Economic Study of Canada's Marine and

Ocean Industries

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Executive Summary

This report highlights the importance of marine and ocean industries to the Canadian economy.

Canada's continental shelf, covering 3.7 million square kilomotres, is the second largest in the world. Three large oceans span Canada's territory including the Artic, the Pacific and the Atlantic. In addition, the St. Lawrence River, the Gulf of St. Lawrence, Hudson Bay, James Bay are important waterways for Canada's economic, defence and political interests.

Canada's oceans generate a considerable number of jobs and economic activity. These oceans provide food and energy resources as well as a venue for transporting goods and people. The quality and efficiency of delivering these ocean resources to Canadians and export markets has increased considerably due to technological innovations and a strong ocean science effort by both governments and the private sector.

This economic study discusses traditional and emerging industries and technologies associated with Canada's oceans. A basket of goods and services has been identified, which covers marine and ocean technologies as well as traditional industries that are being influenced by hardware and software technologies.

The following industry baskets, which are associated with Canada's oceans, are discussed in this report:

- Marine technologies and related industries
- Shipbuilding and boatbuilding
- Resource extraction and water transportation
- Public Service.

In 1998, Canadian marine and ocean industries generated $10.4 billion of gross domestic product (GDP) in constant 1992 dollars and 120,000 full time jobs. This economic activity accounted for 1.4% of total Canadian GDP.

The marine technologies and related industries basket includes:

- Marine communications and electronic Industry
- Marine technology and machinery
- Aquaculture suppliers
- Ocean services
- Marine construction
- Oil and gas exploration and development.

These technology industries, overall, grew at an annual average rate of 11% from 1988 to 1998 and generated $2.3 billion in GDP (1992 dollars) and 30,000 jobs in 1998. This basket is heavily influenced by offshore oil and gas exploration, development and construction of offshore rigs and platforms.

Projections by the Newfoundland Offshore Industries Association (NOIA) indicate that total offshore oil and gas activities will generate $55 billion in capital and operating expenditures over the next 20 years. The offshore oil and gas sector has a substantial impact on other sectors of the economy including metal fabrication, construction, ship technologies, communication equipment, specialized machinery and professional services.

The Canadian shipbuilding industry has experienced declining output and employment in the 1990s due to the completion of several military projects, defence cutbacks, market conditions and restrictive trade practices by competitor countries.

In spite of these disruptive conditions, the shipbuilding industry, overall, has shown periods of high profitability in the 1990s. This phenomenon is likely attributable to increased exports, ship repair work and spin-off benefits from offshore oil and gas developments. The results on productivity are mixed due to the long cycle time to complete projects and a tendency for the industry to hoard skilled labour when production is declining. Productivity generally rose in the 1990s to 1996, then declined sharply from 1996 to 2000.

The shipbuilding industry consists of both shipyards and servicing operations. The industry is operating at low capacity utilization levels, and has been selling off its assets over the past 10 years in order to adjust to the changing environment and reductions in defence and related expenditures by the federal government. The average life span of the industry's machinery and equipment was 5.7 years in 1998 compared to 6.8 years in 1988.

Naval architects perform a critical function in the shipbuilding industry. The quality of a ship is highly dependent on its design and specification.

In addition to being a designer, the naval architect integrates various functions including engineering, structural and environmental aspects of shipbuilding. The role of the naval architect in ensuring high quality and efficiencies in the construction process is central to the overall performance of the shipbuilding industry.

Structural changes in the wild fishery have encouraged the rapid development of the aquaculture industry, especially for salmon and trout. The aquaculture industry has increased by fifteen times over the past decade. Significant investment in research and development in biotechnology and containment facilities is taking place in order to encourage the farming of additional species, especially for groundfish and shellfish.

In spite of the decline in salmon and codfish stocks, the total value of commercial landings in the sea fishery has increased over the past ten years reaching a level of almost $1.6 billion in 1999 compared to $1.4 billion in 1989. These increased revenues is the result of higher fish prices as well as a substantial growth in shellfish landings, which is the most significant species being harvested.

Research priorities for this industry are now focusing on resource sustainability and a better understanding of ecosystems as opposed to the previous goal of catching fish more efficiently.

Fish processing continues to be a key economic driver of the Atlantic Provinces. The fish processing industry employs 23,000 people and generates almost $800 million annually in GDP. Given the growing importance of the aquaculture industry, the fish processing industry will continue to be a dominant marine industry for some time.

One quarter of total Canadian crude oil reserves are situated in the Beaufort Sea and East Coast offshore. Marketable production of crude oil on the East Coast was 8% of the Canadian total in 1999.

The East Coast accounts for 4% of the Canadian total of marketable gas reserves. Future natural gas reserves are considered to be substantial, which will generate considerable economic spin-offs when these reserves are developed.

The Atlantic Canada offshore crude oil and natural gas have considerable implications for the transportation and logistics of supplies and crude oil and/or gas production to and from the sea platforms to the shore. Crude oil is carried by tanker from the sea platform or rig to a distribution center, managed and operated by the Newfoundland Transshipment Limited (NTL) located at Whiffen Head. This terminal became operational

in October 1998. It has 2 tanker berths and 5 crude oil storage tanks each with 500,000-barrel storage capacity. NTL provides transshipment services for the Grand Banks.

Most of Canada's dry good bulk exports are carried by marine transport. Containers are being used for a growing proportion of general merchandise exports. Fierce competition with trucking has kept the use of containers for domestic shipments to a minimum.

The level of government expenditures on marine and ocean industry sectors has declined on average by 6% per annum over the past decade. In spite of this reduction, the federal and provincial governments are providing critical support to the sector, including:

- Port management
- Defence and security
- Ocean science research
- Ice breaking
- Navigation aids
- Regulatory and licensing support
- Environmental support.

The marine and ocean industries in Canada are operating in a highly fluid and changing environment with the decline in fish stocks, reduced government expenditures, defence cutbacks and fluctuating oil and gas prices. The offshore oil and gas industry has replaced these traditional activities as the main engine of growth.

Strong opportunities are evident to supply specialized marine and ocean services and manufactured goods to the Atlantic offshore sector. Export opportunities to the United States and abroad need to be carefully assessed in view of restrictive trade practices and non-tariff barriers. The spin-off industries from offshore developments are substantial. The employment multiplier is in the order of five to one for offshore oil and gas construction. Jobs and growth are generated in a number of manufacturing, construction and service industries.

1. Background

The United Nations has declared that in recognition of the importance of the marine and ocean environment and its contribution to life on earth and for sustainable development, 1998 was the International Year of the Ocean. The objective was to focus and reinforce the attention of governments, decision-makers and the public on the importance of the ocean environment.[1]

In view of the importance of the ocean to Canada and the world, this report provides an overview of the continuing importance of domestic marine and ocean resources to the Canadian economy. Canada has three vast oceans including the Arctic, the Pacific, and the Atlantic. Marine-based industries are critical to economic activity in Canada. The *St.* Lawrence River, the Gulf of St. Lawrence, Hudson Bay, and James Bay also have significant marine and ocean components.

Canada's continental shelf covers 3.7 million square kilometres and is the second largest in the world.[2] Canada's oceans generate considerable commercial activity including shipbuilding, offshore oil and gas, water transport, port activity, fisheries, marine construction, engineering and professional services, specialized equipment, telecommunications and scientific research and development.

Many of Canada's large cities operate as marine ports. In fact, there are over 2,000 significant ports around the world.[3] An estimated 40% of the land covered under Canadian jurisdiction is under water.

It is estimated that marine-related industries generated $1,826.6 billion in revenues on a worldwide level in 1999. The top industries included offshore oil and gas production, oil and gas exploration and development expenditures, shipping revenues, naval expenditures, submarine telecommunication revenues, and leisure boat revenues.

The top markets include Asia, Europe and North America, especially for shipping revenues and naval expenditures.

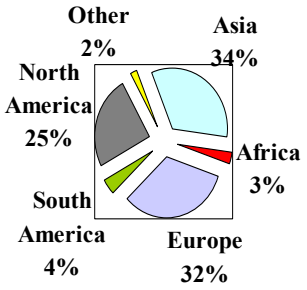
Significant offshore oil and gas expenditure is taking place in these areas as well as in Africa and South America.

[1] http://ioc.unesco.org/iyo/introduction.htm
[2] Environment Canada, Canada's Oceans, Experience and Practices, 1999.
[3] Douglas-Westwood Associates, UK *Marine Industries World Export Market Potential*, a report for the Foresight Marine Panel, October 2000.

Table 1: World marine market sectors ($ Billion Canadian 1999) [4]			
Sector	Value	Sector	Value
Offshore oil & gas production	480.8	Port management	21.2
Oil & gas expenditure	137.0	Leisure boats	15.4
Shipping revenues	375.0	Ship repair	13.2
Naval expenditure	360.6	Submarine cables	12.0
Submarine telecom revenues	110.6	Education & training	5.3
Leisure boating revenues	60.1	Desalination	2.9
Shipbuilding	50.5	Ocean survey	1.7
Aquaculture production	35.3	Minerals	1.7
R&D	30.5	Unmanned Underwater Vehicles (UUVs)	1.4
Port development	30.1	Marine IT	1.4
Cruise industry	28.8	Marine biotechnology	1.2
Marine services	26.4	Total market sectors	1826.6
Marine equipment	23.3		

Asia has the largest marine and ocean market, followed by Europe, North America, South America and Africa. Shipping revenues and naval expenditures are the largest marine and ocean industries in Asia, Europe and North America. Oil and gas expenditures dominate the marine and ocean sector in South America and Africa.[5]

Figure 1: World Marine Markets, 1999



Douglas-Westwood Associates, UK *Marine Industries World Export Market Potential*

[4] UK Marine Industries World Export Market Potential, a report for the Foresight Marine Panel, Douglas-Westwood Associates, October 2000.
[5] Douglas-Westwood Associates, UK *Marine Industries World Export Market Potential*, a report for the Foresight Marine Panel, October 2000.

