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**THE EARLY DAYS OF OCEANOGRAPHY
AT DALHOUSIE UNIVERSITY
1959-1986**

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TABLE OF CONTENTS

Abstract.....	1
Dedication.....	1
Introduction.....	2
Origin.....	3
Initial Objectives, Policy and Organization.....	5
Evolution of the Dalhousie Institute of Oceanography (1959-1986).....	6
Summary.....	67
Acknowledgements.....	68
References.....	69
Appendix 1: Board of Directors and Science Advisory Committee.....	71
Appendix 2: Directors and period of tenure.....	77
Appendix 3: Faculty, associated staff, postdoctoral fellows, degrees awarded, incoming graduate students and administrative and technical staff.....	78
Appendix 4: Summary of student data.....	115
Appendix 5: Student theses.....	116
Appendix 6: Oceanography graduates employed at BIO.....	129

ABSTRACT

In 1959, the Canadian Joint Committee on Oceanography recommended the creation of the Institute of Oceanography at Dalhousie University (IODal) in Halifax. Its mandate was to train the oceanographers needed for the rapidly expanding Canadian oceanographic effort and to conduct academic research in the marine sciences on the east coast and in the Arctic. It complemented a similar institute founded ten years earlier on the west coast at the University of British Columbia. Initial development of the Institute was led by F. Ronald Hayes who served as director for five years until he moved to Ottawa to become the Chair of the Fisheries Research Board of Canada. He was replaced by Gordon A. Riley, an eminent biological oceanographer from Yale University. Under his leadership, and with the unwavering support of President Henry Hicks, the Institute grew steadily in both personnel and program and in 1971 morphed into a full Department of Oceanography. This same year the Department moved into its own building in the new Life Sciences Centre. Gordon Riley stepped down as Director in 1974 but was followed by other directors who kept the ship firmly on course. Over the years, the program developed in very close cooperation with the federal Bedford Institute of Oceanography located across the harbour in Dartmouth. This history documents some of the major achievements over the time period of 1959 to 1986 when the Institute was formally disbanded. During this period, the Dalhousie oceanography program earned an outstanding international reputation that continues today.

DEDICATION

This history is dedicated to Gordon Arthur Riley who, in 1965, moved from the Bingham Oceanographic Laboratory at Yale University to Dalhousie to become the Director of the fledgling Institute of Oceanography. Under his leadership, the Institute grew into the highly respected Department of Oceanography that continues to thrive today.

INTRODUCTION

During the summer of 1962, I had the good fortune to meet both Peter Wangersky and Gordon Riley, then at Yale's Bingham Oceanographic Laboratory, while taking the marine ecology course at the Marine Biological Laboratory (MBL) in Woods Hole, MA. As a young graduate student, I was most impressed with them both. That same year I also met Eric Mills, a graduate student at Yale who was working in the lab of Howard Sanders at the Woods Hole Oceanographic Institution (WHOI) and auditing the MBL marine ecology course. Little did I know that six years later the three of them would be signing my PhD diploma in oceanography at Dalhousie University.

The following year, as a graduate student at the Graduate School of Oceanography at the University of Rhode Island, I worked with Pete on a long cruise of the RV *Trident* to West Africa. We had many pleasant conversations together while sitting on deck watching the water go by. He answered my many questions about oceanography and I developed an interest in learning more about the vast pool of non-living organic matter in the ocean. At the end of the cruise, Pete urged me to consider coming to Yale to pursue a PhD under Gordon after I finished my master's degree in benthic ecology. Gordon was most agreeable to this possibility and so I applied to Yale.

Unfortunately, I was not accepted. Gordon was upset because he never had the opportunity to comment on my application. This was just one of many things he was unhappy with at Yale. Soon after he informed me that he was considering leaving Yale and was actively pursuing other possibilities. In November 1964, I visited him in New Haven and he told me he had just accepted the position as Director of the Dalhousie Institute of Oceanography (IODal) and urged me to apply. My first question was where is Dalhousie? I knew very little about Nova Scotia but figured it would be an interesting place to spend three years doing a PhD under Gordon's tutelage. I subsequently applied, was accepted and moved to Halifax in September 1965 soon after Gordon arrived. Pete Wangersky had also resigned from his Yale position and moved to IODal at the same time.

My three years as a graduate student at IODal were a marvellous experience. I learned much, met many wonderful people who became lifelong friends and fell in love with Nova Scotia. After finishing my doctorate and getting married in 1968, both in the same week, the next step in my career was a faculty position in the Department of Oceanography at the University of Hawaii in Honolulu. However, my wife Joleen and I wanted to return to Nova Scotia as soon as a suitable job opened up at either Dalhousie or the Bedford Institute of Oceanography (BIO). We were delighted to return two years later from our extended honeymoon in Hawaii when, at the invitation of Lloyd Dickie, I joined the Marine Ecology Laboratory (MEL) at BIO where I was privileged to enjoy a long and satisfying career as a research scientist and program manager.

Having a long-standing interest in history, I spent much of the time at home during the COVID-19 pandemic preparing a history of MEL (Gordon 2021a and b). Upon its completion, while the pandemic continued and I still had some gas left in the tank, I decided that my next major writing project would be preparing a similar history of the Dalhousie Institute of Oceanography (IODal).

This account is a labour of love that I hope accurately chronicles the history of IODal and its many contributions to training new oceanographers and advancing our knowledge of the oceans. It covers the time period beginning with its creation in 1959 to when it ceased to exist on paper in 1986 when the last annual report was issued. The focus is on the early years before the Department of Oceanography was created in 1971. It begins by reviewing the origins of IODal. After describing its structure and operation, it reviews the year-by-year evolution of its faculty, students and programs. Also included are some representative research highlights of faculty and graduate students. It then concludes with a brief summary. Further details are provided in appendices which include advisory committees, directors, faculty and students, student theses and graduates who were employed at BIO.

The information included in this history came from a variety of sources, the most important being the annual/biennial reports which were faithfully produced on a regular basis. Another major source was Gordon Riley's unpublished memoirs. Other information was gleaned from a 1967 pamphlet describing IODal, the scientific literature, the Internet, and numerous colleagues as well as my own personal memories.

The immediate target audience for this history is the many colleagues who were part of IODal and are still with us today. I hope that this account brings back an abundance of pleasant memories. In addition, I hope that it will be of interest to the broader oceanographic community as well as those interested in the history of Dalhousie University.

ORIGIN

The early development of Canadian marine science, including the events that led to the creation of IODal, has been reviewed by Mills (2014). Before World War II, oceanography in Canada, including physical oceanography, marine biology and fishery biology, was done entirely by the federal government under the Fisheries Research Board of Canada (FRB) at the St. Andrews Biological Station in New Brunswick and the Pacific Biological Station at Nanaimo in British Columbia. Soon after the war began, increasing attention was paid to physical oceanographic research because of the threat of German submarines and acoustic mines to North Atlantic shipping. In 1944, two new federal organizations were created under the FRB to conduct oceanographic research. On the east coast, the Atlantic Oceanographic Group (AOG) was established at the St. Andrews Biological Station and headed by Harry Hachey while, on the west coast, the Pacific Oceanographic Group (POG) was established at the Pacific Biological Station and headed by Jack Tully.

The mandate of AOG was to study the ocean environment and its dynamics taking into account the processes which maintain or modify ocean conditions in both inshore and offshore waters. The initial focus was on physical oceanography but soon expanded to include geology, chemistry and biology with strong links to fisheries. The geographic area of interest to AOG was initially the continental shelf of Atlantic Canada but later it expanded to include offshore waters and the Arctic. Ship time was provided by the Royal Canadian Navy, in particular the CNAV *Sackville*.

