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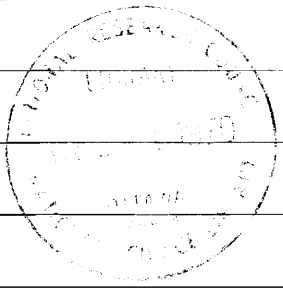
Science Council of Canada

1970 Report No.10

Canada, Science and the Oceans



Canada, Science and the Oceans

A Major Program in Marine Science and Technology for Canada

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The Rt. Hon. Pierre Elliott Trudeau,
P.C., M.P.,
Prime Minister of Canada,
House of Commons,
Ottawa 4, Ontario.

Dear Mr. Prime Minister:
In accordance with sections eleven and thirteen of the Science Council Act, I take pleasure in forwarding to you the views and recommendations of the Council as they concern policies for the development of marine science and technology, in the form of a report entitled "Science Council Report No. 10–Canada, Science and the Oceans."

Yours sincerely,

O.M. Solandt,
Chairman,
Science Council of Canada.

Table of Contents

Summary

As Canada becomes increasingly involved in the oceans off her coasts, the responsibilities of marine science and technology[1], vis-à-vis Canadian needs in the offshore, will multiply. Fortunately we have a strong scientific base on which to build the capabilities necessary to meet the challenges of the coming period of vigorous activity. Recent events have clearly indicated the urgent need to develop a sound national policy for the marine area. Challenges and opportunities exist which, if neglected by Canadians, will be seized by others. The impact of such developments as offshore petroleum exploration and exploitation, new needs in fisheries and transportation, new demands in recreation, antipollution, and climatic prediction and control requires a serious reconsideration of the place of marine science and technology in our total national picture. The time for action is now!

To meet the challenges and profit from the opportunities presented by the marine environment, there is a need for a national program, a Major Program in Marine Science and Technology, which would focus on the Canadian continental shelves, their superjacent waters, ice-cover and the open oceans. The advisory, co-ordination and implementation mechanisms outlined in this document are believed necessary in order to arrive at a balanced research and development program in this area.

Since the present report is mainly concerned with broad perspectives, the Science Council recommends that all those who have some responsibility or interest in the marine field should review the Study Group report[2], which is a comprehensive statement of the present status, needs and opportunities in this field, and try to implement particular suggestions where practicable.

[1]The fisheries aspects are dealt with in a separate Science Council Report, *This Land is their Land*, Report No. 9.

[2]Stewart, R.W., and L.M. Dickie. *Ad mare:* Canada looks to the sea. Science Council of Canada. Special Study No. 16. In press.

The Science Council Focusses on the Sea

In a country cradled by three oceans it is evident that the marine environment will play a major role in the fulfilment of Canadian desires. This natural involvement in our submerged territories–those areas off our coasts which are geologically continental and comprise an area equal to over 40 per cent of our land area–and in the waters over and beyond them requires a strong commitment to marine science and technology to ensure the orderly development of our marine resources.

As can be seen from Figure 1, the national goals suggested by the Science Council[1,2] are closely interwoven with Canada's multifaceted interest in the sea, as outlined in the Special Study by R.W. Stewart and L.M. Dickie.

Historically, the words "marine resources" have usually evoked thoughts of living resources, but offshore mineral resources may soon become just as, if not more, important economically to Canada than the fisheries. It has been estimated that about half of Canada's ultimate potential oil reserves lie offshore.[3] Such vast potential reserves have created much interest in offshore petroleum exploration and exploitation. In the future, economic considerations may bring other offshore mineral resources into the limelight.

It is recognized that the oceans have a considerable impact on weather and climatic pattern. An understanding of the atmosphere–sea coupling–is essential to predict and possibly eventually to control the climate, which has such a profound influence on man's activities.

As long as there is a "territorial imperative" there will be a need for a naval military posture requiring both a scientific and an industrial backing. There may also be a need from time to time to redirect scientific and industrial activity to effect a presence in areas where Canadian sovereignty is questioned.

The multiple use of the marine environment (e.g. recreation, transportation, resources development, waste disposal) presents technological challenges to Canadians, which must be taken up if a balanced development of marine resources is to ensue. The technology developed to solve Canadian problems can also be exported to other industrialized nations and offered as aid to developing countries. This latter aspect is extremely important in a resource-hungry world.

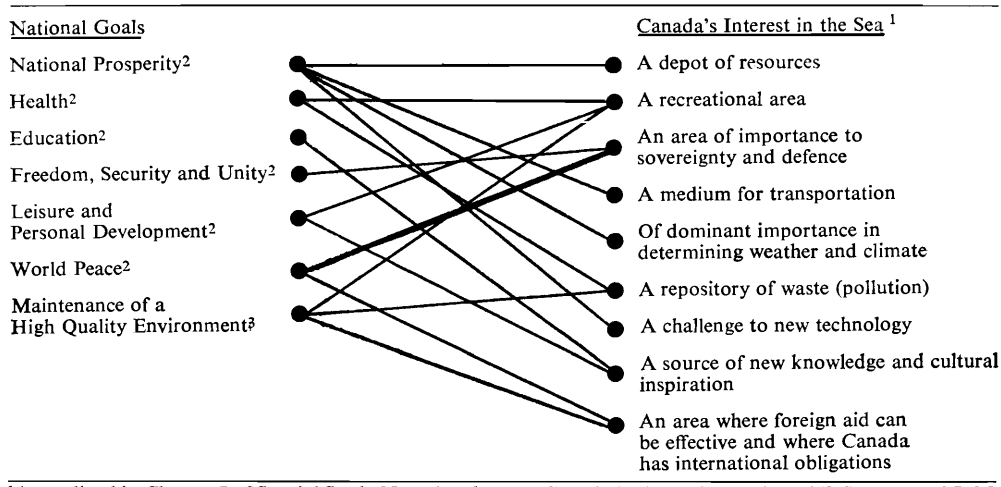
Because of the closely knit relationship between goals, which contain the main aspirations of Canadians, and the potential that the marine environment offers towards the fulfilment of these goals, the Science Council believes that the implementation of the recommendations which follow are essential to ensure the necessary advancement of marine science and development of marine technology in Canada.

