11,251
5,000 - 10,000	3,357	3,447	3,537	3,626	3,716	3,806	3,895	3,985
10,000 - 15,000	1,764	1,805	1,846	1,888	1,929	1,971	2,012	2,053
15,000 - 20,000	1,489	1,529	1,570	1,610	1,650	1,690	1,731	1,771
20,000 - 30,000	1,515	1,558	1,602	1,645	1,689	1,732	1,776	1,819
30,000 - 50,000	364	375	385	395	405	416	426	436
50,000 - 75,000	71	73	75	77	79	81	84	86
75,000 - 100,000	106	109	112	114	117	119	122	125
> 100,000	185	190	195	200	205	210	216	221
TOTAL	**157,479**	**160,109**	**162,739**	**165,369**	**167,998**	**170,628**	**173,258**	**175,888**

Table 12 - **Break Bulk Cargo Vessel Projections: Ship Calls Per Vessel Size (1 of 4)**

GRT	2000	2001	2002	2003	2004	2005	2006
< 200	24,056	25,601	26,557	27,747	28,998	30,330	31,703
200 - 400	19,161	20,377	21,137	22,084	23,080	24,142	25,238
400 - 600	5,094	5,391	5,590	5,840	6,103	6,385	6,680
600 - 1,000	2,008	2,123	2,202	2,300	2,404	2,515	2,632
1,000 - 3,000	1,533	1,569	1,623	1,693	1,768	1,851	1,947
3,000 - 5,000	1,424	1,406	1,450	1,511	1,578	1,654	1,752
5,000 - 10,000	2,401	2,315	2,380	2,475	2,582	2,705	2,874
10,000 - 15,000	1,060	1,020	1,047	1,086	1,130	1,181	1,254
15,000 - 20,000	752	682	693	714	739	769	823
20,000 - 30,000	138	127	130	135	140	147	157
30,000 - 50,000	37	34	34	35	36	38	41
50,000 - 75,000	4	4	4	5	5	5	5
75,000 - 100,000	-	-	-	-	-	-	-
> 100,000	0	0	0	0	0	0	0
TOTAL	**57,667**	**60,651**	**62,847**	**65,624**	**68,565**	**71,722**	**75,107**

Table 12 - **Break Bulk Cargo Vessel Projections: Ship Calls Per Vessel Size (2 of 4)**

GRT	2007	2008	2009	2010	2011	2012	2013
< 200	32,628	33,553	34,478	35,404	36,329	37,254	37,998
200 - 400	25,977	26,717	27,457	28,198	28,939	29,680	30,277
400 - 600	6,880	7,081	7,282	7,484	7,687	7,890	8,055
600 - 1,000	2,711	2,791	2,871	2,951	3,032	3,113	3,178
1,000 - 3,000	2,014	2,082	2,151	2,222	2,294	2,367	2,428
3,000 - 5,000	1,821	1,892	1,966	2,042	2,122	2,203	2,272
5,000 - 10,000	2,996	3,122	3,254	3,391	3,533	3,681	3,806
10,000 - 15,000	1,306	1,361	1,417	1,476	1,536	1,600	1,653
15,000 - 20,000	863	905	949	996	1,045	1,096	1,140
20,000 - 30,000	164	172	180	189	198	207	215
30,000 - 50,000	43	45	47	49	51	54	56
50,000 - 75,000	5	6	6	6	6	6	6
75,000 - 100,000	-	-	-	-	-	-	-
> 100,000	0	0	0	0	0	0	0
TOTAL	**77,410**	**79,727**	**82,059**	**84,407**	**86,771**	**89,152**	**91,084**

Table 12 - **Break Bulk Cargo Vessel Projections: Ship Calls Per Vessel Size (3 of 4)**

GRT	2014	2015	2016	2017	2018	2019	2020
< 200	38,742	39,486	40,229	40,973	41,717	42,314	42,911
200 - 400	30,873	31,470	32,067	32,664	33,262	33,742	34,222
400 - 600	8,220	8,385	8,550	8,716	8,882	9,016	9,150
600 - 1,000	3,244	3,310	3,376	3,442	3,508	3,562	3,616
1,000 - 3,000	2,490	2,553	2,615	2,677	2,741	2,793	2,846
3,000 - 5,000	2,342	2,415	2,486	2,558	2,633	2,694	2,757
5,000 - 10,000	3,935	4,069	4,197	4,329	4,464	4,576	4,691
10,000 - 15,000	1,709	1,766	1,819	1,874	1,931	1,978	2,025
15,000 - 20,000	1,186	1,234	1,276	1,321	1,366	1,404	1,443
20,000 - 30,000	223	232	240	249	257	264	272
30,000 - 50,000	58	60	63	65	67	69	71
50,000 - 75,000	7	7	7	7	7	7	7
75,000 - 100,000	-	-	-	-	-	-	-
> 100,000	0	0	0	0	0	0	0
TOTAL	**93,029**	**94,987**	**96,925**	**98,875**	**100,836**	**102,420**	**104,011**

Table 12 - **Break Bulk Cargo Vessel Projections: Ship Calls Per Vessel Size (4 of 4)**

GRT	2021	2022	2023	2024	2025	2026	2027	2028
< 200	43,684	44,374	45,063	45,752	46,442	47,131	47,821	48,510
200 - 400	34,843	35,397	35,951	36,505	37,059	37,612	38,166	38,720
400 - 600	9,322	9,476	9,630	9,784	9,938	10,092	10,246	10,399
600 - 1,000	3,684	3,746	3,807	3,869	3,930	3,992	4,053	4,115
1,000 - 3,000	2,910	2,969	3,028	3,087	3,146	3,205	3,264	3,323
3,000 - 5,000	2,831	2,900	2,969	3,037	3,106	3,175	3,244	3,312
5,000 - 10,000	4,826	4,952	5,077	5,202	5,328	5,453	5,578	5,704
10,000 - 15,000	2,082	2,134	2,186	2,239	2,291	2,343	2,395	2,448
15,000 - 20,000	1,488	1,531	1,573	1,615	1,657	1,699	1,742	1,784
20,000 - 30,000	280	288	296	304	312	320	328	336
30,000 - 50,000	73	75	77	79	81	83	85	87
50,000 - 75,000	7	7	8	8	8	8	8	8
75,000 - 100,000	-	-	-	-	-	-	-	-
> 100,000	1	1	1	1	1	1	1	1
TOTAL	**106,033**	**107,849**	**109,665**	**111,481**	**113,298**	**115,114**	**116,930**	**118,747**

Table 13 - **Container Cargo Vessel Projections: Ship Calls Per Vessel Size (1 of 4)**

GRT	2000	2001	2002	2003	2004	2005	2006
< 200	22,129	23,554	24,433	25,528	26,679	27,904	29,167
200 - 400	17,495	18,621	19,316	20,181	21,091	22,060	23,058
400 - 600	4,469	4,754	4,931	5,152	5,383	5,630	5,886
600 - 1,000	1,734	1,846	1,915	2,000	2,091	2,187	2,285
1,000 - 3,000	995	1,053	1,092	1,140	1,191	1,245	1,302
3,000 - 5,000	519	549	569	595	622	651	681
5,000 - 10,000	1,586	1,541	1,584	1,645	1,715	1,794	1,903
10,000 - 15,000	1,442	1,348	1,375	1,420	1,472	1,534	1,634
15,000 - 20,000	889	822	840	870	905	946	1,011
20,000 - 30,000	14	13	14	14	15	16	17
30,000 - 50,000	2	3	3	3	3	3	3
50,000 - 75,000	4	4	4	4	4	4	5
75,000 - 100,000	-	-	-	-	-	-	-
> 100,000	0	0	0	0	0	0	0
TOTAL	**51,278**	**54,108**	**56,075**	**58,553**	**61,171**	**63,973**	**66,951**

Table 13 - **Container Cargo Vessel Projections: Ship Calls Per Vessel Size (2 of 4)**

GRT	2007	2008	2009	2010	2011	2012	2013
< 200	30,017	30,868	31,718	32,569	33,419	34,270	34,953
200 - 400	23,730	24,403	25,075	25,748	26,420	27,092	27,633
400 - 600	6,058	6,230	6,402	6,574	6,746	6,918	7,057
600 - 1,000	2,352	2,419	2,485	2,552	2,619	2,685	2,739
1,000 - 3,000	1,341	1,379	1,418	1,457	1,496	1,535	1,567
3,000 - 5,000	701	721	742	763	783	804	821
5,000 - 10,000	1,981	2,061	2,145	2,231	2,321	2,415	2,493
10,000 - 15,000	1,707	1,783	1,863	1,946	2,032	2,123	2,200
15,000 - 20,000	1,059	1,109	1,162	1,217	1,275	1,335	1,387
20,000 - 30,000	17	18	19	19	20	21	22
30,000 - 50,000	3	3	4	4	4	4	4
50,000 - 75,000	5	5	5	5	5	5	6
75,000 - 100,000	-	-	-	-	-	-	-
> 100,000	0	0	0	0	0	0	0
TOTAL	**68,971**	**71,000**	**73,038**	**75,085**	**77,142**	**79,209**	**80,882**

Table 13 - **Container Cargo Vessel Projections: Ship Calls Per Vessel Size (3 of 4)**

GRT	2014	2015	2016	2017	2018	2019	2020
< 200	35,637	36,320	37,003	37,687	38,370	38,919	39,467
200 - 400	28,173	28,713	29,253	29,794	30,334	30,768	31,201
400 - 600	7,195	7,334	7,472	7,610	7,749	7,860	7,971
600 - 1,000	2,792	2,846	2,900	2,953	3,007	3,050	3,093
1,000 - 3,000	1,599	1,630	1,662	1,693	1,725	1,750	1,775
3,000 - 5,000	837	854	871	888	905	919	932
5,000 - 10,000	2,575	2,659	2,738	2,820	2,904	2,973	3,044
10,000 - 15,000	2,281	2,364	2,439	2,517	2,597	2,663	2,730
15,000 - 20,000	1,441	1,497	1,549	1,603	1,659	1,705	1,752
20,000 - 30,000	23	23	24	25	26	26	27
30,000 - 50,000	4	4	4	4	4	4	4
50,000 - 75,000	6	6	6	6	6	6	6
75,000 - 100,000	-	-	-	-	-	-	-
> 100,000	0	0	0	0	0	0	0
TOTAL	**82,562**	**84,251**	**85,922**	**87,600**	**89,285**	**90,642**	**92,004**