By the end of the war, in addition to AOG and POG, the National Research Council (NRC), Royal Canadian Navy (RCN), Defence Research Board (DRB) and several Canadian universities were expanding into ocean science. The need for national program coordination was recognized which led to the creation in 1946 of the Joint Committee on Oceanography (JCO). The JCO was composed of representatives from federal agencies and universities and was charged with coordinating the development of oceanography in Canada and allocating federal resources. Harry Hachey, then the Chief Oceanographer of Canada, was appointed as Chair.

As the various laboratories grew and research programs expanded, there were still few oceanographers and sources of trained personnel in Canada. Training new but inexperienced staff took time and as a result more experienced staff were frequently recruited from outside Canada. It was soon recognized that there was a critical need to establish a training program for oceanographers in Canadian universities. It was proposed that an institute of oceanography be created somewhere in the country and the University of British Columbia (UBC), McGill and Dalhousie expressed interest in hosting such an institute (Mills 1994). After considering many factors, the JCO selected UBC in Vancouver as the site for such an institute because of its location, facilities and proximity to the Pacific Biological Station. Subsequently, the UBC Institute of Oceanography (IOUBC) was created in 1949. Well supported, IOUBC began a ten-year period as the only Canadian university training oceanographers. Its curriculum focused on physical and chemical oceanography and many of the first students were government scientists looking to upgrade their professional qualifications. However, soon after IOUBC was established, under the lead of F. Ronald Hayes, Dalhousie began to lobby for the creation of a similar institute on the east coast, this one focusing on marine bacteriology (Mills 1994). Initially, it was not successful in convincing the JCO of the need for a second academic institute in Canada but conditions later changed and the Institute of Oceanography at Dalhousie (IODal) was thereby created in 1959 with Ron Hayes as Director.

Also in 1959, the JCO was reorganized and expanded to include the University of British Columbia (UBC), the University of Toronto and Dalhousie University and was renamed the Canadian Committee on Oceanography (CCO). William van Steenburgh of the Department of Mines and Technical Surveys was appointed Chair and Harry Hachey served as Secretary. Its mandate was to coordinate and direct work in oceanography and to represent the Canadian government internationally in the field of oceanographic research.

INITIAL OBJECTIVES, POLICY AND ORGANIZATION

The main objectives of the new Institute were to train the oceanographers needed for the rapidly expanding Canadian oceanographic effort and to serve as an academic research centre for advanced studies in the marine sciences on the east coast and Arctic. The Institute, through the University, would award the degrees of MSc and PhD in oceanography.

Two bodies were created to oversee the creation of IODal and the development of its program in the early years. A Board of Directors, chaired by the Dalhousie president was composed of senior university administrators. Ron Hayes served as secretary. A Scientific Advisory Committee, chaired by Ron Hayes, who also chaired the Dalhousie Biology Department, was made up of representatives from University of British Columbia, the University of Toronto, the Marine Sciences Branch (Ottawa), the Fisheries Research Board (Ottawa), the Naval Research Establishment (Dartmouth), the Nova Scotia Research Foundation, as well as the chairs of the Dalhousie departments of chemistry, geology and physics. The composition of the Board of Directors never changed but there were some changes in the composition and membership on the Scientific Advisory Committee (Appendix 1). Both these bodies were not included in the annual reports after 1968 so presumably they had been disbanded by that time when the Institute was firmly established and could run itself.

From the very beginning, the policy was to integrate the new institute into the broader educational program of Dalhousie University. In setting up the academic program, it was recognized that formal instruction in oceanography was essentially limited to the graduate level. The multidisciplinary nature of oceanography required a broad scientific background combined with specialized training in one or more of the basic disciplines. Graduate students were expected to combine oceanographic training with further studies in the basic sciences which were pertinent to their field of speciality. Participation in field courses, cruises and seminars would be required.

It was decided that IODal would offer an introductory class in basic oceanography and a series of advanced classes in specialized subjects. Graduate students working toward both the MSc and PhD degrees were required to take the introductory course and at least one advanced class. They were also expected to take courses in basic sciences which were relevant to their field of specialty. Doctoral students were also required to take an oral comprehensive exam and demonstrate reading proficiency in two foreign languages. However, in general the emphasis was on thesis research and the acquisition of an adequate academic background for future careers. The amount and kind of course work were decided individually according to the particular needs of the student. It was agreed that the advanced courses must be accepted by the basic science departments and open to their honours and graduate students with the hope that the Institute and departments would strengthen each other.

Funding was initially provided by an institutional grant from the National Research Council of Canada (NRC) and university funds. With time, this expanded to include research grants obtained by staff from several federal agencies in both Canada and the US. Also, some students arrived with their own funding such as NRC studentships.

The geographic area of particular interest to the new Institute was envisioned to be the Northwest Atlantic Ocean including offshore waters, the continental shelf, major bays such as the Gulf of St. Lawrence and the Bay of Fundy and coastal waters. While the initial focus was on biology, it was hoped that with time research programs could be established in all the basic oceanographic disciplines. The Institute was most fortunate that there was a commitment by federal agencies to provide ship time at no cost so there was no need to acquire and operate a research vessel. It was also recognized that it would be prudent to develop a close working relationship with other local scientific laboratories at the time with marine interest such as the Atlantic Oceanographic Group, the Naval Research Establishment, the FRB Fisheries Technological Station, the Atlantic Regional Laboratory of NRC and the Nova Scotia Research Foundation. BIO did not appear on the scene until 1962.

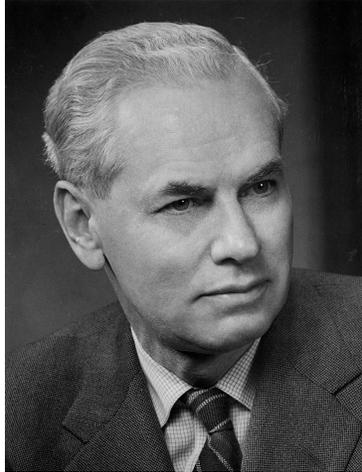
The initial faculty appointments were planned to be in marine zoology, bacteriology, chemistry, physics, geology and geophysics. All faculty members would also have departmental appointments and be physically located in their respective departments. Biologists were located in the Forrest Building, as was the IODal office. Chemists were located in the Chemistry Building and geologists and physicists were located in the Dunn Building.

An Admissions Committee was established and composed of the director and the heads of the four disciplinary departments. Incoming students were to be provided with a university stipend to cover all expenses. In exchange, they were required to serve as demonstrators in undergraduate labs in their respective departments.

EVOLUTION OF THE DALHOUSIE INSTITUTE OF OCEANOGRAPHY (1959-1986)

1959

Members of the initial faculty were Ron Hayes (Director, Biology), Elmer (Tony) Anthony (Biology), John Teal (Biology) and Alan Mills (Chemistry). Physical oceanographic expertise was provided by three associates: Bob Stewart (Defence Research Board), Neil Campbell (Atlantic Oceanographic Group) and Ron Trites (Atlantic Oceanographic Group). The first graduate course offered was in physical oceanography and taught by Bob Stewart. Barbara Hendry was the administrative assistant.



F. Ronald Hayes
Director 1959-1964

From the very beginning, the policy was to integrate the new Institute into the educational program of Dalhousie. Academic staff would hold, as well as an Institute appointment, an attachment to the appropriate university department. Advanced oceanography courses must in general be accepted by one or more departments as having honours or graduate standing. In this way it was hoped that the Institute and departments would strengthen each other.

The faculty organized a speaking tour to Maritime universities to inform them of IODal and to encourage undergraduate students to consider a career in oceanography.

An NRC annual award of \$90,000 was the major source of funding. Ship time was provided by federal agencies without cost.

Two students, Kevin Halcrow and Peter Hochachka, were admitted this first year, both in biology.

1960

The Scientific Advisory Committee met in June and reviewed the activities and plans. It was agreed that the entrance requirements were too rigid to accommodate applicants from a variety of university background training and tended to discriminate against students from outside Dalhousie. Options were introduced into the entrance requirements so that students of high quality would not be rejected.

