BENEFIT COST ASSESSMENT
OF THE
CANADIAN HYDROGRAPHIC SERVICE

Intercambio Limited

by:

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1.0 INTRODUCTION

1.1 GENERAL BACKGROUND

The Canadian Hydrographic Service is a department within the Federal Government, under the jurisdiction of the Department of Fisheries and Oceans. The Canadian Hydrographic Service (CHS) is primarily concerned with the measurement, collection and publication of hydrographic data and marine navigation information of Canada's navigable waters and adjacent international waters. This information is essential for the safe, orderly and efficient conduct of commercial, recreational and defence shipping and related activities. The CHS also has a shared responsibility, with the Department of Energy, Mines and Resources for integrated geophysical/hydrographic surveys of the continental margin and inland seas. Such surveys are essential to obtain a comprehensive description of the extent of the continental land mass and for the control, management and development of mineral and petroleum resources in these areas.
The CHS publishes all of this data in a variety of forms including,

a) nautical charts
b) Sailing Directions
c) Small Craft Guides
d) Tide and Current Tables
e) Water Level Publications
f) Territorial Sea and Fishing Zone Charts
g) Natural Resource Maps, including bathymetry, gravity and magnetic maps
h) General Bathymetric Chart of the Oceans.

This information is distributed to the public at a cost which recoups the cost of the actual printing of the publications, the paper used and the distribution of the publications.
Increasingly, more government programs and activities are falling under scrutiny and evaluation. Departments such as the CHS need to provide justification for their existence and the continuance of) public funding of the service.

To date, several inhouse audit reviews have been performed on the CHS. However, no comprehensive assessment of the benefits and costs of the service has been made. The CHS commissioned this study to analyze the benefits, costs and net benefits of the nautical charting service that they provide.

1.2 OBJECTIVES The overall objective of the study is to provide an assessment and evaluation of the benefits and costs of the Canadian Hydrographic Service activities.
The specific objectives are:
1. To identify the effects of the Canadian Hydrographic Service's charts and related publications on Canadian consumers and producers.
2. To quantify the overall benefits and costs, and the benefitcost ratios from the production of nautical charts and related services.

1.3 METHODS

The procedure for assessing the benefits and costs of the Canadian Hydrographic Service consisted of three integrated and ongoing tasks. The first task involved using personal expertise, reviewing literature, interviewing experts throughout various marine and related industries, and studying secondary data to identify and evaluate the overall effectiveness and impact of the Canadian Hydrographic Service's activities. The second task involved the development of a conceptual framework and analytical model to measure both quantitatively and qualitatively specific impacts of the nautical charting service on user, producer and consumer actions, and on the activities identified in the first task. The third task then involved the quantification of both benefits and costs, and an overall assessment of the economic impact of these charting activities.
During the course of the study, two general data sources were utilized:

1. Secondary data on commercial marine shipping, commercial fishing, arctic shipping and resupply, recreational boating, national defense (budgets, prices, quantities, volumes, etc.) were gathered from such sources as Statistics Canada, Government of Canada Departments, trade associations, etc., and analyzed. An environmental damage assessment model was run. As well, a review of the relevant literature on demand for transportation, fish products and various commodities was conducted. A list of references used is provided in Appendix D.

2. Personal interviews with Canadian Hydrographic Service officials, Coast Guard officials, National Defense officials, various officials in trade associations and companies affected by the production of nautical charts, etc. were conducted to gather information on the Canadian Hydrographic Service's activities including benefits and costs, likely responses and occurrences in the absence of

nautical charts. A list of the interviewees in located in Appendix A.

2.0 RESEARCH PROCEDURES

2.1 ANALYTICAL AND CONCEPTUAL FRAMEWORK

To measure the impact of the CHS activities, the actual situation which currently exists for each of the users of nautical charts was identified. This was compared to the potential situations which could exist for each of the user areas, had the CHS activities never been undertaken. To assume that the CHS activities had never been undertaken, would allow cumulative adjustments and impacts to have occurred prior to 1989, when the benefits were measured. This procedure is different than assuming that the production of charts would be stopped only in 1989 and provides a more accurate assessment of the benefits and costs of the charting service.[1]

It was also recognized that some sort of local area charting would have evolved if the government had not provided the charting service. In this context, we have attempted to estimate the impacts of no government charting but with changes in some user responses to incorporate some local charting to protect their own level of service and therefore sales in their own local area.

The research procedures essentially involve two sets of activities. These are:

1. Conceptualizing and simulating the changes in practices and impacts in activities such as commercial shipping, commercial fishing, national defense and recreational boating, and in areas such as arctic development and environmental issues that would occur in the absence of the Canadian Hydrographic Service, and
2. Measuring benefits and costs of the impacts of these changes in practices and volumes.

2.2 AREAS OF IMPACT

From discussions with members of the CHS and other marine groups who use nautical charts, it has been determined that the charts and

1 In our procedure we assume that changes in practices have been ongoing and have had enough time to reach their full impact by 1989. For example, declines in volumes of shipping and the increased costs to ship by vessel are assumed to be

fully adjusted by 1989, rather than starting to adjust in that year.

publications of the CHS have a significant impact in the following areas:

1. Commercial shipping
2. Commercial fishing
3. Recreational boating
4. National defense
5. Arctic development
6. Environment

Essentially, charts are used to identify water depths so that navigators can maintain enough water under the ships to ensure that the vessels do not ground or come into contact with the bottom. Charts are further used for navigational purposes, to establish routes, and to confirm positions. Before the Canadian Hydrographic Service was established, the British Admiralty was responsible for surveying and charting unknown waters. Indeed, many of the CHS's charts are based on these first editions. However, to survey these areas, a ship had to carefully pick its way into the area, then send out launches with men who would measure the water depths with plumb lines. These surveys would then be drawn up into a more comprehensive chart.

Today, there are still parts of Canadian waters, especially in the Arctic, that are not surveyed or have not been completely surveyed. In these areas, ships travel carefully and if necessary, take their own depth measurements in dangerous areas. For example in the 1950's during the Coast Guard's annual East Arctic resupply, the Coast Guard ships would come into an area, then send out people in launches with echosounders. The men would use the echosounders to take depth readings so that the ship could get safely to shore to unload the cargo for the northern communities, and North Warning and Dew Line sites.

Changes in Activities and Impacts

In order to assess the potential changes throughout the marine environment that would occur in the absence of the present Canadian Hydrographic Service's activities, it is essential to understand the nature of the present activities of the various users of the nautical charts and related publications. These activities can then be assessed to measure the impacts that would occur in performing these activities in the absence of charts. It is however, important to first develop a proposed counter factual scenario against which these impacts can be measured.

Counter Factual Scenario

Clearly the situation does not exist in present day where there is a great deal of marine traffic and no charts by which to navigate. Therefore, to quantify the benefits and costs of the CHS, a counter factual scenario was first developed to establish a base from which the current services of the CHS could be measured.

The counter factual scenario, developed through the many conversations and discussions with various industry authorities, was established as follows.

1. No publicly funded charting service exists.

This would not preclude private parties from charting a certain area to allow safe vessel passage to and from their region and thus maintain their commercial trade. However, there would be no government sponsored charting on a nation wide scale, as exists currently with the CHS. For example, it would be likely that major ocean ports would be charted by their respective port authorities. However the approach areas and smaller ports would not be charted.

2. Other navigation aids would still exist.

These other navigation aids would include the present day systems of loran and satellites which allow navigators to accurately pinpoint their position on the water's surface. As well, buoys and markers would continue to be used in known areas where shallow water or hazards are present under the surface. Without charts however, many of these hazards and shallow spots would remain undetected until a ship grounded or hit something under the water.Given the competitive nature in many areas of shipping, it is likely that these groundings would not be recorded and therefore other ships would hit the same hazard.

3. Increased use of pilots and/or experienced captains.

In the absence of charts, the pilots and captains with experience and a knowledge of how to travel through areas without damage to vessels by avoiding groundings or bottom contacts, would be in great demand by shipowners, the Coast Guard and the Maritime Forces.

The drydock, repair and downtime costs of a ship are very high, as will be discussed in the next section. A pilot or captain who could avoid these costs would be able to demand a greater salary to ensure a ship's safe passage and therefore result in higher costs to operate the ships.

4. Insurance system structured differently for liability.

a) Requirement for up-to-date charts.

At this time, up-to-date nautical charts are required on board commercial ships, for the areas in which they are traveling. Clearly, these laws would not exist in the absence of charts.

b) Liability for chart accuracy.

Currently, the CHS is responsible for the accuracy of their charts. If a private party were to assume the same responsibilities for charting as the CHS, they would then be -responsible for any damages caused through the use of a inaccurate chart produced by the private party. It is unreasonable to expect that a private party could or would assume this type of liability, given the potentially enormous costs of a damaged ship from a bottom contact. Therefore, it is more likely that any private charts that were issued would be "for informational purposes only and not subject to liability". Therefore, the legal liability issues would be different in the absence of charts.

5. Travel between ports.

Travel between ports would be impaired in varying degrees. Traveling between deep sea ports would not be a large problem because of the open water and relative freedom from bottom hazards. However, in areas such as the Maritime and West coastal waters as well as the Great Lakes and St. Lawrence areas, the travel between ports would be more hazardous.

a) Vessels Smaller, Lighter, Shallower

It is expected that in these types of areas, ships would have to travel in smaller vessels and in some cases be loaded lighter in order to have a shallower draft and thus a lower likelihood of striking the bottom or grounding.

b) Vessels Slower With Longer Routes

The ships would have to travel more slowly in unknown areas and would therefore take longer to reach their destinations. Furthermore, the ships would not likely look for shortcuts in their routes across unknown waters, thus leaving the potential for routes which are longer than necessary.

c) Night Travel

In the absence of charts, captains and pilots could have to rely more on sight of known landmarks for the navigation of difficult areas such as the Seaway. This means that travel through areas such as this,would likely be curtailed at night.

As the length of time increases to move the ships to and from their destinations for any or all of the above reasons, the operating costs increase for the overall trip.

6. Accident Rate Increase

As ships move about without a clear knowledge of what hazards and water depths lies under the hull, the risk of groundings (running aground) and bottom contacts (striking an obstacle) would increase significantly. The officials with whom we spoke, suggested that the accident rate could rise as much as 20% to 50% for most of the marine traffic. However, it is very likely that the accidents would be more severe since more bottom contacts and groundings would happen at any time and at any speed. Therefore, it is likely that the effect on insurance rates, cost of replacement of the vessels and repair costs for damages would be proportionately higher than simply the increase in the rate of accidents.

2.2.1 COMMERCIAL SHIPPING

Canada has a vast coast line and system of inland waterways which make the vessel transportation of goods and commodities a viable industry. Commercial shipping on the west coast, east coast and inland waterway is an enormous enterprise, with volumes in 1989 of 62,005,854 tonnes carried domestically and 239,386,791 tonnes carried internationally. Ships use, and are required by law to carry, the most recent and appropriately scaled nautical charts of the areas in which they are traveling.
However, in the counter factual scenario described above, ships would have to traverse the waters without a knowledge of the bottom depths. It has been proposed that the impact on commercial shipping in the absence of charts would be as follows.

1. Major Ports Charted.

It is very likely that the major ports would supply the ships coming in and out of the ports, with a chart of the port area that the port authorities would have had commissioned or would have charted themselves. However, it is likely that the ships would still have to get in and out of the approach areas without charts. It is unlikely that the smaller ports would be able to provide charts for the ships.

3. Increased use of pilots and experienced captains.

In the absence of charts, more ships would be required to use pilots and/or experienced captains to minimize the danger to the ships from grounding or bottom contacts. Currently, pilots are required on all international ships in Canada, 1, 2. However, in the Great Lakes, domestic ships do not require pilots if the captain has verified that he has enough experience in the areas in which he is traveling. At this time, the Canadian Shipowners Association (CSA) estimates that its members spend from $12,000,000 to $14,000,000 per year on pilotage costs. If all ships required pilots, the CSA estimates that the shipowners would pay an additional $ 15,000,000 per year for pilotage fees.

5. Seaway.

To ensure that the Seaway remains clear of sediment and obstacles, it is likely that a body such as the Seaway Authority would be responsible for maintaining a channel of a certain depth through dredging. The Seaway Authority could either have the channels privately surveyed, or they could respond to grounding reports from ships as they find each new hazard by chance. As well, the appropriate vessel channels would be defined with channel markers and buoys as they exist now. The known shallow and hazardous spots could be marked as they are discovered, either by survey (as above) or by chance.

6. Ports.

a) Travel in and around ports.

For many regions in Canada, the ports are important commercial centers. Therefore, it would seem likely that the port authorities would have private surveys of their ports and surrounding areas done to ensure that ships could safely use the port facilities. They would also have to establish a safe route which would allow ships to get to and from the port without damage. However, it is unlikely that this safe route would be completely charted. As well, it is unlikely that the smaller ports would be able to fund these charting activities.