[1]Science Council of Canada. Towards a national science policy for Canada. Report No. 4, October 1968.

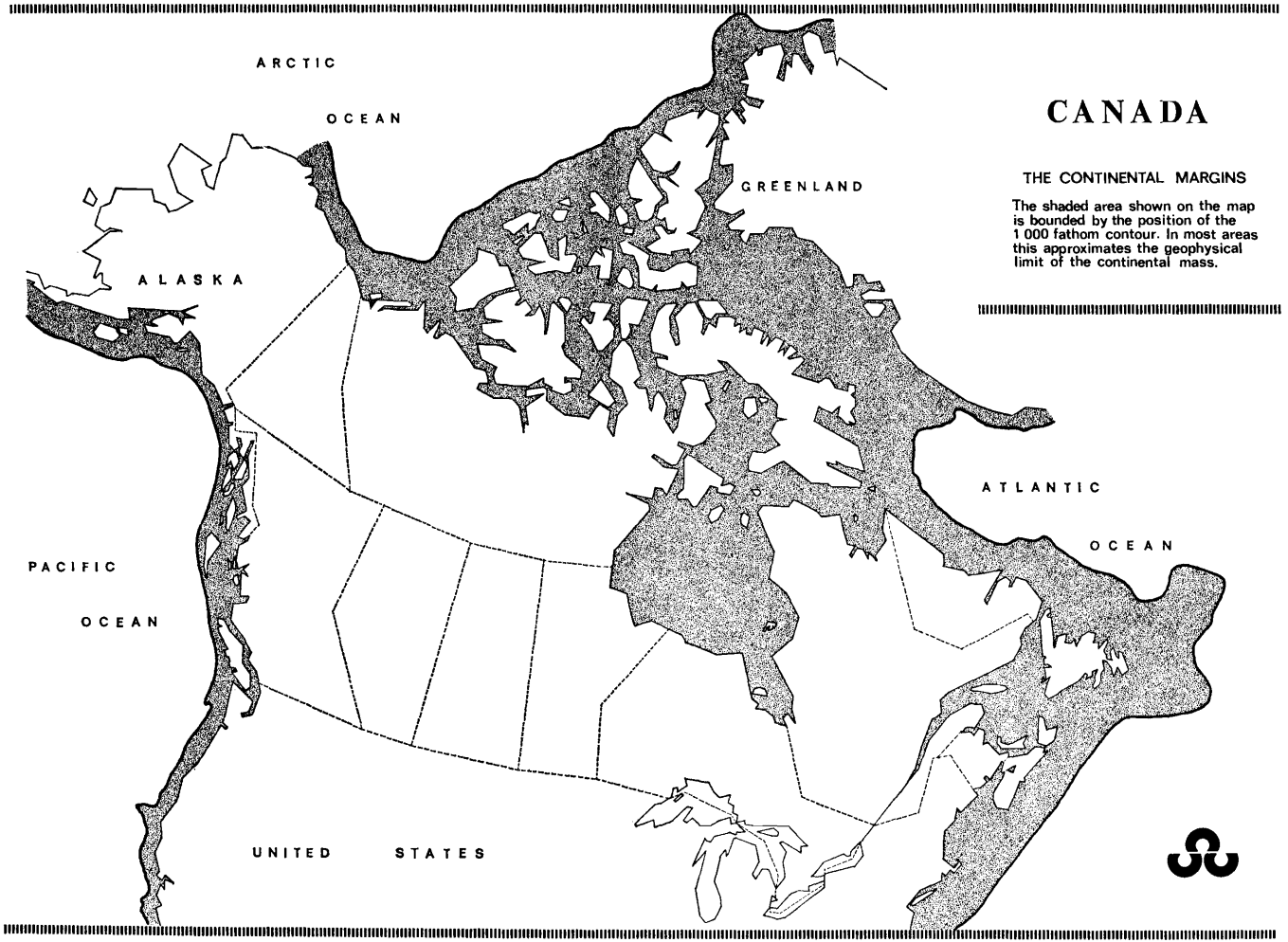
[2]Science Council of Canada. This land is their land. Report No. 9, 1970.

[3]*Oilweek* (May 12, 1969, p. 43) estimates that the ultimate oil reserve offshore from Canada's coastlines to a water depth of 650 feet are in excess of 56 billion (10^9) barrels compared with 65 billion barrels for all the land areas.

Figure 1–Dominant Relationships between National Goals and Interest in the Marine Environment



[1]As outlined in Chapter I of Special Study No. 16, *Ad Mare*: Canada looks to the sea, by R.W. Stewart and L.M Dickie.
[2]Science Council of Canada. Towards a national science policy for Canada. Report No. 4, October 1968.
[3]Science Council of Canada. This land is their land. Report No. 9, 1970.



CANADA

THE CONTINENTAL MARGINS

The shaded area shown on the map is bounded by the position of the 1 000 fathom contour. In most areas this approximates the geophysical limit of the continental mass.

Focus for a Major Program

The Canadian Continental Shelves, their Superjacent Waters and Ice-Cover as a Focus for a Major Program

The marine environment is used for a variety of purposes (see Figure 1), including mineral resources exploitation, fishing, recreation, transportation and waste disposal, each of which will have some influence on the other. There is an urgent need for a much better understanding of oceanic processes in order to develop intelligent policies for a balanced use of this environment. Knowledge of the various processes occurring in the oceans (e.g. ocean currents, mixing mechanisms and energy-transfer processes) are required for a better understanding of phenomena such as marine biological productivity and climate, for the design of equipment and instruments to be used in the marine environment, and to cope with pollution problems.

Canada's rich endowment in marine territories on three oceans presents Canadians with potentially large marine resources, from which we can reap substantial benefits. This is especially evident in the area of mineral resources development, particularly offshore oil and gas exploitation which in the next few years could produce a major socio-economic impact. This impact would be felt not only in the immediate regions where exploration and exploitation activities may take place, but throughout the country as industrial effort is marshalled to support this activity. To quote Stewart and Dickie:

"There is reason to believe that oil resources on the Canadian shelf exceed those of our land areas. Exploitation of these resources promises to produce in a few years economic activity amounting to several billion dollars a year."