Table 13 - **Container Cargo Vessel Projections: Ship Calls Per Vessel Size (4 of 4)**

GRT	2021	2022	2023	2024	2025	2026	2027	2028
< 200	40,178	40,811	41,444	42,077	42,711	43,344	43,977	44,611
200 - 400	31,763	32,264	32,764	33,265	33,766	34,266	34,767	35,268
400 - 600	8,115	8,243	8,371	8,500	8,628	8,756	8,884	9,012
600 - 1,000	3,148	3,198	3,248	3,297	3,347	3,396	3,446	3,496
1,000 - 3,000	1,808	1,837	1,866	1,896	1,925	1,954	1,983	2,013
3,000 - 5,000	950	965	981	997	1,013	1,028	1,044	1,060
5,000 - 10,000	3,128	3,205	3,283	3,360	3,438	3,515	3,593	3,670
10,000 - 15,000	2,810	2,884	2,957	3,031	3,105	3,179	3,253	3,326
15,000 - 20,000	1,807	1,859	1,910	1,962	2,013	2,065	2,116	2,167
20,000 - 30,000	28	28	29	30	31	31	32	33
30,000 - 50,000	4	5	5	5	5	5	5	5
50,000 - 75,000	6	7	7	7	7	7	7	7
75,000 - 100,000	-	-	-	-	-	-	-	-
> 100,000	0	0	0	0	0	1	1	1
TOTAL	**93,745**	**95,306**	**96,866**	**98,427**	**99,987**	**101,547**	**103,108**	**104,668**

Table 14 - **Projections Of Passenger Vessels By Size (1 of 4)**

GRT	2000	2001	2002	2003	2004	2005	2006
< 200	94,689	97,486	101,055	105,500	110,173	115,147	120,273
200 - 400	42,525	43,782	45,384	47,381	49,479	51,713	54,015
400 - 600	16,610	17,100	17,726	18,506	19,326	20,198	21,097
600 - 1,000	5,511	5,674	5,882	6,141	6,413	6,702	7,001
1,000 - 3,000	5,125	5,277	5,470	5,710	5,963	6,232	6,510
3,000 - 5,000	2,774	2,856	2,960	3,090	3,227	3,373	3,523
5,000 - 10,000	5,479	5,641	5,848	6,105	6,375	6,663	6,960
10,000 - 15,000	1,743	1,794	1,860	1,941	2,027	2,119	2,213
15,000 - 20,000	289	297	308	322	336	351	367
20,000 - 30,000	17	18	19	19	20	21	22
30,000 - 50,000	16	17	17	18	19	20	21
50,000 - 75,000	40	42	43	45	47	49	51
75,000 - 100,000	13	13	14	15	15	16	17
> 100,000	22	22	23	24	25	27	28
TOTAL	**174,854**	**180,020**	**186,609**	**194,818**	**203,447**	**212,633**	**222,097**

Table 14 - **Projections Of Passenger Vessels By Size (2 of 4)**

GRT	2007	2008	2009	2010	2011	2012	2013
< 200	123,726	127,179	130,632	134,085	137,538	140,991	143,765
200 - 400	55,566	57,117	58,668	60,218	61,769	63,320	64,566
400 - 600	21,703	22,309	22,915	23,520	24,126	24,732	25,218
600 - 1,000	7,202	7,403	7,604	7,805	8,006	8,207	8,368
1,000 - 3,000	6,697	6,884	7,071	7,257	7,444	7,631	7,781
3,000 - 5,000	3,624	3,725	3,827	3,928	4,029	4,130	4,211
5,000 - 10,000	7,160	7,360	7,559	7,759	7,959	8,159	8,319
10,000 - 15,000	2,277	2,340	2,404	2,467	2,531	2,595	2,646
15,000 - 20,000	377	388	398	409	419	430	438
20,000 - 30,000	23	23	24	25	25	26	26
30,000 - 50,000	21	22	23	23	24	24	25
50,000 - 75,000	53	54	56	57	59	60	61
75,000 - 100,000	17	18	18	19	19	19	20
> 100,000	28	29	30	31	32	32	33
TOTAL	**228,474**	**234,850**	**241,227**	**247,603**	**253,979**	**260,356**	**265,479**

Table 14 - **Projections Of Passenger Vessels By Size (3 of 4)**

GRT	2014	2015	2016	2017	2018	2019	2020
< 200	146,539	149,314	152,088	154,862	157,636	159,863	162,090
200 - 400	65,812	67,058	68,304	69,549	70,795	71,796	72,796
400 - 600	25,705	26,192	26,678	27,165	27,651	28,042	28,433
600 - 1,000	8,529	8,691	8,852	9,014	9,175	9,305	9,435
1,000 - 3,000	7,932	8,082	8,232	8,382	8,532	8,653	8,773
3,000 - 5,000	4,292	4,374	4,455	4,536	4,618	4,683	4,748
5,000 - 10,000	8,480	8,640	8,801	8,962	9,122	9,251	9,380
10,000 - 15,000	2,697	2,748	2,799	2,850	2,901	2,942	2,983
15,000 - 20,000	447	455	464	472	481	488	494
20,000 - 30,000	27	27	28	29	29	29	30
30,000 - 50,000	25	26	26	27	27	28	28
50,000 - 75,000	62	64	65	66	67	68	69
75,000 - 100,000	20	21	21	21	22	22	22
> 100,000	34	34	35	36	36	37	37
TOTAL	**270,602**	**275,725**	**280,847**	**285,970**	**291,093**	**295,206**	**299,318**

Table 14 - **Projections Of Passenger Vessels By Size (4 of 4)**

GRT	2021	2022	2023	2024	2025	2026	2027	2028
< 200	164,974	167,545	170,116	172,687	175,258	177,829	180,400	182,970
200 - 400	74,091	75,245	76,400	77,555	78,709	79,864	81,019	82,173
400 - 600	28,939	29,390	29,841	30,291	30,742	31,193	31,644	32,095
600 - 1,000	9,602	9,752	9,902	10,051	10,201	10,351	10,500	10,650
1,000 - 3,000	8,929	9,068	9,208	9,347	9,486	9,625	9,764	9,903
3,000 - 5,000	4,832	4,908	4,983	5,058	5,134	5,209	5,284	5,360
5,000 - 10,000	9,547	9,695	9,844	9,993	10,142	10,291	10,439	10,588
10,000 - 15,000	3,036	3,083	3,131	3,178	3,225	3,272	3,320	3,367
15,000 - 20,000	503	511	519	527	535	542	550	558
20,000 - 30,000	30	31	31	32	32	33	33	34
30,000 - 50,000	28	29	29	30	30	31	31	32
50,000 - 75,000	70	71	72	74	75	76	77	78
75,000 - 100,000	23	23	23	24	24	25	25	25
> 100,000	38	39	39	40	40	41	42	42
TOTAL	**304,643**	**309,391**	**314,138**	**318,886**	**323,633**	**328,381**	**333,128**	**337,876**

Table 15 - **Projections Of Total Shipping Traffic By Vessel Size (1 of 4)**

GRT	2000	2001	2002	2003	2004	2005	2006
< 200	149,251	155,544	161,280	168,425	175,937	183,936	192,178
200 - 400	108,034	113,473	117,672	122,907	128,410	134,269	140,313
400 - 600	44,805	47,077	48,819	50,991	53,275	55,708	58,220
600 - 1,000	18,917	19,920	20,658	21,578	22,546	23,577	24,643
1,000 - 3,000	18,414	19,299	20,004	20,890	21,825	22,825	23,877
3,000 - 5,000	10,016	10,294	10,653	11,116	11,611	12,148	12,750
5,000 - 10,000	11,172	11,091	11,438	11,907	12,417	12,981	13,676
10,000 - 15,000	5,145	5,054	5,201	5,405	5,629	5,880	6,207
15,000 - 20,000	2,706	2,508	2,558	2,640	2,738	2,852	3,041
20,000 - 30,000	923	846	862	890	923	963	1,030
30,000 - 50,000	227	219	225	235	246	258	275
50,000 - 75,000	80	81	84	88	93	97	102
75,000 - 100,000	68	66	68	71	73	77	81
> 100,000	106	106	111	116	122	129	137
TOTAL	**369,865**	**385,577**	**399,632**	**417,258**	**435,845**	**455,699**	**476,531**

Table 15 - **Projections Of Total Shipping Traffic By Vessel Size (2 of 4)**

GRT	2007	2008	2009	2010	2011	2012	2013
< 200	197,732	203,286	208,840	214,395	219,951	225,507	229,971
200 - 400	144,386	148,459	152,533	156,608	160,684	164,760	168,036
400 - 600	59,914	61,609	63,304	65,000	66,697	68,395	69,760
600 - 1,000	25,362	26,082	26,802	27,522	28,243	28,965	29,545
1,000 - 3,000	24,590	25,305	26,022	26,742	27,465	28,191	28,778
3,000 - 5,000	13,163	13,583	14,007	14,438	14,876	15,320	15,683
5,000 - 10,000	14,163	14,661	15,171	15,694	16,230	16,780	17,238
10,000 - 15,000	6,439	6,677	6,922	7,174	7,434	7,701	7,925
15,000 - 20,000	3,179	3,324	3,475	3,633	3,798	3,971	4,119
20,000 - 30,000	1,079	1,131	1,186	1,243	1,303	1,366	1,420
30,000 - 50,000	287	299	312	326	340	354	367
50,000 - 75,000	106	110	113	117	121	125	128
75,000 - 100,000	84	87	91	94	98	102	105
> 100,000	142	148	154	160	166	172	177
TOTAL	**490,627**	**504,760**	**518,933**	**533,148**	**547,405**	**561,708**	**573,251**