This would impact the least on the deep sea ports such as Halifax, who have relatively safe waters coming into and out of the port. However, for ports such as Vancouver, where the Strait of Juan de Fuca and the Strait of Georgia are full of hazards, the impact of having no charts would be much greater. The inland ports would likely feel the greatest impact since they have relatively little open water in which to move without risk of damage.

b) Travel between ports.

As discussed above, travel between the ports would be impaired in varying degrees. The coastal and inland waters would be most affected by the absence of charts.

Vessels Smaller, Lighter, Shallower

In these areas, ships would have to travel in smaller vessels and in some cases be loaded lighter in order to have a shallower draft and thus a lower likelihood of striking the bottom or grounding.

It has been estimated that for a typical Great Lakes Seaway ship, the loss of one inch of draft would mean that in an average year, the ship would carry 100,000 tonnes less cargo, 3. Clearly the need to load the ships lighter would have a significant impact on the overall volume moved in each region.

Vessels Slower With Longer Routes

The ships would have to travel more slowly and with potentially longer routes. Some night travel might also be prevented since captains and pilots would rely more on sight of known landmarks for the navigation of areas such as the Seaway.

According to the CSA, CHS and Pilotage Authority officials, the Seaway has about 42 hours worth of difficult areas in the transit from Sept. Iles to Thunder Bay. If the ship went through these areas during the day there would be no slow down. However, if because of traffic and/or other factors on the Seaway, the ships were to go through these areas at night, the ships would likely have to anchor until daylight when the captains could again see to navigate the stretches by eye. This could also be a significant problem on the West coast throughout the coastal areas.

As the length of time increases to move the ships to and from their destinations, the operating costs increase for the overall trip. Exhibit 1 shows the typical daily vessel costs of ships that have average bunkering (fuel) costs. The typical ship in the Great Lake would be in the 40 (MDWT) (million dead weighttonne) size category. The officials from the Canadian Shipowners Association estimate that today's daily operating cost for a ship at sea, would be in the neighborhood of $25,000 (Cdn) and as much as $ 75,000 for new ships. For a ship in port, at current prices, the daily cost could be in the neighborhood of $15, 000 .

Exhibit 1. Daily Vessel Costs.
Source: Waters, W.G. et al, (1987), 4.

Accident Rate Increase

As the accident rate rises for ships in the absence of charts, the damage to commercial ships would increase as well. Some figures from the CSA indicate that a damaged ship would incur some or all of the following approximate costs:
Repair Costs
Down time - operating cost per day times the number of days the ship is not in service - $ 15,000 per day (in port cost)

Cargo rate - the freight rate that the ship could have been earning carrying cargo - $ I0/tonne for the bulk carriers
Drydock - $ 50,000 to enter the drydock

- $ 25,000 to $ 40,000 per day to be in drydock - can take 5 to 7 days to repair a hole

Repairs - $ 30,000 per plate to replace an 8'x 20' plate plus the framing under the plate

According to officials at the CSA, some recent repairs have cost from $250,000 (not including the down time and loss of cargo rates) up to $4-5 million.
With the increase in accidents, there would be an increase in the amount of oil spills and other hazardous material spills as more tankers ground and hit bottom. In Canada, polluters are responsible for cleanup costs and damages directly resulting from the spills, for example fishing income losses. These cleanup costs would be carried by the shipowners and/or such funds as the Ship-Source Oil Pollution Fund, as long as there was enough money in these funds to cover all events. Therefore, the costs associated with the increase in spills would result in a higher cost for the shipowners to transport hazardous materials 5,6,7 8

Insurance

As the accidents increase there would be an increase in the insurance or the replacement costs to the shipowners. The figures from the Statistics Canada Report on Shipping indicates that the annual insurance costs for ships are on average, just over 3% of the value of the ship.
From statistics provided by insurance industry representatives, these premiums would rise significantly in the events of an overall increase in accidents. As above, some shipping industry authorities have estimated that the accident rate could increase some 20% to 50% and would be more severe. In this case, the premiums could increase an estimated 40% to 100%, compared to the premium level with charts, (depending on the amount of damage and the number of ships insured at the same time by the same owner), 9, 10

Alternate Mode of Transportation

In the Great Lakes and St. Lawrence areas, shippers often have a choice to send the cargo by rail or by ship. For example, between December and March when the Seaway is frozen shut, the Canadian Wheat Board ships wheat to the lower St. Lawrence by rail. When the Seaway reopens, the wheat is sent by ship because it is a cheaper mode of transportation at current prices. Although it is possible, it is unlikely large volumes of bulk cargo would be shipped by truck because of the cost (see exhibit 2).

If the costs of shipping under the 'no chart' scenario rose to the point where rail and vessel freight rates were similar, shippers would then choose between the two modes of transportation to ship their goods. This availability of a similarly priced alternative mode could result in a further reduction in the volume of cargo being shipped by vessel. In exhibit 2, the relative costs to ship commodities by each of the transportation modes is illustrated. If the cost to ship the goods by water was to rise to a level near that of rail, shippers would be inclined to switch between the modes where appropriate, to ship their goods.

Exhibit 2. Relative Costs of Transportation By Truck, Rail and Water. Source: Waters, W.G. et al, (1987).

The results of the above scenario could be summarized as follows.

1. Decline in Efficiency.

a) Reduced size of vessel b) Reduced draft of vessel c) Reduced speed of vessel d) Increased route length

2. Affects volume of shipping.

3. Affects total cost of shipping.

b) Operating costs increase b) Insurance and/or replacement costs increase as accidents increase c) Pilotage d) Repair

All of these factors translate into an increase in the overall cost to ship cargo and a decrease in the overall volume of commercial shipping.

2.2.2 COMMERCIAL FISHING

Commercial fishermen use nautical charts for several purposes.

a) fish location and species selection b) navigation c) safety from underwater dump sites and other hazards

Without the use of charts, fishermen would experience the following impacts.

1. Decreased catch rate

Without charts to show the bottom contours, fishermen would be less able to follow the correct bottom contours at the optimum fishing depth in order to maximize the total landed catch. Certainly experience would play a part, in that knowledgeable fishermen would have a better idea of where the fish were and thus catch more than the less experienced fishermen. Therefore, the charts are of most importance to the captains with less experience. As well, during the seasons where there was is greater dispersal of the fish populations over an area, a knowledge of the bottom contours from the use of charts could affect the catch rate.

2. Increased costs

The costs to catch the same (or lower) volume of fish would increase because of the longer time to catch the fish. This could result in;
a) a longer season, and/or b) more days of work,

to catch the same volume of fish. As well, without a knowledge of the bottom, there would be a greater rate of snags on bottom objects and accidents, including groundings and bottom contacts. This would result in;

c) a higher frequency of gear loss d) an increase in accidents.

The costs of operating a fishing boat would increase as the fishermen stayed out longer. An official from an East coast fishing firm estimated their operating costs at $ 5,000 per day for a wet fish (groundfish) boat.
An increase in the accident rate would affect the replacement costs or insurance costs for the fishermen. The boats on the East coast for example, are worth an average of $ 30,000 to replace and would likely experience a similar rise in insurance rates as the commercial ships in the

previous section, as the accident rate rose. As well, there would be an increase in gear loss and damage as the boats trolled over and snagged unseen obstacles. A fishing company manager estimated that their firm would have an increase in gear loss of 20% without charts. This is significant when dealing with a current gear damage budget of $ 3.7 million (this figure includes replacement of worn gear) for the one firm alone.

3. Fishing boats

From discussions with fishing industry experts on the West coast, they speculated that without charts and with the reduced volume of fish catches, the following events would occur;
a) decrease in number of boats b) more local boats and fewer 'corporate' fleets

2.2.3 RECREATIONAL BOATING

Another user group of nautical charts are recreational boaters. In this study we have identified the critical users of charts to be those users in boats over 18 feet. We are assuming that in boats under 18 feet, the draft is so shallow that should those boats run aground, they would not have as serious a problem as the larger boats would. Furthermore, according to a study prepared for the Coast Guard by Monenco Consultants Ltd. of Ottawa, 11, there is only a small percentage of recreational boaters who actually rely on charts. Monenco has estimated that there are about 168,000 boats over 18 feet who use the navigational aids placed and maintained by the Coast Guard. Of these boaters, they contend that even fewer would be real users of nautical charts.

Clearly, there are boaters who would be at greater risk of damage to their boats by grounding or bottom contact in the absence of charts. This would result in more of these accidents and thus a higher operating cost to run the boats (assuming that insurance costs and/or replacement costs would be higher).

2.2.4 NATIONAL DEFENCE The Maritime Forces of Canada's Defence Services Program is a large user of nautical charts. Through discussions with officials in the Maritime Command, we have determined that the Maritime Forces carry out the following activities at sea, for which nautical charts are essential. The activities include:

a) search and rescue b) fisheries patrol c) sovereignty patrol d) environmental patrol e) mine countermeasures f) anti air warfare g) anti surface warfare h) anti submarine warfare i) basic navigation

Many of these activities are carried out concurrently with other activities. For example, a patrol of the East Coast fisheries could entail not only the enforcement of Canada's fisheries legislation, but might also be an exercise in maintaining the sovereignty of our borders, including the offshore territorial limits. Furthermore, other activities could be carried out at the same time as these patrols, including warfare exercises for training purposes.
However, even with the satellite and Loran navigational systems to establish a surface position, nautical charts are required to carry out all of the aforementioned activities, to calculate and verify navigational positions and to ensure that the ships maintain an adequate water depth under their hulls.
In concordance with the views of the naval experts, we have proposed that the impacts on the Maritime Forces in the absence of nautical charts and under the general counter factual scenario as described above, would be the following:

1. Decrease in efficiency of performing duties.

a) Longer to travel.

The ships would take longer to travel in areas where there was a chance of bottom contact, especially in the coastal regions. This problem would be less apparent in the offshore areas where bottom contact would be extremely unlikely. However, according to the naval experts, approximately half of a Maritime Command vessel's time is spent in coastal waters.

b) Longer to perform activities.

Because of this increased time to travel, it would take longer to perform any of the activities noted above. The patrols would take longer or conversely, not as much area would be covered in the same time period.

c) Increase in accidents.

there would be a higher cost to the Forces to deal with more repairs and increased equipment replacement costs. It is also likely that there would be an increase in the number of people injured or killed as a result of those accidents. There could be an increase in the loss of life during search and rescue situations. Due to the nature of the accidents which require the Maritime Forces to perform search and rescue missions, many of these problems occur in coastal waters where potential bottom contacts are more likely. Without charts it would hamper the efforts of the Forces to get to the accident site, if they could get there at all. Thus, it is quite likely that there would be a greater incidence of loss of life.

d) Decreased effectiveness.

Overall, most of the activities would be carried out in a less effective manner. For example, it would be difficult to efficiently carry out effective mine counter measures or anti submarine warfare if the bottom depths and contours were unknown. The naval experts felt that their maritime operations would be significantly hampered without charts. However, of all the activities that the Maritime Forces carry out, the officers contend that the anti air warfare activities would be not affected by the absence of charts (except for the time to travel problem).

2. Increase in costs to maintain current level of effectiveness.

As a result of the slower travel, greater incidence of accidents and reduced efficiency of most of the activities, the costs to maintain the same current level of effectiveness of the Maritime Forces would rise. They would require more ships and personnel to cover the same areas that they are patrolling now with the same resulting effect and would have to ensure adequate replacement ships and personnel to deal with the increase in accidents.
These impacts would result in a reduction in the quality or level of services performed by the Maritime Forces, at the current budget level.

In the arctic, ships use charts for navigation to get to,

a) northern communities for resupply b) Dew Line/North Warning Sites for resupply c) commercial mining locations for resupply and to transport ore

Interviews were conducted with an expert in arctic travel, who was a past Coast Guard officer and Ice Master on a number of arctic journeys, to determine the impact on arctic travel in the absence of charts.

Without charts, it is likely that there would be a similar situation as would exist in other areas of commercial shipping, as presented earlier. We would expect the following impacts on arctic travel for similar factors as discussed in the previous sections;

1. no vessel travel in most uncharted waters

2. in the deeper areas where ships could travel, they would be,

a) smaller
b) slower
c) have more accidents

These factors would result in,

1. a decrease in the commercial development of the arctic

2. a decreased volume of shipping and increased use of air freight transportation

Of these results, the economic impact of the commercial mining would be virtually inconsequential compared to the overall shipping volume in Canada.However,Canadians have made a committment to maintain the defense structures in the north, the Dew Line and North Warning Sites. Along with this committment, Canadians have also committed to maintain the northern communities, both to maintain the Aboriginal cultures and to maintain a presence for sovereignty purposes.

To continue to resupply these defense and community sites in the absence of charts, it is very likely that Canada would resort to transporting at least some of the cargo by air, given a reduction in the volume of shipping, particularly in the more remote locations of the arctic.

2.2.6 ENVIRONMENT

With the increase in the number of accidents, it is very likely that there would be a similar increase in spills of hazardous materials that are transported by ship.