Dirk Nota (Geology), from the Netherlands, joined the faculty. The partnership with the Atlantic Oceanographic Group (AOG) was strengthened when it moved from St. Andrews to Halifax and Neil Campbell and Ron Trites took over teaching the physical oceanography course. Staff and students began to participate in field programs, thus initiating the long-standing tradition of Institute personnel working at sea.

Research highlights (including students and PDFs):

- In cooperation with the Nova Scotia Research Foundation, a seismic refraction and reflection survey using a Cape Islander was carried out in the Northumberland Strait.
- In conjunction with the RV *Vema* of the Lamont Geological Observatory, Columbia University, seismic refraction surveys were carried out using CNAV *Sackville* in the Labrador Sea and Gulf of St. Lawrence.
- Phytoplankton productivity was measured using the C-14 method on an Arctic cruise aboard the CGS *Labrador* (Hayes).

Seven new graduate students were admitted in biology, chemistry and physics, including the first woman. One of these, Glen Geen, later transferred to the Department of Biology.

1961

The Scientific Advisory Committee met in November to review activities and plans.

The Bedford Institute of Oceanography (BIO) was now under construction on the shore of Bedford Basin in Dartmouth. This new federal oceanographic institute was expected to further expand the opportunities for marine research in Halifax.

A fully equipped laboratory trailer was established as a summer field station at Baddeck on Cape Breton Island to support a project studying primary productivity in the Bras d'Or Lakes. Alan Mills set up a chemistry lab in the Chemistry Building and Dirk Nota set up a sedimentology lab in the Dunn Building.

John Teal departed to take up a position at the Woods Hole Oceanographic Institution (WHOI) while Mike Keen (Geophysics) arrived to strengthen the geophysical program (Loncarevic 1992). Bob Stewart left to become Professor of Oceanography at the University of British Columbia. F. Uyeno (Biology) arrived as the first postdoctoral fellow.

An annual award of \$15,000 was granted by the Defence Research Board for a study of the geology and geophysics of the sediments in Atlantic Canada coastal waters. This expanding geological program involved collaboration with the Nova Scotia Research Foundation. In addition, the close partnership with the FRB Atlantic Oceanographic Group continued.

Research highlights (including students and PDFs):

- Theoretical work continued on the non-linear interaction between waves and other flows (Stewart).
- In conjunction with the RV *Vema* of the Lamont Geological Observatory, Columbia University, seismic refraction surveys were carried out using CNAV *Sackville* in the Labrador Sea and Gulf of St. Lawrence (Keen).

- Staff and students participated in a cruise of the CNAV *Fort Francis* to study sediments in the Bras d'Or Lakes (Nota).
- Staff and students worked with the Atlantic Oceanographic Group on a cruise of the CNAV *Sackville* to study the geology and chemistry of sediments in the Gulf of St. Lawrence and on the Scotian Shelf (Nota).
- Studies of nitrogen fixation in sediments were initiated using N¹⁵ isotopes which required the use of the mass spectrometer at the NRC Atlantic Regional Laboratory (Mills).
- The concentrations and distribution of bacteria in coastal sediments were studied (Anthony).
- Productivity levels in fresh water lakes, salt water lakes and the open sea were compared (Hayes).
- Studies on the production and energy flow in salt marshes were conducted in cooperation with the University of Georgia (Teal).

The first MSc degree was awarded to Peter Hochachka. Four new students were admitted bringing the total up to twelve.

1962

A major event in the local oceanographic community was the opening of BIO in October. The day before, Dalhousie University awarded Dr. William E. van Steenburgh, the moving force behind the creation of BIO, an honorary degree. In his address he emphasized the need for BIO and IODal to develop their programs together and encourage collaborations and exchanges. To quote:

“The strength of our federal research agencies depends on their partnership with the universities; we shall therefore continue to do all we can to strengthen our academic partners. We look forward to providing our associates of the Dalhousie Institute and its graduate students the means by which they can carry on their research. It is essential that universities avoid to the utmost any emphasis on a planned research program. A well conceived attack on a marine problem will not fail to find whatever support and facilities the Bedford Institute can provide. I hope Dalhousie will recognize the scientific stature of the staff we are assembling. It is important that our most outstanding members be afforded the academic privileges enjoyed by your institution. A research scientist should be exposed to the stimulating and challenging influence which derives from the art of instruction. Both of our institutes would profit by an occasional Bedford scientist lecturing to, and being challenged by, a group of eager and demanding students.”

Graduate courses in biological oceanography, chemical oceanography and geological oceanography were added to the curriculum. The Institute hosted a meeting of the Canadian Committee on Oceanography (CCO) in October. Carl Boyd (Biology) joined the faculty. In addition, Ced Mann (Physics) from the Department of Mines and Technical Surveys at BIO became an associate. This latter appointment further enlarged

opportunities for graduate student training in physical oceanography. David George (Biology) joined the Institute as a postdoctoral fellow.

The Institute established a field station on Dalhousie property at Purcell's Cove, about four miles from campus on the west side of the Northwest Arm near its mouth. A small building was equipped with a running seawater system for testing equipment and performing experimental work with live organisms. It also provided storage for small boats used in fieldwork and a jetty for docking small vessels.

The annual block grant from NRC was increased to \$100,000 and used to cover salaries, student support, operating expenses, lab apparatus and the Purcell's Cove field station. Individual staff also received operating grants from the National Research Council (NRC) and the Defence Research Board (DRB). Total funding was \$169,300.

Research highlights (including students and PDFs):

- Supported by the Nova Scotia Research Foundation, research on phytoplankton production and its utilization by zooplankton in the Bras d'Or Lakes continued at the summer field station in Baddeck (Hayes).
- Geophysical studies were carried out in the Cabot Strait and off Newfoundland using CNAV *Sackville* (Keen).
- Again using CNAV *Sackville*, cores of deep-sea oozes were collected off Bermuda (Mills).

The Institute awarded five MSc degrees. Ten new students were admitted.

The policy was initiated of inviting external visitors to give lectures. This first year these included J.F. Talling (Freshwater Biological Station, UK), Dennis J. Crisp (University College of North Wales) and Bosko D. Loncarevic (Cambridge University).

1963

The Institute hosted another meeting of the Canadian Committee of Oceanography (CCO). In addition, IODal and BIO jointly hosted a meeting of the Scientific Committee on Ocean Research (SCOR) and a concurrent symposium on biogeochemistry.

Consideration was given to developing relationships with the FRB Fisheries Technological Station on Lower Water Street and the NRC Atlantic Regional Laboratory on Oxford Street to gain access to expertise in biochemistry and marine plant physiology.

Ron Hayes was appointed Vice-President of Dalhousie. He continued as Director of the Institute but resigned as Chair of the Biology Department. Dirk Nota departed in March thereby reducing the faculty to five. In addition, Neil Campbell resigned as an associate and moved to Ottawa to become the Chief Oceanographer for the Marine Sciences Branch (MSB), the lead agency at the new BIO. He had played a major role in setting up the Institute and establishing its first courses. He was replaced as an associate by Earlston Doe, an air-sea interaction scientist also from the MSB at BIO.

Total funding was now \$155,600. The Marine Science Branch at BIO obtained blanket authority to loan equipment to IODal. The first items loaned were two motor launches for use at the Purcell's Cove and Bras d'Or Lakes field stations.