Table 15 - **Projections Of Total Shipping Traffic By Vessel Size (3 of 4)**

GRT	2014	2015	2016	2017	2018	2019	2020
< 200	234,436	238,901	243,367	247,833	252,300	255,886	259,472
200 - 400	171,313	174,590	177,866	181,143	184,420	187,052	189,683
400 - 600	71,125	72,491	73,857	75,223	76,590	77,687	78,785
600 - 1,000	30,126	30,707	31,288	31,869	32,450	32,917	33,385
1,000 - 3,000	29,366	29,957	30,545	31,135	31,727	32,203	32,681
3,000 - 5,000	16,052	16,425	16,793	17,165	17,542	17,848	18,157
5,000 - 10,000	17,705	18,184	18,643	19,111	19,589	19,979	20,376
10,000 - 15,000	8,155	8,391	8,613	8,840	9,073	9,263	9,457
15,000 - 20,000	4,272	4,432	4,576	4,725	4,879	5,006	5,136
20,000 - 30,000	1,476	1,535	1,588	1,643	1,700	1,748	1,796
30,000 - 50,000	379	393	406	419	433	444	456
50,000 - 75,000	132	135	138	142	146	149	152
75,000 - 100,000	108	111	114	117	121	123	126
> 100,000	183	188	194	200	207	212	217
TOTAL	**584,828**	**596,440**	**607,989**	**619,567**	**631,175**	**640,517**	**649,880**

Table 15 - **Projections Of Total Shipping Traffic By Vessel Size (4 of 4)**

GRT	2021	2022	2023	2024	2025	2026	2027	2028
< 200	264,114	268,253	272,393	276,533	280,671	284,811	288,950	293,090
200 - 400	193,089	196,126	199,163	202,200	205,237	208,275	211,312	214,349
400 - 600	80,205	81,471	82,738	84,005	85,271	86,537	87,804	89,070
600 - 1,000	33,989	34,528	35,066	35,605	36,144	36,683	37,222	37,760
1,000 - 3,000	33,293	33,841	34,390	34,938	35,486	36,034	36,583	37,131
3,000 - 5,000	18,542	18,891	19,240	19,589	19,936	20,285	20,634	20,983
5,000 - 10,000	20,858	21,299	21,741	22,182	22,623	23,065	23,506	23,947
10,000 - 15,000	9,692	9,906	10,120	10,336	10,550	10,765	10,980	11,194
15,000 - 20,000	5,288	5,429	5,572	5,713	5,855	5,996	6,139	6,280
20,000 - 30,000	1,853	1,905	1,959	2,011	2,064	2,116	2,169	2,222
30,000 - 50,000	470	483	496	508	521	534	547	559
50,000 - 75,000	155	158	162	165	168	172	176	179
75,000 - 100,000	129	132	135	138	141	144	147	150
> 100,000	224	230	235	241	246	252	259	264
TOTAL	**661,900**	**672,654**	**683,409**	**694,163**	**704,915**	**715,669**	**726,426**	**737,179**

2.4 Benefit Assessment

Two benefits have been assessed; (i) vessel operating cost savings, calculated by vessel type and size; and (ii) passenger time savings.

2.4.1 Vessel Operating Costs

Average vessel operating costs have been estimated for vessel size classifications for the four vessel groups for Philippine commercial shipping, using proprietary models[5]. These are summarized as follows;

Table 16 - **Hourly Operating Costs per Vessel Type and Size**

Vessel Size	Estimated Hourly Operating Costs (US$)			
GRT	Bulk Cargo	Break Bulk	Container	Passengers
< 200	38	40	40	62
200 - 400	54	57	57	86
400 - 600	68	73	73	130
600 - 1,000	84	87	139	211
1,000 - 3,000	138	152	193	419
3,000 - 5,000	198	190	251	547
5,000 - 10,000	261	284	327	720
10,000 - 15,000	327	320	451	936
15,000 - 20,000	432	423	585	1,260
20,000 - 30,000	541	528	758	1,598
30,000 - 50,000	643	643	985	1,826
50,000 - 75,000	774	774	1,482	2,041
75,000 - 100,000	1,004	1,004	1,505	2,390
> 100,000	1,308	1,308	1,961	3,631

Source: Meyrick and Associates, Maritime Economics Consultancy

The data and costing models utilized to derive these estimates have been applied in a wide range of studies for international organizations, port authorities, national governments and shipper interests. They were adapted for the present project through specific modifications to reflect:

(i) Fuel costs in the Philippines;

(ii) Labor costs in the Philippines;

(iii) The type and age of vessels currently used in the Philippines

[5] Information provided by Meyrick and Associates, a specialist maritime economics consultancy

The unit costs presented are intended as a guide to the typical long run costs of vessel provision and operation. Costs for individual vessels vary widely depending on time and place of construction, financing arrangements, manning agreements, maintenance practices, vessel operating speed, location of operation and a host of other factors.

Passenger vessel costs in particular can vary dramatically, depending on the quality of the accommodation and quality of passenger service provided. The costs in the accompanying estimates are intended to reflect the type of passenger vessel most commonly used in the Philippines: a ro-ro vessel designed to carry a mix of passengers and freight.

Ship costs are estimated using a synthetic approach, building up the total daily cost from estimates for each individual component. The approach taken to each of the major cost components is outlined below;

Capital Costs

Capital costs are estimated using the following procedure:

(i) typical replacement costs for each vessel type and size are estimated using information from in-house databases[6];

(ii) an average age, economic life and residual value for each vessel type and size is assumed;

(iii) depreciation costs are estimated on a straight-line basis over the life of the vessel

(iv) estimated written down replacement costs are estimate for 'typical' vessels in each category;

(v) a cost of capital of 10% per annum is applied to this value to estimate the required return on capital; and

(vi) capital costs are estimated as the sum of depreciation and required return.

An alternative approach would have been to simply amortize the new building costs over the life of the vessel as a constant annuity. However, this approach does not adequately reflect the reduction in capital costs that result from the use of older vessels in the Philippines and most other developing countries.

Fuel Costs

The relationship between fuel consumption and size for each type of vessels was estimated using in-house databases. These relationships were used to estimate typical fuel consumption for each vessel class used in the analysis. Fuel prices obtained from suppliers of bunkers in the Philippines were applied to these consumption rates to estimate fuel costs.

[6] Shipbuilding markets are notoriously volatile. The replacement costs used in the analysis are the estimated long run equilibrium costs — that is, we have attempted to smooth out the short run cyclical effects that arise from imbalances in demand for and supply of shipbuilding capacity.

Crew Costs

Typical crew complements were based on information obtained on regulatory requirements on crew size and composition promulgated by Marina. Rates of pay were estimated at approximately 70% of the minimum ITF standards for vessels trading internationally.

Insurance

Insurance costs were estimated as a percentage of the vessel value. In line with commercial practice, the percentage applied was higher for older than for newer vessels.

Maintenance Costs

Maintenance costs were estimated as a percentage of the replacement cost of the vessel. The percentage applied was increased with each year by which the age of the vessel exceeds a specified threshold value.

Stores and Lubes

This cost component was also estimated as a percentage of vessel replacement cost.

Administration

Vessel administration costs were estimated as a margin on direct vessel costs.

2.4.2 Passenger Time Savings

Passenger time savings have been established using the following procedure;

(i) Calculating the yearly GDP per employed person for the year 2001, which is US$ 2,642;

(ii) Calculating the hourly GDP per employed person, by dividing the yearly GDP per employed by an assumed average yearly number of hours (8,760), equating to US$ 1.25 per hour;

(iii) By assuming this average, the time value has been expressed as a percentage of the hourly GDP per employed person. This percentage is in general terms set at 25 percent, therefore the unit hourly value of time is of the order of US$ 0.3127[7].

2.4.3 Voyage Duration Assessment

Unit benefits have also been applied to the different vessels (and to their projections) under the following assumptions;

(i) The larger the vessel size, the larger the time saved or lost due to the presence or absence of hydrographic maps and services;

[7] This assumption is in general terms made in a large number of transport studies, and considered an accepted practice to estimate time value.

(ii) As a consequence of curtailment of hydrographic services, the hydrographic charts will become increasingly obsolete over time;

(iii) The rate of obsolescence of charts will vary between ports according to certain characteristics, including geographical features and processes and the rate of infrastructure development, but average estimates may be assumed;;

(iv) Cartographic obsolescence occurs sooner and with greater impact for larger vessels.