The vast majority of these spills are oil spills rather than toxic chemical spills. The cleanup costs of these events are usually borne by emergency funds as the Ship-Source Oil Spill Pollution Fund which will cover a vessel for up to $ 191 million in cleanup and associated damage costs. These funds are provided for by the shippers and would be included in the cost of transporting substances such as crude and refined petroleum products, assuming of course, that there is enough money in the funds to cover all of the spillage events.

What is not included however, is the cost of the environmental damage to the surrounding area. If there are, for example, no fishermen in the area to claim for a decline in their catch rate as a result of a spill, then this type of damage goes unaccounted for in Canada. Unlike the United States, there is no method by which this environmental damage is assessed in Canada even though it may represent a very real social loss to Canadians. As a consequence, these total costs of pollution would not likely be included in the insurance costs to the operators and would be deemed to be an additional cost to Canadians and the economy.

To assess the effect of the environmental damage from these oil spills, a model was used to simulate spills in the Pacific coastal, Atlantic coastal and Arctic areas. The model simulates the spill and analyses it's dispersion and toxic effects on the surrounding wildlife, including fish, seals and seabirds and plantlife. The model estimates the total damages to these animals and plants and also calculates a potential economic cost in terms of recreational uses of the area, if applicable.

A complete description of the model is presented in the paper by Grigalunas, et al, 12.

This model was used to estimate the environmental damages to each of the West coast, East coast and Arctic regions following a representative 100 tonne spill. It should be noted however, that according to consultants in the environmental field, the estimates obtained from this model are considered to be quite low compared to actual damage assessments carried out after real spills.

The problem with using actual costs from real spills is that every spill is unique and has a potentially different effect on the environment than the next spill. More importantly though, there is very little data available because of the infancy of the science of environmental damage assessment, 13, 14. Often the costs to assess the damage are as great as the damage itself (and these assessment costs are included in the damage estimates). Furthermore, as in the case of the Exxon Valdez, the assessed environmental damage costs were thought by a number of experts with whom we spoke, to be greatly inflated compared to the real damage in the area. In that case the attention on the event resulted in much larger damage estimates than other less publicized spills might have been estimated at.

2.3 ASSESSMENT OF IMPACTS AND MEASUREMENT OF BENEFITS

The assessment of the impacts on each area of the marine environment where nautical charts are used, is based on the conceptual framework presented in section 2.2. Since concrete data are not readily available with regard to the impacts on the marine environment in the absence of charts, estimates of the likely responses had to be derived from knowledgeable persons in each area.

Extensive interviews were conducted with officers in the Maritime Forces, Coast Guard officials, officials in organizations and associations representing such areas as commercial shipping, pilotage and fishing, Government authorities and experts in the University and consulting environments. Using this information, the most likely responses in the absence of nautical charts were determined.

The benefits arising from the production of nautical charts are calculated as the difference in conditions that would exist with and without the charts. Benefits include both the impacts from reduced costs and from changes in volumes.

In measuring the total Canadian benefits from charts, the appropriate measure to use is the net increase in the value to the economy. In each area we calculated the consumer surplus and producer surplus, both with and without charts and measured those differences, which represent the net increase or decline in the value to the economy.

Consumer Surplus and Producer Surplus Analysis Approach

The consumer surplus and producer surplus is a useful method to measure the economic impacts of changing prices and/or quantities of goods in the market place. The method uses demand and supply concepts to quantify these impacts.

In figure 1, the supply and demand curve are shown for any good 'X'. The demand curve shows the aggregate maximum price that all of the consumers in the economy are willing to pay to purchase a given quantity of good X. The supply curve shows the minimum price that suppliers are willing to accept for selling a given quantity of good

From figure 1, it can be seen that the consumers are willing to pay more for the product than price Pc, up to a quantity Qc. Therefore the area under the demand curve and above price Po represents the consumer surplus, or the total amount of money that people are willing to spend on good X but do not have to, since the price was Pc. The consumers are better off because they can then spend that money on other goods or services.

Figure 1. Consumer Surplus and Producer Surplus.

where: Pc is the equilibrium price level 'with charts'.
Pm is the minimum price for suppliers to begin producing the product   Qc is the equilibrium level of volume 'with charts'.

Similarly, the suppliers get a benefit at price Pc as well. They are willing to provide the good at a price lower than Pc, (up to quantity Qc) but are able to earn price Pc for the goods. Therefore, they are better off by the total amount of money represented in the area under Pc and above the supply curve, the producer surplus.
In the counter factual scenarios for,

a) commercial shipping, b) commercial fishing, c) recreational boating, d) national defence, and e) arctic resupply,

the supply curves shift to reflect the changes in cost and efficiency in each area as a result of the existence of charts. To evaluate the activities of the CHS, we had to measure the current situation in each area and estimate both the reduction in the volume or efficiency and increase in costs to get the appropriate shift in the supply curve to

the left. The supply curve would shift to the left to reflect these changes, which would be a reduction in volume or efficiency that a supplier would be able to supply at the current price levels.
However, for this analysis, the consumer surplus and producer surplus were measured for the existing situation with charts and for the counter factual scenario without charts. The total changes in each of the consumer surplus and producer surplus were measured as if for a supply curve shift to the right, to show the total gain to the economy as the country moves from the scenario without charts to the situation with charts.

Figure 2. Shift in Supply Curve and Change in Consumer Surplus and Producer Surplus.

where: Pc is the equilibrium price level 'with charts'. Pn is the equilibrium price level 'without charts' Pm is the minimum price for suppliers to begin producing the product

Figure 2 illustrates the situation where the supply curve has shifted from the situation without charts to that of with charts. The change in the consumer surplus, from the supply curve 'without charts' to the supply curve 'with charts' is measured as follows;

area with charts = area of triangle DPcF less area without charts = area of triangle DPnE

total change = Areas A+B

The change in the producer surplus, from the supply curve 'without charts' to the supply curve 'with charts' is measured as follows;

area with charts = area of triangle PmPcF less area without charts = area of triangle PmPnE

total change = Areas C-A

Therefore, the total change in the economy as the country shifts from a scenario without charts to that of one with charts, can be calculated as the change in the consumer surplus plus the change in the producer surplus. The total change is;

areas A+B + C-A = B+C

For each area (other than the environmental area), the total change in the consumer surplus and producer surplus was measured as the effect on the economy by the introduction of charts.

The environmental section was not estimated using the consumer surplus and producer surplus approach. Instead, an environmental damage assessment model was used to quantify the estimated increase in oil spills that would result in the absence of charts. The total effect on the economy was calculated to be the total increase in costs associated with the increase in environmental damages.

To accurately measure the demand and supply curves, including the shift in the supply curves, the following steps were used in each of the areas where the consumer surplus and producer surplus approach was used, 15, 16.

1. Equilibrium point with charts

Determine the equilibrium point of price and quantity in the current situation with charts. This was calculated from available data on such information as;

a) shipping volumes and freight rates/revenue b) fishing catches and landed values c) numbers of recreational boats and insurance prices d) defense budgeting, and e) arctic resupply tonnage and costs.

With this data, it was possible to establish a current price and volume for each area.

2. Demand curve

The demand curve was estimated as a straight line demand curve through the equilibrium point determined in step 1. The slope of the curve was calculated from estimations of the elasticity of demand at the equilibrium point with charts for the appropriate goods or services in each of the areas. These elasticities of demand were found in the relevant literature or were estimated.
It should be noted that a constant slope value was used for the calculations in each area. This implies that the elasticity of demand will change as the quantity changes. However for our purposes, in most of the areas (except for the arctic which will be treated slightly differently) the resulting quantity changes between the 'with and without charts' scenarios is small enough that the change in elasticity over the relevant quantities also will be small. It has also been assumed that the consumers' preferences for the goods and services have not been altered by the absence of charts. This would appear to make sense in that none of the actual goods that consumers purchase would be affected by charts. For example, in shipping, consumers would have an unchanged demand for a good such as coal. The coal itself would be unaltered in the absence of charts and therefore, the demand for coal would not be shifted in any way.

3. Supply curve

The supply curve was estimated as a straight line supply curve through the equilibrium point determined in step 1. The intercept for the supply curve, Pm on the graph in figure 2, was estimated using information based on literature and expert opinion from the appropriate industry experts who were consulted. Very simply, the intercept was based on estimates of the percentage of the current equilibrium price at which all producers would cease providing the goods or services. This point was based to a significant degree on the level of initial capital investment required to provide the services or goods at small quantities. The higher the initial capital investment, the greater the intercept relative to the current price of the goods.

4. Shift in supply at current prices

The shift in supply caused by not having charts available was estimated from consultations with experts in each of the areas discussed and from analysis of the available data. The amount of the shift was made up of both the physical reduction in volume, from the vessels traveling slower or carrying less cargo to ensure a shallower draft, and the additional charges to carry the cargo at current prices, for such things as increased pilotage charges and higher insurance premium rates.
The shift was calculated to be a pivotal shift (that is with the same intercept) rather that a complete shift in the curve (with the exception of the arctic). It was assumed that the minimal price at which producers would start supplying the product (the vertical axis intercept) would be the same for the suppliers regardless of whether or not charts exist. For example in the case of commercial shipping, the price of a ship would not change. Once the ship began to sail however, then the costs would be expected to rise under the no charts situation,to cover such expenses as the higher operating costs and insurance premiums.

The pivotal shift also implies that the very low cost suppliers would be less affected by the absence of charts than would the higher cost suppliers. The low cost suppliers, in the case of shipping for example, might be the ones who travel less dangerous waters or who have more experienced masters. This would mean that their costs would not increase much as a result of not having charts, or conversely, obtaining charts would not reduce their costs as much as the higher cost suppliers.

5. Equilibrium point without charts

The percent supply shift calculated in step 4, would not be the final equilibrium volume of goods or services supplied. From figure 3, it can be seen that the demand curve indicates that at point B, consumers are willing to pay a higher price than Pc for the goods or services, without charts. Therefore suppliers are willing to provide those goods or services at a higher price. Therefore they move up the supply curve in response to the higher prices until an equilibrium point is reached at which supply equals demand at point C, in the absence of charts. (Point A is the equilibrium point with charts).

Figure 3. Equilibrium Points With and Without Charts

where: Pc is the equilibrium price level 'with charts'. Pn is the equilibrium price level 'without charts'. Pm is the minimum price for suppliers to begin producing the product. Ps is the price consumers are willing to pay at volume Qs Qc is the equilibrium level of volume 'with charts'. Qn is the equilibrium level of volume 'without charts'. Qs is the volume resulting from the shift in the supply curve at current prices.

6. Change in the consumer surplus and producer surplus

The change in the consumer surplus and the producer surplus from the 'without charts' to the 'with charts' scenario is calculated for each area as described above.

A complete example of the calculations described above to calculate the change in the consumer surplus and producer surplus from the shift in the supply curve, is contained in Appendix B.

2.3.1 COMMERCIAL SHIPPING

To estimate the benefits from charts with regard to commercial shipping, the steps described in the previous section were performed to evaluate the changes in shipping volume and increase in shipping costs as a result of the absence of charts.

Regions

Canada has very distinctive differences in each of its east and west coastlines and inland waters. Not only are there physical differences in each of the areas, but the transportation requirements, vessel types and alternate transportation modes are unique to each. For these reasons, the shipping areas of the country were divided into the three regions; west coast, east coast and inland (which includes the St. Lawrence and Great Lakes).

Each of these areas were further subdivided into domestic and international shipping. Cargos are often carried different distances, at different freight rates and in some areas, by different routes and vessel types, particularly in the coastal regions. Therefore, it was appropriate to make these distinctions.

Equilibrium Point with Charts

To determine the current equilibrium point, the volume of cargo and the current price to ship that cargo was required. The volume of cargo carried through each region, both domestically and internationally, was calculated on a tonne kilometer basis. The distances measured were those distances that a ship would have to travel through, which would be deemed to be difficult or hazardous water. The hazardous areas and distances were confirmed by officials in the CHS. To calculate the cargo tonnage through each area, the data from the Canadian Shipowners Association annual reports, 17, the Statistics Canada's "Report on Shipping", 18, and the St. Lawrence Seaway Authority's 1989 Traffic Report, 19, was used.

It is important to note that particularly for the international cargo, the tonne kilometers were based on the distance the ships would have to travel through hazardous water, and not necessarily for the whole trip. For example, the tonne kilometers measured for ships traveling between Vancouver and Japan would be from the Port of Vancouver to 125° west, at which point the ships would be clear of the hazards in the Strait of Juan de Fuca and would be on the open ocean.

It was not possible to use industry data on cargo shipping rates since these freight rates are not published figures. Contracts are made privately between shipper and ship owner and vary greatly from fixed long term contracts to rates on a per tonne basis. Therefore, a representative average freight rate figure was estimated using several steps. From data in Statistics Canada's Report on Shipping, the total shipping revenue for each region was calculated, both domestically and internationally. Each of these revenue figures was divided by the total tonne kilometers for each region to get a representative freight rate for each area.

Elasticity of Demand for Transportation

In the literature, the elasticity of demand for transportation has been investigated for transportation in general and for rail and truck transportation in particular, 20, 21, 22, 23. Unfortunately, there are no studies which have been done specifically for transportation by ship. Oum, 24, 25, has estimated the demand for rail and truck transportation to be very inelastic, with values of approximately -0.54 to -0.64. This implies that for relatively large price increases in the costs to ship freight, there will be relatively small changes in the total volume shipped.

