

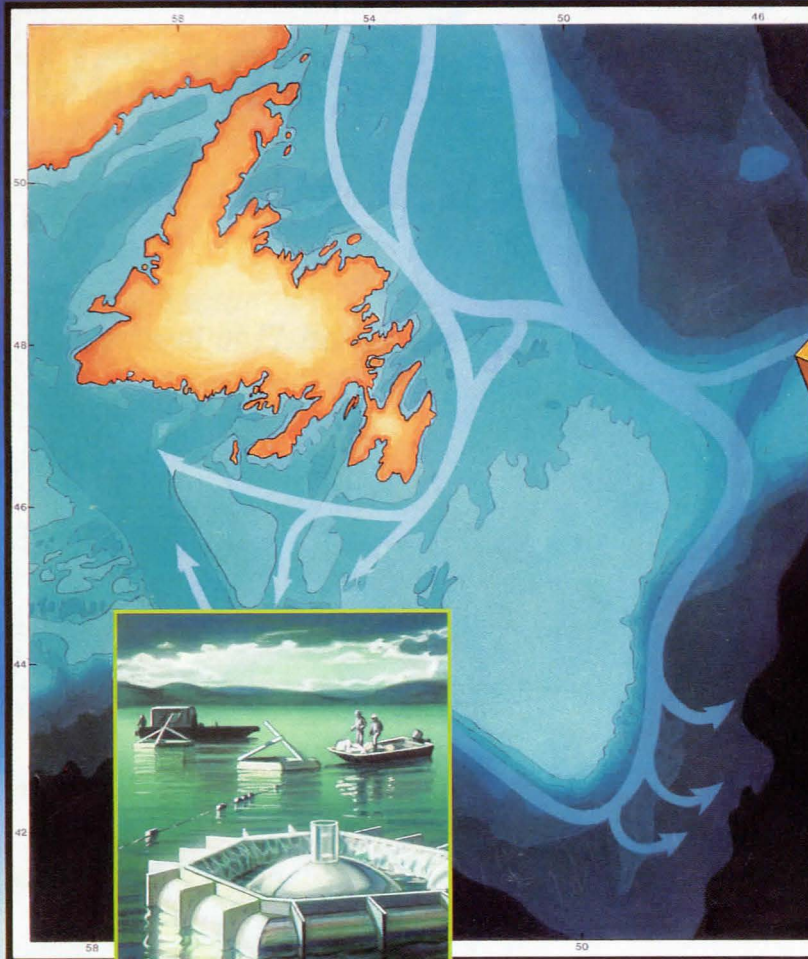
Discovering the Ocean's Secrets

Scientific Excellence in Canada's Waters

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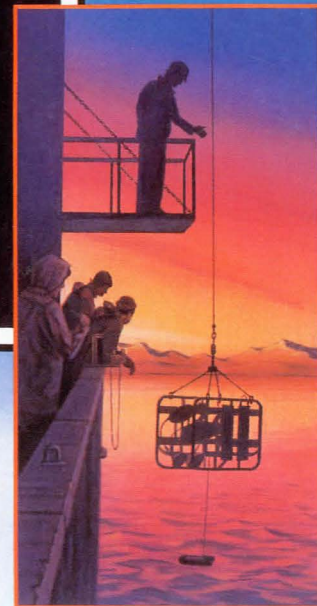


Researching Marine Pollution

Mapping Ocean Currents



Studying the Oceans from Space



Measuring Ocean Variables

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Discovering the Ocean's Secrets

Exploring the World's Oceans



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Discovering the Ocean's Secrets

Physical and Chemical Sciences

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*This is one of a series of brochures describing the
Department of Fisheries and Ocean's Science Program.*

The others are:

***Exploring the Underwater World (Science Sector)
Understanding the Living Resources (Biology)
Charting the Future (Hydrography)***

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Canada and the Oceans

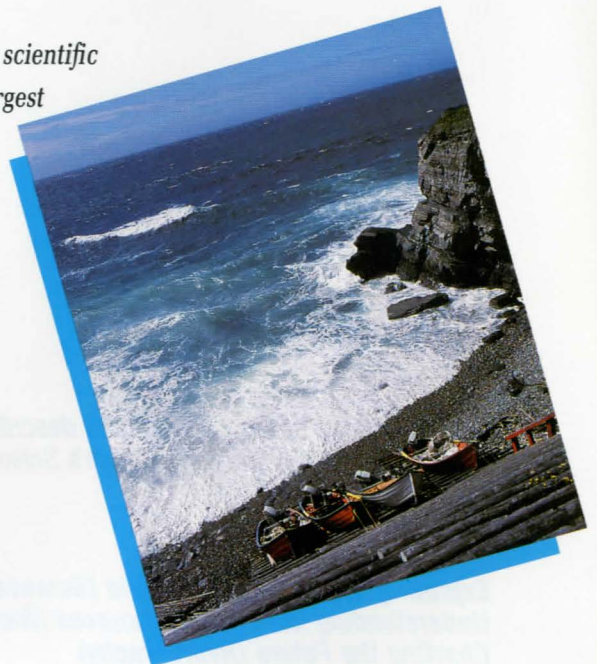
Wherever you live in Canada — the ocean touches your life.