Offshore petroleum exploration is pressing ahead and exploitation seems likely to follow. Onshore petroleum exploration and exploitation are dealt with at length in the Science Council Study on Solid-Earth Sciences.[1] The problems in the two areas are closely related and it is only an accident of geological history that places these resources in their respective environments.

A "systems" approach to the multiple use of the marine environment is required in order to optimize the benefits which the oceans can offer to Canadians. Since marine science and technology will have to play a major role in the development of Canadian marine resources, it is essential to concentrate an important fraction of new national scientific and technological effort in this area. The Science Council believes that the most fruitful results will be obtained through a *Major Program*[2] *in Marine Science and Technology* directed towards the systematic acquisition of scientific knowledge about the Canadian marine environment, and a balanced development of the marine resources[3] of Canada's three continental shelves. Although this major program will command a large part of the effort in marine science and technology in Canada,

[1]Blais, R.A., C.H. Smith, J.E. Blanchard, J.T. Cawley, D.R. Derry, Y.O. Fortier, G.G.L. Henderson, J.R. Mackay, J.S. Scott, H.O. Seigel, R.B. Toombs, H.D.B. Wilson. Earth sciences serving the nation. Science Council of Canada. Special Study No. 13, 1970.

[2]The Science Council has defined Major Programs "as large, multidisciplinary mission-oriented projects having as a goal the solution of some important economic or social problem and in which all sectors of the scientific community must participate on an equal footing" (Report No. 4, ref. 2).

[3]The marine resources of the continental shelves include those of the subsoil, bottom and superjacent waters, as well as the recreational potential of the marine environment.

The Territorial Sea and Fishing Zones Act (1964) gives Canada exclusive control of access to the mineral and living resources in the water, on the bottom and in the subsoil within the limits of Canada's internal waters and territorial sea, and to the living resources in the waters of Canada's exclusive fishing zones. Beyond the territorial sea, Canada's sovereign rights over the natural resources of the continental shelf are supported by customary international law and the 1958 Geneva Convention of the Continental Shelf, to which Canada is a party. Canada does not, however, exercise "sovereign rights" over the non-sedentary species of fish in the superjacent waters of its continental shelves.

other important and essential programs in this field, such as Canadian participation in international scientific activities, should not be neglected.

Since the field is so vast and the problems are so varied, action will be required on many fronts. There is a clear need for immediate action and planning for the longer term. The Science Council believes that a balanced program can best be formulated, co-ordinated and implemented through the organizational mechanisms recommended in following sections of this document.

Catalyzing Early Action

The Quest for Offshore Resources

The recent recognition that the Canadian marine environment holds valuable mineral resources, as well as living resources, has stirred much interest in Canada and abroad. The Science Council believes that *immediate* action is necessary by government, industry and the universities to ensure that Canadians make the main contributions to, and gain the most benefit from, the development of these resources.

The need for action in the area of offshore oil and gas exploration is particularly pressing. The potential benefits that may accrue to Canada from the eventual development of offshore petroleum resources resulting from this exploration are immense. To lift only one corner of the curtain, industry expenditures on offshore exploration are expected to grow from about $25 million in 1969 to a minimum of $40 million in 1970.[1] The work requirements on federal government offshore petroleum exploration permits[2] may result in an expenditure of some $1 billion by 1980.[3] If exploitation follows, the financial outlays will certainly dwarf these exploration figures.

Governmental guidelines and regulations are urgently required to ensure enlightened management and orderly development of these offshore resources. General policies can be implemented effectively only if each regulatory agency operates in full awareness of the goals and activities of all other agencies concerned. The Science Council therefore recommends that an interdepartmental committee be established immediately to satisfy this need. This committee should consist of senior representatives of federal departments having responsibilities in the marine environment, including Energy, Mines and Resources; External Affairs; Fisheries and Forestry; Indian Affairs and Northern Development; Industry, Trade and Commerce; National Defence; Regional Economic Expansion; and Transport. Possibly the Interdepartmental Committee on Resources (ICR) would satisfy this requirement. At any rate, its terms of reference should ensure that inconsistencies in the practices and policies of agencies and departments with responsibilities in the offshore are avoided or kept to a minimum as regards the exploration and exploitation of petroleum resources of the Canadian continental shelves. Obviously the provinces should be involved with respect to matters of provincial concern. This might best be achieved by means of a federal-provincial advisory committee at the ministerial level which could act as a "Review Board" on such matters.

In addition to regulatory responsibilities, Government has, through its laboratories, other responsibilities such as the preparation of geological maps of the Canadian continental shelves. While the government laboratories do gather and collate oceanographic and geological information, so do the various oil companies during their exploration programs. Close collaboration is required between government laboratories and the oil industry to minimize duplication so that the rate of progress in this area will be sufficient to meet the planning needs of both parties.

Optimal development of our offshore resources will not occur until the various internal and international jurisdictional disputes are settled. The oil industry, for example, can choose from a large number of promising areas around the world and will neglect those areas in dispute. The Science Council therefore recommends that a concerted effort be made to resolve these jurisdictional difficulties with dispatch.

Studies on the consequences and control of potential *pollution hazards* from the

[1] *Oilweek* (May 12, 1969, p. 43) estimates that the ultimate oil reserve offshore from Canada's coastlines to a water depth of 650 feet are in excess of 56 billion (10^9) barrels compared with 65 billion barrels for all the land areas.

[2] These permits cover over half of the total area of Canada's continental shelves (see Fig. 2.1, reference 1).

[3] Smith, D.W. The potential of Canada's offshore mineral resources. CIMM Symposium, February 13th, 1969.

development of petroleum resources offshore and industrial activity onshore, and in near-shore areas where the waters are highly valued for their other uses, are particularly urgent. In areas of shared responsibilities offshore, the federal and provincial governments must act in concert to initiate thorough studies on the potential impact of particular industrial and resource developments on the local marine environment. Oil exploration in the Strait of Georgia is a case in point. An *immediate* study is needed, as the basis for rational decision-making, on the potential impact of this exploration and possible exploitation of petroleum resources on the marine environment, now highly valued for its scenic and recreational value as well as its sports and commercial fishery.