Table 17 summarizes the assumptions regarding time gains and losses per vessel size over time, assuming that the hydrographic services cease completely, and compared with the current level of investment;

Table 17 - **Time Losses/Savings Over Time Per Vessel Size (Minutes)**

Vessel Size (GRT)	Year 5	Year 10	Year 15	Year 20	Year 25
< 1,000 Tons	1	2	3	4	5
1,000 to 5,000 Tons	3	6	9	12	15
5,000 to 20,000 Tons	5	10	15	20	25
20,000 to 100,000 Tons	8	16	24	32	40
> 100,000 Tons	10	20	30	40	50

2.5 Results

The evaluation process has been implemented on the assumption that hydrographic services cease completely at the commencement of the evaluation period, resulting in the progressive degradation in hydrographic charts and services, in turn resulting in the lengthening of vessel voyage duration, as elaborated in Table 17. The impact in terms of vessel operating cost-increases, and passenger time-losses for the various size classifications of the four vessel types are presented on the following tables;

Table 18 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Bulk Vessels (US$) – (1 of 4)**

GRT	2003	2004	2005	2006	2007	2008
< 200	1,528	3,195	5,013	6,989	8,265	9,766
200 - 400	7,484	15,642	24,539	34,201	40,435	47,766
400 - 600	6,090	12,729	19,970	27,831	32,902	38,866
600 - 1,000	3,898	8,147	12,781	17,815	21,062	24,882
1,000 - 3,000	21,222	44,354	69,592	97,061	114,813	135,709
3,000 - 5,000	14,652	30,610	48,044	67,263	79,801	94,622
5,000 - 10,000	9,142	18,974	29,674	42,174	50,633	60,784
10,000 - 15,000	6,521	13,612	21,376	30,146	35,966	42,899
15,000 - 20,000	6,613	13,645	21,223	30,238	36,387	43,786
20,000 - 30,000	13,003	26,954	42,143	60,176	72,504	87,362
30,000 - 50,000	3,830	8,034	12,696	18,039	21,633	25,943
50,000 - 75,000	894	1,887	3,000	4,260	5,104	6,116
75,000 - 100,000	1,872	3,892	6,092	8,619	10,311	12,334
> 100,000	4,970	10,490	16,668	23,639	28,296	33,870
TOTAL	**101,717**	**212,163**	**332,810**	**468,452**	**558,114**	**664,703**

Table 18 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Bulk Vessels (US$) – (2 of 4)**

GRT	2009	2010	2011	2012	2013	2014	2015
< 200	11,531	13,605	16,042	17,846	19,745	21,839	24,146
200 - 400	56,385	66,510	78,400	87,193	96,450	106,649	117,884
400 - 600	45,876	54,111	63,780	70,928	78,454	86,745	95,876
600 - 1,000	29,373	34,648	40,845	45,427	50,252	55,568	61,425
1,000 - 3,000	160,292	189,200	223,177	248,387	274,930	304,203	336,478
3,000 - 5,000	112,134	132,823	157,256	175,700	195,132	216,664	240,520
5,000 - 10,000	72,968	87,590	105,141	119,152	133,979	150,655	169,412
10,000 - 15,000	51,154	60,986	72,693	81,790	91,385	102,098	114,062
15,000 - 20,000	52,687	63,398	76,286	86,662	97,676	110,095	124,097
20,000 - 30,000	105,268	126,850	152,863	173,919	196,217	221,384	249,789
30,000 - 50,000	31,111	37,309	44,743	50,657	56,882	63,874	71,726
50,000 - 75,000	7,328	8,780	10,520	11,901	13,350	14,975	16,798
75,000 - 100,000	14,751	17,639	21,091	23,806	26,677	29,893	33,497
> 100,000	40,542	48,526	58,081	65,630	73,550	82,425	92,371
TOTAL	**791,398**	**941,974**	**1,120,919**	**1,259,001**	**1,404,680**	**1,567,066**	**1,748,081**

Table 18 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Bulk Vessels (US$) – (3 of 4)**

GRT	2016	2017	2018	2019	2020	2021	2022
< 200	26,688	28,801	31,073	33,394	35,883	38,705	41,122
200 - 400	130,254	140,523	151,552	162,829	174,911	188,612	200,337
400 - 600	105,932	114,278	123,241	132,407	142,226	153,361	162,888
600 - 1,000	67,872	73,226	78,977	84,856	91,156	98,300	104,414
1,000 - 3,000	372,008	401,587	433,387	465,886	500,731	540,250	574,134
3,000 - 5,000	266,747	288,885	312,798	337,177	363,415	393,186	418,951
5,000 - 10,000	189,679	207,422	226,821	246,477	267,835	292,095	313,582
10,000 - 15,000	127,183	138,500	150,813	163,321	176,859	192,230	205,721
15,000 - 20,000	139,001	152,067	166,359	180,838	196,576	214,452	230,299
20,000 - 30,000	280,419	307,477	337,145	367,163	399,854	436,995	470,069
30,000 - 50,000	80,456	88,147	96,572	105,101	114,382	124,926	134,301
50,000 - 75,000	18,858	20,678	22,674	24,693	26,892	29,390	31,615
75,000 - 100,000	37,404	40,793	44,487	48,235	52,298	56,912	60,975
> 100,000	103,611	113,513	124,361	135,341	147,291	160,867	172,936
TOTAL	**1,946,113**	**2,115,897**	**2,300,258**	**2,487,719**	**2,690,309**	**2,920,280**	**3,121,346**

Table 18 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Bulk Vessels (US$) – (4 of 4)**

GRT	2023	2024	2025	2026	2027	2028
< 200	43,680	46,385	49,246	52,272	55,472	58,854
200 - 400	212,740	225,857	239,728	254,395	269,902	286,294
400 - 600	172,966	183,624	194,895	206,812	219,411	232,730
600 - 1,000	110,882	117,722	124,956	132,605	140,692	149,241
1,000 - 3,000	609,986	647,914	688,034	730,466	775,338	822,785
3,000 - 5,000	446,249	475,166	505,793	538,226	572,566	608,919
5,000 - 10,000	336,423	360,695	386,482	413,872	442,957	473,834
10,000 - 15,000	220,042	235,243	251,372	268,483	286,633	305,881
15,000 - 20,000	247,147	265,052	284,077	304,287	325,749	348,537
20,000 - 30,000	505,253	542,669	582,447	624,727	669,652	717,377
30,000 - 50,000	144,272	154,872	166,140	178,114	190,835	204,345
50,000 - 75,000	33,981	36,498	39,174	42,018	45,040	48,250
75,000 - 100,000	65,291	69,873	74,737	79,900	85,379	91,191
> 100,000	185,772	199,420	213,926	229,341	245,718	263,112
TOTAL	**3,334,683**	**3,560,990**	**3,801,009**	**4,055,519**	**4,325,344**	**4,611,350**

Table 19 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Breakbulk Vessels (US$) – (1 of 4)**

GRT	2003	2004	2005	2006	2007	2008
< 200	4,624	9,666	15,165	21,135	24,986	29,516
200 - 400	5,245	10,963	17,201	23,976	28,348	33,491
400 - 600	1,776	3,713	5,826	8,128	9,616	11,367
600 - 1,000	834	1,743	2,735	3,817	4,516	5,340
1,000 - 3,000	3,216	6,719	10,550	14,798	17,581	20,876
3,000 - 5,000	3,588	7,496	11,786	16,641	19,870	23,720
5,000 - 10,000	14,644	30,556	48,011	68,027	81,450	97,510
10,000 - 15,000	7,240	15,072	23,624	33,440	40,017	47,879
15,000 - 20,000	6,291	13,021	20,324	29,011	34,950	42,106
20,000 - 30,000	2,375	4,941	7,750	11,047	13,289	15,987
30,000 - 50,000	756	1,564	2,439	3,479	4,188	5,042
50,000 - 75,000	119	249	391	545	645	763
75,000 - 100,000	-	-	-	-	-	-
> 100,000	18	37	58	80	95	112
TOTAL	**50,725**	**105,739**	**165,861**	**234,126**	**279,552**	**333,710**

Table 19 - **Vessel Operating Cost Losses If Hydrographic Services Suspends Activity: Breakbulk Vessels (US$) – (2 of 4)**

GRT	2009	2010	2011	2012	2013	2014	2015
< 200	34,839	41,094	48,439	53,868	59,585	65,883	72,820
200 - 400	39,537	46,640	54,984	61,156	67,655	74,815	2,704
400 - 600	13,429	15,854	18,705	20,822	23,051	25,510	28,222
600 - 1,000	6,309	7,450	8,792	9,789	10,839	11,998	13,276
1,000 - 3,000	24,779	29,398	34,866	39,024	43,407	48,272	53,675
3,000 - 5,000	28,311	33,784	40,309	45,399	50,765	56,763	63,467
5,000 - 10,000	116,725	139,714	167,221	188,943	211,865	237,568	266,391
10,000 - 15,000	57,277	68,513	81,945	92,524	103,700	116,226	130,264
15,000 - 20,000	50,729	61,119	73,640	83,768	94,502	106,615	120,287
20,000 - 30,000	19,233	23,139	27,838	31,621	35,619	40,125	45,203
30,000 - 50,000	6,071	7,309	8,799	10,002	11,277	12,715	14,337
50,000 - 75,000	901	1,063	1,255	1,397	1,546	1,711	1,893
75,000 - 100,000	-	-	-	-	-	-	-
> 100,000	133	156	184	205	227	251	277
TOTAL	**398,272**	**475,234**	**566,976**	**638,519**	**714,038**	**798,452**	**892,815**

Table 19 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Breakbulk Vessels (US$) – (3 of 4)**

GRT	2016	2017	2018	2019	2020	2021	2022
< 200	80,459	86,799	93,609	100,572	108,032	116,492	123,731
200 - 400	91,391	98,607	106,358	114,283	122,774	132,404	140,648
400 - 600	31,208	33,697	36,373	39,108	42,040	45,367	48,220
600 - 1,000	14,684	15,859	17,122	18,413	19,798	21,368	22,716
1,000 - 3,000	59,614	64,659	70,120	75,681	81,676	88,479	94,391
3,000 - 5,000	70,841	77,225	84,181	91,242	98,893	107,580	115,222
5,000 - 10,000	297,975	325,533	355,630	386,144	419,271	456,895	490,152
10,000 - 15,000	145,547	158,830	173,318	188,016	203,957	222,060	238,023
15,000 - 20,000	134,969	147,917	162,106	176,467	192,100	209,860	225,660
20,000 - 30,000	50,728	55,602	60,945	66,351	72,238	78,925	84,876
30,000 - 50,000	16,077	17,608	19,285	20,983	22,830	24,929	26,793
50,000 - 75,000	2,093	2,260	2,439	2,622	2,819	3,042	3,233
75,000 - 100,000	-	-	-	-	-	-	-
> 100,000	306	330	356	383	411	443	471
TOTAL	**995,892**	**1,084,926**	**1,181,842**	**1,280,265**	**1,386,839**	**1,507,842**	**1,614,136**