Canada is a maritime nation. This is the country with the longest coastline in the world, the longest inland waterway, the largest archipelago, part of the world's largest fresh-water system, some of the richest fishing grounds and some of the largest untapped offshore oil and natural gas reserves. This is a country that lives by trade that travels by sea.

We need to learn about the waters — how to live with the ocean, how to use it safely, how to protect it from pollution, how to navigate its surface and to exploit its resources wisely. We need to understand more about the ocean's vast and intricate influence on weather and climate.

These interests are not limited to people in lakeside towns or seaports. The prairie farmer and the coastal fisherman, the big city commuter and the merchant seaman, the offshore oil rig worker and the skiers of Mont Tremblant and Whistler have this in common. The ocean makes a difference.

Canada's federal government is responsible for mounting much of the scientific effort needed to build our understanding of the oceans. The nation's largest ocean research effort is conducted by the Department of Fisheries and Oceans (DFO).

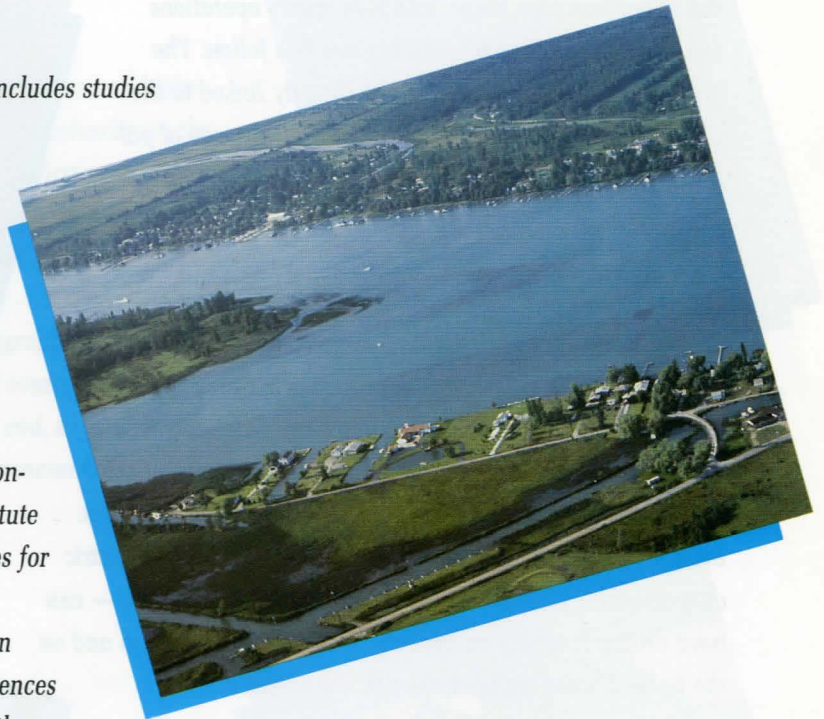


Encompassing both the fisheries and the oceans and marine and freshwater environments, DFO's scientific expertise is consolidated within one organization known as the Science Sector.

The Sector covers three main areas : Biological Science, Physical and Chemical Sciences (the subject of this brochure) and Hydrography.

DFO's work in Physical and Chemical Sciences includes studies in physical and chemical oceanography and research on chemical contaminants that affect both seawater and freshwater ecosystems.

The Physical and Chemical Sciences marine programs are concentrated in three major centers: the Bedford Institute of Oceanography in Dartmouth, N.S., the recently-completed Maurice Lamontagne Institute in Ste. Flavie, Quebec and the Institute of Ocean Sciences in Sidney, B.C. The main centres for freshwater studies are the Bayfield Institute at Burlington, Ontario and The Freshwater Institute in Winnipeg, Manitoba. A Physical and Chemical Sciences unit is also located in St. John's Newfoundland at the Northwest Atlantic Fisheries Centre.





The Living Sea

Changes in the physical nature and the chemistry of oceans, lakes and rivers affect the creatures that live in them. Shifts in ocean temperature can alter the survival rates of larvae and young fish. They can play havoc with fishermen's operations too, by changing the migration routes fish follow. The growth and health of fish are also directly linked to the chemistry of the water — the presence or absence of pollutants for instance — and the amount of oxygen and nutrients.

To understand and, if possible, predict the impact of changes in these characteristics, scientists must pick their way through a maze of interactions between water-dwelling creatures and their environment. Some impacts are direct, some work their way through many links of the food chain that stretches from microscopic plankton to whales. Even seemingly remote pressures — for instance a hydroelectric dam changing the pattern of freshwater runoff to the sea — can have dramatic effects on production of fish and plankton and on the habitat areas which make fish life possible.