We have proposed that the demand for transportation by vessel would be similar to the demand for transportation by rail. It can be argued that similarities exist between the shipment of goods by rail and by water.

1. Both involve large capital expenditures to enter the market.
2. Both are fixed in terms of where the goods can be transported to. Rail can only travel on established railways where ships are limited to waterways.
3. Both can carry large volumes of goods per trip, compared to truck transportation.
4. The demand for these modes of transportation is an implied demand. That is, consumers do not demand transportation itself. Rather they demand the goods that are transported. Therefore, since the costs to transport the goods is usually a fraction of the total cost of the goods, the consumers are relatively less responsive to price changes in the freight rates, which implies an inelastic demand for transportation.

It was also proposed that there would be differences in the elasticity of demand for vessel transportation in each region.Because of the physical geography of each area, the availability of alternate methods of transportation would differ in each. The inland area has a complex transportation system of water, rail and highway. Therefore it is likely that the demand for shipping would be the most elastic in the area, given the range of choices that a shipper has to move his goods. The shipper would be relatively more responsive to price changes in transportation in this area compared to the others.On the other hand, the west coast has many remote coastal areas which can only be accessed by water. Clearly, there would be no alternative transportation modes in these areas. Therefore, the demand for vessel transportation would be the most inelastic in this region. The Atlantic provinces lie in between, in that there are some alternatives to shipping especially within the provinces. However, travel between most of the islands is restricted to ships. Therefore, the value for the elasticity of demand for transportation in this area would lie between those of the other regions.

Intercept of Supply Curve

With regard to the supply curve, it was proposed that there would be a minimum price level at which shippers would be able to provide shipping services. The shipping industry is a very capital intensive business since the ships must first be purchased before any goods are moved. Therefore, a minimum price of shipping was estimated to be 50% of the current freight rate price.

Shift in Supply Curve at Current Prices

Through conversations and discussions with a variety of industry, government and consulting specialists, an average reduction in shipping within each of the regions was determined, domestically and internationally, as a result of the factors described above, in the absence of charts.

Equilibrium Point Without Charts

The equilibrium point without charts was calculated from the intersection point of the demand curve and supply curve (without charts). An example of this calculation is in Appendix B.

Change in Consumer Surplus and Producer Surplus

Using the procedure described in the previous section, the change in the consumer surplus and producer surplus was determined for each region, both domestically and internationally.

Atlantic Region Domestic

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;

volume = 7,632,936,000 tonne kilometers price = $ 0.00917 per tonne kilometer

The figures for the tonne kilometers were obtained from data from the Canadian Shipowners Association annual report since member Canadian carriers transport most of the cargo in the Atlantic region.
The price per tonne kilometer was calculated from shipping revenue data from Statistics Canada's "Report on Shipping, 1989", by estimating the total shipping revenue by Canadian shippers in the Atlantic region for the domestic transport of commodities and dividing this by the total number of tonne kilometers.

2. Elasticity of demand

The elasticity of demand for transportation was estimated to be -0.5, as similarly reported by Oum for rail transportation.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 50% of the current price;
supply intercept = $ 0.00459

4. Shift in the supply curve at current prices

The shift in the supply curve at current prices was estimated to be 25%.
From discussions with mariners and industry experts, and from analysis of available data, it appears that much of the domestic volume is moving throughout the Maritime region and in particular, through the smaller ports.
Throughout the coastal areas and in the Gulf of St. Lawrence, there are many hazardous areas which would result in a decline in the volume of shipping and an increase in the cost to ship the goods at current prices, as discussed previously.

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 7,155,877,000 tonne kilometers price = $ 0.01032 per tonne kilometer

The overall change in volume as a result of having no charts, is 6.3%, which equals 93.7% of the volume shipped with charts.

6. Change in consumer surplus and producer surplus

The total benefit in 1989 to Canadians from the use of nautical charts in the Atlantic domestic shipping industry is $ 5,468,750.

Table 1 outlines these calculations in more detail.

Table 1: Atlantic Domestic: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for shipping	-0.5	
With Charts:		
Total shipping revenue ($'000)	70,000	
Total shipping volume (tonne km, '000)	7,632,936	
Shipping cost per tonne km ($)	0.00917	
Minimum price of shipping ($)	0.00459	
Without Charts:		
Supply shift at current prices	25%	
Equilibrium shipping volume (tkm, '000)	7,155,877	
Overall decline in volume	6.3%	
Equilibrium shipping cost per tonne km ($)	0.01032	
Consumer Surplus:		
Without charts ($)	61,523,438	
With charts ($)	70,000,000	
Change in consumer surplus ($)		8,476,562
Producer Surplus:		
Without charts ($)	20,507,813	
With charts ($)	17,500,000	
Change in producer surplus ($)		(3,007,813)
Total change with charts ($)	5,468,750	

To test how sensitive the change in the consumer surplus and the producer surplus was to different values of the elasticity of demand, a sensitivity analysis was done for the domestic Atlantic shipping region. The values from table 1 were recalculated using different elasticities of demand. The results are outlined in the following table.

Table 2: Atlantic Domestic: Total Change in Consumer Surplus and Producer Surplus With Different Elasticities of Demand.

Elasticity of demand	-0.5	-1.0	-2.0
Change Consumer Surplus ($)	8,476,562	6,650,000	4,642,857
Change Producer Surplus ($)	(3,007,813)	(1,400,000)	357,143
Total change with charts ($)	5,468,750	5,250,000	5,000,000

The changes in the values for the elasticity of demand for transportation do not vary the total change in the consumer surplus and producer surplus very much. However, what does change dramatically, is which parties lose money and which parties win under the 'with charts scenario'.

The consumers in this situation, are those people who pay for transportation either directly to the ship owners, or indirectly, in the costs of the goods that are transported. The producers in this situation are the ship owners who transport cargo for a fee. Clearly in this example, if transportation is truly an inelastic demand (at -0.5) the consumers are the big winners in the 'with charts' scenario. The producers would be better off shipping slightly less cargo and charging a higher price for that freight without charts.

On the other hand, if the demand was elastic (-2.0), then both parties are better off under the 'with charts' scenario. However, as discussed above, it is unlikely that the demand for transportation is indeed elastic.

To test how sensitive the change in the consumer surplus and the producer surplus was to different values for the shift in the supply curve at current prices, a second sensitivity analysis was done for the domestic Atlantic shipping region. The values from table 1 were recalculated using different shifts in the supply curve at current prices. The results are outlined in the following table.

Table 3: Atlantic Domestic: Total Change in Consumer Surplus and Producer Surplus Using Different Shifts in the Supply Curve At Current Prices.

Shift in the Supply Curve at Current Prices	25%	30%	20%
Change Consumer Surplus ($)	8,476,562	10,616,343	6,507,937
Change Producer Surplus ($)	(3,007,813)	(3,708,449)	(2,341,270)

Total change with charts ($) 5,468,750 6,907,895 4,166,667

For each 1% shift in the supply curve at current prices, the change in the consumer surplus and producer surplus is approximately $ 275,000.

<u>Atlantic Region International</u>

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;

volume = 4,076,431,000 tonne kilometers price = $ 0.00245 per tonne kilometer

The figures for the tonne kilometers were obtained from data from the Statistics Canada's "Report on Shipping, 1989" and from estimations of the total distance of hazardous water, (from the CHS and industry officials).
Much of the international shipping in the Maritime region occurs in and out of the deep sea ports such as Halifax. These areas would be less affected by the absence of charts because of the greater depth of the water and the relative freedom from hazards.
However, significant volumes of cargo are carried in and out of ports such as Saint John which has difficult stretches of water for approximately 200 kilometer£s until reaching the safer open sea. Therefore, the tonne kilometer figure accounts for the cargo traveling through these hazardous areas.
The price per tonne kilometer was calculated from shipping revenue data from Statistics Canada's "Report on Shipping, 1989", by estimating the total shipping revenue by Canadian shippers in the Atlantic region for the international transport of commodities and dividing this by the total number of tonne kilometers.

2. Elasticity of demand

The elasticity of demand for transportation was estimated to be -0.5, as similarly reported by Oum for rail transportation.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 50% of the current price;
supply intercept = $ 0.00123

4. Shift in the supply curve at current prices

The shift in the supply curve at current prices was estimated to be 5%.
From discussions with mariners and industry experts, and from analysis of available data, it appears that much of the international volume is mainly moving through the larger, deep sea ports.
Therefore, the impact of charts would be significantly less on the international shipping volumes than on the domestic shipping volumes.

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 4,033,969,000 tonne kilometers price = $ 0.00250 per tonne kilometer

The overall change in volume as a result of having no charts, is 1%, which equals 99% of the volume shipped with charts.

6. Change in consumer surplus and producer surplus.

The total benefit in 1989 to Canadians from the use of nautical charts in the Atlantic international shipping industry is $ 130,208.
Table 4 outlines these calculations in more detail.

Table 4: Atlantic International: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for shipping -0.5

With Charts:
  Canadian shipping revenue ($'000) 10,000
  Total shipping volume (tonne km, '000) 4,076,431

Shipping cost per tonne km ($) 0.00245
Minimum price of shipping ($) 0.00123

Without Charts:
Supply shift at current prices 5%
Equilibrium shipping volume (tkm, '000) 4,033,969
Overall decline in volume 1%
Equilibrium shipping cost per tonne km ($) 0.00250

Consumer Surplus:
Without charts ($) 9,792,752
With charts ($) 10,000,000
Change in consumer surplus ($) 207,248

Producer Surplus:
Without charts ($) 2,577,040
With charts ($) 2,500,000
Change in producer surplus ($) (77,040)

Total change with charts ($) 130,208

To test how sensitive the change in the consumer surplus and the producer surplus was to different values for the shift in the supply curve at current prices, a second sensitivity analysis was done for the international Atlantic shipping region. The values from table 4 were recalculated using different shifts in the supply curve at current prices. The results are outlined in the following table.

Table 5: Atlantic International: Total Change in Consumer Surplus and Producer Surplus Using Different Shifts in the Supply Curve At Current Prices.

Shift in the Supply Curve at Current Prices	5%	10%	2%
Change Consumer Surplus ($)	207,248	430,057	81,136
Change Producer Surplus ($)	(77,040)	(158,318)	(30,323)
Total change with charts ($)	130,208	271,739	50,813

For each 1% shift in the supply curve at current prices, the change in the consumer surplus and producer surplus is approximately $ 26,000.

Inland Region Domestic

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;

volume = 36,786,122,000 tonne kilometers price = $ 0.00870 per tonne kilometer

The figures for the tonne kilometers were obtained from data from the Canadian Shipowners Association annual report since member Canadian carriers transport virtually all of the cargo in the inland region.
The price per tonne kilometer was calculated from shipping revenue data from Statistics Canada's "Report on Shipping, 1989", by estimating the total shipping revenue by Canadian shippers in the inland region for the domestic transport of commodities and dividing this by the total number of tonne kilometers.

2. Elasticity of demand

The elasticity of demand for transportation was estimated to be -0.6.
This figure is more elastic than the demand for transportation in the Atlantic region since there is more alternative modes of transportation available. Given this choice of available transportation, the shippers are slightly more responsive to price changes than in the coastal regions.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 50% of the current price;

supply intercept = $ 0.00435

4. Shift in the supply curve

The shift in the supply curve at current prices was estimated to be 25%.
Throughout the Gulf of St. Lawrence, the Seaway and the Great Lakes, there are a multitude of hazardous areas which would result in a decline in the volume of shipping as a result of the absence of charts (as previously discussed). Only during the crossing of the large lakes in the Great Lakes area, would there be areas of relatively safe water. Therefore, we estimated a fairly large shift in the supply curve at current prices.

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 34,158,541,000 tonne kilometers price = $ 0.00973 per tonne kilometer

The overall change in volume as a result of having no charts, is 7%, which represents 93% of the volume shipped with charts.

6. Change in consumer surplus and producer surplus

The total benefit in 1989 to Canadians from the use of nautical charts in the Inland domestic shipping industry is $ 24,761,905.
Table 6 outlines these calculations in more detail.

Table 6: Inland Domestic: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for shipping	-0.6
With Charts:	
Total shipping revenue ($'000)	320,000
Total shipping volume (tonne km, '000)	36,786,122
Shipping cost per tonne km ($)	0.00870
Minimum price of shipping ($)	0.00435

Without Charts:
Supply shift at current prices 25%
Equilibrium shipping volume (tkm, '000) 34,158,541
Overall decline in volume 7%
Equilibrium shipping cost per tonne km ($) 0.00973

Consumer Surplus:
Without charts ($) 229,931,973
With charts ($) 266,666,667
Change in consumer surplus ($) 36,734,694

Producer Surplus:
Without charts ($) 91,972,789
With charts ($) 80,000,000
Change in producer surplus ($) (11,972,789)

Total change with charts ($) 24,761,905

To test how sensitive the change in the consumer surplus and the producer surplus was to different values for the shift in the supply curve at current prices, a second sensitivity analysis was done for the domestic Inland shipping region. The values from table 6 were recalculated using different shifts in the supply curve at current prices. The results are outlined in the following table.