Table 19 - **Vessel Operating Cost Losses If Hydrographic Service Suspends Activity: Breakbulk Vessels (US$) – (4 of 4)**

GRT	2023	2024	2025	2026	2027	2028
< 200	131,388	139,486	148,049	157,104	166,677	176,796
200 - 400	149,368	158,591	168,345	178,659	189,564	201,092
400 - 600	51,240	54,435	57,815	61,390	65,171	69,170
600 - 1,000	24,143	25,653	27,250	28,940	30,727	32,617
1,000 - 3,000	100,658	107,301	114,340	121,798	129,699	138,068
3,000 - 5,000	123,339	131,956	141,102	150,809	161,108	172,033
5,000 - 10,000	525,493	563,039	602,918	645,264	690,220	737,935
10,000 - 15,000	254,980	272,990	292,112	312,412	333,956	356,815
15,000 - 20,000	242,465	260,334	279,329	299,516	320,964	343,745
20,000 - 30,000	91,206	97,937	105,092	112,697	120,776	129,359
30,000 - 50,000	28,776	30,884	33,125	35,505	38,034	40,720
50,000 - 75,000	3,435	3,650	3,876	4,116	4,369	4,637
75,000 - 100,000	-	-	-	-	-	-
> 100,000	500	531	563	598	634	673
TOTAL	**1,726,992**	**1,846,786**	**1,973,919**	**2,108,809**	**2,251,899**	**2,403,659**

Table 20 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Container Vessels (US$) – (1 of 4)**

GRT	2003	2004	2005	2006	2007	2008
< 200	4,255	8,893	13,952	19,444	22,987	27,154
200 - 400	4,793	10,018	15,718	21,905	25,896	30,590
400 - 600	1,567	3,275	5,138	7,161	8,466	10,001
600 - 1,000	1,159	2,422	3,799	5,295	6,259	7,394
1,000 - 3,000	2,750	5,745	9,010	12,564	14,861	17,564
3,000 - 5,000	1,867	3,902	6,123	8,542	10,106	11,947
5,000 - 10,000	11,209	23,365	36,662	51,847	61,994	74,112
10,000 - 15,000	13,344	27,670	43,229	61,401	73,688	88,427
15,000 - 20,000	10,603	22,053	34,580	49,296	59,307	71,352
20,000 - 30,000	359	750	1,181	1,673	2,002	2,395
30,000 - 50,000	93	194	304	424	501	592
50,000 - 75,000	201	421	661	21	1,088	1,286
75,000 - 100,000	-	-	-	-	-	-
> 100,000	24	51	80	111	131	155
TOTAL	**52,224**	**108,759**	**170,437**	**240,585**	**287,288**	**342,969**

Table 20 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Container Vessels (US$) – (2 of 4)**

GRT	2009	2010	2011	2012	2013	2014
< 200	32,051	37,804	44,559	49,553	54,811	60,603
200 - 400	36,107	42,588	50,198	55,824	61,747	68,272
400 - 600	11,806	13,926	16,415	18,256	20,195	22,330
600 - 1,000	8,727	10,294	12,133	13,493	14,925	16,502
1,000 - 3,000	20,744	24,483	28,876	32,134	35,565	39,349
3,000 - 5,000	14,113	16,662	19,658	21,883	24,225	26,809
5,000 - 10,000	88,586	105,871	126,515	142,717	159,823	178,975
10,000 - 15,000	106,106	127,315	152,757	173,034	194,502	218,638
15,000 - 20,000	85,846	103,288	124,278	141,178	159,046	179,182
20,000 - 30,000	2,866	3,428	4,101	4,631	5,190	5,816
30,000 - 50,000	699	825	972	1,081	1,196	1,322
50,000 - 75,000	1,518	1,790	2,110	2,346	2,595	2,870
75,000 - 100,000	-	-	-	-	-	-
> 100,000	183	216	255	283	313	346
TOTAL	**409,351**	**488,488**	**582,828**	**656,415**	**734,131**	**821,013**

Table 20 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Container Vessels (US$) – (3 of 4)**

GRT	2015	2016	2017	2018	2019	2020	2021
< 200	66,982	74,007	79,838	86,099	92,502	99,362	107,140
200 - 400	75,459	83,372	89,941	96,995	104,208	111,936	120,699
400 - 600	24,683	27,273	29,423	31,732	34,094	36,623	39,492
600 - 1,000	18,239	20,152	21,740	23,445	25,188	27,056	29,174
1,000 - 3,000	43,520	48,105	51,919	56,018	60,208	64,699	69,792
3,000 - 5,000	29,659	32,797	35,413	38,225	41,099	44,182	47,678
5,000 - 10,000	200,420	223,846	244,178	266,344	288,837	313,222	340,914
10,000 - 15,000	245,778	275,022	300,573	328,490	356,787	387,518	422,422
15,000 - 20,000	201,876	226,545	248,310	272,164	296,305	322,588	352,446
20,000 - 30,000	6,517	7,291	7,966	8,704	9,452	10,264	11,187
30,000 - 50,000	1,461	1,614	1,741	1,878	2,018	2,167	2,337
50,000 - 75,000	3,172	3,505	3,781	4,077	4,381	4,705	5,074
75,000 - 100,000	-	-	-	-	-	-	-
> 100,000	383	423	456	492	529	568	612
TOTAL	**918,148**	**1,023,953**	**1,115,278**	**1,214,665**	**1,315,608**	**1,424,890**	**1,548,967**

Table 20 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Container Vessels (US$) – (4 of 4)**

GRT	2022	2023	2024	2025	2026	2027	2028
< 200	113,796	120,836	128,282	136,155	144,480	153,281	162,585
200 - 400	128,197	136,128	144,516	153,386	162,765	172,680	183,161
400 - 600	41,947	44,544	47,290	50,195	53,266	56,512	59,945
600 - 1,000	30,986	32,903	34,931	37,075	39,342	41,738	44,272
1,000 - 3,000	74,156	78,773	83,657	88,823	94,286	100,063	106,170
3,000 - 5,000	50,677	53,851	57,209	60,762	64,519	68,493	72,696
5,000 - 10,000	365,311	391,225	418,743	447,958	478,968	511,875	546,789
10,000 - 15,000	453,300	486,117	520,985	558,023	597,357	639,118	683,448
15,000 - 20,000	379,017	407,278	437,330	469,276	503,228	539,301	577,618
20,000 - 30,000	12,002	12,869	13,790	14,768	15,807	16,910	18,080
30,000 - 50,000	2,482	2,636	2,798	2,970	3,151	3,343	3,546
50,000 - 75,000	5,389	5,723	6,075	6,448	6,843	7,260	7,700
75,000 - 100,000	-	-	-	-	-	-	-
> 100,000	650	691	733	778	826	876	929
TOTAL	**1,657,911**	**1,773,573**	**1,896,339**	**2,026,617**	**2,164,836**	**2,311,451**	**2,466,939**

Table 21 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Passenger Vessels (US$) – (1 of 4)**

GRT	2003	2004	2005	2006	2007	2008
< 200	27,254	56,923	89,239	124,282	146,861	173,407
200 - 400	16,978	35,460	55,592	77,422	91,488	108,025
400 - 600	10,024	20,936	32,822	45,711	54,016	63,779
600 - 1,000	5,399	11,276	17,677	24,619	29,091	34,350
1,000 - 3,000	29,907	62,464	97,927	136,381	161,159	190,289
3,000 - 5,000	21,130	44,132	69,187	96,356	113,862	134,443
5,000 - 10,000	91,576	191,265	299,851	417,597	493,465	582,663
10,000 - 15,000	37,859	79,071	123,962	172,639	204,004	240,879
15,000 - 20,000	8,446	17,640	27,655	38,515	45,512	53,739
20,000 - 30,000	1,035	2,161	3,388	4,719	5,576	6,584
30,000 - 50,000	1,109	2,315	3,630	5,055	5,973	7,053
50,000 - 75,000	3,057	6,386	10,011	13,942	16,475	19,453
75,000 - 100,000	1,161	2,424	3,801	5,293	6,255	7,385
> 100,000	3,674	7,673	12,029	16,752	19,795	23,374
TOTAL	**258,609**	**540,126**	**846,772**	**1,179,283**	**1,393,532**	**1,645,423**

Table 21 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity: Passenger Vessels (US$) – (2 of 4)**

GRT	2009	2010	2011	2012	2013	2014
< 200	204,601	241,237	284,245	315,995	349,430	386,260
200 - 400	127,457	150,280	177,071	196,850	217,679	240,622
400 - 600	75,253	88,727	104,546	116,223	128,521	142,067
600 - 1,000	40,529	47,786	56,305	62,595	69,218	76,513
1,000 - 3,000	224,520	264,723	311,918	346,758	383,449	423,864
3,000 - 5,000	158,628	187,032	220,376	244,991	270,914	299,468
5,000 - 10,000	687,476	810,577	955,087	1,061,768	1,174,115	1,297,865
10,000 - 15,000	284,210	335,101	394,842	438,946	485,391	536,550
15,000 - 20,000	63,406	74,760	88,088	97,927	108,289	119,702
20,000 - 30,000	7,768	9,159	10,792	11,998	13,267	14,666
30,000 - 50,000	8,322	9,812	11,561	12,853	14,213	15,711
50,000 - 75,000	22,952	27,062	31,886	35,448	39,199	43,330
75,000 - 100,000	8,714	10,274	12,106	13,458	14,882	16,451
> 100,000	27,578	32,516	38,313	42,593	47,100	52,064
TOTAL	**1,941,412**	**2,289,046**	**2,697,137**	**2,998,404**	**3,315,666**	**3,665,132**

Table 21 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity:**

Passenger Vessels (US$) – (3 of 4)