With mounting oil exploration activity offshore and the increasing size of oil tankers, regulations and the anticipation of mishaps cannot totally prevent accidents that could result in serious damage to the marine environment. On the one hand we must obtain the scientific underpinnings necessary to understand the effects of oil on the marine environment[1], while on the other we must develop a capability to deal with these problems as they occur. The Science Council notes that the Armed Forces have a capability for responding rapidly to emergencies and urges that this capability be included in plans for dealing with oil spills. A competence to deal with such emergencies certainly fit with maritime responsibilities of the Canadian Armed Forces. Recent experience indicates that we need better scientific knowledge, better technology and better preparedness to deal with such emergencies.

Develop Canadian Marine Technology–A Major Project

Marine technology is about to enter an era of rapid growth. Its development requires close attention to ensure an orderly growth with a substantial Canadian participation. Here is an area that can benefit the investor and provide meaningful employment to skilled Canadians, if we are willing to accept the challenge. If Canada does not act, others will try and they will reap the benefits.

Canadians have been active in the areas off our coasts for some time, and the technological capability necessary to support our coastal fisheries, maritime forces and scientific activities offshore does exist, but mainly in government and university laboratories. Unfortunately this expertise has not found its way into industry. Since technology transfer is essential to the development of a viable marine industry, the Science Council recommends that the following steps be taken immediately to strengthen relationships among the three sectors:

–Government and university scientists should take steps to inform the relevant industries of their particular expertise so that information transfer may be improved. A mechanism to stimulate this interchange is proposed below.

–Government and university laboratories should make a special effort to contract out, where possible, some of their work in order to develop technical expertise in industry. Existing contracting regulations and procedures should be modified to facilitate the establishment of strong bonds between particular groups in the three sectors.

–Steps should be taken to facilitate the exchange of technical personnel among the three sectors, by providing more portable pension plans, etc. The Science Council Report on Fisheries and Wildlife Research in Canada deals in some detail with this problem.

–The facilities present within government agencies, such as specialized testing equipment, data centres and ships, should be shared with industry. The embryonic industry would benefit greatly from the use of such facilities.

–Because the development of ocean technology depends on an adequate supply

[1]For example, the physical and chemical properties of petroleum products in near-freezing sea-water are practically unknown and far from being understood.

of engineers and applied scientists, the existing university-based institutes of oceanography are urged to take steps to develop graduate courses in ocean engineering.

Although the implementation of the above recommendations will be an important step in the development of a strong technological capability in Canada, they are not enough. Considering the opportunities in the marine field and Canada's present position in the North American economy, explicit action is required to stimulate the development of an industry which will be of major benefit to Canada. It must be remembered that marine technology *will* be developed in other countries and that to obtain a viable Canadian industry will require a deliberate government policy. What is required is an industrial-type organization wholly under Canadian control which could quickly undertake to organize marine development and innovation projects (to be carried out in the industrial sector) for which existing government departments or agencies are not well suited, and to actively promote the marketing of the products and services with a special eye to international markets. The Science Council recognizes that there can be several alternative mechanisms that will accomplish these ends, but in view of the need to establish a solid technological base as rapidly as possible, and since Crown Corporations have successfully fulfilled such mandates in the past, it recommends the establishment of such a corporation, a *Canadian Ocean Development Corporation* (CODevCo).

This agency would be the "systems" manager for the development of Canadian marine technology; that is, it would evaluate and co-ordinate the projects undertaken, but would contract the components to Canadian enterprises. CODevCo would take on, in concert with industry and the universities, various imaginative programs with the aim of developing a strong technological competence in the industry. The development, for example, of capabilities for fully submerged drilling and for geological surveys in ice-congested waters, as suggested by the Study Group, would find application here and abroad. The technological "know-how" developed would also be applicable to solving other problems.

Existing activities in marine science and technology are dispersed and new ones are sprouting throughout the country. This necessitates an efficient mechanism, other than the library-type repository or circulation service of information, to stimulate the exchange of information in a fast-growing field. The Science Council recommends the formation of a marine technical information service group, whose sole job would be to visit various groups across the country–government, university and industry–in order to keep abreast of the work in progress and to pass on to them relevant information about what others are doing. This group should be within CODevCo but should establish close ties with the Scientific and Technical Information Service of the National Research Council.

To provide not only Canadian ownership of marine technological enterprises, but also to ensure that a significant proportion of the activities involved are carried out by Canadians, the Canadian Ocean Development Corporation should have a small Board of Directors, drawn from Canadian industry, government and university. The Chairman of the Board could be from either government or industry, but the President of the Corporation, who should also be a member of the Board, should be drawn from industry. In order to keep abreast of new policies and national policy formulation in the marine field, one Board member should sit on the National Board on Marine Activity discussed in the following section. The Corporation should report to Parliament through the Minister of the Department of Industry, Trade and Commerce.

Preparing for the Longer Term

Global Interactions–The Need to Widen Horizons

"A major part of the energy of storms and winds is transmitted from the sun to the atmosphere through the ocean. Air, heated by contact with the warm ocean surface, carries water vapour aloft. As the rising air cools and contracts, the vapour condenses, releasing its latent heat, and the air expands again and rises still further. The density distribution in the atmosphere is thus grossly perturbed. Enormous amounts of energy enter the air through this mechanism of evaporation at the sea surface and condensation aloft. Under the constraints exerted by the rotation of the earth, this energy contributes to the formation of the hurricanes of the tropics and the cyclonic storms of mid-latitudes.

"The winds, in turn, drive the surface currents of the sea, thereby determining the location of the warm water masses that are the principal regions of evaporation, and hence of energy transfer, from sea to the air. In this way, the ocean and the atmosphere form an interacting or feed-back system on a very large scale."[1]

Since the oceans cover some 71 per cent of the earth's surface, man and his environment cannot escape from the far-reaching effects of the strong coupling between the atmosphere and the oceans. Marine science, which embraces all of the scientific disciplines having an interest in the sea, is therefore a main branch of environmental science, since its contribution is essential to the understanding of the subtle interactions of our global ecological system. We must strive to understand these interactions if we are to deal intelligently with serious problems such as environmental degradation.