Table 7: Inland Domestic: Total Change in Consumer Surplus and Producer Surplus Using Different Shifts in the Supply Curve At Current Prices.

Shift in the Supply Curve at Current Prices	25%	30%	20%
Change Consumer Surplus($)	36,734,694	45,840,000	28,297,521
Change Producer Surplus($)	(11,972,789)	(14,640,000)	(9,388,430)
Total change with chart($)	24,761,905	31,200,000	18,909,091

For each 1% shift in the supply curve at current prices, the change in the consumer surplus and producer surplus is approximately $ 990,500.

Inland Region International

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;

volume = 103,321,212,000 tonne kilometers price = $ 0.00503 per tonne kilometer

The figures for the tonne kilometers were obtained from data from the Statistics Canada's "Report on Shipping, 1989", the Canadian Shipowners Association annual reports and from estimations of the total distance of the St. Lawrence and Great Lakes (from the CHS).
Much of the international shipping in the inland region travels over the same water as the domestic shipping. The distance of the difficult stretches of water for the overseas cargo was estimated from the inland region up to Cabot Strait, after which the water is relatively hazard free.
The price per tonne kilometer was calculated from shipping revenue data from Statistics Canada's "Report on Shipping, 1989", by estimating the total shipping revenue by Canadian shippers in the inland region for the international transport of commodities and dividing this by the total number of tonne kilometers.

2. Elasticity of demand

The elasticity of demand for transportation was estimated to be -0.6, as in the domestic shipping area.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 50% of the current price;
supply intercept = $ 0.00252

4. Initial supply curve shift

The shift in the supply curve was estimated to be 25%.
From discussions with mariners and industry experts, and from analysis of available data, it appears that much of the international volume is moving across the Great Lakes, through the Seaway, and/or out into the Gulf of St. Lawrence on its way to the Eastern US coast or overseas.

Since most of this water is hazardous, the shift in the supply curve was estimated to be quite large.

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 95,941,126,000 tonne kilometers price = $ 0.00563 per tonne kilometer

The overall change in volume as a result of having no charts, is 7%, which represents 93% of the volume shipped with charts.

6. Change in consumer surplus and producer surplus

The total benefit in 1989 to Canadians from the use of nautical charts in the Inland international shipping industry is $ 40,238,095.

Table 8 outlines these calculations in more detail.

Table 8: Inland International: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for shipping	-0.6
With Charts:	
Total shipping revenue ($'000)	520,000
Total shipping volume (tonne km, '000)	103,321,212
Shipping cost per tonne km ($)	0.00503
Minimum price of shipping ($)	0.00252
Without Charts:	
Supply shift at current prices	25%
Equilibrium shipping volume (tkm, '000)	95,941,126
Overall decline in volume	7%
Equilibrium shipping cost per tonne km ($)	0.00563
Consumer Surplus:	
Without charts ($)	373,639,456
With charts ($)	433,333,333
Change in consumer surplus ($)	59,693,878
Producer Surplus:	
Without charts ($)	149,455,782
With charts ($)	130,000,000
Change in producer surplus ($)	(19,455,782)
Total change with charts ($)	40,238,095

To test how sensitive the change in the consumer surplus and the producer surplus was to different values for the shift in the supply curve at current prices, a second sensitivity analysis was done for the Inland international shipping region. The values from table 8 were recalculated using different shifts in the supply curve at current prices. The results are outlined in the following table.

Table 9: Inland International: Total Change in Consumer Surplus and Producer Surplus Using Different Shifts in the Supply Curve At Current Prices.

Shift in the Supply Curve at Current Prices	25%	30%	20%
Change Consumer Surplus ($)	59,693,878	74,490,000	45,983,471
Change Producer Surplus ($	(19,455,782)	(23,790,000)	(15,256,198)
Total change with charts ($)	40,238,095	50,700,000	30,727,273

For each 1% shift in the supply curve at current prices, the change in the consumer surplus and producer surplus is approximately $ 1,620,000.

<u>West Coast Domestic</u>

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;

volume = 5,172,321,000 tonne kilometers price = $ 0.04060 per tonne kilometer

The figures for the tonne kilometers were obtained from data from the Statistics Canada's "Report on Shipping, 1989", and from estimations of the distances along the west coastline (from the CHS and industry experts).
The price per tonne kilometer was calculated from shipping revenue data from Statistics Canada's "Report on Shipping, 1989", by estimating the total shipping revenue by Canadian shippers in the west coast region for the domestic transport of commodities and dividing this by the total number of tonne kilometers.

2. Elasticity of demand

The elasticity of demand for transportation was estimated to be -0.4 because of the lack of alternative modes of transportation.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 50% of the current price;

supply intercept = $ 0.02030

4. Shift in the supply curve

The shift in the supply curve at current prices was estimated to be 25%.
Shipping in this area is quite hazardous near the coast because of the countless inlets, straits, rivers, islands, hazardous areas and shallows which impede coastal navigation. Generally, the hazards are lessened the further from land one travels, moving towards open water. However, most of the goods travel up and down the coast and therefore travel in the more hazardous waters.

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 4,900,094,000 tonne kilometers price = $ 0.04594 per tonne kilometer

The overall change in volume as a result of having no charts, is 5%, which represents 95% of the volume shipped with charts.

6. Change in consumer surplus and producer surplus

The total benefit in 1989 to Canadians from the use of nautical charts in the West Coast domestic shipping industry is $ 16,578,947.

Table 10 outlines these calculations in more detail.

Table 10: West Coast Domestic: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for shipping -0.4

With Charts:

Total shipping revenue ($'000)	210,000
Total shipping volume (tonne km, '000)	5,172,321
Shipping cost per tonne km ($)	0.04060
Minimum price of shipping ($)	0.02030

Without Charts:

Supply shift at current prices	25%

Equilibrium shipping volume (tkm, '000) 4,900,094
Overall decline in volume 5%
Equilibrium shipping cost per tonne km ($) 0.04594

Consumer Surplus:
Without charts ($) 235,595,568
With charts ($) 262,500,000
Change in consumer surplus ($) 26,904,432

Producer Surplus:
Without charts ($) 62,825,485
With charts ($) 52,500,000
Change in producer surplus ($) (10,325,485)

Total change with charts ($) 16,578,947

To test how sensitive the change in the consumer surplus and the producer surplus was to different values for the shift in the supply curve at current prices, a second sensitivity analysis was done for the domestic West coast shipping region. The values from table 10 were recalculated using different shifts in the supply curve at current prices. The results are outlined in the following table.

Table 11: West Coast Domestic: Total Change in Consumer Surplus and Producer Surplus Using Different Shifts in the Supply Curve At Current Prices.

Shift in the Supply Curve at Current Prices	25%	30%	20%
Change Consumer Surplus ($)	26,904,432	33,833,333	20,580,000
Change Producer Surplus($	(10,325,485)	(12,833,333)	(7,980,000)
Total change with charts($)	16,578,947	21,000,000	12,600,000

For each 1% shift in the supply curve at current prices, the change in the consumer surplus and producer surplus is approximately $ 660,000.

West Coast International

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;

volume = 24,046,027,000 tonne kilometers price = $ 0.00500 per tonne kilometer

The figures for the tonne kilometers were obtained from data from the Statistics Canada's "Report on Shipping, 1989", and from estimations of the distances along the Pacific coastline, and from Vancouver to 125° west and from Prince Rupert to the west end of the Dixon Entrance (from the CHS and industry experts).
The price per tonne kilometer was calculated from shipping revenue data from Statistics Canada's "Report on Shipping, 1989", by estimating the total shipping revenue by Canadian shippers in the west coast region for the international transport of commodities and dividing this by the total number of tonne kilometers.

2. Elasticity of demand

The elasticity of demand for transportation was estimated to be -0.4, as in the domestic shipping area.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 50% of the current price;
supply intercept = $ 0.00250

4. Initial supply curve shift

The shift in the supply curve was estimated to be 20%.
From discussions with mariners and industry experts, and from analysis of available data, it appears that much of the international volume is moving out of the large ports such as Vancouver and Prince Rupert. Once the ships are through the hazardous straits and narrows, they reach the open sea and are relatively free from hazards. However, because the water is quite difficult in those straits and narrows, we estimated the shift in the supply curve to be quite substantial, but not quite as large as the domestic situation, where most of the traffic is along the coast.

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 23,084,186,000 tonne kilometers price = $ 0.00549 per tonne kilometer

The overall change in volume as a result of having no charts, is 4%, which represents 96% of the volume shipped with charts.

6. Change in consumer surplus and producer surplus

The total benefit in 1989 to Canadians from the use of nautical charts in the west coast international shipping industry is $ 7,200,000.
Table 12 outlines these calculations in more detail.

Table 12: West Coast International: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for shipping -0.4

With Charts:

Total shipping revenue ($'000)	120,000
Total shipping volume (tonne km, '000)	24,046,027
Shipping cost per tonne km ($)	0.00500
Minimum price of shipping ($)	0.00250

Without Charts:

Supply shift at current prices	20%
Equilibrium shipping volume (tkm, '000)	23,084,186
Overall decline in volume	4%
Equilibrium shipping cost per tonne km ($)	0.00549

Consumer Surplus:

Without charts ($)	138,240,000
With charts ($)	150,000,000
Change in consumer surplus ($)	11,760,000

Producer Surplus:

Without charts ($)	34,560,000
With charts ($)	30,000,000
Change in producer surplus ($)	(4,560,000)

Total change with charts ($) 7,200,000

To test how sensitive the change in the consumer surplus and the producer surplus was to different values for the shift in the supply curve at current prices, a second sensitivity analysis was done for the international West Coast shipping region. The values from table 12 were recalculated using different shifts in the supply curve at current prices. The results are outlined in the following table.

Table 13: West Coast International: Total Change in Consumer Surplus and Producer Surplus Using Different Shifts in the Supply Curve At Current Prices.

Shift in the Supply Curve at Current Prices	20%	25%	15%
Change Consumer Surplus ($)	11,760,000	15,373,961	8,448,980
Change Producer Surplus ($)	(4,560,000)	(5,900,277)	(3,306,122)
Total change with charts ($)	7,200,000	9,473,684	5,142,857

For each 1% shift in the supply curve at current prices, the change in the consumer surplus and producer surplus is approximately $ 360,000.

Benefits From International Shipping

The net benefits from the 'with charts' scenario for international shipping in each of the regions, were measured using Canadian revenue figures. However, Canadian ships only carry 21.3% of the international cargo. Statistics Canada provides information regarding revenue from Canadian owned ships. However, revenues form foreign owned ships are not reported in Canada.
The 'with charts' scenario would really provide Canadians with a larger consumer surplus than is indicated in the above calculations, since Canadians do not have to pay higher freight rates (both domestically and internationally), assuming that Canadians are price takers in the world market. This means that they must buy and sell the goods at world prices and therefore must bear the full increased cost of transportation under the 'without charts' scenario.
The producer surplus loss in the 'with charts' scenario, will represent a loss to both Canadian producers (ship owners) as well as to foreign producers. The benefits from charts due to the increase in the consumer surplus and the reduction in producer surplus (the portion attributable to the foreign producers) were estimated as follows;
East coast consumer surplus increase: $ 765,749
Inland area consumer surplus increase: $ 220,559,068
West coast consumer surplus increase: $ 43,451,268

Total consumer surplus increase: $ 264,776,085

East coast foreign producers loss: $ (284,651)
Inland area foreign producers loss: $ (71,885,919)
West coast foreign producers loss: $ (16,848,451)

Total foreign producers loss: $ (89,019,021)

Total increase in benefits internationally: $ 175,757,064

These were calculated by measuring the consumer surplus and producer surplus for the situation with the Canadian revenue alone, compared to the situation with the Canadian and estimated Foreign revenues combined. Information from

Statistics Canada shows that in 1989, Canadian ships carried 21.3% of the total cargo carried. There is no breakdown of this Canadian carried volume by region Therefore, the Canadian volume calculations were based on this average figure of 21.3% for each of the West coast, East coast and Inland regions. The calculations are provided in Appendix D.

2.3.2 COMMERCIAL FISHING

To estimate the benefits from charts with regard to commercial fishing, the steps described above, were performed to evaluate the changes in fishing volumes and increase in costs as a result of the absence of charts.

Regions

Canada has two major and very distinct fisheries, one on each coast. Each region catches a unique mix of fish species, and has its own market and physical characteristics. Therefore for this study, the Canada's fisheries have been separated into the East Coast and West Coast regions.

East Coast Region

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;

volume = 1,267,222 tonnes price = $ 755 per tonne

The data regarding the total volume and landed value of fish caught on the east coast, by fish species, was taken from statistical data obtained from the Department of Fisheries and Oceans, 26.
The price per tonne was calculated by dividing the total landed value by the total volume of fish caught on the west coast.