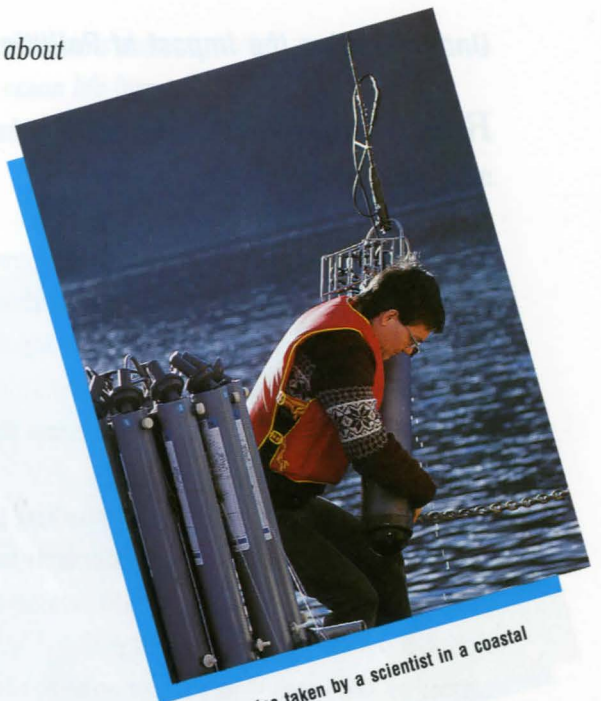


Deployment of plankton net.

Only recently have really large-scale efforts been made to learn more about these relationships. Within DFO's unified science organization, oceanographers and biologists are working together in research aimed at learning more about the relationships between the conditions of the marine environment and the abundance and availability of various fish species.

On the Pacific and Atlantic coasts, DFO oceanographers and biologists are engaged in a study of the influence of ocean behavior on the survival rates of salmon, particularly in their critical first year at sea. The researchers are using satellite-mounted imaging systems, acoustic current profilers, drifting buoys and other advanced equipment.

In Newfoundland, biologists and physical oceanographers are cooperating in studies to determine the influence of ocean currents and temperature on the inshore migrations of the cod, so vital to the social and economic well-being of many coastal communities.



Water samples taken by a scientist in a coastal inlet.



Fishing for cod.



Understanding the Impact of Pollution

Rivers, lakes and oceans are the drains and sinks of the planet into which materials, natural and man-made flow ceaselessly.

In the pre-industrialized age when there were fewer people on Earth, these inputs were easily absorbed and diffused. Today, massive increases in the input volume and the presence of new, highly toxic chemicals, have challenged the capacity of the waters to cleanse themselves.

A large share of the contaminants reaching the ocean do so via rivers and other water runoff. Pollutants from the Great Lakes, for instance, flow down the St. Lawrence and into the Atlantic. But the sea is also being polluted by particles and gases carried on the winds — in fact for some substances, this is the major pathway. There is also direct contamination — intentional dumping of wastes at sea for instance, and the pollution back-wash of energy exploration, shipping, fishing and other human activity.

Understanding how these substances reach the sea and what happens to them after that are high-priority questions for DFO scientific research. So are questions about the possible domino effects on the web of life in the ocean and, eventually, on human uses of the sea.



Chemical analysis is an important part of DFO's work

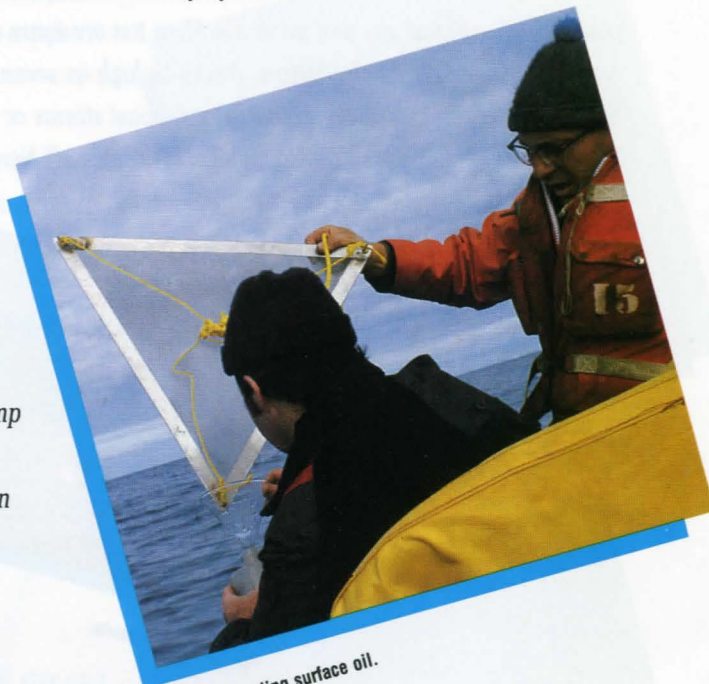
The search for answers ranges in scope from the detection of chemical pollutants dangerous in concentrations as small as parts per billion, to the counting of ocean life forms on an oil-soaked beach and the tracking of long-term changes in the chemistry of Arctic waters.