Research highlights (including students and PDFs):

- Three cruises were run to study the oceanic waters between Nova Scotia and the Azores with particular attention on the confluence of the Gulf Stream and Labrador Current (Mann).
- A closely integrated physical, geological, chemical and biological oceanographic study of the Gulf of St. Lawrence was initiated (Campbell and Trites).
- In cooperation with the Nova Scotia Research Foundation, a cruise on the CGS *Labrador* carried out geophysical studies in the Labrador Sea, Baffin Bay and Smith Sound. In addition to seismic surveys, measurements of gravity and the magnetic field were initiated. Thickness and structure of the earth's crust at the edge of the continental shelf were also investigated using the CNAV *Sackville* and shore recording stations on Sable Island (Keen).
- Staff participated in a joint cruise of the CSS *Baffin* and CNAV *Sackville* between Newfoundland and Greenland which was part of the second International North West Atlantic Survey sponsored by the International Council for the Exploration of the Sea (ICES). Work included geophysical, chemical and production measurements (Keen).
- Surveys of submarine topography in relation to the regional distribution of surface sediments continued in the Gulf of St. Lawrence (Nota).
- Studies of the physical properties and chemistry of deep-sea sediments collected by cores were conducted (Mills).
- Research at the field station in Baddeck centered on phytoplankton production and the dynamics of its conversion to zooplankton in the Bras d'Or Lakes (Hayes).
- Studies of sediment bacteria were conducted in the Bras d'Or Lakes (Anthony).
- A new program on zooplankton physiology and ecology was initiated (Boyd).

Two MSc degrees were awarded. Six new students were admitted bringing the total up to fifteen.

1964

The Institute could now offer graduate courses in physical oceanography, chemical oceanography, biological oceanography and marine geology and geophysics. A weekly seminar series was established which all faculty and students were required to attend and talks were given by faculty, students, scientists from other university departments and local marine science labs as well as visiting scientists from out of town. Since faculty and students were widely dispersed over the university campus, these seminars played a valuable roll in bringing all personnel together.

Ron Hayes departed in July to become the Chair of the Fisheries Research Board of

Canada based in Ottawa. As a result, Ewart Blanchard from the Department of Physics joined the faculty and became the Acting Director. A search was then initiated to find a permanent director. Alan Mills also resigned so another search was begun for a new chemical oceanographer. Daniel Stanley (Geology) joined the faculty in August. In addition, Arthur Levin (Engineering Physics) and Bosko Loncarevic (Geophysics) were appointed as associates. Faculty and associates now numbered twelve and covered the disciplines of bacteriology, marine zoology, chemistry, physics, geology, geophysics and engineering.

Total funding from sources outside Dalhousie dropped slightly and totaled \$135,500.

Research highlights (including students and PDFs):

- A joint expedition involving MV *Theta* and CNAV *Sackville* carried out geophysical studies in the Gulf of St. Lawrence and on the Scotian Shelf (Keen/Blanchard).
- A cruise on the CSS *Hudson* obtained deep-sea cores along a line from Sable Island out to the abyssal plain (Stanley).

Two MSc degrees were awarded. One of these was earned by Gerald Ewing who went on to become the Dominion Hydrographer and the Director General of Ocean and Aquatic Sciences. Seven new students were admitted bringing the total up to 21.

Out of town visitors giving seminars included Dale Krause (Graduate School of Oceanography, University of Rhode Island), Dan Livingston (Duke University), Fred E.J. Fry (University of Toronto), J.D. Costlow (Beaufort Marine Laboratory, Duke University). Peter J. Wangersky (Bingham Oceanographic Lab, Yale University) and Gordon A. Riley (Bingham Oceanographic Lab, Yale University).

Meanwhile, events were beginning to take place south of the border that would have a huge impact on the future of the Institute. Yale University in New Haven, CT, was the home of the Bingham Oceanographic Laboratory. In this small lab, closely associated with the Zoology Department, faculty members trained graduate students and conducted marine research. The assistant director was Gordon A. Riley, a highly respected biological oceanographer (Gordon 2019). He had done his doctorate in limnology at Yale under the supervision of the eminent ecologist G. Evelyn Hutchinson (Slack 2010) and later worked at the Woods Hole Oceanographic Institution as well as the Bingham Lab. Gordon wanted to create a Department of Oceanography at Yale to help train the increasing number of scientists needed for the rapidly expanding US oceanographic program but he was unsuccessful in convincing the university of the wisdom of such action. He was most disappointed and felt that without a full department there was no future for oceanography at Yale. Therefore, he began to consider moving to another laboratory. Word of his displeasure with the situation at Yale began to circulate around the US oceanographic community and before long he started to receive job offers from other universities, including the University of Alaska and the nearby Graduate School of Oceanography at the University of Rhode Island.

One of Gordon's close associates at Bingham was Peter Wangersky, a chemical oceanographer who also had done his doctorate at Yale under the guidance of Hutchinson (Sharp et al. 2007). He too was unhappy with the situation at Yale and began to look for employment elsewhere. It did not take him long to learn that the Institute of Oceanography at Dalhousie University was recruiting a chemical oceanographer. He inquired and soon after flew to Halifax in the late summer of 1964 for an interview. He was most impressed with the relatively new Institute and its potential for growth. The Institute was equally impressed with him and soon after his visit offered him the position which he immediately accepted. Upon returning to Bingham, Pete told Gordon that the Institute was looking for a new director to replace Ron Hayes and urged him to apply. Subsequently, Gordon flew to Halifax in October for interviews and to give a seminar. Since the director of the Institute reported directly to the university president, he began his interviews with President Henry Hicks. The two hit it off immediately. Gordon found Henry to be affable, open and frank. He summarized the structure of the Institute and its funding. Although it was a small organization, Henry said he wanted it built up into a centre of excellence and would do everything he could to support it. He spoke convincingly and Gordon believed him. Gordon also had interviews with Walter Trost, Dean of the Faculty of Graduate Studies, and Basil Cooke, Dean of the Faculty of Arts and Sciences, both members of the Institute's Board of Directors who were equally supportive. Gordon then met faculty members and gave his seminar before returning home.

Although he thought it was a very strange setup, obviously influenced to suit Ron Hayes who had had a long association with Dalhousie and had also chaired the Department of Biology, Gordon was most impressed with what he saw and the great potential for growth with the full backing of the university president. The Institute faculty had the sole responsibility for admission of students, formulation of the curriculum and recommendations for degrees. He felt this was an odd but very necessary arrangement for an organization that wasn't really a department. Also on the plus side was the agreement that free ship time was available on federal ships and the block grant from the National Research Council covered general operating expenses. However, there were also a few negative aspects, the major one being that professional appointments were in the basic science departments. This meant that hiring, promotions and granting of tenure were at the discretion of these departments. Only the director's salary was paid out of university funds while other faculty salaries came out of the NRC block grant. In addition, faculty and students were widely dispersed over the campus and only came together for seminars.

Soon after, Gordon received a letter from Henry Hicks inviting him to apply for the job. After considering his various options, Gordon felt that the Dalhousie situation offered the greatest potential to do what he wanted to do so he subsequently applied. Before long he received a formal offer with a salary about what he was getting at Yale. At first he was concerned about uprooting his family which at the time consisted of his wife Lucy, three teenage daughters and his mother-in-law. At first they were reluctant to leave New Haven but after discussing other options agreed it would be a wise move. So, with the concurrence of his family, he accepted the offer in November. Pete Wangersky also

accepted his offer. Hence, two prominent scientists at the Bingham Oceanographic Laboratory were emigrating to Canada which was a huge blow to the small but highly respected Yale University oceanography program.

1965

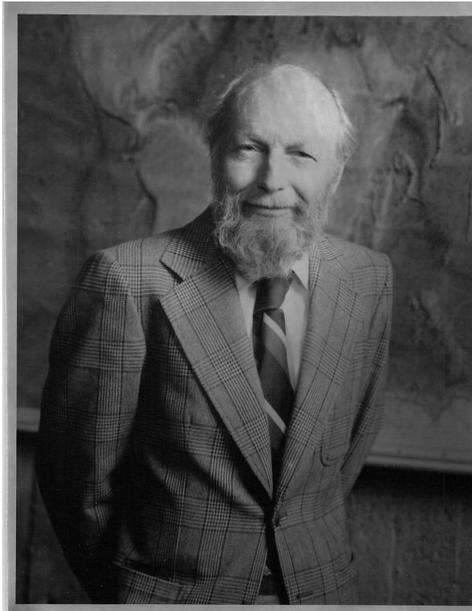
Early in the year, Gordon made two trips to Halifax to attend meetings. Lucy came with him on the first trip for house hunting purposes. This was not successful but soon after Kraft von Maltzahn, Chair of the Biology Department, located a suitable house on nearby Vernon Street which the Riley's bought sight unseen. Gordon looked forward to be able to walk to work, something he had not been able to do since he lived in Woods Hole.