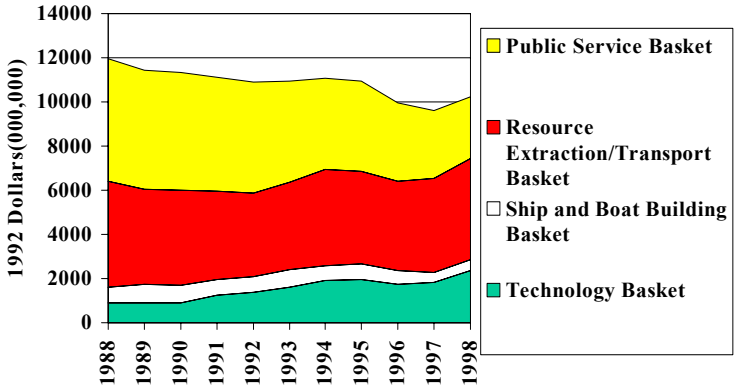
The federal department of Fisheries and Oceans (DFO) have provided data estimates on a number of specific marine and ocean industries, which are partially serving the marine and ocean sector. In addition to the information provided by DFO, Statistics Canada has prepared custom tabulations for the ship and boat building sector and on the impact of offshore oil and gas construction activities. Statistics on conventional industries, which are one hundred percent marine and ocean-related, have been obtained from Statistics Canada publications or its online service (CANSIM).

Estimates have been made in order to convert data from current dollar revenues to GDP in constant 1992 dollars and employment. Statistics Canada's Input-Output Division provided the GDP and employment conversion ratios. The data was converted to constant dollars based on the appropriate deflator from Statistics Canada's GDP price series.

The following basket of industries is included in our definition of marine and resource industries:

- Marine technologies and related industries
- Shipbuilding and boatbuilding
- Resource extraction and water transportation
- Public Service.

Figure 2: Marine and Ocean Industry Segments, Gross Domestic Product, 1988 to 1998

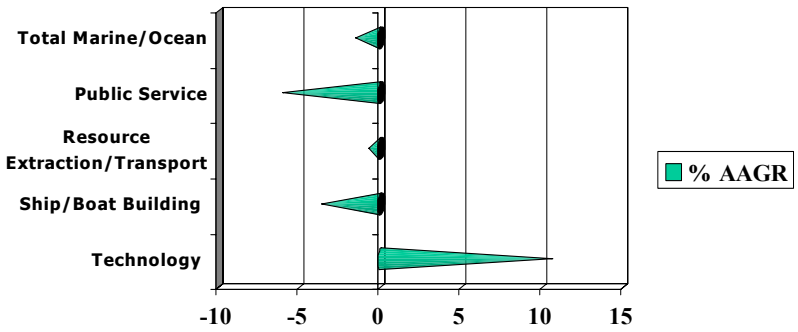


Source: Department of Fisheries and Oceans and Statistics Canada

2. Economic Performance of Marine and Ocean Industries

Total marine and ocean related GDP including government services was $10.5 billon in 1998. Total marine and ocean related employment was 120,000. The public service component and resource extraction industries represent the largest shares of this basket. Technology industries are growing in importance.

Figure 3: Annual GDP Growth Marine and Ocean Industries, 1988 to 1998

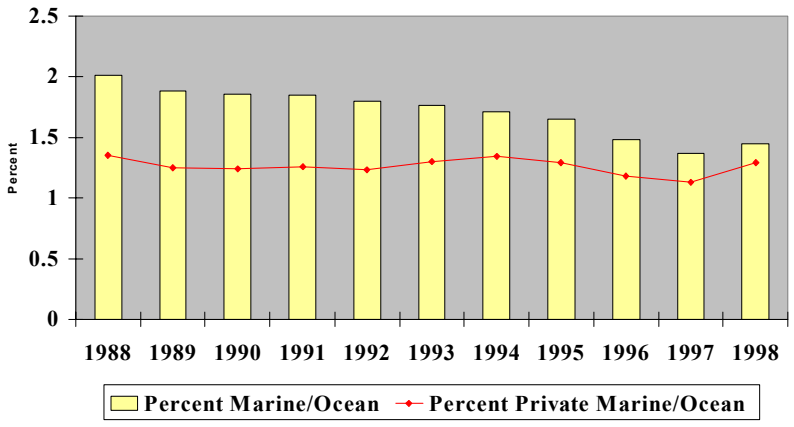


Source: Department of Fisheries and Oceans and Statistics Canada

In 1998, marine/ocean industries accounted for 1.4% of total GDP at factor cost. Private sector industries represented 1.3% of business GDP at factor cost.[6] Marine and ocean technology related industries grew at an annual rate of 11% from 1988 to 1998. Other sectors declined.

[6] The numerator and denominator included business GDP excluding government and non-private activities.

Figure 4: Marine and Ocean Industries as a Percentage of Canadian GDP



Source: Department of Fisheries and Oceans and Statistics Canada

2.1. Marine and Ocean Technologies

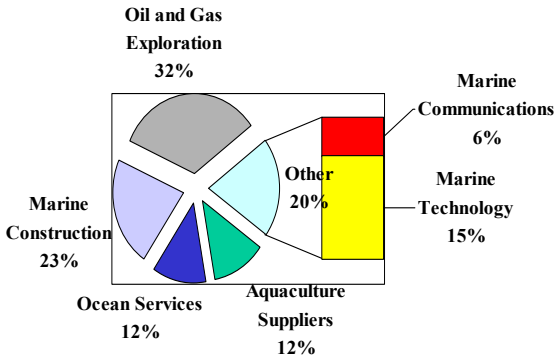
The marine technologies and related industries basket includes:

- Marine Communications and Electronic Industry
- Marine Technology and Machinery
- Aquaculture Suppliers
- Ocean Services
- Marine Construction
- Oil and Gas Exploration/Development.

Total marine and ocean technology related GDP was $2.3 billion[7] in 1998. Employment was 30,000. Oil and gas development and marine construction are the main economic drivers of this basket.

[7] GDP at factor cost in constant 1992 dollars.

Figure 5: Marine/Ocean Technology Related Industries, GDP, 1998



Source: Department of Fisheries and Oceans and Statistics Canada

The communication and electronic equipment basket includes:

- Sensors and Robotics
- Maneuvering and Propulsion Equipment
- Hydraulics and Flow Equipment
- Other Communications and Electronic Equipment.

Aquaculture suppliers include the sale of cages, equipment and engineering design used in the aquaculture industry.

Professional services include performance assessments of ships, offshore structures, small craft, survival equipment and other marine systems in a range of severe conditions from arctic environments to extreme seas.

Specific examples of professional services include:

- Electronic Engineering
- Offshore Platform Design
- Rig supply, handling, repair and support
- Materials and Structural Design
- Systems Integration
- Oceanography and Meteorology
- Ocean Surveying and Mapping
- Marine Communications

- Navigation Systems
- Naval Architecture
- Environmental Engineering
- Science Research (Iceberg Research, Ice Research, Oceanography, etc.)
- Other Engineering and Professional Services
- Diving and salvage.

Significant trends in navigation systems include:

- Increasing use of electronic chart systems
- Improved accuracy of satellite positioning systems
- Mapping of the sea floor.

2.1.1. Ocean Engineering

Marine and ocean engineering in Canada provides vital support and services to the core industries including the offshore oil and gas, marine navigation and transportation, ship design and construction, maritime defence, fishing and aquaculture and ocean technology. These industries demand highly specialized expertise, services and equipment adapted especially to the harsh ocean environment.

Ocean engineering involves the design of ships, floating and fixed offshore structures, mooring and propulsion systems, ice engineering, structural engineering, diving and salvage, marine navigation technologies, physical and numerical modeling, computational fluid dynamics, sub-sea systems, underwater technology, survival technology, specialized instrumentation for ocean mapping, environmental monitoring, underwater communications, and underwater hydro-acoustics.

Marine and ocean engineering requires a solid understanding of how the ocean interacts with these systems including hydraulics, wave movements, salt, corrosion, wind conditions, currents, ice flows, ice formation, etc.

2.1.2. Ocean Mapping and Charting

The mapping and charting of Canada's oceans provides valuable information to many players in the marine and ocean sector including offshore oil and gas companies exploring for development wells, mineral exploration on the ocean floor, environmental interests, port management, location for possible pipelines, etc. The ocean and mapping

industry involves extensive use of new hardware and software technologies and spatial data management and data warehousing.

2.1.3. Ocean Technology

The ocean technology sector forms a key part of the "high-tech" small business community in Canada. Ocean technology companies are largely small and medium sized enterprises (SME's) that produce equipment and electronics for domestic and export markets. They are an important part of the outfitting or refitting part of the shipbuilding industry.

Marine and ocean technology products include, ships outfitting, engines, pipes, etc. as well as electronic navigational charts, navigation systems, remote and autonomous underwater vehicles, marine communications technology, advanced marine acoustics, aquaculture equipment, underwater sensors, sub-sea equipment for the oil and gas industry, advanced radar technology, marine environmental monitoring technology, ocean engineering , seismic data and interpretation services.

In Canada, approximately 500 firms were operating in this sector in 1997. On average, these firms employ 10 to 20 persons and generate sales of about $100,000 to $200,000 per employee.[8]

This industry initially relied on government and defence contracts. The decline in government spending and the strong emergence of the offshore oil and gas market has resulted in structural changes for this industry, which have both positive and negative impacts. Successful companies have adapted to this changing environment and are providing intermediate components to the offshore oil and gas and related industries.