Man is producing waste in increasingly vast quantities, some of which he will eventually learn to recycle, but he will dump the rest either on land or at sea. The temptation to blindly use the oceans as a huge garbage dump is great but must be resisted. Today we do not know how much waste of what kinds can be deposited in the oceans with impunity. This knowledge can only come from research.

Since the atmosphere-ocean interaction is felt on a world scale, marine science, as an environmental science, is very much an international science, and participation in international activities is essential to obtain a better understanding of global phenomena. There is a long history of Canadian participation in international marine science which should be maintained.

With this in mind, the Science Council recommends that a *Standing Advisory Committee on Marine Science and Technology* be established to advise on matters relating to the marine environment (see Figure 2). When the proposed Environmental Council[2] is created, it should absorb this Committee into its organization. The members of this Committee, appointed by the Council, should be Canadians who are distinguished for their knowledge of marine environmental problems. In addition, because of the common interest we share with the U.S.A. and the U.S.S.R. in the marine area, distinguished individuals from each of these two neighbours should be invited to sit with this Committee on appropriate occasions.

The international flavour of marine science makes it a useful instrument of foreign policy and foreign aid. A Canadian presence abroad can be established through the activities of Canadian marine scientists and the export of Canadian technological expertise to specific areas around the world.

Policy Formation

Because of the increasing activity in the marine field, the Science Council believes that the formulation of national policy in this area can best be achieved through advice offered by a *National Board on Marine Activity* with representatives from

[1]UNESCO. Perspectives in oceanography 1968. Intergovernmental Oceanographic Commission Technical Series No. 6.

[2]Science Council of Canada. This land is their land. Report No. 9, 1970.

government, industry and university. This Board, which is akin in concept to several other national advisory committees now in existence, would pass its recommendations directly to the policy-making level through the minister responsible for science policy (see Figure 2). The membership should include the Chairman of the Canadian Committee on Oceanography (CCO) and at least one other member from another department represented on the CCO (see following section). As mentioned in the previous section, this body must include a member chosen from the Board of Directors of the Canadian Ocean Development Corporation (CODevCo) to ensure a close liaison with this Crown Corporation which will play such a vital role in the development of marine technology in Canada. It would also be desirable to have representatives from the Science Secretariat and Treasury Board. In matters relating to mineral resources development, the Board should be closely allied with the proposed National Advisory Committee on Mineral Resources Research which is to co-ordinate a national program of mineral resources research.[1]

Policy Implementation

At the federal level, policy will be implemented through federal government departments. A number of these departments are doing excellent work in the marine field, but as the activity grows and responsibilities multiply, it will become essential to review and alter the status of these bodies. For example, the Department of Industry, Trade and Commerce, through its Marine Division, must be equipped to respond effectively to the challenges ahead.

The principal marine research activities in federal government departments are and should continue to be co-ordinated under the *Canadian Committee on Oceanography* (CCO)[2] which has proved to be a most effective mechanism. In view of the recommended policy formulation mechanisms (i.e. National Board on Marine Activity), the Science Council believes that the CCO is the place where the federal operating agencies should meet to co-ordinate joint implementation of national policy in the marine field. Since policy implementation functions will include some development activities as well as research, the CCO will have to establish strong ties with the Canadian Ocean Development Corporation. It would therefore be appropriate for the President of this Corporation to sit on the Canadian Committee on Oceanography.

To ensure strong ties between the policy formation and policy implementation bodies, it is recommended that the CCO share with the National Board on Marine Activity a common secretariat, which should be administratively housed in a suitable departmental member of the CCO.

Marine Science and Technology in the 1970s

As Canadians turn towards the sea, marine science and technology will be called on to provide new scientific information and services. The rapidly growing industry will require scientific services in the fields of survey, forecasting and improved methods and facilities. In order to arrive at a balanced use of the marine

[1]Science Council of Canada. Earth sciences serving the nation–recommendations. Report No. 7, April 1970.

[2]Canadian Committee on Oceanography (CCO) is an association of senior representatives from the federal Departments of Energy, Mines and Resources, Fisheries and Forestry, National Defence, Transport, the National Research Council and the directors of the four principal university "oceanographic" institutes–University of British Columbia, University of Toronto, McGill University and Dalhousie University. Observers are also invited to sit in on the discussion of the CCO.

The *purposes* of the Committee are to provide a forum and channels of negotiations for voluntary co-operation and co-ordination of plans, resources, research and applications, and exchange of pertinent information. When requested, the Committee advises the Government on matters concerning the sea.

The purposes of the Committee are accomplished at the regional level through four *working groups* (modelled on the CCO): Ice in Navigable Waters; West Coast; East Coast; Great Lakes.

environment, there is a need for new information and methods for improved management of the natural resources to control pollution. Thus the quality of our total environment would be ensured for future generations.

In order to be prepared to deal effectively with the plethora of specific problems that will arise in the years ahead, the Science Council believes that the needed background information and the necessary expertise can best be obtained by concentrating a significant proportion of the total marine science effort in Canada on a few clearly identifiable major objectives, attainable in a reasonable time. The variety of skills and expertise drawn on and developed in the three sectors to attain these major objectives will also be applicable to solve other problems. The urgent need to *develop marine technology* for the exploration and exploitation of marine resources, referred to earlier, is such a Major Project. Two other Major Projects, which deserve close attention, have been suggested by the Study Group. Each project, which involves the study of a major oceanographic system, is of real scientific and social significance.

The Control of the Ice-cover on the Gulf of St. Lawrence project would be to place the ice-cover fully under the control of man rather than nature. Because this project would provide the world's first serious test of the possibilities of deliberate climate control, there would be a need for a "systems" approach since the socio-economic implications, as well as the scientific-technological aspects, would require careful consideration. The new knowledge gained through the background studies necessary to evaluate the feasibility of such a scheme would, regardless of the final verdict on the project, contribute greatly to our understanding of ice formation, ice flow, weather and climate in the Gulf of St. Lawrence. In turn this information would be of help, for example, to those interested in shipping and offshore oil exploration in this area.