The second trip was to participate in a meeting of the NRC review committee. He returned to New Haven by way of Ottawa where he met Ron Hayes, Bill Cameron and Bill Ford. Ron of course was now the Chair of the Fisheries Research Board and most interested in developing stronger interactions with universities. He was also in the process of converting the Atlantic Oceanographic Group (AOG), now located at BIO, into an independent FRB lab and had just appointed Lloyd Dickie as director. A few years later this lab was formally named the Marine Ecology Laboratory (MEL). Bill Cameron, a physical oceanographer, had been on the Scientific Advisory Committee when the Institute was first set up and was now with the Marine Sciences Branch (MSB) in the Department of Energy, Mines and Resources, the lead agency at BIO.

Bill Ford was with the Defense Research Board but about to move to Halifax to assume the directorship of BIO (Gordon 2016). Gordon and Bill had worked together at the Woods Hole Oceanographic Institution in the 1940s and were good friends. They had participated together on cruises of the RV *Atlantis* and in Operation Crossroads, a program of nuclear weapon tests conducted by the US military at Bikini Atoll in the Marshall Islands in the western Pacific Ocean. Bill may have encouraged Gordon to take the Dalhousie job. Gordon found it comforting to know that Bill would be in charge at BIO for he knew it was important to have friendly relations with the big federal sister oceanographic institute across the harbour. Over the years, Bill Ford was indeed very supportive of the developing oceanography program at Dalhousie, in particular encouraging personal exchanges, facilitating joint projects and ensuring adequate ship time was available on BIO vessels.

While in Ottawa, Gordon also had the chance to talk with NRC officials about Institute financing and got a mixture of good and bad news. The block grant would be renewed for another three years but they wanted to gradually phase it out and therefore advised Gordon to take steps to increase the level of university salary support. This provided Gordon some leverage to do what he had already intended. They also discussed the proposal for a large capital grant to construct a running seawater system that Carl Boyd had submitted several years earlier. They had not yet given it serious consideration on the grounds that the current small institute was unlikely to be able to use it fully and effectively. However, they became more interested when they heard of Gordon's plans for expansion.

Gordon officially took over the duties of Director of IODal on 1 July 1965. He moved into a small re-modeled office with some adjoining lab space located in the basement of the Forrest Building on the Carleton Campus. The Forrest Building at that time also housed the Department of Biology and the medical school. The construction of the Tupper Building next door, which would house the medical school, had just started. Barbara Hendry was the Institute secretary and administrative assistant. She had served in this capacity under Ron Hayes and so knew all the ropes of university administration. The biological oceanography graduate students were located next door in what was known as the Wet Lab. Also located nearby were a few small offices and labs for faculty, hallway lockers and a lounge for medical students, the morgue and a CNIB canteen. Gordon described these cramped conditions as a rabbit warren.



Gordon A. Riley
Director 1965-1973

Pete Wangersky also arrived with his family in June to replace Alan Mills as the Institute's chemical oceanographer. He set up his office and lab in the Chemistry Building. Other scientific faculty at the time were Mike Keen (Geophysics), Dan Stanley (Sedimentary Geology), Don Swift (Sedimentary Geology), Tony Anthony (Microbiology) and Carl Boyd (Zooplankton). Without a full time physical oceanographer, the Institute was still dependent on BIO associates for teaching the physical oceanography course. Franco Medioli and Walton Watt arrived as new postdoctoral fellows. Graduate student enrollment was now up to 21 and the Institute now had 12 associates.

The Institute continued to be heavily dependent on the federal government for financial support. The block grant from NRC was increased to \$120,000 and the DRB grant was increased to \$20,000. External funding now totaled \$197,900. Additional financial support for equipment was provided by FRB and the Nova Scotia Research Foundation

(NSRF) while ship time continued to be provided without cost by MSB and DND. In addition, an increasing number of Institute students were winning scholarships from NRC and other external agencies.

Arrangements were made with Bill Purcell, who ran a ferry service between Point Pleasant Park and Purcell's Cove, to charter his Cape Islander for work in Halifax Harbour and Bedford Basin. The Bras d'Or Lake and Purcell's Cove field station continued to provide experimental facilities.

Research highlights (including students and PDFs):

- A stable mast mooring was developed to measure energy exchange across the air-water interface (Doe).
- In conjunction with BIO, geological and geophysical studies were carried out in Hudson Bay using the CSS *Hudson* and MV *Theta* as the shooting ship. Using CNAV *Sackville* and in cooperation with the Nova Scotia Research Foundation and BIO, seismic reflection studies using a sparker system were carried out on the Grand Banks off Newfoundland (Blanchard, Keen and Loncarevic).
- Using CNAV *Sackville*, studies of morphology, sediments and microfauna were carried out on the Scotian Shelf and in the Bay of Fundy and Gulf of Maine (Stanley, Swift and Medioli).
- A new program was initiated to study the distribution, composition and dynamics of non-living dissolved and particulate organic matter in the ocean (Riley and Wangersky).
- Microbiological studies expanded to include using bacteria to identify oceanic water masses and observations of Foraminifera (Anthony).
- A CSS *Hudson* cruise to the Grand Banks measured energy flow in zooplankton, visual perception and pigments of the nauplius eye, the micro-distribution of zooplankton and the neuroanatomy of deep-sea polychaetes. Four students, including Charlotte Keen, Joleen Aldous and Kai-Mai Pold, were the first women to sail on CSS *Hudson*. On the outward leg the ship stopped at Sable Island to offload supplies for the Transport Canada station (Boyd).
- A project was initiated to develop an electronic plankton counter to study the micro-distribution of marine plankton (Boyd and Levin).

The first two PhD degrees were awarded to W.G. MacIntyre and R.R. Weiler. In addition, three additional MSc degrees were awarded. Eight new students were admitted so there were now twenty-one graduate students covering all the major disciplines except physical oceanography, with most in biological oceanography.

Out of town visitors giving lectures included K.O. Emery (Woods Hole Oceanographic Institution), Max J. Dunbar (Marine Science Centre, McGill University), Ian A. McLaren (Marine Science Centre, McGill University), W.T. Williams (Southampton University, UK), Delphine McLellan (Marine Science Centre, McGill University) and R. von Herten (UNESCO).

1966

Once Gordon had settled in as director, he immediately started to work toward his objectives of achieving full departmental status, a university budget that paid salaries, an expanded and more diversified staff and a building to house the entire oceanography program under one roof. He expected problems with other departments in reaching these goals and they soon appeared, especially from the Department of Geology (Waite 1998). The Chair, C.G.I. Friedlander, was a crusty old Swiss who would not share an inch of his territory with anyone else. He had earlier fought with Ron Hayes over the formation of the Institute and was against creating a Department of Oceanography. However, he retired shortly after.

Gordon had discussions with the other departmental heads about creating a Department of Oceanography. Walter Chute in Chemistry offered no opposition at all. However, Ernie Guptill in Physics was not supportive. Apparently he thought that oceanography was not a real discipline and therefore did not deserve departmental status. Kraft von Maltzahn in Biology was also not supportive at first because he thought that losing the biological oceanographers, co-located in the Forrest Building, would be a detriment to his department. Gordon also discussed the possibility of departmental status with Ron Hayes during a visit to Dalhousie. Gordon was surprised to learn that he too did not favour departmental status. He was quite content to see things continue as they had been when he was in charge, primarily as a biological oceanographic institute, and felt that maintenance of a close alliance with the Department of Biology was desirable. Gordon argued that the mandate of the Institute was to produce the oceanographers required for the expanding federal labs and this required graduates in all disciplines, not just biological oceanography.