Two of DFO's recently established Centres of Disciplinary Expertise (CODES) focus on the problems of contamination. They are the Centre for Marine Contaminants and Toxicology in the Department's Scotia-Fundy Region and the Centre for Freshwater Fisheries Contaminants and Toxicology in the Central and Arctic Region.

The dangers of using the ocean as an aquatic garbage dump are now better recognized. Canada is one of many nations which have signed an international agreement to limit ocean dumping and DFO scientists advise on its implementation.

GREAT LAKES RESEARCH

Since the early 1970s, the Canada/US International Joint Commission has coordinated one of the largest environmental rehabilitation operations in history — cleanup of the Great Lakes. DFO researchers at the Canada Centre for Inland Waters at Burlington, Ontario provide much of the scientific backup for this work.

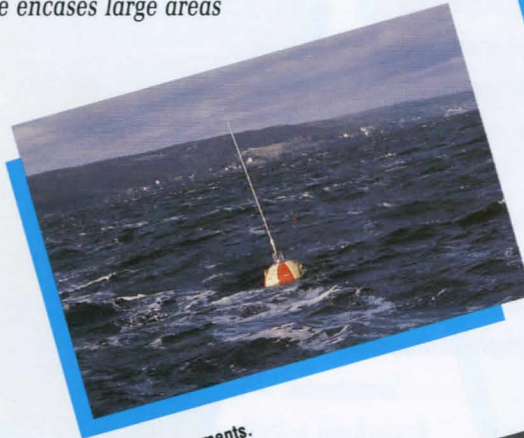


Scientist sampling surface oil.



Frontier Resources

Locked in the seabed off Canada's coasts are some of the world's richest deposits of oil, natural gas and minerals. Here too are some of the world's toughest ocean challenges. Waves as high as seven-storey buildings are frequently generated by east coast storms or deep Pacific swells. Icebergs infest the navigation routes off Newfoundland and Labrador, and pack ice encases large areas of the Arctic.

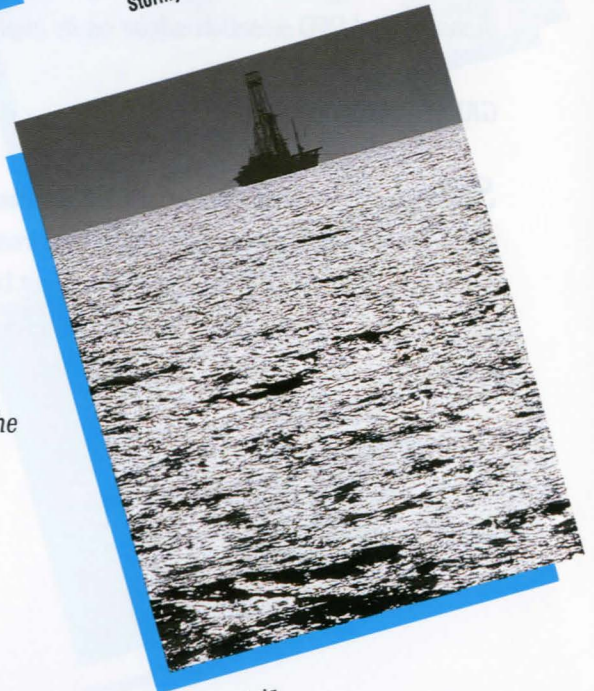


Wave measurements.



Stormy weather.

Industries working on Canada's sea frontiers need to see these challenges coming in time to react. Oil rigs, for instance, are immensely expensive to keep on station. To use them safely and cost-effectively, operators need as much advance warning about waves, currents, ice movement and other ocean events as they can get. To build survivability into them, designers need valid information about ocean forces in the area of operation.



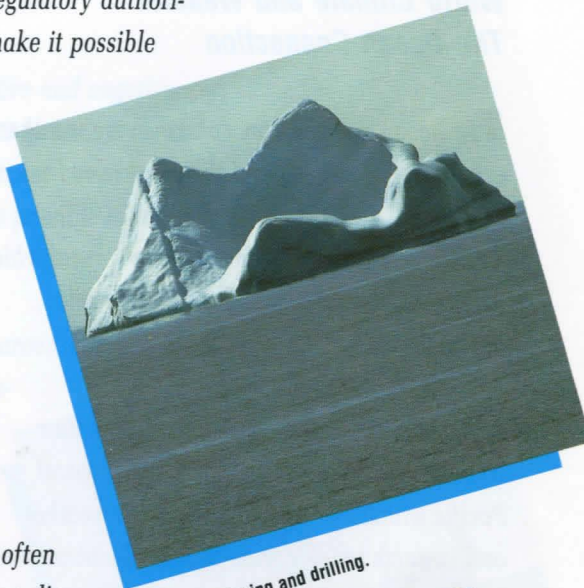
Offshore oil rig.

The shipping sector needs this information too. Data on tides allow regulatory authorities to set safe loading standards for ships. Data on ice and currents make it possible to design hulls to stand up to the pressure of Arctic ice. A reliable wave forecasting system can make the difference between a safe passage and a dangerous one.