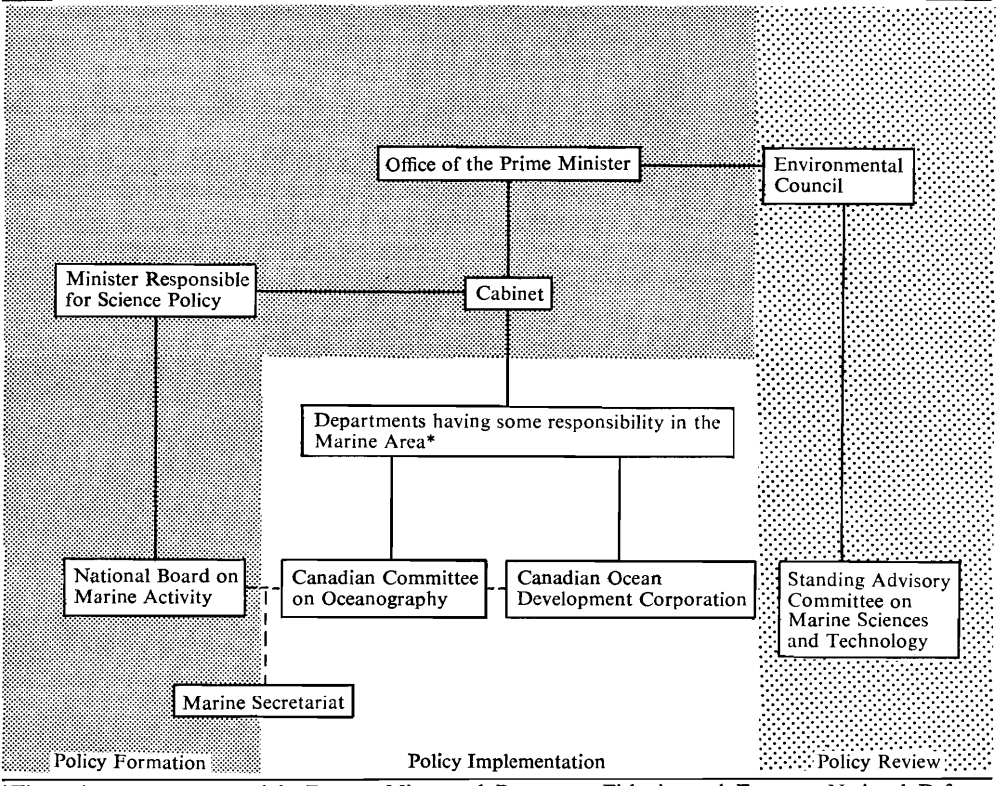
The Management of the Strait of Georgia project would aim, through studies of this total environment, at a balanced management of this multiple use area. The urgent study on the potential impact of oil exploration and exploitation in this area, referred to earlier, would be an initial phase of this project. Again, the information gained in this study would find useful application in solving particular problems here and elsewhere.

Such projects, which meet the criteria established by the Science Council, would be particular foci from which Canada can extend its reach to the sea. As mentioned earlier, the vehicle to initiate development of marine technology is the Canadian Ocean Development Corporation (CODevCo). Since the other two Major Projects will affect large segments of the population, there is a need for public participation in evaluating alternative courses of action as well as co-ordination of the research activity. There can be several approaches to the management of these two projects, but an approach suggested by the Study Group is worth investigating. Public participation should be the responsibility of a socially oriented "non-operating" organization such as the Department of Regional Economic Expansion at the federal level and equivalent agencies in the provinces concerned. Research co-ordination for the Gulf of St. Lawrence project, which is a physical problem, could be within the Department of Energy, Mines and Resources, while the Department of Fisheries and Forestry, which already has broad experience in dealing with aquatic and terrestrial flora and fauna, could co-ordinate the Management of the Strait of Georgia project.

Facilities for the Future

Adequate facilities are essential prerequisites for the healthy development of marine science and technology in Canada in the years ahead. The Science Council believes that a *Marine Science Research Institute*, such as the one proposed by the federal Department of Energy, Mines and

Figure 2–Marine Science Organization at the Federal Government Level Incorporating Changes Suggested in this Report



*These departments are mainly Energy, Mines and Resources, Fisheries and Forestry, National Defence Transport and Industry, Trade and Commerce, along with the National Research Council.

Resources, is needed on Canada's Pacific coast to complement the extremely valuable work performed by the Bedford Institute on the Atlantic coast. Since the study of the Pacific Ocean off Canada is of such scientific and socio-economic importance to the country (e.g. depot of natural resources, origin of much of the climate affecting Canada), a base is needed from which to co-ordinate and to launch scientific programs. For example, one important study which the institute should undertake is a program to improve long-range weather forecasting. When formed, the proposed institute should be closely allied with the U.B.C. Institute of Oceanography and should unite with the Bedford Institute to spearhead a balanced research program on the Arctic Ocean in concert with the Marine Science Centre at McGill University and the Arctic Institute of North America. The Major Program in Marine Science and Technology would then be properly focussed on three oceans.

Deep-sea marine biological research requiring ships larger than small launches should be carried out from these two major oceanographic centres. The support given to individual university ventures in marine biology should be judged on their merits as educational programs necessary to a proper training in both the classical biological and the environmental scientific disciplines. Such work can be carried out nearer shore. There is, for example, genuine need for student field training facilities at St. Andrews, N.B., and those being proposed by the western universities consortium at Bamfield, B.C.

With a growing activity in the marine field, which will require specialized expertise and services, full advantage must be taken of the experience of the provincial research councils as well as that of the federal government laboratories, particularly the Nova Scotia Research Foundation and the British Columbia Research Council, which have, as might be expected, developed marine expertise in specific areas. These provincial research agencies supplement the activities in the other sectors and their potential and expertise should be fully understood and developed by the CODevCo.