These arguments dragged on interminably but the one thing more than anything else that helped to resolve them was the development of the building program. The timing was right. The economy was fairly prosperous, university populations were growing and everything was conducive to major building projects. The Treasury Board was prepared to award a substantial grant if matched by NRC. These federal funds ultimately were approved and Henry Hicks was able to raise additional funds from the Province of Nova Scotia. The total building fund was nearly eighteen million dollars. This new building was to be known as the Life Sciences Centre and would house oceanography, biology, and psychology. Gordon was appointed as Chair of the Building Committee with the other members being the Chairs of the Biology and Psychology departments and the university architect.

Gordon's hopes for oceanography fitted neatly into this larger scheme envisioned by Henry Hicks. It would allow the entire Institute to come together in a new and expanded space under one roof, including a state of the art running seawater experimental facility, later named the Aquatron, which had been in the planning for several years. Biology was pleased as well for they would get a much needed new home without having to struggle for it. The perennial space problems were about to be resolved. In the meantime, the Institute started to get additional staff members on the university budget and Henry Hicks told Gordon that he did not think there would be much difficulty in gaining departmental

status once the Institute moved into the new building. Therefore, initial steps were taken for obtaining formal approval for a full department from the University Senate and Board of Governors.

A new course, Introduction to Oceanography, was added to the curriculum for first year graduate students but was also open to properly prepared undergraduates. The minimum course requirements for graduate students were Introduction to Oceanography, one advanced class and additional courses in related basic science. The requirements were tailored to individual needs and the main emphasis was on thesis research and independent reading.

Tony Anthony departed to take up a position at the University of Guelph. Dan Stanley and Don Swift also departed. Ewart Blanchard resigned to become the director of the Nova Scotia Research Foundation in Dartmouth but continued as an associate. Walton Watt, a phytoplankton specialist, and Roy Hyndman, a geophysicist, joined the faculty while Lloyd Dickie, a fisheries scientist from BIO, became an associate. Edward Batoosingh, a recent graduate, became a postdoctoral fellow.

The financial situation improved further due to additional support from the university as well as Canadian (National Research Council, Defense Research Board, Geological Survey of Canada) and US (National Science Foundation and Atomic Energy Commission) operating grants so that the budget now totaled \$314,950. While this income was adequate for routine operation, additional funding was needed for capital items.

The space situation was expected to ease somewhat next year when the new medical school building would be completed and the Institute would be able to take over some of the freed space in the Forrest Building.

The excellent support from BIO continued. The Institute got its fair share of ship time and the BIO staff associates were most helpful in teaching and thesis supervision, particularly in physical oceanography which did not yet have a full time faculty member. A few BIO junior staff enrolled for degrees on a part-time basis.

Research highlights (including students and PDFs):

- Two hydrophones and accompanying electronic systems were developed and tested in the field (Levin).
- Studies of the Gulf Stream southeast of Newfoundland were completed (Mann).
- Studies of physical oceanographic properties and processes using current meters, temperature recorders, salinometers and fluorometers were carried out in Margaree Harbour, Petite Passage and St. Margaret' Bay (Trites).
- A three-component thrust anemometer was developed and installed on a stable platform tower at the entrance to Halifax Harbour for studies of air-sea exchanges (Doe).
- A cruise on the CSS *Hudson* to the northeast Newfoundland margin investigated the structure of the crust and upper mantle, magnetic anomalies and tested an

- ocean bottom seismometer and recording buoy (Keen).
- Regional surveys collected a large amount of gravity and magnetic data in the Arctic Archipelago, Baffin Bay, Labrador Sea, Grand Banks, Scotian Shelf, North Atlantic Basin and the Mid-Atlantic Ridge and on-board processing using digital computers became a standard practice (Loncarevic).
 - The CNAV *Sackville* was used to collect sparker profiles, box core samples and bottom photographs on the Scotian Shelf and Slope (Swift).
 - Another cruise on CNAV *Sackville* was carried out to Bermuda to study deep water carbonates (Stanley).
 - Improvements were made in methods for determining dissolved and particulate organic carbon in seawater (Wangersky).
 - In collaboration with BIO, water samples were collected throughout the water column during a physical oceanographic survey of the Irminger Sea south of Baffin Island on the CSS *Hudson* for studies of bacteria plus dissolved and particulate organic matter (Riley and Wangersky).
 - The release of extracellular materials by marine diatoms was studied under field and laboratory culture conditions (Watt).
 - Studies continued on the feeding rates, metabolism, visual perception, size frequency relationships and small-scale distribution of zooplankton. The new electronic plankton counter was used to count phytoplankton for copepod feeding experiments and to obtain direct estimates of zooplankton distribution in the field (Boyd).
 - Studies were initiated to investigate the metabolic expenditures, growth, food intake and food supplies of fish communities (Dickie).

Four MSc and one PhD degrees were awarded. Ten new students were admitted bringing the total up to 25. Student enrolment was still limited due to the extreme space limitations.

Visiting speakers from out of town included Robert J. Conover (Woods Hole Oceanographic Institution), Henry Stommel (Massachusetts Institute of Technology), Robert A. Phinney (Princeton University), G. Stephen Pond (National Institute of Oceanography, UK), Frederick J. Vine (Princeton University), Eric L. Mills (Queens University) and M. Caputo (University of British Columbia).

The biological oceanography students in the basement of the Forrest Building were a particularly cohesive cohort and well integrated into the Department of Biology. Morning coffee in the basement CNIB canteen and afternoon tea in the second floor Biology lecture room with staff were staunch traditions. Students also participated in the annual Christmas skits. Occupants of the basement Wet Lab maintained a journal called 'The Wetlab Papers' (Pearre 1966) which included an amusing collection of newspaper clippings, cartoons, photographs, memos, poems and song lyrics. An informal outing club was formed which pursued hiking, cross-country skiing, camping, canoeing and fishing on the weekends. Springtime canoe trips down the Shubenacadie River with BIO colleagues to pick fiddleheads became a longstanding tradition. The graduate students also organized frequent parties and potluck suppers fuelled with homebrew which were

enjoyed by staff as well. In addition, Pete and Ellie Wangersky welcomed students to their home on South Street for coffee and conversation on Sunday afternoons. Looking for a weekend escape from the city, Gordon and Lucy Riley bought a large acreage of woodland with a camp on Coxs Lake out in Hammonds Plains and encouraged students to come out and visit. All in all, it was a large and happy family.

1967

As director of the Institute, Gordon was required to serve on the Canadian Committee on Oceanography (CCO). Originally known as the Joint Committee on Oceanography (JCO) but reorganized in 1959, this had been a powerful committee composed of senior officials from agencies dealing with marine matters. It had established the Institute of Oceanography at UBC in 1949 as well as IODal in 1959. However, by the time Gordon joined, the influence of the CCO had declined considerably. His attendance was a necessary duty, but he found that the rewards were not great. However, at these meetings he got to know other academic marine scientists in Canada such as Max Dunbar at the McGill Marine Sciences Centre, Donald Meisner at the Great Lakes Institute of the University of Toronto and George Pickard at the Institute of Oceanography at UBC.

To attract new students, the IODal prepared a pamphlet describing the Institute and its academic program. The courses and their instructors listed at that time were:

- Introduction to Oceanography (Staff)
- Physical Oceanography (Doe and Trites) (from BIO)
- Biological Oceanography (Riley and Boyd)
- Marine Geology and Geophysics (Keen)
- Chemical Oceanography (Wangersky)

Planning for the new Life Sciences Centre was initiated. Each department developed its own wishes which were then transmitted to the overall building committee. Each department presented its projected space requirements which then had to be chopped down to fit the budget. The oceanography request was the most modest while the others were obviously inflated. Gordon gave no ground during the subsequent discussions and in the end, while the others were chopped down, oceanography got what it asked for.