2. Elasticity of demand

The elasticity of demand for fish was estimated to be -2.0. In the literature, although there were figures for the elasticities of demand for groundfish in the US, Tsoa et al, 27, these figures were based on the domestic consumption of groundfish. Since about 80% of our fish is exported to the US, it is expected that the elasticity of demand would be much more elastic than the estimate of approximately -0.5 that Tsoa et al, calculated for the domestic demand of groundfish.
As well, there are other fish species caught in the east besides groundfish. It was assumed that given their relative volumes and landed values, the demands of the more highly prized fish would be offset by the demands for the less valued fish. Therefore, the average elasticity of demand for fish on the east coast was estimated to be -2.0.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 30% of the current price;

supply intercept = $ 252

The fishing industry is a capital intensive business, although not as much so as the commercial shipping industry. Therefore, it was estimated that the supply intercept would be 30% of the current price of fish.

4. Initial supply curve shift

The shift in the supply curve was estimated to be 10%. The industry experts with whom we spoke felt that there would be a small decline in the volume of fish caught, especially in the seasons when the fish are normally more dispersed. They felt that an experienced captain who had a good feel for where the fish were from years of fishing in the same place, would not have to refer to the charts in most cases. However, the relatively lesser experienced captains would rely more on the chart information to follow the bottom contours.
Therefore, it was estimated that there would be a small decline in the fishing volume as well as an increase in cost to catch that volume (given the same price per tonne for fish). Thus, an overall 10% decline in the volume of fish caught has been proposed.

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 1,191,567 tonnes price = $ 778 per tonne

The overall change in volume as a result of having no charts, is 6%, which represents 94% of the volume of fish caught with charts.

6. Change in consumer surplus and producer surplus

The total benefit in 1989 to Canadians from the use of nautical charts in the east coast fishing industry is $ 33,321,532.
Table 14 outlines these calculations in more detail.

Table 14: East Coast Fishing: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for fish	-2.0

With Charts:

Total landed value ($'000)	956,804
Total landed volume (tonnes)	1,267,222
Average price per tonne ($)	755
Minimum price of fish ($)	252

Without Charts:

Shift in supply curve	10%
Equilibrium landed (tonnes)	1,191,567
Overall decline in volume	6%
Equilibrium price per tonne ($)	778

Consumer Surplus:

Without charts ($)	211,492,263	
With charts ($)	239,201,000	
Change in consumer surplus ($)		27,708,737

Producer Surplus:

Without charts ($)	313,321,871	
With charts ($)	318,934,667	
Change in producer surplus ($)		5,612,795

Total change with charts ($) 33,321,532

To test how sensitive the change in the consumer surplus and the producer surplus was to different values for the shift in the supply curve at current prices, a sensitivity analysis was done for East Coast fishing. The values from table 14 were recalculated using different shifts in the supply curve at current prices. The results are outlined in the following table.

Table 15: East Coast Fishing: Total Change in Consumer Surplus and Producer Surplus Using Different Shifts in the Supply Curve At Current Prices.

Shift in the Supply Curve at Current Prices	10%	5%	15%
Change Consumer Surplus ($)	27,708,737	13,764,030	41,815,920
Change Producer Surplus ($)	5,612,795	2,531,902	9,311,011
Total change with charts($)	33,321,532	16,295,932	51,126,931

For each 1% shift in the supply curve at current prices, the change in the consumer surplus and producer surplus is approximately $ 3,200,000.

West Coast Region

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;

volume = 272,305 tonnes price = $ 1,529 per tonne

The data regarding the total volume and landed value of fish caught on the west coast, by fish species, was taken from statistical data obtained from the Department of Fisheries and Oceans.
The price per tonne was calculated by dividing the total landed value by the total volume of fish caught on the west coast.

2. Elasticity of demand

The elasticity of demand for fish was estimated to be -4.86. In the literature, figures for the elasticities of demand for salmon in Canada were found from DeVoretz, 28, and Kabir, 29. These figures were based on the combined domestic and export consumption of fresh/frozen and canned salmon. For an appropriate elasticity figure, a weighted average based on the percentage of landed salmon that would end up in a can versus the percentage that would be sold in a fresh/frozen form was calculated. This is an elastic demand which reflects the fact the salmon is considered to be a luxury good. Consumers are very responsive to small changes in price by purchasing relatively larger quantities (in the case of a small price decline).
On the west coast, the largest single fish family caught is salmon. There are also significant volumes of herring and shellfish caught. However, there are no estimates of the elasticities of demand for these products in the literature. Therefore, it was assumed that they, as an aggregate, would have a similar elasticity of demand as salmon. The herring are valued at a lower price per tonne than salmon and would likely have a more inelastic demand since they are not as highly prized by consumers (based on the likely willingness to pay and the reflection of this willingness to pay in the landed value of the fish). On the other hand, the shellfish are valued at a higher price per tonne and likely have an even more elastic demand than the salmon. Given these opposite effects, it was felt that there was just cause to

assume they would act as an equalizer and exhibit an elasticity of demand in the neighborhood of that of salmon.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 30% of the current price;

supply intercept = $ 510

The fishing industry is a capital intensive business, although not as much so as the commercial shipping industry. Therefore, it was estimated that the supply intercept would be 30% of the current price of fish.

4. Initial supply curve shift

The shift in the supply curve was estimated to be 20%. The industry experts with whom we spoke felt that there would be quite a large decline in the volume of fish caught in the absence of charts. Because of the nature of the coastline and the fishing methods used, such as the troller fleets, charts are an important tool for the fishermen. Therefore, it was estimated that there would be a larger decline than in the east coast fishery.

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 228,633 tonnes price = $ 1,579 per tonne

The overall change in volume as a result of having no charts, is 16%, which represents 84% of the volume shipped with charts.

6. Change in consumer surplus and producer surplus

The total benefit in 1989 to Canadians from the use of nautical charts in the West coast fishing industry is $ 29,127,467.
Table 16 outlines these calculations in more detail.

Table 16: West Coast Fishing: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for fish -4 . 86

With Charts:

Total landed value ($'000)	416,294

Total landed volume (tonnes)	272,305
Average price per tonne ($)	1,529
Minimum price of fish ($)	510

Without Charts:

Shift in supply curve	20%
Equilibrium landed (tonnes)	228,633
Overall decline in volume	16%
Equilibrium price per tonne ($)	1,579

Consumer Surplus:

Without charts ($)	30,209,823
With charts ($)	42,852,933
Change in consumer surplus ($)	12,643,110

Producer Surplus:

Without charts ($)	122,280,310
With charts ($)	138,764,667
Change in producer surplus ($)	16,484,356

Total change with charts ($) 29,127,467

To test how sensitive the change in the consumer surplus and the producer surplus was to different values for the shift in the supply curve at current prices, a sensitivity analysis was done for West coast fishing. The values from table 16 were recalculated using different shifts in the supply curve at current prices. The results are outlined in the following table.

Table 17: West Coast Fishing: Total Change in Consumer Surplus and Producer Surplus Using Different Shifts in the Supply Curve At Current Prices.

Shift in the Supply Curve at Current Prices	20%	25%	15%
Change Consumer Surplus ($)	12,643,110	15,631,397	9,577,989
Change Producer Surplus ($)	16,484,356	21,234,404	12,000,429
Total change with charts($)	29,127,467	36,865,801	21,578,419

For each 1% shift in the supply curve at current prices, the change in the consumer surplus and producer surplus is approximately $ 1,450,000.

2.3.3 RECREATIONAL BOATING

To estimate the benefits from charts with regard to recreational boating, the benefits were measured by the differences in insurance costs. As discussed previously, the boats would be subject to more accidents in the absence of charts and the resulting increase in damages would cause the insurance premiums to rise significantly.
To measure the change in the consumer surplus and the producer surplus as a result of charts, the demand was measured as the demand for insurance for boats and the supply was measured as the supply of boat insurance.

Recreational Boating

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;

volume = 84,000 boats price = $ 750 per boat for insurance costs

The consulting firm, Monenco Consultants Ltd., estimated the number of recreational boaters who used navigational aids to be 168,000 across Canada (of boats over 18 feet). Of these they stated, fewer would be real users of charts. From discussions with an official at the Canadian Power Sail and Squadron, it was estimated that the number of recreational boaters who would rely on charts for their navigation to be approximately half of those who use navigational aids, or 84,000 boats.
From conversations with various marine insurance experts, it was estimated the average value of the recreational boats over 18 feet to be $ 25,000. A standard annual insurance rate for boats up to 26 feet, a category in which the majority of these boats would fall, is $3 per $100 of value (or 3%).
Therefore, the price of insurance per boat was calculated to be the average premium times the number of boats.

2. Elasticity of demand

The elasticity of demand for insurance for recreational boats was estimated to be -0.4.
Since the cost of insurance makes up a relatively very small proportion of the cost of owning and running a boat, it was proposed that the demand for insurance for these boats would be very inelastic. This implies that the boat owners are willing to absorb relatively large increases in the insurance premiums before giving up the insurance coverage

on their boats or conversely, giving up their boats altogether.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 50% of the current price;

supply intercept = $ 300

With regard to the estimate of the supply curve, it was determined that there would be a minimum price level at which insurers would be able to provide their services. They would have to have some pool of funds available to cover the damage from the accidents as they occur. Therefore, a minimum price of insurance of 40% of the current premium price was established.

4. Initial supply curve shift

The shift in the supply curve was estimated to be 50%. It was estimated that in the absence of charts, the recreational boaters would likely experience a similar increase in groundings and bottom contacts as the other forms of shipping (although probably on the lower end of the scale). Therefore, an accident rate increase of 20% was estimated. As well, in a manner similar to the shipping, the accidents would likely be of a more serious nature and therefore result in greater damages. According to the insurance experts, this could translate into an insurance premium increase of 50% (depending upon factors such as amount of damage, number of boats insured, replacement value of the boat, the number of accidents a particular owner has had, and so on).

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 67,200 boats price = $ 1,125 per boat for insurance costs

This scenario was evaluated slightly differently from the other marine areas impacted by charts. The shift in the supply curve was on the price side (as insurance premiums rise). Therefore, the final equilibrium point was measured as a result of the insurance increase, rather than a reduction in the volume of boats.
The overall change in volume as a result of the rise in premiums with the absence of charts, is 20%, which represents 80% of the volume of boats with charts. This represents the reduction in the number of people taking out

insurance for their boats (from either simply not insuring the boats and/or from selling the boat as a result of the increased cost to run it).

6. Change in consumer surplus and producer surplus

The total benefit in 1989 to Canadians from the use of nautical charts in the recreational boating industry is $ 19,530,000.

Table 18 outlines these calculations in more detail.

Table 18: Recreational Boating: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for Insurance -0.4		
With Charts:		
Total number of boats (>18',using charts)		84,000
Average value of boats ($)		25,000
Average insurance cost per boat		3%
Average cost of insurance per boat ($)		750
Minimum price of insurance ($)		300
Without Charts:		
Shift in insurance premiums	50%	
Equilibrium number of boats	67,200	
Overall decline in number	20%	
Equilibrium price of insurance per boat ($)		1,125
Consumer Surplus:		
Without charts ($)	50,400,000	
With charts ($)	78,750,000	
Change in consumer surplus ($)		28,350,000
Producer Surplus:		
Without charts ($)	27,720,000	
With charts ($)	18,900,000	
Change in producer surplus ($)		(8,820,000)
Total change with charts ($)	19,530,000 -	

To test how sensitive the change in the consumer surplus and the producer surplus was to different values for the shift in the supply curve at current prices, a sensitivity analysis was done for recreational boats. The values from table 18 were recalculated using different shifts in the supply curve at current prices. The results are outlined in the following table.

Table 19: Recreational Boats: Total Change in Consumer Surplus and Producer Surplus Using Different Shifts in the Supply Curve At Current Prices.

Change in Insurance Premium	50%	60%	40%
Corresponding Shift in Supply	20%	24%	16%
Change Consumer Surplus ($)	28,350,000	33,264,000	23,184,000
Change Producer Surplus ($)	(8,820,000)	(9,828,000)	(7,560,000)
Total change with charts($)	19,530,000	23,436,000	15,624,000

For each 1% shift in the supply curve at current prices, the change in the consumer surplus and producer surplus is approximately $ 976,500.

2.3.4 NATIONAL DEFENCE

To estimate the benefits from charts with regard to national defence, the steps described in the previous section were performed to evaluate the changes in the efficiency of the Maritime Forces in the absence of charts and the resulting effect on the Canadian economy.

Reduction in Efficiency

The activities performed by the Maritime Forces were determined through consultations with the officers from the Maritime Command. (as presented in section 2.2). Based on the factors discussed in that section, the officers proposed an approximate percentage reduction in the efficiency of each activity, given the absence of charts. These reductions were based on the assumption that the current budget was still in place and thus the total expenditure of the Maritime Forces did not change. These reduction in efficiency figures are assumed to reflect (in addition to the reduced effectiveness of each activity) an increase in costs as a result of more accidents as well as an increase in operating costs due to the longer travel times. Table 18 outlines the officers' estimates of the reduction in efficiency of each activity, given the current spending level for the Maritime Forces operations.