GRT	2015	2016	2017	2018	2019	2020	2021
< 200	426,818	471,472	508,504	548,268	588,943	632,513	681,892
200 - 400	265,888	293,705	316,774	341,546	366,884	394,026	424,787
400 - 600	156,984	173,408	187,028	201,654	216,614	232,639	250,801
600 - 1,000	84,547	93,393	100,728	108,605	116,662	125,293	135,074
1,000 - 3,000	468,371	517,372	558,009	601,645	646,279	694,091	748,277
3,000 - 5,000	330,913	365,533	394,244	425,074	456,609	490,389	528,672
5,000 - 10,000	1,434,144	1,584,185	1,708,615	1,842,227	1,978,898	2,125,295	2,291,213
10,000 - 15,000	592,889	654,918	706,359	761,595	818,096	878,619	947,211
15,000 - 20,000	132,271	146,110	157,586	169,909	182,514	196,016	211,319
20,000 - 30,000	16,206	17,901	19,307	20,817	22,361	24,016	25,890
30,000 - 50,000	17,360	19,177	20,683	22,300	23,955	25,727	27,735
50,000 - 75,000	47,880	52,889	57,043	61,504	66,067	70,955	76,494
75,000 - 100,000	18,178	20,080	21,657	23,351	25,083	26,939	29,042
> 100,000	57,531	63,550	68,541	73,901	79,384	85,256	91,912
TOTAL	**4,049,980**	**4,473,693**	**4,825,079**	**5,202,395**	**5,588,350**	**6,001,773**	**6,470,319**

Table 21 - **Vessel Operating Cost Losses If Hydrographic Services Suspend Activity:**

Passenger Vessels (US$) – (4 of 4)

GRT	2022	2023	2024	2025	2026	2027	2028
< 200	724,124	768,792	816,028	865,975	918,781	974,603	1,033,607
200 - 400	451,096	478,922	508,348	539,462	572,358	607,133	643,889
400 - 600	266,334	282,763	300,136	318,507	337,929	358,460	380,162
600 - 1,000	143,440	152,288	161,645	171,539	181,999	193,057	204,745
1,000 - 3,000	794,621	843,638	895,473	950,282	1,008,229	1,069,486	1,134,234
3,000 - 5,000	561,415	596,046	632,669	671,392	712,333	755,612	801,358
5,000 - 10,000	2,433,119	2,583,205	2,741,923	2,909,748	3,087,181	3,274,748	3,473,006
10,000 - 15,000	1,005,876	1,067,923	1,133,539	1,202,919	1,276,272	1,353,814	1,435,776
15,000 - 20,000	224,407	238,250	252,888	268,367	284,731	302,031	320,316
20,000 - 30,000	27,494	29,190	30,983	32,880	34,885	37,004	39,245
30,000 - 50,000	29,453	31,270	33,191	35,223	37,371	39,641	42,041
50,000 - 75,000	81,232	86,242	91,541	97,144	103,068	109,330	115,949
75,000 - 100,000	30,840	32,743	34,755	36,882	39,131	41,508	44,021
> 100,000	97,605	103,626	109,993	116,725	123,843	131,367	139,320
TOTAL	**6,871,057**	**7,294,897**	**7,743,112**	**8,217,045**	**8,718,109**	**9,247,794**	**9,807,669**

Table 22 - **Value Of Passenger Time Losses If Hydrographic Services Suspend Activity (US$) – (1 of 4)**

GRT	2003	2004	2005	2006	2007	2008
< 200	15,132	33,500	55,880	82,959	102,344	126,161
200 - 400	8,106	17,945	29,934	44,440	54,824	67,582
400 - 600	3,550	7,859	13,109	19,461	24,009	29,596
600 - 1,000	1,698	3,759	6,270	9,308	11,483	14,156
1,000 - 3,000	7,570	16,760	27,957	41,505	51,203	63,119
3,000 - 5,000	6,488	14,365	23,961	35,573	43,885	54,097
5,000 - 10,000	23,579	52,201	87,075	129,272	159,479	196,591
10,000 - 15,000	6,972	15,434	25,746	38,222	47,153	58,126
15,000 - 20,000	1,892	4,189	6,987	10,373	12,797	15,775
20,000 - 30,000	17	38	64	95	117	144
30,000 - 50,000	81	179	299	444	548	676
50,000 - 75,000	1,355	3,000	5,004	7,429	9,164	11,297
75,000 - 100,000	20	44	74	110	136	167
> 100,000	1,540	3,410	5,689	8,446	10,419	12,844
TOTAL	**78,000**	**172,684**	**288,048**	**427,636**	**527,562**	**650,331**

Table 22 - **Value Of Passenger Time Losses If Hydrographic Services Suspend Activity (US$) – (2 of 4)**

GRT	2009	2010	2011	2012	2013	2014
< 200	155,405	191,295	235,316	273,111	312,640	357,756
200 - 400	83,248	102,473	126,054	146,300	167,475	191,643
400 - 600	36,456	44,875	55,202	64,069	73,342	83,926
600 - 1,000	17,437	21,464	26,403	30,644	35,079	40,142
1,000 - 3,000	77,750	95,706	117,730	136,639	156,416	178,988
3,000 - 5,000	66,637	82,027	100,903	117,109	134,059	153,405
5,000 - 10,000	242,161	298,086	366,683	425,577	487,173	557,476
10,000 - 15,000	71,600	88,135	108,417	125,831	144,043	164,829
15,000 - 20,000	19,432	23,919	29,424	34,150	39,092	44,734
20,000 - 30,000	178	219	269	312	357	409
30,000 - 50,000	832	1,024	1,260	1,463	1,674	1,916
50,000 - 75,000	13,916	17,129	21,071	24,456	27,995	32,035
75,000 - 100,000	206	254	312	362	415	475
> 100,000	15,821	19,475	23,956	27,804	31,828	36,421
TOTAL	**801,079**	**986,081**	**1,213,002**	**1,407,826**	**1,611,588**	**1,844,154**

Table 22 - **Value Of Passenger Time Losses If Hydrographic Services Suspend Activity (US$) – (3 of 4)**

GRT	2015	2016	2017	2018	2019	2020	2021
< 200	409,237	467,964	522,486	583,174	644,079	711,206	788,320
200 - 400	219,220	250,679	279,886	312,395	345,021	380,980	422,288
400 - 600	96,002	109,779	122,569	136,806	151,093	166,841	184,931
600 - 1,000	45,918	52,507	58,625	65,435	72,268	79,800	88,453
1,000 - 3,000	204,744	234,125	261,403	291,765	322,237	355,821	394,401
3,000 - 5,000	175,480	200,662	224,041	250,064	276,179	304,964	338,030
5,000 - 10,000	637,696	729,207	814,167	908,734	1,003,639	1,108,241	1,228,404
10,000 - 15,000	188,548	215,605	240,725	268,686	296,747	327,674	363,203
15,000 - 20,000	51,171	58,514	65,332	72,920	80,536	88,929	98,571
20,000 - 30,000	468	535	597	666	736	813	901
30,000 - 50,000	2,192	2,506	2,798	3,123	3,449	3,809	4,222
50,000 - 75,000	36,645	41,903	46,786	52,220	57,674	63,684	70,590
75,000 - 100,000	543	621	693	774	854	944	1,046
> 100,000	41,662	47,641	53,191	59,369	65,570	72,404	80,254
TOTAL	**2,109,525**	**2,412,249**	**2,693,300**	**3,006,130**	**3,320,082**	**3,666,110**	**4,063,612**

Table 22 - **Value Of Passenger Time Losses If Hydrographic Services Suspend Activity (US$) – (4 of 4)**

GRT	2022	2023	2024	2025	2026	2027	2028
< 200	860,718	939,544	1,025,355	1,118,756	1,220,401	1,331,003	1,451,334
200 - 400	461,070	503,296	549,263	599,296	653,746	712,993	777,452
400 - 600	201,915	220,406	240,537	262,447	286,292	312,238	340,466
600 - 1,000	96,576	105,421	115,049	125,529	136,934	149,344	162,846
1,000 - 3,000	430,623	470,060	512,992	559,720	610,574	665,909	726,112
3,000 - 5,000	369,074	402,874	439,670	479,720	523,305	570,731	622,329
5,000 - 10,000	1,341,219	1,464,050	1,597,766	1,743,307	1,901,697	2,074,043	2,261,550
10,000 - 15,000	396,559	432,877	472,412	515,445	562,276	613,234	668,674
15,000 - 20,000	107,624	117,481	128,210	139,889	152,599	166,429	181,475
20,000 - 30,000	983	1,073	1,172	1,278	1,394	1,521	1,658
30,000 - 50,000	4,610	5,032	5,491	5,992	6,536	7,128	7,773
50,000 - 75,000	77,072	84,131	91,815	100,178	109,280	119,184	129,959
75,000 - 100,000	1,142	1,246	1,360	1,484	1,619	1,766	1,925
> 100,000	87,625	95,649	104,385	113,894	124,242	135,501	147,752
TOTAL	**4,436,810**	**4,843,141**	**5,285,478**	**5,766,935**	**6,290,895**	**6,861,025**	**7,481,304**

Table 23 presents the total cumulative impact of hydrographic services cessation over the period of evaluation.