Concomitant with this were discussions within each department of what to expect in future growth and how to organize the internal space allotted to them. There were already indications that the future financial climate might not be as good as it had been in the past. Gordon's view was that some oceanographic institutions had become too big for the effective interdisciplinary communication that oceanography needed while on the other hand some labs were too small to be viable. The consensus of the faculty was that there must be some intermediate optimum size with on the order of 20-25 faculty members, 75 graduate students plus postdoctoral fellows and technicians, and so the Institute planned accordingly. Gordon wanted to build a balanced department with faculty members from all the major oceanographic specialties but also realized that additional assistance could be requested when needed from BIO and other nearby labs.

The critical space situation started to ease somewhat with the completion of the Tupper Building and departure of the medical school from the Forrest Building. The biological oceanographers were now able to expand into the space vacated in the basement. In addition, the chemical oceanographers moved from the Chemistry Building into expanded space in the new wing of the NRC Atlantic Regional Laboratory on Oxford Street.

Eric Mills, a benthic ecologist, arrived from Queens University to join the faculty. Stephen Baig arrived as a new postdoctoral fellow. There were now seven full time faculty members and six associates.

The number of students increased from 25 to 33 with 5 in physics, 5 in geophysics, 2 in geology, 5 in chemistry and 16 in biology. A growing number of students were staff of nearby institutions on educational leave.

Operating funds increased to total of \$374,900 and continued to come from the usual sources plus the Petroleum Research Fund. However, it was noted that a large portion of the operating costs including ship time, university services, student demonstratorships and teaching and advising by associates was not covered in the budget. It was estimated that the overall cost of running the Institute was now on the order of \$600,000 annually.

Students started to become involved in the St. Margaret's Bay ecosystem program being organized by the FRB lab at BIO. There was also hope of establishing an IODal-FRB offshore collaborative program in the near future.

Research highlights (including students and PDFs):

- With financial support from the Defense Research Board, work continued on the development of instrumentation to measure vortex shedding in water (Levin).
- Studies of the mixing of the Labrador Current and the Gulf Stream and of flooding of warm water into basins on the Scotian Shelf were underway (Mann).
- The gross seasonal features in the temperature, salinity patterns and circulation patterns were determined in St. Margaret's Bay in order to get an idea of exchange rates with offshore waters (Trites).
- Detailed geophysical studies continued to be carried out over the Mid-Atlantic Ridge and eastern and Arctic Canada with particular attention given to the precise measurement of gravity and automatic data processing at sea (Keen).
- Tilt meters were installed in abandoned mines to measure the response of the Earth's crust to the macrotides in the Bay of Fundy (Blanchard).
- Work was initiated on geomagnetic depth sounding and magnetotelluric measurements over the continental margin of eastern Canada (Hyndman).
- Detailed geophysical studies near the crest of the Mid-Atlantic Ridge continued and the magnetic anomaly map produced showed a strong lineation associated with the orientation of the median valley (Loncarevic).
- Water samples for studies of carbonates, lithium and dissolved and particulate organic matter in the water column were collected on two transects across the North Atlantic on a cruise of the CSS *Baffin* to Monaco organized by BIO to

- wave the Canadian flag at an international hydrographic conference during Canada's Centennial Year (Wangersky).
- Using the RV *Panulirus*, water samples were collected at the Bermuda Biological Station hydrostation for studies of non-living particulate organic matter. In addition, further studies of the quantity, biochemical composition and biological significance of organic matter in seawater were carried out on a cruise of the CNAV *Sackville* to the northwestern Atlantic (Riley).
 - The role of bacteria in the utilization of particulate organic matter, the transformation of dissolved and colloidal organic matter into large particles by bubbling and the distribution, composition and dynamics of organic particles continued (Riley).
 - Laboratory investigations of the environmental factors controlling primary production and extracellular release by phytoplankton continued (Watt).
 - On a cruise of the RV *Te Vega*, vertical hauls were made for the determination of plankton volume and dry weight using the new electronic plankton counter (Boyd).
 - Faculty and students participated in a cruise on CSS *Hudson* to continue various biological and chemical studies, including testing the new electronic plankton counter (Riley/Boyd).
 - Taxonomic studies of amphipod crustaceans off eastern North America were begun (Mills).
 - Further studies were made of the relations between food metabolism and growth of fishes (Dickie).

Three PhD degrees were awarded. Eleven new students were admitted bringing the number of graduate students up to 33. There were currently five students each in physical oceanography, geophysics and chemical oceanography, two in marine geology and the rest in biological oceanography.

Out of town visitors giving seminars included Sir Edward Bullard (Cambridge), Robert O. Fournier (Graduate School of Oceanography, University of Rhode Island), C.L. Drake (Lamont Geological Observatory), Erskine K. Paasche (University of Oslo, Norway), Raymond B. Montgomery (Chesapeake Bay Institute, Johns Hopkins University), L.K. Coachman (Arctic Institute of North America) and Owen P. Bricker (Johns Hopkins University).

1968

The architectural planning for the new oceanography building in the Life Sciences Centre was nearing completion. It was hoped that it would be ready for occupation by late 1970.

Rudolf Gees and Franco Medioli, both geologists, joined the faculty. In addition, George Needler and Helmut Sandstrom from BIO became associates and took over the teaching responsibilities for the physical oceanography course. An increase in the number of applications in physical and chemical oceanography had made it necessary to strengthen faculty in these fields and, despite continuing space limitations, the recruitment of new

faculty began. Carl Boyd departed on sabbatical leave at the Institut Océanographique de Monaco while Mike Keen departed on sabbatical leave at Cambridge University. Elizabeth Alloit (Biology), F. Barbière (Geology), Robert Fournier (Biology) and Manu C. Raheja (Chemistry) arrived as postdoctoral fellows.

There was a sharp drop in funding this year due to tighter money policies in both Canada and the US so that the total budget from both the university and various granting agencies was now down to \$294,200. The Institute could still operate but it had to postpone the purchase of several important capital items.

Research highlights (including students and PDFs):

- Studies of North Atlantic currents system and convective processes at high latitudes continued (Mann).
- Theoretic and experimental work began to improve understanding of internal waves (Sandstrom).
- Theoretic studies were conducted on the properties of wave motion in rotating stratified fluids (Needler).
- Physical oceanographic studies in St. Margaret's Bay continued and a similar program was initiated in Halifax Harbour (Trites).
- Magnetic anomalies on the eastern seaboard of North America were studied. In collaboration with Cambridge University and BIO, refraction and reflection experiments were conducted on the Mid-Atlantic Ridge on CSS *Hudson*. Studies continued on the response of the earth's crust to the macrotides in the Bay of Fundy (Keen).
- The measurement of geothermal heat flow was initiated at a Mobil Oil exploration well on Sable Island. A magnetic variation recording system was acquired and used at seven locations between Dartmouth and the north shore of the St. Lawrence River. A statistical analysis of oceanic heat flow at the Mid-Atlantic Ridge was carried out (Hyndman).
- Using digital computers, improvements were made in the acquisition and processing of geophysical data at sea so that it was now possible to have the results of magnetic and gravity surveys ready for inspection and interpretation within a few hours after collection. A joint cruise with the Canadian Hydrographic Service to the Gulf of St. Lawrence on CSS *Baffin* mapped the Odd-twin Magnetic Anomaly off the west coast of Newfoundland (Loncarevic).
- A new program on near shore sediment dynamics was begun (Gees).
- The distribution of Foraminifera on the Scotian Shelf was investigated (Medioli).
- Work continued on the development of a dissolved organic carbon analyzer as well as a method for measuring amino acids in seawater. In addition, a new method was developed for measuring dissolved oxygen, nitrogen and carbon dioxide in seawater (Wangersky).
- Studies continued on the formation of particulate organic matter from dissolved and colloidal matter by bacterial activity and adsorption processes (Riley).
- Using the CNAV *Sackville*, a transect was run southeast from Halifax to carry out plankton studies using bottle casts and net tows. In addition, lab and field studies continued of the environmental factors controlling primary production and

- extracellular release of marine phytoplankton (Watt).
- Using CSS *Hudson*, plankton studies were made along a transect south from Halifax (Fournier).
 - The maiden cruise of the CSS *Dawson* was made to the Sargasso Sea for further studies of particulate organic matter and testing the LINC-8 computer for use at sea. Software was developed to analyze data on the size and abundance of zooplankton collected with the electronic plankton counter (Boyd).
 - Taxonomic and ecological studies of deep-sea amphipod crustaceans continued (Mills).
 - Work continued on the development of various population models of marine production systems to predict the effects of predation and an experimental study of feeding by American plaice in St. Margaret's Bay was completed (Dickie).