2.1.4. Marine Communications

Increased use of data communications at sea is driving new developments in the marine communications sector. New satellite communications systems are being developed, which potentially will offer wider bandwidth and lower costs. Geomatics, mapping and surveying are a part of this sector's newly developing expertise.

2.1.5. Marine Sensors

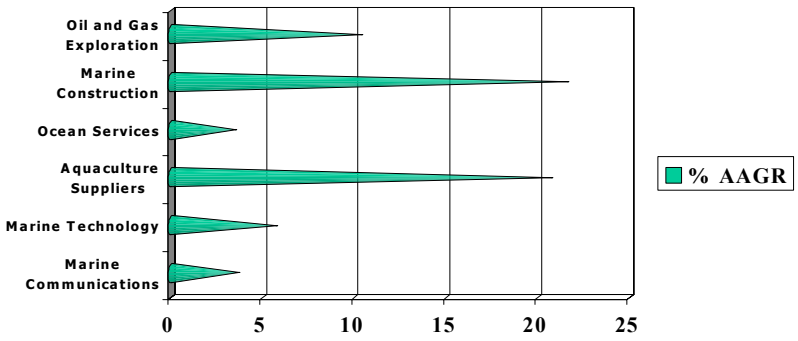
Sensor and sensor systems technologies are resulting in better processing time, lower costs and more data. Improvements in this area are being driven by low cost computer technology, enhanced marine communications and provide more accurate satellite positioning.

[8] Innova Quest, *A study on Global Trends and Opportunities in the Marine Technology Sector*, prepared for the Canadian Centre for Marine Communications, May 2000

2.1.6. Applications

The various functions onboard ships are being integrated and operated through computer software technologies. The critical functions onboard a ship may eventually be monitored offshore through the use of ship-to-shore computer hardware and software technologies.

Figure 6: Annual GDP Growth Marine and Ocean Technology Related Industries, 1988 to 1998



Source: Department of Fisheries and Oceans and Statistics Canada

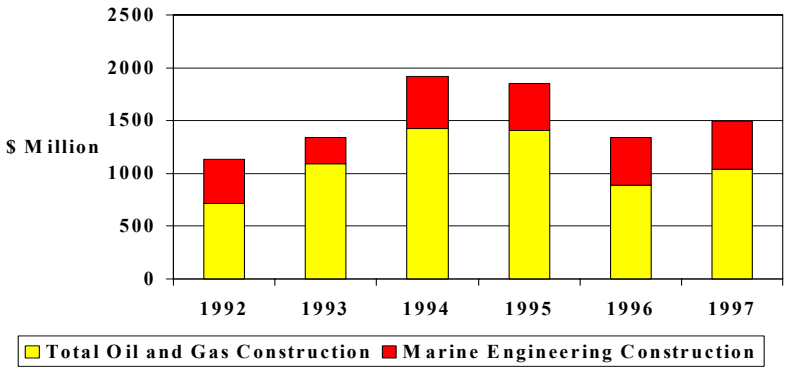
2.1.7. Marine Construction

Marine construction includes:

- Offshore oil and gas facility construction
- Docks, Wharves, Piers and Terminals
- Dredging and Pile Driving
- Breakwaters
- Canals and Waterways
- Other Marine Construction.

Approximately $1.5 billion was spent on marine construction projects in 1997, of which $1.0 billion was for offshore oil and gas construction (rigs, platforms, etc.).

Figure 7: Total Offshore and Marine Construction



Statistics Canada, Catalogue No. 61-223 XIB

2.1.8. Offshore Oil and Gas Developments

Offshore oil and gas developments have been taking place in various parts of the world, e.g., the Gulf of Mexico, North Sea, Canada's East Coast, etc., for some 30 years now. The availability of long-term supplies and the world price of crude oil are the main drivers of new investment.

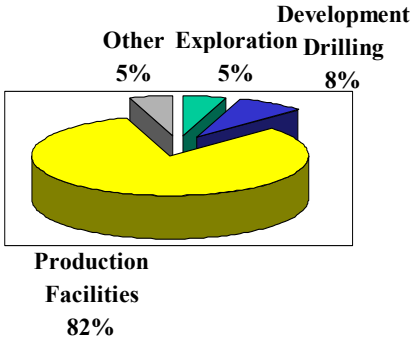
Traditionally, the offshore oil and gas sector has used "tried and true" technologies rather than experimenting on developmental or emerging technologies. The industry operates under extremely harsh conditions, high risk, tight timelines and budgets. The industry is making new technology-related investments regarding both safety and adhering to regulatory concerns.

Exploration activities are moving to deeper and colder waters, which is encouraging greater use of new techniques, deep-water oceanographic instruments and better seismic data. An important priority is to transmit data in real-time from the deep water to the ship.

Table 2: East Coast Offshore Oil and Gas Projects[9]			
Project	Start Up Date	Production	Corporate Ownership
Natural Gas			
Sable Offshore Energy Project	December, 1999	Tier I 510 million cubic feet per day natural gas NGLs: 22,000b/d Tier II 3 natural gas fields at 650mmcf/day; start up 2003-07	ExxonMobile Canada Shell Canada Imperial Oil Nova Scotia Resources Mosbacher Operating
PanCanadian Petroleum Limited (DeepPanuke field off Nova Scotia)	2005	400 million cubic feet per day	PanCanadian Petroleum Limited
Crude Oil			
Hibernia*	November 1997	200,000 b/d	ExxonMobile Canada Chevron Canada Resources Petro Canada Canada Hibernia Holding Murphy Oil Norsk Hydro
Terra Nova*	Late 2001	130,000b/d	Petro Canada ExxonMobile Canada Husky Energy Murphy Oil Mosbacher Operating Chevron Canada Resources
White Rose*	2004	75-110,000 b/d	Husky Energy Petro-Canada
Hebron/BenNevis*	2005	97,000 b/d	Chevron Canada Resources ExxonMobile Canada Petro-Canada Norsk Hydro
Petro-Canada		Exploration Activity: Flemish Pass, Salar Basin	
*Jeanne d'Arc Basin, Nfld.			

[9] Scotiabank Group, *Canada's New Energy Frontier – the East Coast Offshore*, March 1, 2001.

Figure 8: Offshore Oil and Gas Construction, 1997



Statistics Canada, Catalogue No. 61-223 XIB

Oil and gas exploration has been taking place on the Canadian east coast for three decades. A number of oil and gas fields have been developed including the Cohasset Panuke oil field off Sable Island in the early 1990's, which was followed shortly afterwards by the Hibernia development. Hibernia is a huge field, with more than 750 million barrels of recoverable oil, which is currently producing at a rate of 150,000 barrels of oil per day. The most recent field to be developed is the Sable Offshore Energy Project, which is a gas field located near Sable Island. This field began bringing gas ashore via a sub-sea pipeline in December 1999.[10]

The next field to go into production is the Terra Nova field, which contains an estimated 600 million barrels of recoverable oil. The Terra Nova field will use a floating production storage and offloading vessel (FPSO). The development of the White Rose and Hebron fields are both in the planning stages.[11]

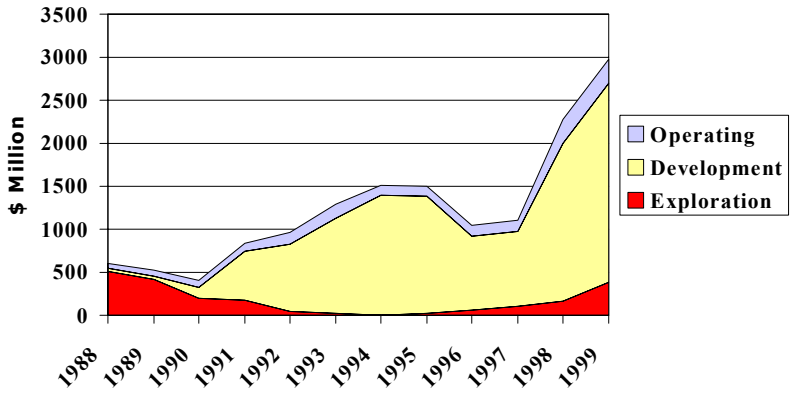
Capital spending on Canadian major offshore project development will likely exceed $12 billion by mid decade. Total exploration expenditures will probably be in the $2 billion range. Average expenditures per

[10] Scotiabank Group, Canada's New Energy Frontier – the East Coast Offshore, March 1, 2001.
[11] Scotiabank Group, Canada's New Energy Frontier – the East Coast Offshore, March 1, 2001.

exploratory well in the Jeanne d'Arc basin amount to $30 million and about $50 million in deeper waters.[12]

Projections by the Newfoundland Offshore Industries Association (NOIA) indicate that total offshore oil and gas activities will generate $55 billion in new capital and operating investments over the next 20 years. The offshore oil and gas sector has a substantial impact on other sectors of the economy including metal fabrication, construction, ship and ocean technologies, communication equipment, specialized machinery, transportation, and professional services.[13]

Figure 9: Offshore Net Cash Oil and Gas Expenditures, 1988 to 1999



Source: Statistics Canada, Catalogue No. 26-213 - XPB

A moratorium has been in place on offshore drilling in British Columbia since 1989 as a result of major oil spill from the Exxon Valdez tanker and the Tug Nestucca.[14] The Geological Survey of Canada estimate that the reserves in the moratorium area to be 43 trillion cubic feet of gas and 10 billion barrels of oil.[15]

2.1.10. Environmental Protection

[12] Scotiabank Group, *Canada's New Energy Frontier – the East Coast Offshore*, March 1, 2001.

[13] Newfoundland Ocean Industries Association, *Harnessing the Potential*, 1998

[14] British Columbia Northern Development Commission, News Release, September 15, 1999.