Manpower Needs for the Future and University Research

The changing requirements in specialities needed to meet the challenges of the present decade are well illustrated in Figures 3 and 4 which present the current relative positions respectively of the main divisions of marine science and of the main areas of development in the marine field. Considering the state of the art, relative Canadian involvement and Canadian market demand, the Study Group has estimated that the *present* effort in certain areas in marine science (see Figure 3), such as near-shore biology and hydrography, are approaching an equilibrium and should not grow much faster than say the adult population (i.e. about $2\frac{1}{2}\%$ per year), while others, such as physical oceanography and ice studies, placed near the 0.1 mark, should grow about a factor of 10 in the present decade. Since geochemistry is still in its infancy, it should therefore grow faster in the next 10 years. These disciplines should be applied to the problem areas shown in Figure 4, especially the less developed ones near the lower end of the curve. It should be remembered that in the long term no activity can continue to grow faster than the growth of the adult population. These curves reflect the state of development of marine science and technology in Canada and do not necessarily relate to any other country. University management and granting bodies must consider these needs in planning and funding graduate programs.

Where the demand for graduates is not unusually large, the responsible agencies could relieve the year-to-year dependence of university research on the output of graduates by the use of postdoctorate fellows and technicians for research support and by ensuring that most of the products of graduate schools leave the university environment. In other fields, such as physical oceanography and ocean

engineering, where the demand is expected to be significantly greater than the supply in the present decade, a vigorous university program is of course required. There is no need for emergency measures, since it can be expected, as in the past, that scientists and engineers from other disciplines will enter the field of marine science and technology.

The *financing* of university research must relate to the needs of the country. The Study Group has found that at present the National Research Council is the major source of research support, that foreign sources contribute more than do the mission-oriented government departments (apart from ship time), and that these departments make their contribution almost entirely in the form of ship time. There are anomalies in this situation. Most of the marine research being carried out by university groups is in fact mission-oriented and yet the mission-oriented government departments have very little chance to influence the direction of university research, since their present support is mainly by providing ship time.

The Science Council believes that while some university research is justified on the basis of *excellence* alone (this applies only to a small minority of the best researchers) and should continue to be funded by the National Research Council, the criterion of *relevance* ought to become absolutely central in supporting much university research in the marine field. As quickly as possible a larger proportion of the support for university research should come from the mission-oriented government departments, in the form of grants and contracts, since these agencies are the best judges of the relevance of university research to a specific mission. One of the better possibilities of providing this support is through development grants. It must always be remembered that a university researcher must retain a great deal of flexibility; in the course of a research program directed towards a certain goal, he must be allowed to pursue other new and possibly more promising avenues which turn up.

Figure 3–Symbolic Representation of the Current Relative Positions on a Growth Curve of the Main Divisions of Marine Science. (The areas of science shown at the lower left end of the curve are those which are least developed in Canada and consequently should undergo the most rapid expansion; conversely, those areas at the upper right end are closest to an optimum level and can well grow at a much more modest rate.)

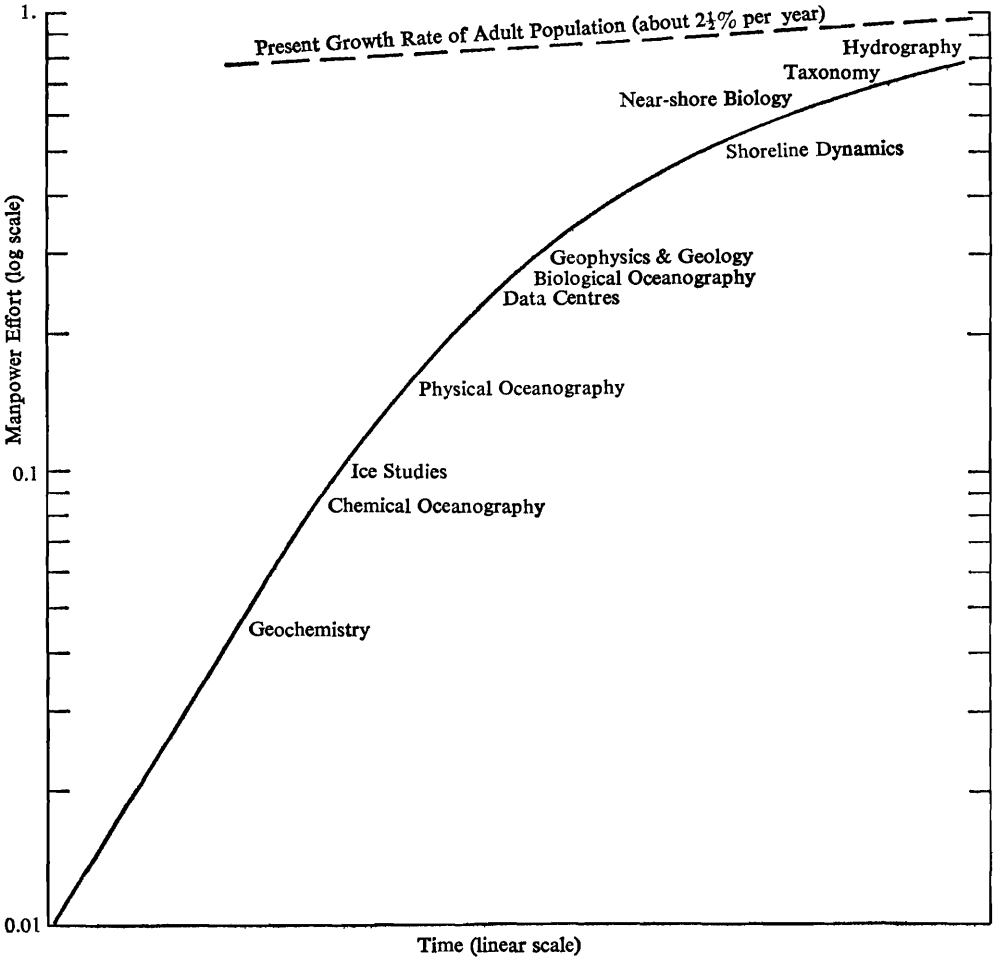
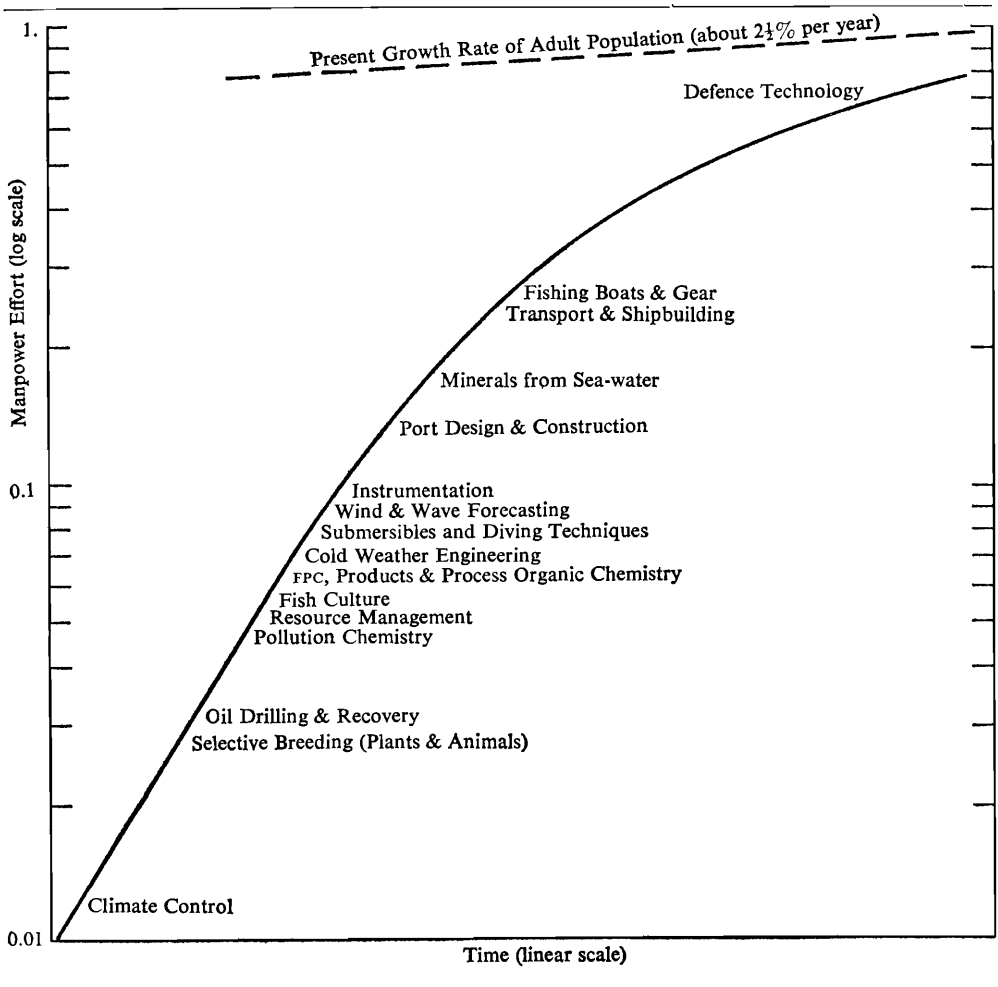