As noted previously, since many of the activities are carried out concurrently, it is difficult to separate out each activity to determine the share of the total budgeted time and cost that the activity would represent. However, with the assistance of the naval experts, we were able to calculate an approximate budget allocation for each activity.

Table 20 indicates the estimated budget allocation for each activity of the Maritime Forces and the total budget assigned for these duties for the 1990-1991 year. The figures for the total maritime operations budget, search and rescue and fisheries patrol were obtained from the Deputy Minister's Office of the Department of National Defence. These figures were converted from 1990-1991 dollars to 1989 dollars by the consumer price index, to be consistent with the benefit calculation from all uses of nautical charts.

Table 20. National Defence.

Reduction in Efficiency Without Nautical Charts at Current Budget Levels

Activity	1990-1991 Budget Share	Budget Share 1989 Dollars	Reduction in Efficiency	Result in 1989Dollars
Search & Rescue	2,900,000	2,784,000	50%	1,392,000
Fisheries Patrol	17,100,000	16,416,000	10%	14,774,400
Sovereignty Patrol	75,000,000	72,000,000	10%	64,800,000
Environmental Patrol	75,000,000	72,000,000	10%	64,800,000
Mine Counter Measures	80,000,000	76,800,000	50%	38,400,000
Anti Air Warfare	190,300,000	182,688,000	0%	182,688,000
Anti Surface Warfare	190,300,000	182,688,000	5%	173,553,600
Anti Submarine Warfare	190,300.000	182.688,000	25%	137,016.000
Totals	820,900,000	788,064,000	14.15	676,552,944

The budget share of each activity was deflated by its corresponding percent reduction in efficiency to obtain an overall weighted reduction in the budget as a result of the absence of nautical charts. Therefore, this reduction reflects the level of service that would be available at the current budget, given the lack of charts. With the estimates provided by the Defence staff, the overall total weighted reduction in the effectiveness at current prices in the Maritime Forces operation is 14.15%. This then, represents the shift which would occur in the absence of charts.
In the procedure outlined in the previous section, the calculation of the change in the consumer and producer surplus for national defence, with and without charts, is as follows.

National Defense

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;
volume = 7,881,000,000 worth of services price =$ 7,881,000 per 1% of current service level

Clearly, levels of defence are not measured in terms of 'units' and therefore, a 'price per unit' does not exist. However, a total budget does exist, as does the current

level of service for the Maritime Forces. Therefore, the total budget was divided by 100 to get the price to provide 1% of the current service level of the Forces.
This provides a means to measure the current equilibrium point in terms of volume, percent of current service level (at current defense costs), and a price for each percent of the current service level.
Therefore, as the Forces become more inefficient in the absence of charts, the service level at current prices declines, implying that the Forces perform fewer duties at the current budget level.

2. Elasticity of demand

The elasticity of demand for national defence was estimated to be -0.5.
The demand for defence by Canadians was estimated to be very inelastic. This implies that for a given level of defence, Canadians are willing to absorb relatively large price changes for that level of defence. Canadians are willing to pay for certain commitments that they have consented to, such as NATO involvement and UN peacekeeping roles. If the cost of these commitments varies from year to year, Canadians are still willing to pay these costs, within reason.
However, Canadians are not willing to pay anything for defence. An example of this would be the rejection of the nuclear submarine fleet several years ago. Canadians were not willing to pay that price for the patrol of our north by a new submarine fleet. Therefore, it has been proposed that the demand for defense would best be represented by an inelastic demand curve.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 50% of the current price;

supply intercept = $ 3,940

In a similar manner as shipping, setting up a defence force would involve a large initial capital outlay to purchase the airplanes, ships, tanks and other equipment required for defence duties. Therefore, it has been proposed that a minimum price of defence would reasonably be 50% of the current defence cost.

4. Initial supply curve shift

The shift in the supply curve was estimated to be 14.15% (as above) which represents a reduction in efficiency of 14.15% of the current service level at current prices.

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 96.8% of the current service level price = $ 8,384,000 per 1% of service level

Because the demand curve for defence is not perfectly inelastic, if the Forces were less efficient then Canadians would demand more defence spending and therefore increase the output of the Forces.

6. Change in consumer surplus and producer surplus

The total benefit in 1989 to Canadians from the use of nautical charts in the west coast (international shipping industry is $ 31,436,360.

Table 21 outlines these calculations in more detail.

Table 21: National Defense: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for defense	-0 . 5
With Charts:	
Total marine operations budget ($)	788,064,000
Current effectiveness (%)	100
Current price (per 1% of effect,$'000)	7,881
Minimum price of defense ($'000)	3, 940
Without Charts:	
Supply shift at current prices	14.15%
Equilibrium defence effectiveness	96.8%
Overall decline in volume	3.2%
Equilibrium price of defence ($'000)	8,384
Consumer Surplus:	
Without charts ($)	738,568,394
With charts ($)	788,064,000
Change in consumer surplus ($)	49,495,606
Producer Surplus:	
Without charts ($)	215,075,246

With charts ($)		197,016,000
Change in producer surplus	($)	(18,059,246)
Total change with charts	($)	31,436,360

2.3.5 ARCTIC

To estimate the benefits from charts with regard to the Arctic, a slightly different approach was taken compared to the other areas above, to measure the effect of the absence of charts on the Canadian economy.
From discussions with experts in Arctic travel, it was determined that without charts, in many areas of the arctic, the cargo would have to be flown in by air to carry out the resupply of the defence sites and northern communities. Since the mode of transportation must be changed, the analysis cannot be carried out with a pivotal shift of the supply curve. The change of transportation mode means that the whole cost basis would change for the arctic resupply, and must therefore use a complete shift of the supply curve to reflect this new method of travel.

Figure 4 shows the shift in the supply curve as the goods are transported by air rather than by vessel. The consumer surplus and producer surplus are measured the same way as previously.

Figure 4. Supply Shift for the Arctic Resupply.

Arctic Resupply

1. Equilibrium point with charts

The existing equilibrium point was calculated to be;

volume = 56,000 tonnes price = $ 268 per tonne

The current volume of cargo and cost to transport those goods to the arctic was determined from discussions with an expert in the arctic resupply. The total cost for the transportation of the goods was estimated at $ 15,000,000. The price per tonne was calculated by dividing the total volume by the total cost of the resupply.

2. Elasticity of demand

The elasticity of demand for arctic resupply was estimated to be -O.1 .
It has been estimated that the demand for Arctic resupply by Canadians would be very inelastic. This implies that Canadians are willing to absorb relatively very large price changes to maintain the northern defence sites and communities. again it is unlikely that Canadians are willing to pay anything for this resupply. Therefore, it was proposed that the elasticity of demand for arctic resupply have used an elasticity of demand value of -0.1.

3. Intercept of the supply curve

The intercept of the supply curve was estimated as 50% of the price of freight transportation;
supply intercept, with charts = $ 134 supply intercept, without charts = $ 1,071

The value of 50% of the price to transport the cargo was used because of the high costs to get material to the arctic.
The intercepts for both supply curves were estimated since the supply curves shifts completely, rather than pivots at one intercept point.

4. Initial supply curve shift

The shift in the supply curve was estimated to be 8 times that of the cost to ship cargo by vessel, as estimated by the arctic expert.

5. Equilibrium point without charts

The final equilibrium point without charts was;

volume = 28,000 tonnes price = $ 1,607 per tonne

The overall change in volume as a result of having no charts, is 50%, which represents 50% of the volume shipped with charts.

6. Change in consumer surplus and producer surplus

The total benefit in 1989 to Canadians from the use of nautical charts in the arctic resupply is $ 52,500,000.

Table 22 outlines these calculations in more detail.

Table 22: Arctic Resupply: Total Change in Consumer Surplus and Producer Surplus.

Elasticity of demand for arctic resupply		-0.1
With Charts:		
Total resupply cost ($'000)	15,000	
Total shipping volume (tonnes	56,000	
Shipping cost per tonne ($)	268	
Minimum price of shipping ($)	134	
Without Charts:		
Shift in supply curve	8 times	
Equilibrium resupply volume (tonnes)		28,000
Overall decline in volume	50%	
Equilibrium shipping cost per tonne ($)		1,607
Consumer Surplus:		
Without charts ($)	18,750,000	
With charts ($)	75,000,000	
Change in consumer surplus ($)		56,250,000
Producer Surplus:		
Without charts ($)	7,500,000	
With charts ($)	3,750,000	
Change in producer surplus ($)		(3,750,000)
Total change with charts ($)	52,500,000	

2.3.6 ENVIRONMENT

To calculate the benefits to Canadians of charts with regard to the environmental damage, the Natural Resource Environmental Damage Assessment Model for Coastal and Marine Environments by Grigalunas, et al, was used.

As previously discussed, the costs of oil spills that are borne by ship owners and funds such as the Ship-Source Oil Pollution Fund are only those for cleanup and direct damages as a result of the spill. The other environmental damages are real costs to the economy and are costs in addition to the shipowners' costs.

The costs of the environmental damage were calculated for both the relatively minor spills and for major disaster spills, such as the Exxon Valdez spill in Alaska.

Minor Spills

The current oil spill accident rate was estimated from documents provided by Environment Canada. From the commercial shipping section, the estimated figure of the increased rate of shipping accidents of 20% was used. The increased number of spills that would occur in the absence of charts was then calculated.

To obtain the current spill rate, past data was analyzed for the period from 1794 to 1983. The spill rate from 1983 to the present was then estimated as follows.

From the Environment Canada's "Summary of Spill Events in Canada, 1974-1983", 30, the number of oil spills was calculated for tankers, bulk carriers and other watercraft, as a result of accidents from collision (including bottom contact), grounding and sinking. In the absence of charts, it was determined that these types of accidents would increase. In this report, it was thought that the number of spills would stay relatively constant over the long term, and that oil would continue to be the substance most spilled.

To show that this has been the case, Transport Canada's "Marine Casualty Investigations, Statistical Summary of Marine Accidents" was reviewed from 1984 to 1989, 31. The number of boats grounding and suffering collisions has remained relatively constant over the six year period. Therefore, it was interpreted that the number of spills would likely have remained fairly constant as well with charts.

Therefore, it has been estimated that the current spill rate is on average, 1475 tonnes of oil spilled per year as a result of the aforementioned accidents. The average amount spilled is 116 tonnes, with a large spill being 1027 tonnes on average.

If the accident rate was to increase by 20 to 50% and result in more damage to the vessels than is current experienced, it is likely that there would be twice as much oil spilled in the 'minor spills'. This would represent an increase of 1475 tonnes of oil spilled every year.
The Natural Resource Damage Assessment Model of Grigalunas et al, was used to estimate the potential loss to the economy from this increase in oil spills. The model simulates actual spills in specific areas and marine environments. Factors such as amount and substance spilled, area spilled in, wind speed, ocean current direction and speed and temperature as well as a host of other parameters are used to model a particular spill. However, the following tables outlines some representative figures for a spill of 100 tonnes of diesel fuel.

Table 23: Economic Damages from Spills of Diesel Fuel in the East Coast for Various Quantities Spilled During the Summer Season (in 1989, US dollars) Source: Grigalunas et al, 1988.

Quantity Spilled		Damages in Estuarine	Damages in Marine
Tonnes	Barrels	Environments	Environments
5	36.75	$ 2,840	$ 375
10	73.50	5,406	1,076
50	367.50	27,785	9,420
100	735.00	53,637	16,302
150	1,102.50	78,999	31,958
250	1,837.50	129,968	58,465
500	3,675.00	239,856	153,484
750	5,512.50	354,508	240,968
1,000	7,350.00	486,402	356,110

Table 24: Economic Damages from 100 Tonnes Spill of Diesel Fuel in Estuarine Environments by Province and Season (In 1989, US dollars).
Source: Grigalunas et al, 1988.

	Spring	Summer	Fall	Winter
Acadia	$ 22,400	$ 32,409	$ 21,901	$ 16,784
Columbia	65,727	217,486	91,816	107,422
Fjord	46,977	56,329	44,796	22,230
Arctic	74,208	121,450	54,954	1,386

If there were 1475 more tonnes of oil spilled per year, at an average of 100 tonnes per spill (as above), the environmental damage could be as much as (for example, during the summer in the Columbian province, which is representative of the south B.C. coast);

14.75 x $ 217,486 = $ 3,207,918 (US)

In Canadian 1989 dollars (given the US dollar at $ 0.86 Canadian) this would be $ 3,730,138.

Major Spill

If there was one major spill every ten years, similar to the Exxon Valdez, then the associated environmental damages could be very high. It is extremely difficult to estimate a figure for an event such as this. The Exxon Valdez cost in the order of $ 3 billion, part of which was cleanup and part of which was environmental damage. The experts from Environment Canada and the petroleum industry however, thought that this was a very inflated figure and did not represent the true cost of the event. One estimate that was proposed was an oil spill event that would cause $ 500,000,000 in damage. If this were to occur every ten years on average, then $ 50,000,000 could be used as an annual figure to represent the potential cost of a major spill. If a portion of this (one third) was covered under the existing oil spill funds, then an estimate of the additional environmental damage would be $ 33,333,333 per year. However, it should be noted that if the shipowners and/or cleanup funds were to run out of money for the cleanup, this would leave the tax payers with the cleanup bill and therefore represent an additional social loss.