[15] British Columbia Northern Development Commission, News Release, September 15, 1999.

In addition to water clean-up activities, the environmental sector includes monitoring, sensing, and modeling of marine and ocean phenomena such as climate and water quality. The marine and ocean environmental market has shown considerable growth in the 1990s.

The need to properly manage renewable resources and the potential impact of global warming and other climate-related phenomena has contributed to the development of this sector. The environmental industry is innovative and often beta tests new technologies.

Many environmental protection and clean-up firms are small and highly specialized. They are dependent on environmental regulations regarding the requirement for offshore oil and gas companies to conduct environmental impact assessments.[16]

2.1.11. Marine Training

The marine training sector serves the entire range of marine and ocean industries, which depend on highly skilled workers who are continuously upgrading their skills. The use of sophisticated hardware and software technologies, especially wireless broadband communications has been a strong economic driver for the training industry. The continuous upgrading of skills is a prerequisite for the marine and ocean sector. Wireless broadband technologies offer strong potential for the development of virtual ship-to-shore training centers.

Simulations are an important part of the training industry, especially with the shortage of highly skilled staff and marine officers. Simulation training is delivered electronically and will likely involve the use of the Internet in the near future.[17]

A number of marine education and training companies are serving clients in the offshore oil and gas sector, marine transportation and communications. These companies face strong challenges as in order for them to be effective educators, new software and hardware technologies must be continuously purchased in order to keep up with rapidly changing developments. Trainers and educators must also operate under established standards and safety concerns. The use of the Internet and online training in the future may alleviate these constraints to some extent, although smaller training firms would undoubtedly benefit from forming alliances with larger organizations who have the requisite

[16] Canadian Centre for Marine Communications, A study on Global Trends and Opportunities in the Marine Technology Sector, Innova Quest, May 2000.
[17] Canadian Centre for Marine Communications, A study on Global Trends and Opportunities in the Marine Technology Sector, Innova Quest, May 2000.

resources to purchase and work with new technologies, when appropriate.

Memorial University situated in St. John's, Newfoundland has world-class expertise in marine and ocean technologies research. Its major activities include ocean engineering, ocean science, earth resources, marine simulations and fisheries science.

Dalhousie University similarly has expertise in marine and ocean industries. For example, the Atlantic Petroleum Institute promotes research, education and training for the university and a number of partners including Mobil Canada, Shell Canada, Imperial Oil and PanCanada Resources. This collaborative relationship between industry and academia is intended to better serve the research, education and training needs of the offshore oil and gas industry.

3. Ship and Boat Building Industries

While in excess of 100 firms are included in Statistics Canada's business registry in the shipbuilding and related services industry, the shipbuilding sector is dominated by seven large shipbuilders that employee about 3,500 people in seven provinces.[18] The key companies in this industry are Allied Shipbuilders, Canadian Shipbuilding and Engineering, Friede Goldman Newfoundland, Industries Davie, Irving Shipbuilding, Washington Marine Group and Verreault Navigation.

Although the marine transportation sector has grown steadily, the Canadian shipbuilding industry has experienced declining output and employment. Currently, the industry's revenues have declined to about 1/3 of its size 10 years ago when several military projects were in progress. In addition to government and defence cutbacks, unfavorable trade and market conditions, especially involving trade with the United States and subsidies in Europe and Asia have had a negative effect on the shipbuilding industry. The United States has restricted foreign producers from this potentially lucrative market.

[18] Shipbuilding Association of Canada Impacts of Measures Contained in Bill C-213, Final Report, KPMG, 2000.

Table 3: Major Canadian Shipyards[19]		
Company	Location	Products
Allied Shipbuilders	Vancouver, British Columbia	The shipyard has constructed 25 vessels for the offshore oil industry, of which 18 operate in the Artic Ocean. Conducts ship repair
Canadian Shipbuilding and Engineering	Port Weller Dry Docks in Ontario	Produce s bulk carriers, tankers, barges, ferries and coast guard vessels and ship repair.
Friede Goldman Newfoundland	Marystown, Newfoundland	Services offshore oil and gas sector by constructing anchor handling tugs, offshore supply vessels and oil rig component construction and refitting. and ship repair
Industries Davie	Lévis, Quebec	Produce stankers and bulk carriers, container ships, offshore exploration and production platforms, offshore modules for production platforms, naval vessels, ice breakers, coast guard vessels, passenger/vehicle ferries, industrial products for petrochemical, pulp, paper and mining industries and ship repair.
Irving Shipbuilding	Saint John, New Brunswick Halifax, Nova Scotia Georgetown Harbour, Prince Edward Island Dartmouth, Nova Scotia	Produce soffshore platforms and modules, offshore supply vessels, ferries, tugs, fishing vessels, semi-submersible rigs, ice breakers, coast guard vessels, naval vessels, commercial ships, ship conversions and ship repair
Washington Marine Group	Vancouver, British Columbia Victoria, British Columbia	Produces Deep-sea ships, Ferries, Tugs, fishing vessels, artic class ships, offshore supply and seismic research vessels, barges offshore marine structures, ship conversions and ship repair
Verreault Navigation	Verreault, Quebec	Produces dredges, tugs, fishing vessels, barges and ferries and ship repair

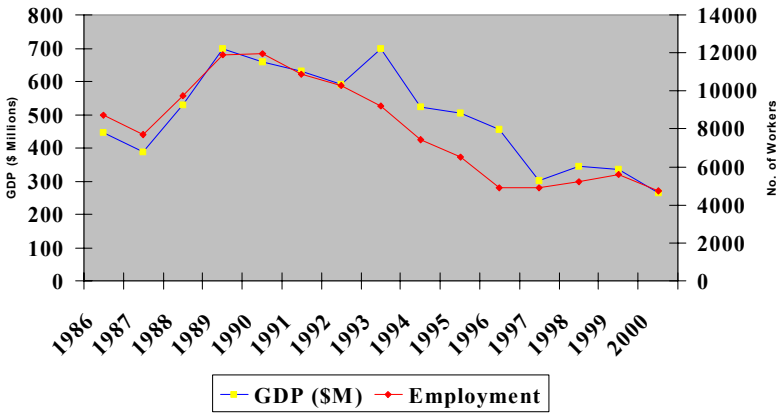
The shipbuilding industry has substantially reduced its net assets or capital stock in the 1990s, especially in building and other structures. The average life span of the industry's machinery and equipment was 5.7 years in 1998 compared to 6.8 years in 1988.

From 1988 to 1996, GDP declined by 3% annually and employment declined 9% annually. Productivity based on output per hour worked grew by 6% during this period.[20] From 1996 to 2000, GDP declined much faster than employment, which is currently at just under 5,000 jobs. GDP per worker declined from $93,000 in 1996 to $56,000 in 2000. This decline in output per worker is indicative of either declining productivity

[19] Shipbuilding Association of Canada Impacts of Measures Contained in Bill C-213, Final Report, KPMG, 2000.
[20] Statistics Canada, CANSIM Matrix Number 9465.

and/or a radically changing product mix. The period from 1988 to 1996 was heavily influenced by government contracts. The production associated with these government contracts was undoubtedly associated with higher output per worker ratios than what is occurring for the shipbuilding and repair sector's current product mix of smaller scale and ship repair projects.

Figure 10: Shipbuilding and Repair, GDP and Employment



Statistics Canada, CANSIM Matrices, 4677 and 4285

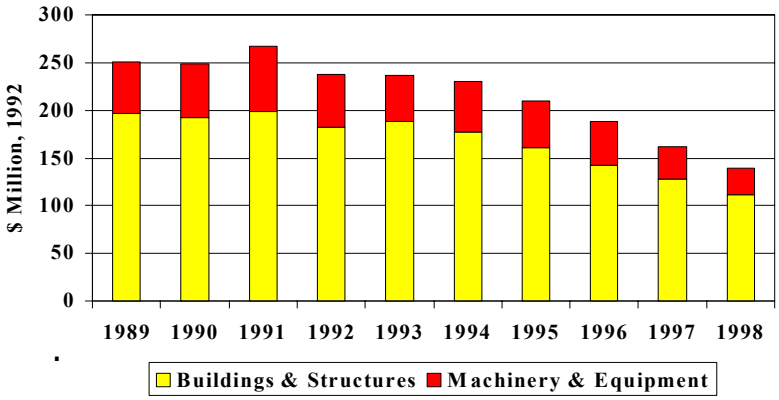
Table 4: Financial Information for the Shipbuilding and Repair Industry, Company Averages [21]

	1993	1994	1995	1996	1997	1998
Per Company, $000						
Assets	6411.0	6693.5	7562.6	5402.7	3430.0	4253.8
Inventory	743.1	878.8	478.1	428.2	431.9	380.1
Liabilities	6476.3	6657.9	5241.1	3359.8	1762.0	2270.2
Total Equity	-65.3	35.6	2321.5	2042.9	1668.0	1983.5
Retained Earnings	-1302.4	-1181.6	2080.3	1797.9	1484.8	1663.3
Operating Revenue	13840.7	10559.4	10592.6	9684.2	4067.3	3650.4
Operating Expenses	13832.5	10331.6	8834.0	7953.1	3841.5	3824.7
Operating Profit	8.3	227.8	1758.6	1731.1	225.8	-174.4
Profit Before Income Tax	26.3	272.4	1786.9	1798.0	238.2	764.4
Profit After Income Tax	-29.1	218.4	239.8	834.9	125.2	736.2
Operating Profit Margin (%)	0.1	2.2	16.6	17.9	5.6	-4.8
Net Profit Margin (%)	-0.2	2.1	2.3	8.6	3.1	20.2

[21] Source Statistics Canada, Special Tabulation of all firms in the shipbuilding and repair industry filing tax returns.