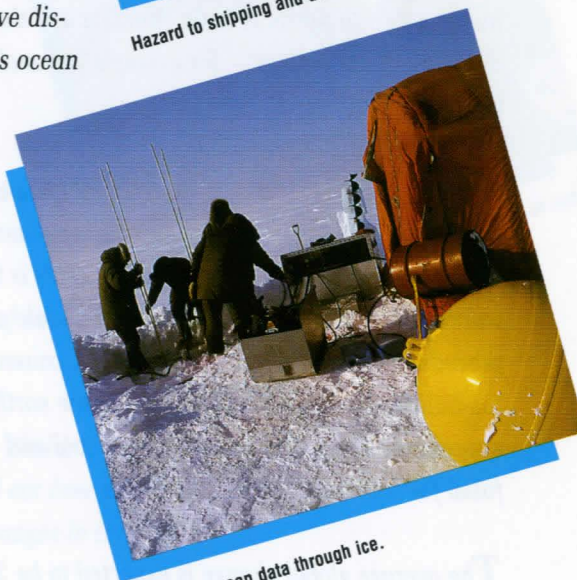
Canadian industry and government are working together to develop forecasting systems of two kinds. Offshore industries — particularly oil companies — concentrate on short-range measurement studies at specific sites. DFO and other government research focuses mostly on long-term measurements, climate trends, and studies of the processes involved.

In ocean studies, what looks on the surface to be a purely local event often turns out to be part of a global chain of cause and effect. Scientists have discovered that slow-moving waves triggered as far away as Asia can cross ocean basins and influence coastal currents off the west coast.

Pack ice drifting south from the Arctic is a problem for oil rigs and shipping off Newfoundland and Labrador. DFO oceanographers are working with industry and with the Department of Energy, Mines and Resources to develop systems for forecasting ice movements. Scientists collect data in helicopter-borne expeditions to the ice surface and with the use of satellite- and aircraft-based remote sensing systems.



Hazard to shipping and drilling.



Collecting ocean data through ice.



World Climate and Weather The Ocean Connection

The ocean and the atmosphere shape weather and climate — and along with them, the economies of nations and the day-to-day lives of people throughout the world.

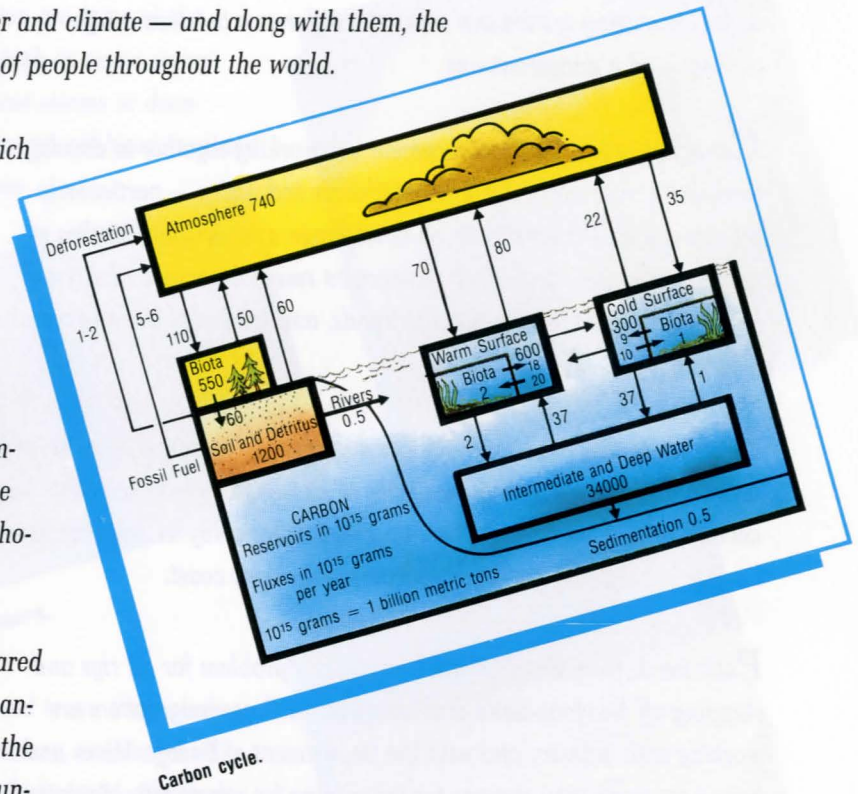
DFO's scientific programs include several which focus on these relationships and their impact on society.

For instance: studies of El Nino — a major change in ocean temperature in the tropical Pacific which has caused changes in weather and impacts ranging from drought-induced famine in Africa to floods in Latin America and the devastation of fisheries — for example the anchoveta fishery off Peru.

These impacts are likely to seem small compared with those of another phenomenon, this one man-made: the so-called Greenhouse Effect. This is the warming of the earth's atmosphere on a scale unprecedented over the past 100,000 years, caused by the buildup of CO₂ and other gases in the earth's atmosphere due to the burning of oil, coal and other fossil fuels throughout the world.