Total Environmental Costs

Given the minor and major spill scenarios, it was proposed that the annual increase in environmental damage on average, could be as much as;

$ 3,730,138 + $ 33,333,333 = $ 37,063,471

2.4 SUMMATION OF BENEFITS

The total benefits from the use of charts have been summarized in the following table.

Table 25: Summary of the Benefits from Charts.

Commercial shipping.	
Atlantic domestic	$ 5,468,750
Atlantic international	611,307
Inland domestic	24,761,905
Inland international	188,911,245
West coast domestic	16,578,947
West coast international	33,802,817
Commercial fishing:	
East coast	33,321,532
West coast	29,127,467
Recreational Boating	l9,530,000
National Defence	31,436,360
Arctic	52,500,000
Environment	37,063,471
Total Benefits	$ 473,113,801

2.5 DETERMINATION OF COSTS

The costs of the charting service were provided by the CHS. According to the CHS, the average life of a chart is 15 years. Therefore, we apportioned one fifteenth of each of the past l5 years of costs to the benefits measured for 1989, from the use of the charts in existence in 1989.

The budgeted costs for 1989, l988 and l987 were used. To estimate the costs back to 1975, the 1987 figure was deflated for each year back to 1975 by the CPI.Those figures were then deflated by the CPI to get the equivalent 1989 dollar for each year. Those costs were then compounded forward to 1989 dollars, using both a 2% and a 5% rate of interest, (see table 26 below).
One fifteenth was then taken from each year in 1989 dollars, to represent that year ' s contribution towards producing the charts which were in existence in 1989 when the benefits were measured. The sum of these then represents the cost, in 1989 dollars, to produce the charts that are available in 1989 and which generated the benefits measured in 1989. At a 2% interest rate, the cost of the charts in 1989 is $ 40,174,100. At a 5% interest rate, the cost of the charts in l989 is $ 50,170,100.

Table 26. Costs of the CHS Attributable to 1989 Benefits from Charts, t'000).

YEAR	CPI	BUDGET	REVENUE	TOTAL COST	1989 $'S	1/15th at 2%	1/15th at 5%
1975	44.2			13567.2	34992.4	**3078.1**	**4618.8**
1976	47.5			14580.2	34992.4	3017.8	4398.9
1977	51.3			15746.6	34992.4	2958.6	4189.4
1978	55.8			17127.9	34992.4	2900.6	3989.9
l979	61.0			18724.0	34992.4	2843.7	3799.9
1980	67.2			20627.1	34992.4	2787.9	3619.0
1981	75.5			23174.8	34992.4	2733.3	3446.7
1982	83.7			2569l.8	34992.4	2679.7	3282.5
1983	88.5			27165.2	34992.4	2627.1	3126.2
1984	92.4			28362.3	34992.4	2575.6	2977.3
1985	96.0			29467.3	34992.4	2525.1	2835.6
1986	100.0			30695.1	34992.4	2475.6	2700.6
1987	104.4	33781.0	1735.3	32045.7	34992.4	2427.1	2571.9
1988	108.6	35011.0	1970.8	33040.2	34683.1	2358.4	2427.8

l989 114.0 34998.9 2217.4 32781.5 32781.5
2185.4 2185.4

TOTAL COSTS IN 1989 DOLLARS 40174.1 50170.1

2.6 DETERMINATION OF BENEFIT-COST RATIOS

The benefit-cost ratios are as follows;

Using the 2% compounding value:

473,113,801/40,174 ,100 = 11 . 78

Using the 5% compounding value:

473,113,801/50,170,100 = 9.43

The benefit-cost ratios show the return earned for every dollar invested in the CHS. Therefore, with benefit-cost ratios from 9/1 to 17/1 clearly, the CHS is a great investment for the Canadian economy.

APPENDIX A

LIST OF RESOURCE PERSONNEL AND/OR COMPANIES CONSULTED

Canada Coast Guard

Captain Brian Tuomi Regional Superintendent Aids to
Navigation Aids & Waterways - Western Region Vancouver, B.C.

Alfie Yip
Regional Superintendent - Navigational Aids
Ontario

William Clark
Superintendent
Ontario Region

Canadian Hydrographic Service

Ross Douglas
Director

Earl Brown
Director, Hydrography
Central & Arctic Region

John O'Shea
Chief of Planning

Maritime Forces, Department of Defence

L.Cmdr. Jim Bradford
Section Head, Hydrographic Operations and Plans
D Geo Ops 2
Directorate of Geographic Operations

L.Cmdr. Jim Reddy
Department of National Defence

L.Cmdr. Bill McKillip
Department of National Defence

Marine User Group Representatives

Captain C.L. Ball

Senior Vice-President & CEO
Halifax Port Corporation

Richard Oliphant Harbour Master Vancouver, B.C.

Dave Bachelor
Manager, Operations
Pacific Pilotage

Peter Woodward
Council of Marine Carriers

Michael O'Connor Manager, Fleet Services and Strategy
National Sea Products Ltd.

Norman Hall
President
Canadian Shipowners Association

Neil Hunter
Manager, Marine Operations
Canadian Shipowners Association

Ronald Watkins
Chief Commander
Canadian Power & Sail Squadrons

Alanna Lantela Occupational Health and Safety Director
United Fishermen and Allied Workers' Union Vancouver, B.C.

Chuck Bailey
Manager, Spill Response Co-ops
Ontario Division

Captain P. Hansell
Western Supervisor
Great Lakes Pilotage Authority

Captain K. Driver
Corporation of Great Lakes Pilots

Ken McMillan
McQuest Marine Sciences Limited
Burlington, Ontario

Michael Majerovich General Manager, Log Supply and Transportation Fletcher Challenge Ltd. Vancouver, B.C.

Helge Tomter FedNav Vancouver, B.C.

Government

J.E. Slater
Director, Environmental Emergencies Branch
Inland Waters Directorate Conservation & Protection
Environment Canada

Su Brassat
Environmental Emergencies Branch
Inland Waters Directorate Conservation & Protection
Environment Canada

Daniele Dion
Barrister & Solicitor
Admiralty and Maritime Law
Department of Justice

Captain Brian Thorne
Director of Investigations - Marine
Transportation Safety Board of Canada

Bill Raney
Head, Costing and Statistical Analysis
Provincial Transportation Systems Office
Ministry of Transportation, Ontario

John Rogers
Chief, Economic Policy
Department of Fisheries & Oceans

Heather Campbell
Barrister & Solicitor
Ministry of the Environment, Ontario

University and Other

Dr. Tom Grigalunas
Chairman, Department of Resource Economics
University of Rhode Island

Dr. Heads
Director
Transportation Institute
University of Manitoba

Dr. Barry Prentis
Transportation Institute
University of Manitoba

Dr. Diane Dupont
Department of Economics
Brock University

Dr. W.G. Waters
Center for Transportation Studies
University of British Columbia

Canadian Wheat Board
Winnipeg, Manitoba

Dofasco
Hamilton, Ontario

Tom Irvine
Associate
InterCon Consultants

Robert Trout
Senior Vice President
Marsh & McLennan

Dennis Fitzgerald
Vice President
Marsh & McLennan

Lisa Taylor
Peter Taylor Insurance Brokers Limited
Thornhill, Ontario

Gary Mauseth
Beak Environmental Consultants
Kirkland, Washington

Peter Troop
Administrator
Ship-Source Oil Pollution Fund

APPENDIX B

SAMPLE CALCULATIONS OF CONSUMER SURPLUS AND PRODUCER SURPLUS

Atlantic Domestic: Total Change in Consumer Surplus and Producer Surplus.

Total shipping revenue ($): 70,000,000
Total shipping volume (tonne km): 7,632,936,000
Shipping cost per tonne km ($): 70,000,000 = 0.00917
7,632,936,000
Minimum price of shipping ($): 0.00917 = 0.00459

Elasticity of demand for shipping = slope X (price/volume) - 0.5 = slope X 0.00917 7,632,936,000 slope = - 0.000000000002403 Equation of a linear curve: price = intercept + (slope X volume) Equation of the demand curve: price = intercept + (slope X volume) intercept = 0.00917 - [(-0.000000000002403) X (7,632,936,000)] = 0.02751
Equation of the supply curve with charts: price = intercept + (slope X volume) l/slope = 0.00917 - 0.00459 7,632,936,000 = -0.000000000000801

Supply shift at current prices: 25%

Equation of the supply curve without charts: price = intercept + (slope X (volume X (l - supply shift)) l/slope = 0.00917 - 0.00459 (7,632,936,000) X (1-0.25)
= -0.000000000000601

Equilibrium shipping volume (tonne km): supply curve without charts = demand curve intercept + (slope X volume) = intercept + (slope X volume)

volume = 0.00459 - 0.02751
(-0.000000000002403) - (-0.000000000000601)
= 7,155,877,365
Overall decline in volume: 7,155,877,365 = 6.3%
7,632,936,000

Equilibrium shipping cost per tonne km ($): Price = 0.00459 + (-0.000000000000601 X 7,155,877,365)
= 0.01032

Consumer surplus without charts ($): = (intercept - equilibrium price) X equilibrium volume/2
= 61,523,438
Consumer surplus with charts ($): = (intercept - price) X volume/2
= 70, 000, 000

Change in consumer surplus ($):
= 70,000,000 - 61,523,438
= 8,476,562
Producer surplus without charts ($):
= (equilibrium price - minimum price) X equilibrium volume/2

= 20,507,813
Producer surplus with charts ($):
= (price - minimum price) X volume/2
= 17,500,000
Change in producer surplus ($):
= 17,500,000 - 20,507,813
= (3,007,813)
Total change with charts ($): = 17,500,000 + (3,007,813)
= 5,468,750

APPENDIX C

INTERNATIONAL BENEFITS FROM CHARTS INCLUDING FOREIGN REVENUES

Atlantic International: Total Change in Consumer Surplus and Producer Surplus including Foreign Benefits.

Elasticity of demand for shipping -0.5

With Charts:
- Total shipping revenue ($'000) 46,948
- Canadian shipping revenue ($'000) 10,000
- Total shipping volume (tonne km, '000) 4,076,431
- Canadian shipping volume (tonne km, '000) 868,280
- Shipping cost per tonne km ($) 0.01152
- Minimum price of shipping ($) 0.00576

Without Charts:
- Supply shift at current prices 5%
- Equilibrium shipping volume (tkm, '000) 4,033,969
- Overall decline in volume 1%
- Equilibrium shipping cost per tonne km ($) 0.01176

Consumer Surplus:
- Without charts ($) 45,975,360
- With charts ($) 46,948,357
- Change in consumer surplus ($) 972,997

Producer Surplus:
- Without charts ($) 12,098,779
- With charts ($) 11,737,089
- Change in producer surplus ($) (361,691)

Total change with charts ($) 611,307

Inland International: Total Change in Consumer Surplus and Producer Surplus Including Foreign Benefits.

Elasticity of demand for shipping -0.6

With Charts:
Total shipping revenue ($'000) 2,441,480
Canadian shipping revenue ($'000) 520,000
Total shipping volume (tonne km, '000) 103,321,212
Canadian shipping volume (tonne km, '000) 22,007,418
Shipping cost per tonne km ($) 0.02363
Minimum price of shipping ($) 0.01181

Without Charts:
Supply shift at current prices 25%
Equilibrium shipping volume (tkm, '000) 95,941,126
Overall decline in volume 7%
Equilibrium shipping cost per tonne km ($) 0.02644

Consumer Surplus:
Without charts ($) 1,754,175,849
With charts ($) 2,034,428,795
Change in consumer surplus ($) 280,252,946

Producer Surplus:
Without charts ($) 701,670,339
With charts ($) 610,328,638
Change in producer surplus ($) (91,341,701)

Total change with charts ($) 188,911,245

West Coast International: Total Change in Consumer Surplus and Producer Surplus Including Foreign Benefits.

Elasticity of demand for shipping	-0.4
With Charts:	
Total shipping revenue ($'000)	563,378
Canadian shipping revenue ($'000) `	120,000
Total shipping volume (tonne km, '000)	24,046,027
Canadian shipping volume (tonne km,'000)	5,121,804
Shipping cost per tonne km ($)	0.02343
Minimum price of shipping ($)	0.01172
Without Charts:	
Supply shift at current prices	20%
Equilibrium shipping volume (tkm, '000)	23,084,186
Overall decline in volume	4%
Equilibrium shipping cost per tonne km ($)	0.02577
Consumer Surplus:	
Without charts ($)	649,014,085
With charts ($)	704,225,352
Change in consumer surplus ($)	55,211,268
Producer Surplus:	
Without charts ($)	162,253,521
With charts ($)	140,845,070
Change in producer surplus ($)	(21,408,451)
Total change with charts ($)	33,802,817

APPENDIX D

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