Profit margins for all firms filing a tax return the shipbuilding and repair industry has been volatile, probably due to long cycle times to manufacture ships, dredgers, platforms, floating docks, oil rigs, etc. Profit margins were high in 1996 and 1998. Exports grew substantially in 1998 and 1999, which may have stimulated higher profits.[22]

Figure 11: Net Capital Stock in Shipbuilding Industry



Source: Statistics Canada, Industrial Monitor

3.1. Naval architecture

Naval architects perform a critical function in the shipbuilding industry. The quality and efficiency of a ship is highly dependent on its design and specification. In addition to being a designer, the naval architect integrates various functions including engineering, structural and environmental aspects of shipbuilding. The role of naval architects in ensuring high quality and efficiencies in the construction process, and in the ships operations, are central to the overall performance of the shipbuilding industry.[23]

[22] Data reported by Industry Canada in the report, *Performance of Shipbuilding and Repair Industry in Canada in the 1990s* on profit margins for small and medium sized firms in FY 1996-97 show profit margins to be 1.8% and 0.6% respectively. Table 4 shows the whole industry including large firms to have a profit margin of 3.1% in 1997 and 8.6% in 1996. It is likely these higher profit margins for the entire industry are attributable to the performance of larger firms.

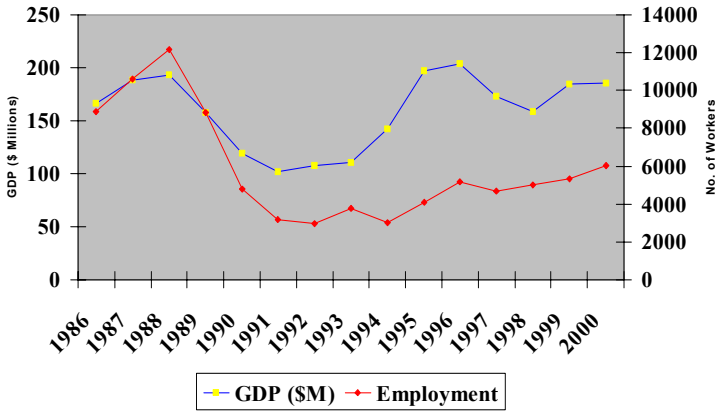
[23] The Society of Naval Architects and Marine Engineers, Eastern Canadian Section, *A History of Canadian Marine Technology*, 1995, edited by Roger Westwood, Keith Farrel and Abigail Fyfe.

3.2. Boat Building Industries

Gross domestic product in constant dollars for the boatbuilding sector grew at an annual rate of 12% from 1990 to 1996. Employment grew at an annual rate of 3% during this time frame. From 1996 to 2000, GDP declined by 1% and employment grew by 4%.

Constant dollar GDP per worker grew at an annual rate of 9% from 1990 to 1996 reaching $39,000. After 1996, GDP per worker declined at an annual rate of 5% to 2000 falling to $31,000 per worker.

Figure 12: Boatbuilding GDP and Employment



Statistics Canada, CANSIM Matrices, 4677 and 4285

Table 5: Financial Information for the Boatbuilding and Repair Industry, Company Averages [24]						
	1993	1994	1995	1996	1997	1998
Per Company, $000						
Assets	508.8	492.9	586.2	616.8	850.0	841.9
Inventory	143.1	147.3	170.8	182.8	197.1	244.6
Liabilities	373.2	356.9	388.1	406.6	451.3	548.8
Total Equity	135.6	136.0	198.1	210.1	398.7	293.1
Retained Earnings	87.0	104.8	199.5	143.2	157.0	202.4
Operating Revenue	830.9	677.8	816.1	843.0	946.9	1120.0
Operating Expenses	841.5	675.3	787.9	835.1	928.8	1100.1
Operating Profit	-10.6	2.5	28.2	8.0	18.1	19.8
Profit Before Income Tax	-3.3	4.7	33.1	12.9	21.3	32.5
Profit After Income Tax	-8.5	-1.1	25.2	6.6	13.9	23.4
Operating Profit Margin (%)	-1.3	0.4	3.5	0.9	1.9	1.8
Net Profit Margin (%)	-1.0	-0.2	3.1	0.8	1.5	2.1

4. Resource Extraction and Water Transport Industries

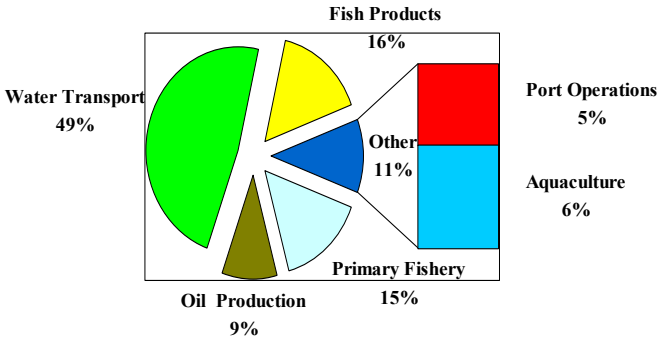
This basket includes:

- Aquaculture
- Primary Fishery
- Offshore Oil and Gas Production
- Water Transport
- Fish Products
- Port Operations.

Total resource extraction and transportation-related GDP was $4.6 billion in 1998. Total resource extraction and transportation-related employment was 55,000 in 1998.

[24] Source Statistics Canada, Special Tabulation of all firms in the boatbuilding and repair industry filing tax returns.

Figure 13: Resource Extraction and Transport, GDP, 1998



Source: Department of Fisheries and Oceans and Statistics Canada

4.1. Aquaculture

The structural changes in the wild fishery have encouraged the development of the aquaculture industry where new species of fish involving new technologies are being harvested and processed. The aquaculture industry has experienced substantial growth over the past decade. The aquaculture industry is currently focusing on salmon and shellfish, although additional species will likely be farmed in the future.

Globally, aquaculture accounts for 29% of food fish production and is growing at an annual rate of 7% to 10% per annum. This industry will continue to experience rapid growth due to an increased demand for seafood and the reduction in wild fish stocks.[25]

In Canada, structural changes in the wild fishery have encouraged the rapid development of the aquaculture industry, especially for salmon and trout. The Canadian aquaculture industry has increased by fifteen times over the past decade. In 1986 the aquaculture industry had a total production of $35 million dollars. By 1989 this had increased to $139 million and by 1999 production had reached $569 million.[26] The following species are harvested:

[25] Douglas-Westwood Associates, UK *Marine Industries World Export Market Potential*, a report for the Foresight Marine Panel, October 2000.
[26] Department of Fisheries and Oceans

- Atlantic Salmon
- Steelhead Trout
- Cod
- In-shore shellfish including oysters and mussels
- Scallops
- Quahogs
- Artic Char.

The aquaculture industry is supported by a growing number of specialized services and products including:[27]

- Aquaculture Planning
- Education and Training
- Extension Services to Aquaculture Operators
- Fish Health Systems
- Research and Development (Biotechnology, Marine Science, etc.)
- Fish Food (Feed)
- Physical Equipment (Cages, Filters, Etc.).

Opportunities include the development of fish-oil products for the health food sector, low cost feed stocks derived from seaweed, medicines and pharmaceuticals, specialty foods and increased harvesting of shellfish and other species.

Significant investment in research and development in biotechnology and containment facilities is taking place in order to encourage the farming of additional species, especially for groundfish and shellfish.

Table 6: Aquaculture Revenues, 1999[28]

Category	Value ($000)
Whole fish dressed or chilled	329,050
Fish eggs or live fish for grow out	25,300
Whole live fish (except for grow out)	3,300
Whole fish dressed and frozen	7,000
Fish fillets, fresh or frozen	33,400
Fish, dressed, smoked or in brine	450
Total Finfish	497,300
Total mollusks	40,050
Other revenues	31,780
Total Revenues	569,130

[27] Nordicity Group ltd, Syntel Consulting Inc. and Horizon Consulting Ltd, *Prospects for Growing Knowledge-Based Industrial Clusters in Atlantic Canada*, prepared for the Atlantic Canada Opportunities Agency, July 31, 1997.
[28] Department of Fisheries and Oceans (DFO)

4.2. Primary Fishing

In spite of substantial declines in cod and wild salmon stocks, the total value of commercial landings has risen from $1.4 billion in 1989 to almost $1.6 billion in 1998.

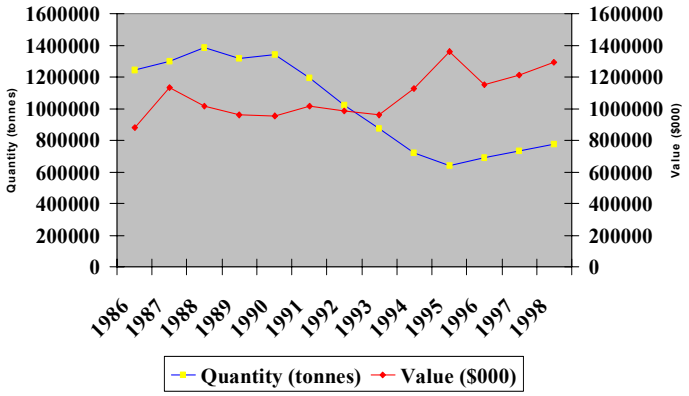
The decline in cod and salmon has been more than compensated by the rise in shellfish harvesting. The value of Canada's shellfish landings has risen from $548 million in 1989 to almost $1.0 billion dollars in 1998 mostly for lobster, shrimp and crab.[29]

The focus of fisheries research and development has shifted from increasing catch rates and profitability to the development of new and improved methods of measuring and monitoring the quantities and health of the fish stock. The development of alternative fishing technologies including engineering achievements that increase selectivity and reduce environmental damage is also a research priority.