Figure 4–Symbolic Representation of the Current Relative Positions on a Growth Curve of the Main Areas of Development in the Marine Field



A Financial Envelope for Growth

The Study Group has arrived at an estimate of the financial effort necessary to meet the challenges ahead by juxtaposing the present effort in the various areas of marine science and technology (shown symbolically in Figures 3 and 4) and the needs of the 1970s. The Science Council includes these estimates as an indication of the importance of this field, but does not necessarily endorse the total recommended. The Council will make specific comments of its own at a later date, in the context of a wider review of Canada's use of science in relation to natural resources.

The federal government's overall expenditure in marine science and technology, given in Table 1, should reach some $300 million per year by 1980 (i.e. a growth rate of 16% per year). It is expected that about half of the $300 million per year will be spent on contracts to industry, since this sector will play a leading role in the development of marine technology in Canada. The industry itself is expected to spend large sums in the marine field, especially in offshore petroleum resources development. Some government contracts and grants should also be given to support university research relevant to government missions.

Since the Canadian Ocean Development Corporation (CODevCo) will be an important catalyst for the development of Canadian industrial capability in the marine field, yearly expenditures of about $50 million by 1980 appear reasonable in view of the potential returns to Canada.[1] Most of these funds will be employed in contracts to industry.

Apart from the Canadian Ocean Development Corporation, the growth in effort which this expenditure represents should be divided about equally between the east and west coasts, so that the east coast based effort will remain greater than that in the west, but the disparity will be reduced. It is also recommended that the effort should be distributed in a 2:1:1 ratio for Atlantic (including Gulf of St. Lawrence): Pacific (including the Strait of Georgia): Arctic (including Hudson Bay).

[1]Stewart, R.W., and L.M. Dickie. *Ad mare:* Canada looks to the sea. Science Council of Canada. Special Study No. 16. In press.

Table 1–Projected Growth of Federal Government Expenditure in Marine Science and Technology

Department	1969	Growth Factor[1,2]	1980
	$000 000	$000 000	$000 000
Energy, Mines and Resources (EMR):			
Polar Continental Shelf Branch	2.1	2	4.2
Marine Sciences Branch without Hydrography	10.6	4	42.4
Marine Sciences Branch with Hydrography	10.4	1.5	15.6
Fisheries and Forestry (Resource and Industrial Development)	4.6	2	9.2
Fisheries Research Board (FRB) (Product Quality Research)	2.5	2	5.0
Fisheries Research Board (FRB) (Resource and Environmental Research)	10.0	2.5	25.0
Defence Research Board (DRB)	11.0	1	11.0
	51.2		**112.4**
+Canadian Ocean Development Corporation			50
			162.4
Total with sophistication-inflation factor of 6%			**$300 million**

Note: Detailed projections for DRB expenditures are at present uncertain. The figures quoted above should certainly prove to be conservative given, for example, the renewed interest by the Armed Forces in the Arctic.

[1]This "growth factor" does not take account of increases attributable to the sophistication-inflation factor.

[2]Over an 11-year period, a growth factor of 1.5 = 3.8% per year; 1.9 = 6% per year; 2 = 6.5% per year; 2.5 = 8.7% per year; 4 = 13% per year.

Appendices

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The Committee is grateful for the expert assistance provided to it by Drs. Stewart and Dickie and by the Project Officer, Dr. R.D. Voyer.

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