The average global change is expected to be 2-4 degrees C by the mid 21st century — with considerably higher increases in some areas.

Scientists cannot yet make ironclad predictions of changes the Greenhouse Effect will bring. But changes, they agree, will come.



No one is certain — and that is part of the problem.

On the basis of today's evidence scientists speculate on a mix of positive and negative impacts. With winter temperatures in 2050 AD in the North higher by 10 to 15 degrees C, the Arctic would have less ice cover and be easier to navigate. Drought may parch the southern prairie farmlands of today but, given the right soil, it could be possible to farm several hundred miles further north than previously possible.

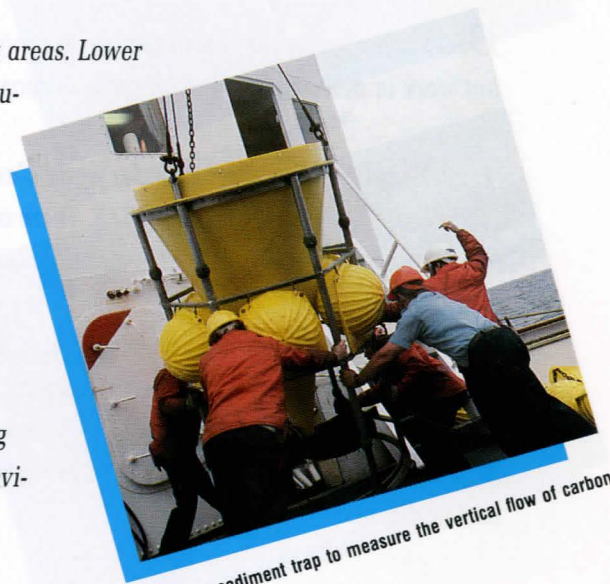
Melting polar ice could raise sea levels causing flooding in low-lying areas. Lower water on the Great Lakes could pose problems for industry and communities and freshwater fisheries could be threatened.

All this is educated guesswork. To get a clearer picture — which we must have to plan adjustments — we need to understand more about the Greenhouse effect — notably about the immense influence of the ocean and its role as a sink for CO₂.

DFO scientists are in the forefront of the search for answers, working closely with colleagues in the Atmospheric Environment Service of Environment Canada, universities and provincial governments.

Canada is also working with other nations to build an understanding of the relationship between the ocean, climate and weather.

*The major organizational umbrella for this international effort is **The World Climate Research Program**. This study has two ambitious aims: to find out how exactly climate can be predicted, and to determine the impact of man-made changes in the environment on climate.*



Launching sediment trap to measure the vertical flow of carbon



New Technology on the Ocean Frontier

Vessels of Discovery

Columbus, Magellan and Vespucci explored the world with wooden ships. The frontiers of ocean science are probed with high-technology vehicles and platforms, working on and below the surface.

DFO's ocean science programs include not only studies in Canadian waters but work in other oceans and latitudes in cooperation with other nations.

The scientific surface fleet includes world class research ships such as the C.S.S. HUDSON and the C.S.S. TULLY. These ocean-going laboratories have special built-in capabilities — they can, for instance, place and retrieve instrument moorings up to a mile long. They can position instruments in a variety of settings — suspended in mid-ocean, on the continental shelf or under the Arctic icepack.

Surface vessels also serve as control centres for explorations by manned and unmanned vehicles.

Tools of modern oceanography

New technologies have extended the reach of ocean science.

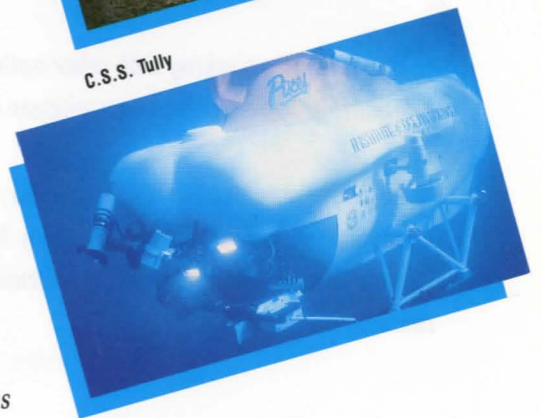
Probably the world's busiest deep-sea submersible, DFO's PISCES, has been used for everything from the placing and retrieval of instruments on the seabed to underwater geological studies. Canadian-designed and built for DFO, PISCES was used by University of Victoria and University of Washington for observations of seabed "volcanoes" and the strange life forms that cluster around them.



C.S.S. Hudson



C.S.S. Tully



Piscès

Canada's newest underwater exploration tool is a remotely-operated vehicle (ROV) designed and built for DFO by International Submarine Engineering of B.C. The ROV can carry out lengthy studies at depths of 5,000 metres and more — transmitting live black-and-white and color video images to the surface from depths where ocean pressures reach 7500 lbs. per square inch (5200 kilopascals).