Understanding how to catch fish better rather than more efficiently is critically important. The sustainability of the resource and a better understanding of ecosystems with increased emphasis on improving the quality of processing are the main drivers of the sector. These structural changes have provided opportunities for the development and adoption of new marine and ocean technologies.[30]

[29] Department of Fisheries and Oceans (DFO)
[30] Canadian Centre for Marine Communications, A study on Global Trends and Opportunities in the Marine Technology Sector, Innova Quest, May 2000.

Figure 14: Sea Fisheries Quantity and Value



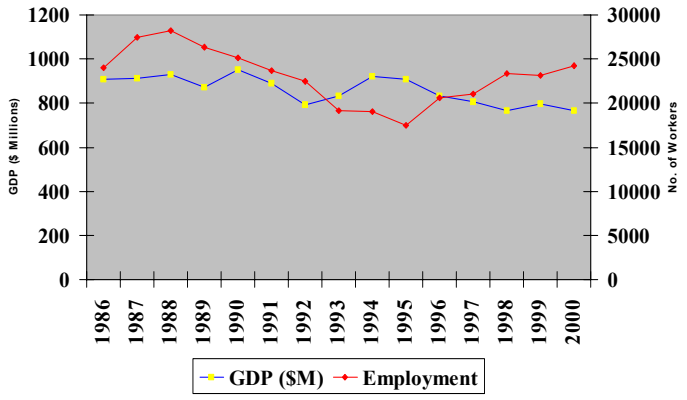
Source: Department of Fisheries and Oceans

4.3. Fish Processing

Fish processing remains a critical industry in the Atlantic Provinces. In 2000, it generated $766 million of GDP at factor cost (1992 dollars) and over 24,000 jobs. Given the potential growth and development of the aquaculture sector, the fish processing industry will likely grow in proportion to it, which will continue to drive technological developments and innovation.

Constant dollar GDP per worker grew 5% annually from 1988 to 1996 reaching $40,500. This amount declined to $31,500 per worker by 2000.

Figure 15: Fish Products
GDP and Employment



Statistics Canada, CANSIM Matrices, 4677 and 4285

4.4. Crude Oil and Offshore Gas Production

The Beaufort Sea and East coast reserves account for 25% of total Canadian reserves.[31]

The offshore marketable natural gas reserves amounted to 4% of total Canadian reserves in 1999. Phase I of the Sable Offshore Energy Project (SOEP) is producing 510 million cubic feet per day. Phase II, which will start up between 2003 and 2007, will significantly add to Canada's marketable reserves.[32]

Marketable production of crude oil in East coast was 8% of the Canadian total in 1999.[33]

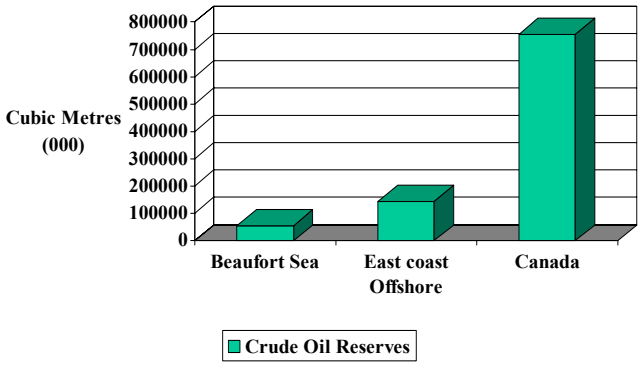
The offshore crude oil and natural gas have considerable implications for the transportation and logistics of supplies and crude oil and/or gas production to and from the sea platforms to the shore. Currently, crude oil is carried by tanker from the sea platform or rig to a distribution center, managed and operated by the Newfoundland Transshipment Limited (NTL) located at Whiffen Head. This terminal became operational in October 1998. It has 2 tanker berths and 5 crude oil storage tanks

[31] Statistics Canada, Oil and Gas Production, Catalogue No. 26-213-XPB
[32] Scotiabank Group, *Canada's New Energy Frontier – the East Coast Offshore*, March 1, 2001.
[33] Statistics Canada, Oil and Gas Production, Catalogue No. 26-213-XPB

each with 500,000-barrel storage capacity. NTL provides transshipment services for the Grand Banks.[34]

Tankers to the United States transships most of the crude oil.

Figure 16: Crude Oil Reserves, 1999



Source: Statistics Canada, Catalogue No. 26-213 - XPB

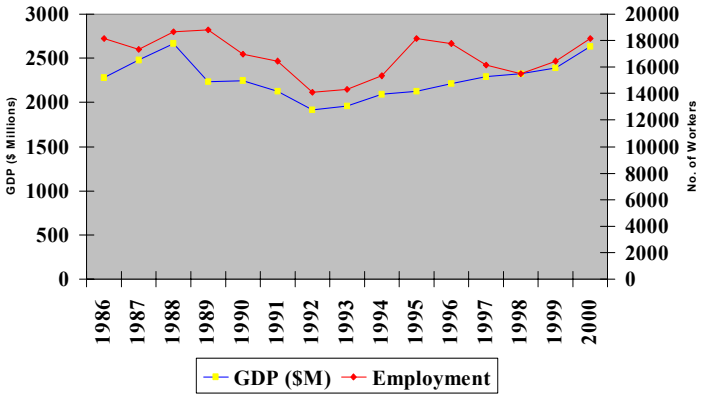
The logistics of moving people and supplies on and off the offshore platforms are as important as the logistics of moving the crude oil to markets. Workers stay on the platform for about three weeks at a time. Provisions have to be supplied and stored as well as parts, equipment and servicing for the equipment and machinery onboard the rigs. The offshore oil and gas industry has stimulated the development of an emerging third party logistics sector in Newfoundland and Nova Scotia.

4.5. Water Transportation

Marine transportation is a major carrier of Canadian goods and people. For hire marine carriers generate revenues in excess of $2 billion annually. A great deal of Canada's exports, especially dry bulk goods are shipped by marine transport. Containerized cargo is gaining in importance for international shipping. Regarding domestic shipment, the level of containerized cargo remains relatively small due to fierce competition with trucking.

[34] Newfoundland Offshore Industries Association (NOIA)

Figure 17: Water Transport GDP and Employment



Statistics Canada, CANSIM Matrices, 4677 and 4285

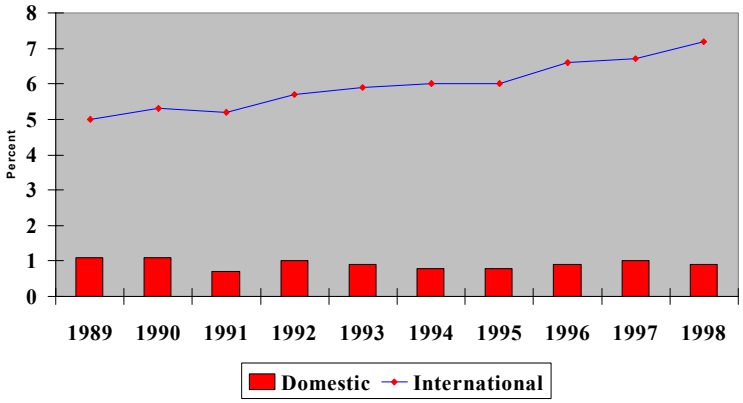
4.6. Canadian Merchant Fleet

The Canadian merchant fleet (all self-propelled Canadian flag vessels of 1000 gross tons and over that carry cargo or passengers, excluding Canadian Coast Guard vessels) has declined steady over the past 25 years. While fewer Canadian registered ships are carrying cargo and passengers, these vessels have increased in terms of both size and efficiency. Globally, both the number and size of vessels have increased. The Canadian fleet is also older, on average than the merchant marine fleets of other countries. In Canada, commercial shipping is used mostly for transporting dry bulk goods, and to a lesser extent container traffic.[35]

This industry has taken a conservative approach in adopting new technologies. Software-based technologies are given higher priority than hardware-based technologies as marine managers perceive that software can be inexpensively replaced or upgraded, whereas, investment in new hardware is costly and may become obsolete before the investment has been paid off.[36]

[35] Canadian Centre for Marine Communications, A study on Global Trends and Opportunities in the Marine Technology Sector, Innova Quest, May 2000.
[36] Canadian Centre for Marine Communications, A study on Global Trends and Opportunities in the Marine Technology Sector, Innova Quest, May 2000.

Figure 18: Containerized Cargo Share of Domestic and International Shipping



Source: Statistics Canada, Catalogue No. 54-205-XIB

Computers are being increasingly used to improve ship management and the exchange of data between the ship and shore.

5. Role of Government in Marine and Ocean and Industries

The public service includes:

- Federal Government department and agencies including Fisheries and Oceans, DND, NRC, etc.
- Provincial Government services including fisheries, aquaculture, marine transportation, oil and gas administration, etc.

Overall public service ocean and marine related expenditures have declined at an average annual rate of 6.1% from 1988 to 1998. These cutbacks are largely attributable to reduced spending by Transport Canada and DND. Fisheries and Oceans Canada has increased its spending levels during this timeframe partly due to the transfer of coast guard operations from Transport Canada to DFO and the need for strong regulatory and policy support for the primary fishery sector.

The completion of a number of shipbuilding programs in the late 1980s and early 1990s contributed to the reduced government expenditures. These capital programs including TRUMP, the Canadian Patrol Frigate Program and the Marine Coastal Defence Vessels Program (MCDV)

provided $8.2 billion of government contract work in the 1980s and early 1990s. The completion of these major shipbuilding initiatives as well as reduced government contracts for refits and new construction of ships has had a major impact on the shipbuilding industry. As a consequence, the industry is restructuring, reducing net assets and rebounding to new markets such as oil and gas construction and repairing and refitting ships. However, the foreign competition is stiff and Canada provides a liberal foreign component environment, unlike a number of competitor countries.