Table 23 - **Value Of Impact If Hydrographic Services Suspend Activity (US$)**

Years	Vessel Operating Costs					Passenger Time Savings	**Total**
	Bulk	General Cargo	Container	Passengers	Total		
2003	101,717	50,725	52,224	258,609	463,275	78,000	541,275
2004	212,163	105,739	108,759	540,126	966,786	172,684	1,139,470
2005	332,810	165,861	170,437	846,772	1,515,879	288,048	1,803,928
2006	468,452	234,126	240,585	1,179,283	2,122,446	427,636	2,550,082
2007	558,114	279,552	287,288	1,393,532	2,518,487	527,562	3,046,048
2008	664,703	333,710	342,969	1,645,423	2,986,805	650,331	3,637,136
2009	791,398	398,272	409,351	1,941,412	3,540,433	801,079	4,341,512
2010	941,974	475,234	488,488	2,289,046	4,194,742	986,081	5,180,823
2011	1,120,919	566,976	582,828	2,697,137	4,967,860	1,213,002	6,180,862
2012	1,259,001	638,519	656,415	2,998,404	5,552,338	1,407,826	6,960,164
2013	1,404,680	714,038	734,131	3,315,666	6,168,515	1,611,588	7,780,103
2014	1,567,066	798,452	821,013	3,665,132	6,851,664	1,844,154	8,695,817
2015	1,748,081	892,815	918,148	4,049,980	7,609,024	2,109,525	9,718,549
2016	1,946,113	995,892	1,023,953	4,473,693	8,439,651	2,412,249	10,851,900
2017	2,115,897	1,084,926	1,115,278	4,825,079	9,141,181	2,693,300	11,834,481
2018	2,300,258	1,181,842	1,214,665	5,202,395	9,899,160	3,006,130	12,905,290
2019	2,487,719	1,280,265	1,315,608	5,588,350	10,671,942	3,320,082	13,992,024
2020	2,690,309	1,386,839	1,424,890	6,001,773	11,503,811	3,666,110	15,169,921
2021	2,920,280	1,507,842	1,548,967	6,470,319	12,447,408	4,063,612	16,511,021
2022	3,121,346	1,614,136	1,657,911	6,871,057	13,264,451	4,436,810	17,701,261
2023	3,334,683	1,726,992	1,773,573	7,294,897	14,130,144	4,843,141	18,973,286
2024	3,560,990	1,846,786	1,896,339	7,743,112	15,047,228	5,285,478	20,332,706
2025	3,801,009	1,973,919	2,026,617	8,217,045	16,018,590	5,766,935	21,785,525
2026	4,055,519	2,108,809	2,164,836	8,718,109	17,047,273	6,290,895	23,338,168
2027	4,325,344	2,251,899	2,311,451	9,247,794	18,136,488	6,861,025	24,997,513
2028	4,611,350	2,403,659	2,466,939	9,807,669	19,289,617	7,481,304	26,770,921

The Philippines currently spends approximately US$ 3.5 million annually in hydrographic service provision. It follows that if the hydrographic activity is suspended, the economy will “save” the current hydrographic investment (US$ 3.5 million per year). But for such a scenario, the economy will also progressively suffer additional costs in terms of increased vessel operating costs and passenger time costs. These costs are estimated on Table 23 above, for example US$ 541,275 for the year 2003, rising to US$ 26,770,921 for the year 2028.

Conversely, if the current hydrographic investment (of US$ 3.5 million annually) is maintained, the cost to the economy will be US$ 3.5 million annually when compared to the above scenario. However, the economy will also benefit because it will not incur vessel operating costs and

passenger time costs as shown on the table, for example, US$ 541,275 for the year 2003, rising to US$ 26,770,921 for the year 2028.

According to this scenario, it is also possible to evaluate the sustainability of hydrographic service annual expenditure for the Philippines. Utilizing these results, the annual expenditure flow of US$ 3.5 million represents a Net Present Value (NPV) at a 12 percent discount rate of US$ 19.2 million, and an Internal Rate of Return (IRR) of 23.6 percent. This means that the investment (of US$ 3.5 million annually) in hydrographic services represents a sound expenditure indeed, with a considerable economic return in terms of vessel operating and passenger time savings.

The assessment has also been utilized to estimate the level of expenditure in hydrographic services that can be sustained to achieve an IRR of 12 percent for the benefit analysed. An IRR of 12 percent is considered by the international community to represent an acceptable return on this type of investment. The results of the study indicate that hydrographic services expenditure can be increased to approximately US$ 5.9 million, and still maintain an internationally acceptable IRR (12 percent) for the investment made. This represents an increase of nearly 70 percent over and above the current expenditure level. This means that the benefits to commercial shipping from existing hydrographic services in the Philippines are significant enough to allow expenditure to be increased to nearly US$ 6 million, and still return an acceptable IRR.

It is also important to note that the analysis is considered to be conservative, and only assumes relatively small incremental impacts in vessel operating and passenger time costs and savings of a matter of minutes over voyages often of many hours. The scope of the study has been restricted by the limited data available. There appears to be the potential for much greater savings in specific cases. For example, international shipping entering the Sulu Sea from the Macassar Strait and traveling north towards Luzon is unable to sail directly north by the shortest route partly because of inadequate hydrographic surveys, but instead must sail west to enter the China Sea south of the Palawan Islands, and then north east to Luzon. This extends the voyage by some 150 miles, or up to 10 hours, probably for thousands of ships each year. Data does not currently exist to assist an analysis of this potentially dramatic improvement to maritime traffic. This is an aspect of regional hydrographic services that is worthy of further study by APEC, with the intention to identify routes that may deliver economic benefits resulting from regional co-operation in surveying and charting.

In addition, not all of the benefits from improved efficiency of inter-port voyages will flow to the Philippine economy. Many of the ships will be ships in transit, and the benefits will flow to the economies of the ports of departure and destination within the region. It is suggested that APEC might research ways to collate data on transit voyages on a regional basis so that these potential benefits can be defined. It is also important to emphasize that vessel navigation-related benefits only represent a fraction of the cumulative benefits to a given APEC economy from hydrographic services. Other significant benefits relate to the commercial fishing sector, environmental protection, sovereign and economic zone maintenance, national defence, coastal resource management, mineral exploration, emergency response, and recreational fishing and boating.

In summary, the analysis indicates the tremendous economic benefits to the Philippine economy from the current expenditure in hydrographic services. It also indicates that by considering only the sole navigation-related benefit, representing a fraction of the total benefits, additional hydrographic services expenditure can be justified to further improve the hydrographic services.

3 EXTRAPOLATION TO OTHER APEC ECONOMIES

3.1 Introduction

The previous section presented the economic impacts from vessel-operating and passenger-time voyage savings as a result of varying investment levels in hydrographic services for the selected APEC economy (the Philippines). It reveals that the impacts are considerable; increased or decreased hydrographic services expenditure greatly affects vessel voyage efficiency and corresponding costs. The analysis of this single benefit alone reinforces the considerable economic viability and importance of hydrographic services to the Philippine economy, and highlights the potential for significant, additional benefits through increased expenditure. The economic benefits of hydrographic services and economic justification to increase investment for the Philippines have been demonstrated from this one benefit alone.

The objective of Section 3 of this report is to relate the results of the Philippine case study to other APEC economies that responded to the hydrographic questionnaire, in order to assess their relative economic sensitivity to the impact of hydrographic services on their economy. The analysis produced the possibility to classify (cluster) APEC economies responding to the questionnaire into three broad classifications;

(i) Substantial Impact (High sensitivity to increased investment in hydrographic services);

(ii) Moderate Impact (Moderate sensitivity to increased investment in hydrographic services);

(iii) Low Impact (Low sensitivity to increased investment in hydrographic services)

As shown in the previous section, the methodology utilized to develop the economic assessment for the Philippine case is both extensive and complex. It requires significant input data, including;

(i) detailed voyage data for a range of vessel categories and size classifications;

(ii) vessel operating cost data, which varies for each economy; and

(iii) variable economic growth rates.

To complete an analysis in similar detail for other APEC economies therefore, would involve individual assessment of each economy, as each possesses markedly variable and unique base parameters. This is beyond the scope of this project, but is a clear recommendation of the assessment. Furthermore, once assessment of individual economies has been completed, then the assessment could consider regional effects.

However, a preliminary assessment has been performed in order to identify a relative measure of the impact between the different APEC economies that responded to the questionnaire. This has been accomplished by identifying two sets of key indicators, which are used to estimate the relative economic sensitivity of the impacts benefit-wise for each of the APEC economies. These two parameter sets are; (i) navigational parameters which relate to physical and infrastructure characteristics for each economy; and (ii) economic parameters, which consider the relative impacts to the national economies.

These are further described as follows;

3.2 Navigation Indicators

As outlined above, the assessment considers the economic impact of reducing or extending the time taken for each voyage due to the quality of hydrographic services. From a navigational sense, this would depend on a number of key factors, but all of which relate to the length of voyage during which hydrographic services influence. For example, for a vessel sailing through open ocean, the impact of hydrographic services would be relatively minimal, whereas for a vessel sailing around the coast, the impact would be greater. Also affecting the voyage and the reliance on hydrographic services is the relative complexity of the seabed, on which the dependency of hydrographic services would increase. From this, therefore, there are a number of key indicators that provide an indication of the length of voyage influenced by hydrographic services, the "navigational complexity", and therefore the reliance on the hydrographic services. These are summarized as follows;

(i) Length of coastline – coastal waters are generally shallow in nature, and contain hazards to navigation which must be surveyed and published in charts. The longer the coastline, then the greater the task facing the hydrographic services;

(ii) Continental shelf – which is shallow and potentially dangerous to navigation. The greater the width of the continental shelf, the greater the task facing hydrographic services;

(iii) Archi-pelagic Waters – which are waters within island groups, which represent a special case of wide shallow seas and complex coastlines, which increase the task facing hydrographic services and for which good charts are essential; and

(iv) Ports – the production of charts for ports requires a higher degree of accuracy, and therefore an increasing number of ports increases the relative complexity of navigation. The restricted navigation of ports and high volume of traffic requires that surveys and charts be developed to much higher specifications and revised at more frequent intervals, which increases the task of the hydrographic services.

The hydrographic audit provides data about the differing geographic circumstances of the APEC economies. The Philippines has a long coastline, extensive areas of shallow water, an archi-pelagic geography and many ports. By contrast, Singapore has a relatively short coastline, a narrow continental shelf, one major port and practically no archi-pelagic waters. The impact on navigation therefore of increasing hydrographic services investment would be greater from a navigational sense in the Philippines than in Singapore.