In Nova Scotia, DFO scientists developed the BATFISH, an underwater "aircraft" that flies behind and beneath a research vessel, diving and climbing to different altitudes to record variations in temperature, salinity and other ocean characteristics while collecting plankton samples.



DFO's remotely-operated vehicle (ROV).



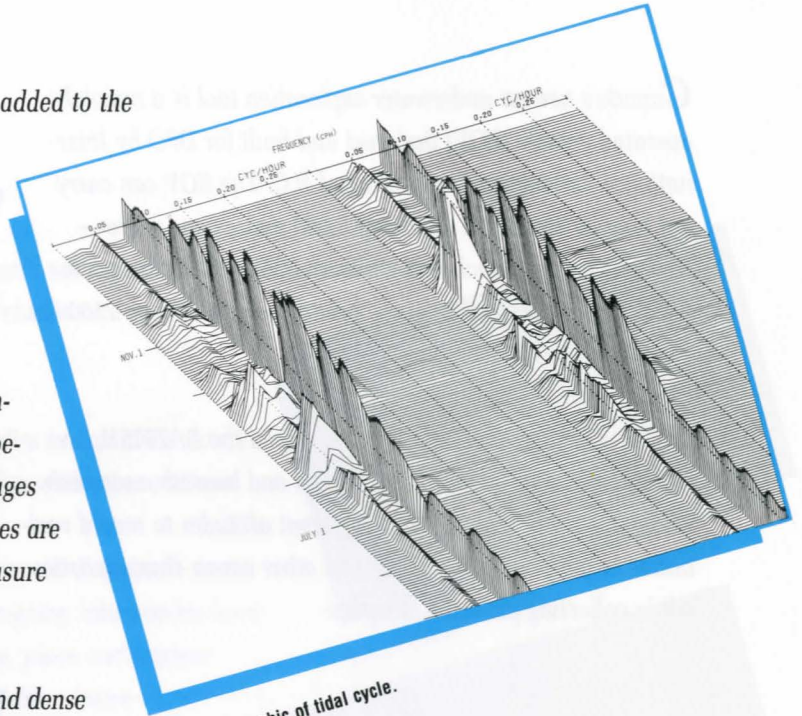
Batfish



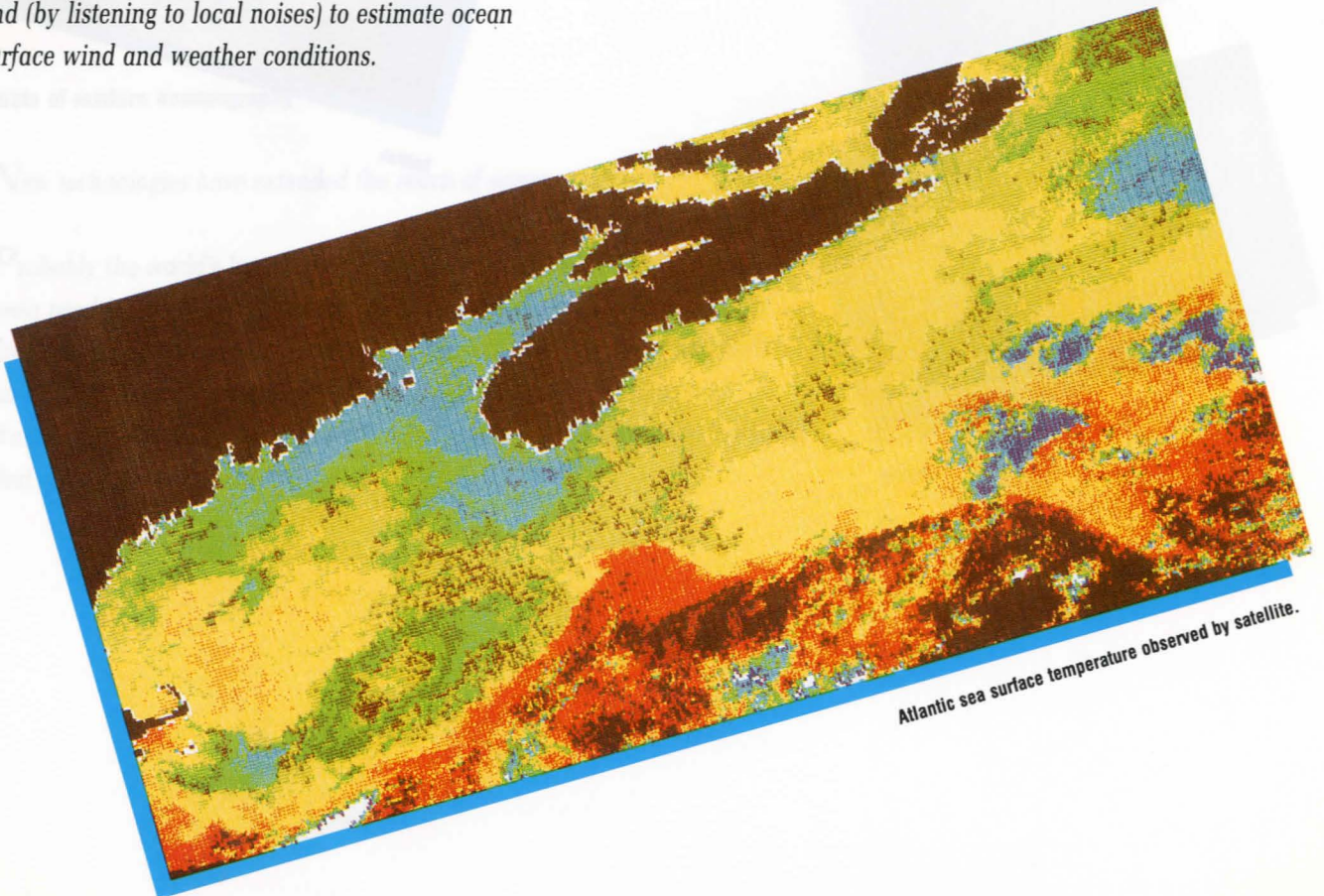
Developments in super-computer technology have added to the capacity of oceanographic research. Faced with the challenge of understanding the virtually infinite chains of cause and effect that determine ocean behavior, scientists can simulate them with mathematical models.