5.1. Port Development and Management

Shipping lines are building faster and larger vessels. Canadian ports must continually invest in new technologies in order to service these ships and to keep cargoes, especially containerized cargo moving efficiently. A modern port is a heavy user of hardware and software technologies, especially communication systems. Modern ports also have shifted from a heavy labour intensive focus to an efficient and high technology industry relying heavily on information and communications systems and innovative logistics and material handling systems.

5.2. Defence and Security

The defence and security sector consists of the Canadian Navy, the RCMP, and the Coast Guard. Firms normally considered to be part of the aerospace sector also develop, produce and service products for the marine defence and security sector.

Defence and security-related marine/ocean technologies include:

- Defence electronics including radar electro-optics, antisubmarine warfare, underwater acoustic equipment, secure computer systems, vessel traffic management systems, communications and network management.
- Marine/naval systems including warships, small craft, underwater vehicles and ship-based systems and equipment.[37]

A fundamental shift is occurring in the defence industry in Canada and the rest of the world. The industry is concentrating more on information technology (data fusion, simulation, modeling and communications) and less on producing hardware.

[37] Canadian Centre for Marine Communications, A study on Global Trends and Opportunities in the Marine Technology Sector, Innova Quest, May 2000.

During the cold war era, the Canadian Navy was primarily engaged in anti-submarine warfare activities. With the end of the Cold War, the Navy has changed its focus to the surveillance of Canada's territorial waters and international peace and security.

The Canadian military's research and development arm is Defence R&D Canada. Defence R&D Canada is subdivided into several divisions including air, land and maritime. The Maritime Directorate is called the Defence Research Establishment Atlantic, (DREA. It is located in Dartmouth, Nova Scotia.

DREA conducts research and development in undersea warfare and naval platform technology. This initiative investigates and develops techniques, components and systems for detecting submarine, surface, mine, and torpedo targets. Naval and airborne sonar systems and sensor management is an important priority for DREA as is the electro-magnetic detection of submarines from maritime aircraft. A key objective of the Canadian Navy is to maximize the Forces' operational effectiveness as well as to sustain environmental and personal safety by developing and putting in place new platform and materials technologies. The Navy is enhancing its expertise in ship noise, ship dynamics, structural acoustics, structures and marine materials.

5.3. Maritime Helicopter Program (DND)

This DND program is based on a comprehensive understanding of current capabilities of the Sea King during all phases of its operations, which includes launch and recovery, on-deck securing, maneuvering and traversing, long term hanger securing and securing during ship maneuvers.

Research studies involve the use of ship motion simulation tools for both linear and non-linear simulations and experimentally measured ship motion.

5.4. Helicopter/Ship Design Interface

Onboard helicopters are assuming an increasing role for modern navy and coast guard ships. Marine helicopters expand the coverage capability of ships, especially during search and rescue missions.

Ship motion in heavy seas is a serious concern for the safe operation of onboard helicopters. The securing and handling system must be designed to be effective under an extremely harsh environment associated with considerable motion and marine dynamics.

Computer simulations have proven to be an invaluable tool in assessing various marine dynamic scenarios.[38]

5.5. Institute for Marine Dynamics (IMD)[39]

The Institute For Marine Dynamics (IMD) was created in 1985. Initially ice engineering was the main focus of this organization. With the development of the Canadian offshore oil and gas industry, IMD began to test complex offshore structures and to engage in the modeling of ocean environments and structures that operate in the ocean's harsh conditions.

IMD has evolved into being an internationally recognized leader in ocean engineering research. IMD's interests in offshore engineering include:

- Wave impact analysis and scooping
- Low speed propulsion
- Mooring system dynamics
- Modeling deepwater installations
- Dynamic control systems
- Offshore safety systems
- CFD modeling
- Aquaculture engineering.

IMD's ship technology research includes:

- Vessel performance modeling
- Maneuvering software development
- Ice effects on marine systems
- Underwater vehicle technology
- Modeling ship structural loading
- Systematic model series for yachts
- Viscous drag.

IMD's current programs include the Ocean Engineering Technology Cluster Initiative and the Marine and Ocean Technology Roadmap. The Technology Cluster Initiative is part of the National Research Council's contribution to technology clusters in several Canadian communities, which include the information technology cluster in Ottawa and the plant biotechnology cluster in Saskatoon. The Ocean Engineering Technology Cluster Initiative is intended to make St. John's a world-class center for

[38] Indal Technologies, *The Technology of Better Handling Systems*, December 2000.
[39] This section is based on working documents provided by the National Research Council and the Institute for Marine Dynamics.

ocean engineering excellence. The NRC is facilitating collaboration amongst the key players in ocean technologies. This initiative provides a supporting environment to develop marketable technologies.

The Marine and Ocean Technology Roadmap will promote industry-wide consultation on market trends and opportunities in order for the sector to be better positioned to identify and develop research priorities consistent with these identified opportunities.

IMD has formed an alliance with Memorial University of Newfoundland and Marineering Ltd. to form the Oceanic Consulting Corporation. This organization is an engineering firm specializing in performance evaluation of naval architecture and ocean engineering systems. It provides considerable expertise and research facilities for commercial clients in the performance of ships and offshore structures, small craft, survival equipment and other marine systems operating under harsh conditions and cold weather. Marineering Ltd. is responsible for the organization's marketing and project management.

5.6. Other Organizations

Other organizations that provide excellence in ocean technology research, which are situated in St. John's Newfoundland are C-CORE and the Canadian Centre for Marine Communications (CCMC).

C-CORE has expertise in ice engineering, remote geotechnical engineering and intelligence systems that can be applied to mining, oil and gas sectors that operate under harsh land or marine environments. C-CORE's key clients work in the pipeline, oil, mining and fishing sectors.[40]

The Canadian Centre for Marine Communications (CCMC) collaborates with the Canadian marine information technology sector in advancing marine communications, navigation and information technologies.[41]

[40] C-CORE Profile, March 2001
[41] CCMC Profile, March 2001

6. Changing Conditions and Industry Dynamics

A wide range of marine and ocean industry sectors has been discussed in this paper. The technology-related industries have grown significantly. The traditional industries such as primary fishing, fish processing, shipbuilding, etc. have generally either remained static or experienced lower output and employment. Technological developments based on both market-based R&D and the ocean science activities of organizations such as the Institute for Marine Dynamics have helped facilitate the high growth in offshore oil and gas, aquaculture and in related machinery, equipment and service industries. The marine and ocean industry in Canada is operating in an environment of reduced fish stocks, the completion of major shipbuilding initiatives associated with the defence sector and lower government expenditures for equipment and services.

Canadian challenges and opportunities revolve around the ability of the various industry sectors to respond to these changes and to successfully meet the demands of the offshore oil and gas industry and related supporting industries. Technological developments and innovation has a large role to play in this transformation.

Marine and ocean industries constitute a key part of the United States economy as well as Canada's. Strong opportunities are evident for the Canadian marine and ocean industries to sell products and services to the United States. The United States has 95,000 miles of coastline and 3.4 million miles of ocean within its territorial seas. In excess of 40% of the value of United States Trade is routed through American ports. Eighteen percent of its crude oil and 27% of its natural gas are produced from the Outer Continental Shelf. [42] Although the United States is a large market, it is difficult to access due to restrictive policies and practices. The U.S. Jones Act (shipbuilding) and Buy America attitudes are formidable trade barriers for some marine and ocean industry sectors.

Approximately 85,000 people are employed in the United States offshore oil and gas industry with an equal number in supporting jobs. The industry has shown considerable technological progress resulting in better and safer working conditions, especially in deep-water wells. New technologies have allowed deeper wells as much as 5,500 feet to be developed. These deeper wells provide substantially greater demands on safety conditions and on the ability of coastal ports and communities to provide the necessary services.[43]

[42] http://www.yoto98.noaa.gov/papers.htm
[43] http://www.yoto98.noaa.gov/papers.htm

The ocean is an important aspect of the United States defence and security system for both North American and for troubled regions around the world.

In addition to the United States, considerable opportunities in Asia, Europe, South America and Africa may be evident in this sector. Offshore oil and gas developments are occurring in many parts of the world, especially in deeper waters in Africa and Asia. Port development and shipping in South America offer promising opportunities.[44] Accessing these opportunities, however, may be difficult due to restrictive trade practices and non-tariff barriers of many countries for reasons of national security and policies supporting local employment.

Many larger oil companies are moving towards buying complete integrated packages where the design, procurement and build aspect of a project is completed as a system rather than purchasing isolated components. Canadian companies need to collaborate with larger players in order to be able to produce these integrated systems. The offshore oil and gas industry has been in business for over three decades. Major oil and gas companies have had considerable time to develop relationships with preferred suppliers. These suppliers are expected to be responsible for R&D related product development. A lot of the high technology developments in the offshore oil and gas sector have occurred in Europe by state oil companies. The challenges for Canadian firms to be able to realize the emerging opportunities are significant.[45]

While the marine and ocean sector is large globally, the important decisions are made in select regions. For example, most major offshore oil and gas decisions are made in the United States and Europe. Most major shipbuilding decisions that affect global trends are made in South East Asia.[46]

Ocean surveying and mapping represents another strong opportunity for Canadian firms to participate in the global arena. Ocean surveying is needed for safe navigation in ports and harbors as well as by extractive industries to determine the location of offshore rigs and platforms, pipelines and seabed minerals.