3.3 Economic Indicators

The economic benefits in this study flow from improved efficiency of shipping, measured in voyage time savings, the number of vessel voyages, vessel cargo values, and passenger movements, represented by the following primary indicators;

(i) Volume of maritime foreign trade – from which is derived an indication of the number of vessel voyages. When these are aggregated, it provides an indication of the total time saved;

(ii) Maritime foreign trade as share of GPD – indicating the relative economic importance of international shipping;

(iii) Per capita GDP – indicating the value of passenger time savings; and

(iv) Volume of maritime domestic trade – indicating the relative economic importance of domestic shipping.

The economic impact can be again illustrated using the example of Singapore and the Philippines. Singapore has a relatively high dependence on foreign trade and high per capita GDP. In comparison, the Philippines has a lower dependence on foreign trade and lower GDP.

3.4 Scoring System

In order to infer the relative importance of each indicator to the various economies responding to the questionnaire, each economy has been assessed in terms of each of the navigational and economic indicators. A simplified "scoring system" has been utilized, whereby each economy has been assessed for each elementary indicator according to the following three relative levels;

(i) A score of 3 points is given where there is considered to be a high impact;

(ii) A score of 2 points is given where there is considered to be a medium impact;

(iii) A score of 1 point is given where there is considered to be a low impact.

The process of comparison is completed by summing up the value of all the indicators for each economy to provide an overall "impact score". The results of this are shown on Table 24. Where data was lacking, professional judgment was applied.

Table 24 - **Elementary Indicators Score Structure**

Economy	Economic Factors					Navigational Factors					Overall Impact Indicator
	Foreign Trade	Foreign Trade/GDP	Domestic Trade/GDP	Per Capita GDP	Total	Ports	Coastline	Continental Shelf	Archi-Pelagic Waters	Total	
AUS	M	S	S	L	7	M	L	L	S	9	**16**
CAN	L	M	S	L	9	M	L	L	S	9	**18**
CHL	S	S	S	M	5	M	L	M	S	8	**13**
HKG	L	L	S	L	10	S	S	S	S	4	**14**
IND	M	S	L	S	7	M	L	L	L	11	**18**
JAP	L	S	M	L	9	M	M	M	M	8	**17**
KOR	L	M	S	M	8	M	M	S	S	6	**14**
MEX	M	M	M	M	8	M	M	M	S	7	**15**
NZE	S	S	M	L	7	S	M	M	S	6	**13**
PER	S	S	S	S	4	S	S	S	S	4	**8**
PHI	S	M	L	S	7	L	L	L	L	12	**19**
SIN	L	L	S	L	10	S	S	S	S	4	**14**
USA	L	S	S	L	8	M	L	L	S	9	**17**

Legend: L (Large Impact) = 3 points, M (Medium Impact) = 2 points, S (Small Impact) = 1 point.

3.5 Weighting

The overall impact indicators have then been weighted according to the status of hydrographic surveying and charting in each economy, as reported in the hydrographic questionnaire. This weighting represents the size of the outstanding hydrographic task. Thus economies whose surveying and charting is well advanced received a low weighting, and those that have large outstanding areas for surveying and charting receive a high rating. This represents the relative effect of improving hydrographic services, in that economies which still have lots to do, will benefit more than those whose task is well advanced. The weighting utilized is as follows;

(i) Where little hydrographic services improvement is considered necessary: 1 point;

(ii) Where medium hydrographic service improvement is necessary: 2 points;

(iii) Where large improvements are considered necessary: 3 points.

Table 25 illustrates the results of the weighting system developed, and the total weighted score for each economy.

Table 25 - **Relative Impact Of Hydrographic Services Among APEC Economies**

Economy	Factor Scores			Weighting System	Final Rating
	Economic	Navigational	Total		
PHI	7	12	19	3	57
IND	7	11	18	3	54
MEX	8	7	15	3	45
CAN	9	9	18	2	36
USA	8	9	17	2	34
AUS	7	9	16	2	32
NZE	7	6	13	2	26
CHL	5	8	13	2	26
JAP	9	8	17	1	17
PER	4	4	8	2	16
HKG	10	4	14	1	14
KOR	8	6	14	1	14
SIN	10	4	14	1	14

3.6 Other Considerations

Two other matters have been considered in coming to a view about the impact of increased investment in hydrographic services in different economies.
These are summarized as follows;

(i) The identification of critical issues and problems in the responses to the questionnaire is to some extent subjective, reflecting the financial realities and service expectations of individual economies. Some well-developed economies

have the goal of total hydrographic coverage of the EEZ to the most comprehensive IHO standards, with highly developed navigation services.

Other less well-developed economies have more restricted goals, reflecting the current state of economic development and priorities. This means that a certain status of surveying and charting might be regarded as acceptable in a developing economy, but not acceptable in a developed economy;

(ii) We have also observed that some economies with relatively large hydrographic budgets regard the size of the budget as a critical issue, whereas other economies with relatively small hydrographic budgets have not reported the value of the budget as an issue.

These issues have been taken into consideration during the evaluation.

3.7 Evaluation

As shown on Table 25, the results of the analysis have revealed that the APEC economies that responded to the questionnaire can be broadly classified into the following three groups;

(i) Substantial Impact – This group shows the economies where the benefits associated with increased hydrographic services expenditure are considered to be substantial. Economies: Philippines, Indonesia, and Mexico;

(ii) Medium Impact – Where the impact of increased hydrographic service expenditure is considered to be medium. Economies: Canada, Australia, USA, New Zealand, Chile, Japan and Peru;

(iii) Low Impact – Representing economies in which increased expenditure on hydrographic services would seem to offer relatively less benefit. Economies: Hong Kong, Korea and Singapore.

It must be remembered that the extrapolation process has not taken into account the actual investment that economies presently make in hydrography. Therefore the grouping in itself does not suggest that all members of Group 1 and 2 for example should necessarily increase their present investment in hydrographic services. It rather takes account of the responses (where they were received) of the economies' hydrographic authorities as to whether in their opinion the present rates of funding are sufficient.

Importantly, when interpreting the implications of these responses, it needs to be remembered that such an opinion is highly dependent on the aspirations and social norms of the economy in question. Consequently the response in investment terms will mean very different things between for example the extremes of a developing economy and a developed economy.

Rather these groupings indicate the importance of hydrography for an economy. In other words they indicate the relative potential within an economy for generating economic gain by investing in hydrography. Countries in Group 1 should see hydrographic services as potentially providing major value to their economies. For those in Group 2 the potential benefit of increased investment is smaller. While those in Group 3 should see hydrographic services as important but possibly not as critical an issue for economic development, because their present level of investment seems appropriate to their needs.

Also the analysis of the Philippines case conducted within this report provides a valuable benchmark for economies to gauge their investment requirement. In the case of the Philippines it is clear from the economic analysis that a minimum investment of the order of US$ 5.9 million per annum is justified based purely on the benefits to shipping efficiency. While additional investment on and above US$ 6 million per year is clearly justifiable when benefits to ships in transit and other non-transport sector benefits of hydrographic services are taken into account.

Other economies of the Group 1 category can use this benchmark to provide an indicative gauge of their needs by considering the length and difficulty of their coastline and economic status of their economy in relation to that of the Philippines. Because of the evident limitations in this extrapolation of the Philippine results, we repeat our recommendation that a full hydrographic audit and economic assessment should be a priority for economies in the top tier grouping, and an important management tool for other economies.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Conclusions of the economic assessment are summarized as follows;

(i) The economic assessment demonstrates that the provision of hydrographic services has a significant and positive economic impact to the efficient and safe performance of the maritime transport sector in the selected APEC case study economy of the Philippines;

(ii) Based on the economic assessment, the entire national expenditure for hydrographic service provision can be justified from the benefits accruing from only one solitary benefit[8] of hydrographic services. The economic benefits from this single benefit alone when compared with the annual hydrographic services expenditure of US$ 3.5 million, are sufficient to achieve a Net Present Value (NPV) at a 12 percent discount rate of US$ 19.2 million and an Internal Rate of Return (IRR) of 23.6 percent;

(iii) The assessment of this one benefit also indicates that hydrographic service investment can be increased by nearly 70 percent from the current investment level to US$ 5.9 million and still achieve an internationally acceptable Internal Rate of Return (IRR) of 12 percent;

(iv) The cumulative benefits of hydrographic services to the Philippine economy are considerably higher than even this estimate, since the numerous other benefits accruing from hydrographic service provision have not been included in the assessment. These include benefits relating to fisheries, mineral exploration, national defence, delineation and maintenance of sovereign- and economic-zones, search and rescue, environmental protection, sustainable resource management and maritime recreational uses;

(v) There is sound economic justification that the Philippine economy can benefit significantly from progressive and carefully planned additional investments in hydrographic services;

(vi) An initial qualitative assessment performed in order to infer relative economic sensitivity to varying hydrographic service investment levels in economies responding to the questionnaire has resulted in a broad classification of three major groupings. These include APEC economies where the benefits from increased investment are considered to be of; (i) substantial value (Philippines, Indonesia and Mexico); (ii) medium value (Canada, Australia, USA, New Zealand, Chile, Japan and Peru, and; (iii) of lower value (Hong Kong, Korea and Singapore).

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[8] Vessel-operating and passenger-time savings / costs accruing from voyage time savings / losses associated with vessel movements.

4.2 Recommendations

The following actions are recommended to supplement this initial assessment;

(i) A similar economic assessment, incorporating the model developed herein, should be performed for each of the other APEC economies in order to assess both current expenditure levels and benefits, and where appropriate, to define future expenditure level. This should be a priority for economies in the top tier grouping;

(ii) Where necessary, additional and more detailed hydrographic and economic assessment should be performed for APEC economies in order to further refine optimum investment levels and strategies for sector development;

(iii) Consideration should also be made to initiate further studies in order to evaluate the cumulative economic benefits of improving hydrographic services of regional sea lanes, with the objectives of developing improvement strategies, identifying appropriate levels of investment, and defining options for future co-operative hydrographic activity.

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