Satellite technology, used in combination with computers, for the processing and storage of data, has become a vital tool of the oceanographer. Satellite images are used to identify nutrient-rich ocean areas. Satellites are also used to monitor the ocean's movements, to measure surface currents and to sense ocean temperatures.

Sound travels faster and more easily through cold and dense (salty) water. Variations in the speed of sound waves bounced off various layers of ocean depth can be interpreted to yield information about these values. DFO scientists also use acoustic signals to communicate with distant measuring instruments, to measure ocean current speed and (by listening to local noises) to estimate ocean surface wind and weather conditions.



Computer graphic of tidal cycle.



Atlantic sea surface temperature observed by satellite.

The Sea. Where it all began.

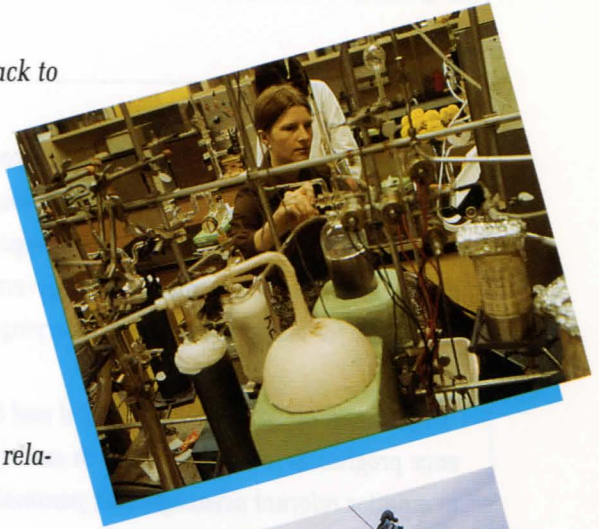
The sea is where we all began. The human race traces its ancestry back to life forms which lived in the primeval waters.

Man still depends on the ocean. We have had to learn to navigate its surface, to explore its depths and to exploit its resources wisely. And we are only now beginning to understand the most important relationship of all — the influence of the ocean on the atmosphere and climate of the earth.

Today, new uses of the ocean and new pressures on it have made the relationship between people and the sea more challenging than ever.

As the world's population grows and societies become more industrialized, demands on the sea increase, mistakes are more costly and guesswork becomes more dangerous. Our approaches must be guided by a scientific understanding of the physical, chemical and biological processes of the sea.

The Department of Fisheries and Oceans is at the forefront of scientific effort aimed at understanding these processes and unlocking the ocean's secrets.





The Official Mandate

The overall objective of Fisheries and Oceans Science is: to ensure that scientific information of the highest international standard is available to the Government of Canada for use in developing policies, regulations and legislation regarding the oceans and aquatic life, and to other government departments, private industry and the public for use in planning and carrying out aquatic activities.

The overall objective of the Physical and Chemical Sciences component of the Science program is to conduct research on the oceans (marine and estuarial waters), to monitor relevant oceanographic parameters and, particularly, to acquire the scientific knowledge and database needed to:

- *relate the marine environment to the growth, movement and population dynamics of fish and marine ecosystems;*
- *describe, quantify and predict the marine climate and its relation to fish stocks, other aquatic species and ecosystems and the atmosphere;*
- *describe, quantify and predict parameters of the marine environment relevant to marine engineering, transportation and other activities;*
 - *describe, quantify, and predict ocean processes.*
- *conduct research on chemical contaminants of fish and fish habitat, to monitor relevant parameters, and particularly to acquire scientific knowledge needed to:*
 - *determine the impact of deleterious substances on fish and fish products, other aquatic species, fish habitat and ecosystems;*
 - *maintain the quality of the aquatic environment;*
- *provide professional services and effectively communicate reliable scientific advice; and*
- *develop and refine methodology and technology needed to carry out the Physical and Chemical Sciences program.*

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