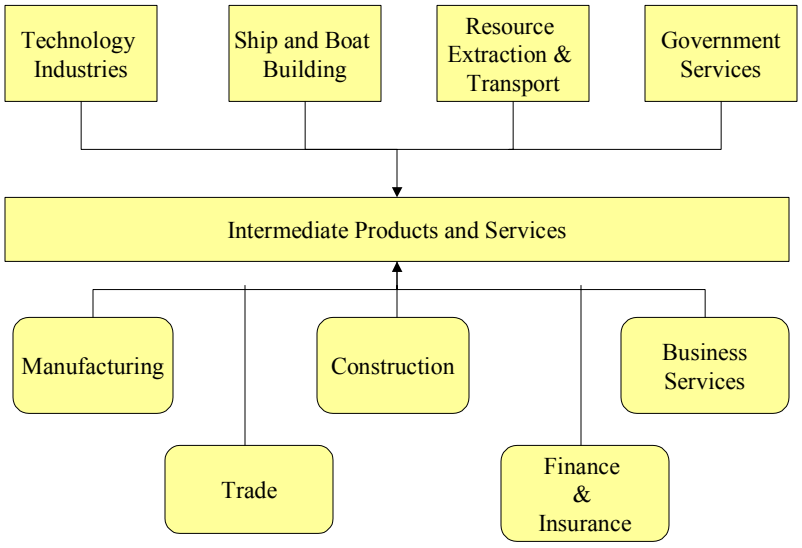
[44] Douglas-Westwood Associates, UK *Marine Industries World Export Market Potential*, a report for the Foresight Marine Panel, October 2000.
[45] Douglas-Westwood Associates, UK *Marine Industries World Export Market Potential*, a report for the Foresight Marine Panel, October 2000.
[46] Douglas-Westwood Associates, UK *Marine Industries World Export Market Potential*, a report for the Foresight Marine Panel, October 2000.

6.1. Marine and Ocean Industry Linkages

Excluding government services, the Canadian marine and ocean industries discussed in this paper generated $8 billion in GDP (1992 dollars) and almost 100 thousand jobs. For every dollar of direct GDP generated, an additional dollar of indirect GDP materialized. Similarly, for every direct job, there was an indirect job being generated in marine and ocean industries.

The construction of offshore oil and gas rigs is one of the prime economic drivers influencing the entire marine and ocean sector. For example, in 1997, the offshore oil and gas facility construction industry generated $239 million in GDP and 2,200 direct jobs. After tabulating all the spin-off output and jobs, the direct and indirect impact of the offshore facility construction industry was $666 million in GDP and 10,600 jobs in various sectors of the Canadian economy. The GDP multiplier is 2.8 and the employment multiplier is 4.9.

Figure 19: Marine and Ocean Industries Value Chain



The main manufacturing spin-offs included primary metal industries, fabricated metal products, machinery industries, transportation equipment, electrical and electronic products, chemical products and other manufacturing industries.

The key business services being generated by offshore oil and gas construction included accounting, legal services, engineering, architectural, scientific and technical services.

Table 7: Direct and Indirect Impact on Total Economy Resulting from Offshore Oil and Gas Facility Construction, 1997[47]

	GDP ($000)	Employment
Agricultural and related services industries.	500.3	17
Fishing and trapping industries	907.8	30
Logging and forestry industries	326.8	4
Mining, quarrying and oil well industries	34825.3	671
Manufacturing industries	87818.9	1349
Construction industries	243056	2247
Transportation and storage industries	20490.8	459
Communication and other utility industries.	24655	257
Wholesale trade industries	43999.2	839
Retail trade industries	9133.4	436
Finance, insurance and real estate industries.	36565.6	494
Business service industries	129279.2	2902
Educational service industries	4.7	1
Health and social service industries.	405.7	8
Accommodation and food services industries.	3826.5	161
Other service industries	20400	531
Non-profit institutions serving households	497.3	22
Government sector	8987.7	193
Total Impact	665680.2	10621
Direct Impact	239432.0	2160
Indirect Impact	426248.2	8461
Multiplier	2.8	4.9

The four baskets discussed in this paper including technology industries, ship and boat building, resource extraction/transportation industries and government services are highly interdependent. For example, offshore oil facility, which is included in the technology basket, is interdependent with the other three baskets. Shipbuilding firms are involved in constructing and servicing offshore rigs and platforms. Once the oil or gas wells are brought on stream, production wells are included in the resource extraction and transportation basket. Crude oil and gas are pumped from the well and transported to the shore for processing. Of course, the federal and provincial governments administer licenses, collect royalties and enforce environmental regulations.

[47] Statistics Canada, Special Tabulation

Table 8: Direct and Indirect Impact on Manufacturing Industries Resulting from Offshore Oil and Gas Facility Construction, 1997[48]		
	GDP ($000)	Employment
Food industries	1649.8	35
Beverage industries	493.1	4
Tobacco products industry	49.7	0
Rubber products industries	1094.2	13
Plastic products industries	2739.8	53
Leather and allied products industries	64.6	2
Primary textile industries	108.9	1
Textile products industries	215	6
Clothing industries	246.9	8
Wood industries	465.9	10
Furniture and fixture industries	60.7	1
Paper and allied products industries	2675.9	27
Printing, publishing and allied industries	5005.9	100
Primary metal industries	27425.6	307
Fabricated metal products industries	18642.6	372
Machinery ind. (except electrical mach.)	8582	143
Transportation equipment industries	3693.4	43
Electrical and electronic products industries..	2793.9	44
Non-metallic mineral products industries	2257	35
Refined petroleum and coal products industries..	851	12
Chemical and chemical products industries	3936.8	43
Other manufacturing industries	4765.8	87
Total Manufacturing	87818.5	1349

Table 9: Direct and Impact on Business Service Industries Resulting from Offshore Oil and Gas Facility Construction, 1997[49]		
	GDP ($000)	Employment
Computer and related services	5017	94
Accounting and legal services	12867.8	355
Architectural, engineering, scientific & tech. services.	99774.6	2080
Advertising services	1650.4	53
Miscellaneous business service industries	9969	320
Total Business Service Industries	129278.8	2902

[48] Statistics Canada, Special Tabulation
[49] Statistics Canada, Special Tabulation

7. Bottom Line

A large number of Canadians earn their living directly or indirectly from the sea. Canada's oceans provide food, energy and a means of transportation for its people and goods. Historically, the marine and ocean economy was driven by the wild fishery and government contracts for marine equipment, machinery, shipbuilding and related procurement. The reduced fish stocks and government cutbacks have changed the basic economic structure of the industry.

The rapidly growing aquaculture industry has evolved from the changed dynamics in the primary fishing industry. Aquaculture production should continue to grow, especially with the strong global demand for seafood.

Offshore oil and gas development is accelerating. An estimated $55 billion is slated to be invested in offshore oil and gas exploration, development and operations over the next two decades. Even with oil and gas companies importing major components and systems, the spin-off benefits to the Canadian economy are substantial. Cold-water engineering, metal fabrication, transportation equipment, construction, third-party logistics providers, etc., benefit strongly from these offshore developments.

Considerable opportunities are emerging for the marine and ocean industry sectors both domestically and globally, although accessing foreign markets may prove to be difficult. Close collaboration between all the players including industry, academia, research organizations and government agencies is needed in order to take advantage of emerging opportunities and to overcome the constraints.

The following areas for future research are suggested:

1. Markets for existing and future technologies need to be identified relative to the ability and competitive strengths of Canadian companies to realize these opportunities. This analysis would require a survey of the technological capabilities and competitive advantages of the Canadian companies in the sector.

2. The value chain for offshore oil and gas facility construction was outlined in detail in this report. Other sub-sectors including oil and gas exploration and development, engineering services, shipbuilding, boatbuilding could be similarly mapped. These value chain maps are expensive to produce at the regional level,

although they provide critical information to policy makers and strategic planners following the sector.[50]

3. The statistics on ocean and marine industries are based on both soft and hard data. Hard data, at a sector level, includes shipbuilding, boatbuilding, aquaculture, primary fishing, offshore oil and gas exploration, development and construction, marine construction, water transportation and government services. Statistics Canada publishes aggregate data for these industries. Data on ocean services including engineering, marine architecture, marine training, etc. is soft as these industries have considerable non-marine and ocean components based on the classification structure and reporting system used by Statistics Canada. Similarly, data on ocean and marine machinery and equipment is soft. Estimates, provided by the Department of Fisheries and Oceans (DFO), were used in this paper for these industries. More research based on primary surveys and interviews with Canadian firms in this sector is needed in order to improve the information base.

4. The statistics on the shipbuilding and repair industry published by Statistics Canada do not adequately explain the dynamics and competitiveness strengths and weaknesses of this sector. For example, the high productivity gains in the early from 1988 to 1996 and the sharp decline in output per worker hour in from 1996 to 2000, on the surface, appear to be inconsistent with the high profit margins in 1998. The shipbuilding industry was likely hoarding skilled workers in the late 1990s, in spite of declining output. Labour hoarding is necessary due to long production cycle times and the shortage of skilled workers. The high profit margin in 1998 is more difficult to explain. This profit margin may be due to increased exports, e.g., refitting an offshore platform for Brazil or a strong demand for ship repair work in Canada and in the United States.

5. Regarding the prospects for the shipbuilding and repair sector, there may be niche opportunities related to Canadian offshore oil and gas developments and ship repair work. The large yards, however, are not likely able to sustain the level of business which occurred in the 1980s and early 1990s. At best, the prospects are that niche markets are emerging. At worst, the large yards will continue to experience very low capacity utilization levels due to

[50] Statistics Canada charges $800 per industry to create detailed value chains and interprovincial and international trade flows. This analysis is based on simulation shocks from the 1996 interprovincial input output tables.

significant constraints globally and minimal government procurement work.

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