Two MSc and two PhD degrees were awarded. Seven new students were admitted and enrollment reached an all time high of 39.

Out of town visitors giving seminars included Robert R. Hessler (Woods Hole Oceanographic Institution), Ellsworth H. Wheeler (Graduate School of Oceanography, University of Rhode Island), Alistair D. Christie (Department of Transport), Ralph A. Horne (Arthur D. Little Inc.), Roy Overstreet (University of Washington), Ferren MacIntyre (Scripps Institute of Oceanography), Fraser S. Grant (University of Toronto), E.K. Duursma (Laboratory of Marine Radioactivity, Monaco), Dana R. Kester (Oregon State University).

1969

Tenders for the construction of the Life Science Centre, which included the oceanography building and a large running seawater facility now named the Aquatron, were put out in March. By the end of the year there was an enormous hole in the ground and concrete work was beginning to emerge. At the time when the Institute moves into its new quarters, it will probably become a Department of Oceanography as was the wish of staff. Accordingly, discussion was initiated of the kind of revision and expansion of the curriculum that would be desired.

Roy Overstreet, a physical oceanographer from the University of Washington, joined the faculty. He was the Institute's first full time physical oceanographer and filled a most critical need. He took over the teaching responsibilities from BIO associates. New associates included Jim Craigie from the NRC Atlantic Regional Laboratory and Georgiana Deevey from Yale University. Pete Wangersky departed on sabbatical leave to Barcelona.

After completing his five-year term as Chair of the Fisheries Research Board in Ottawa, Ron Hayes returned Dalhousie to join the Department of Biology. By this time, the Institute was getting closer to departmental status and Gordon was concerned that he might throw a monkey wrench into the works. Fortunately, these fears were later proved unfounded.

While total funding increased slightly up to \$324,820 the financial situation continued to be difficult and the Institute had to run a deficit. While Canadian grants were stable, inflation was taking its toll. The US grants had run out and severe limitations had been put on foreign grants, even if US students were being supported. As a result, the Institute had to reduce the number of incoming students, invest less in capital items and curtail some research programs. The short-term financial outlook was not optimistic making it hard to plan for the future with any confidence.

Plans for the new building had been drawn up at a time when the demand for oceanographers appeared to be unlimited and the Institute felt justified in developing a facility that would permit it to grow to about three times in size. However, that kind of growth was now not possible in the current financial climate. It was also felt that it was not desirable to increase the size of the student body until the job market improved. Nevertheless, there was a long-term need for the expansion of Canadian oceanography to deal with new emerging issues including fisheries, offshore mineral and hydrocarbon resources and pollution. It was hoped that sooner or later the federal government would realize this and increase support for academic oceanography.

The oil and gas industry was now rapidly expanding off the east coast and Halifax was becoming the centre of operations. The Southeastern Commonwealth Drilling Company (SEDCO) offered the Institute the opportunity to use their exploratory drilling platforms for oceanographic observations. This would provide a wonderful opportunity for studying processes such as offshore productivity and frequent monitoring from these platforms would be a great improvement over periodic cruises. While funding was tight, planning commenced for a new program which hopefully could be carried out in collaboration with BIO.

Research highlights (including students and PDFs):

- Theoretical studies of steady-state ocean circulation were initiated to obtain realistic solutions of the non-linear equations describing the spatial distributions of density and velocity (Overstreet).
- Work continued on the development of theoretical models of internal wave motion in ocean basins (Sandstrom).
- Field programs measuring the flushing, circulation and dynamics were carried out in St. Margaret's Bay, Halifax Harbour, Canso Strait, Long Harbour and Conception Bay (Trites).
- The thickness of sediment at the Mid-Atlantic Ridge was investigated by seismic profiling and shown to increase with distance away from the ridge crest in reasonable agreement with known rates of seafloor spreading and sedimentation. In addition, work continued using tilt meters to measure earth tides (Keen).
- Crustal heat flow measurements continued at various sites around the Maritimes and were used to estimate crustal and upper mantle temperatures. In addition, geophysical observations were made in the Labrador Sea on the RV *Jean Charcot* from France (Hyndman).
- Studies of the Mid-Atlantic Ridge continued and included sampling exposed bedrock with the BIO hydrostatic rock core drill (Loncarevic).

- Surficial sediment studies were initiated at a variety of locations off the east coast of Canada, the Mid-Atlantic Ridge and Bermuda. In addition, an oblique view map of the bathymetry of eastern North America from Florida to Newfoundland was produced and later published by the Canadian Hydrographic Service (Gees).
- Bathymetric definition of a kidney bean-shaped topographic feature northeast of the Grand Banks was thought to be a possible continental fragment and named Orphan Knoll (Ruffman).
- Field and laboratory work on Foraminifera continued (Medioli).
- Work continued on the measurement of amino acids in seawater, using isomeric enzyme systems to study genetic relationships between herring stocks, studying aerobic-anaerobic transformation in seawater, separation and identification of organic phosphorus compounds of marine origin, the design of a direct injection technique for measuring oxygen, nitrogen, carbon dioxide and argon in seawater and developing improved methods for determination of dissolved organic carbon in seawater (Wangersky).
- A cruise on the CSS *Hudson* to the Sargasso Sea carried out a wide variety of projects including phytoplankton productivity, particulate organic carbon and carbonate distribution in the water column and collection of sediment cores (Watt, Wangersky, Hyndman).
- In November, CSS *Hudson* departed on her epic eleven-month circumnavigation of the Americas. Numerous Institute faculty members and students participated in different legs to take advantage of the outstanding research opportunities in both the Atlantic and Pacific oceans. Projects on the first two legs in the Atlantic included measuring phytoplankton productivity and dissolved nitrogen, argon, total carbonate and particulate organic carbon (Watt, Wangersky).
- Plans were initiated to collect information at weekly intervals on the species composition, abundance and productivity of phytoplankton on the Scotian Shelf from a SEDCO drilling platform (Watt).
- A comprehensive review paper on the distribution of particulate organic matter in seawater and its relationship with biological populations was completed. Research conducted over the past few years clearly demonstrated that organic particles can be created in seawater by physical adsorption and bacterial aggregation of dissolved and colloidal organic matter and that such particles provide a food supplement for marine animals and a substrate for bacterial growth (Riley).
- Work continued on the nature and distribution of non-ionic carbohydrate derivatives in algae (Craigie).
- The electronic zooplankton system was now fully operational and, coupled to the LINC-8 computer, allowed the real time collection of data on the size-frequency of zooplankton biomass in oceanic water (Boyd).
- Research continued on the deep-water zooplankton of the Sargasso Sea (Deevey).
- Studies of deep-sea amphipods between Halifax and Bermuda continued plus benthic ecological studies were carried out in St. Margaret's Bay, Prince Edward Island and Cape Cod Bay (Mills).

Three MSc and two PhD degrees were awarded. Thirteen new students were admitted

bringing the total up to another all time high of 44.

Out of town visitors giving seminars included Howard L. Sanders (Woods Hole Oceanographic Institution), Fabrizio Aumento (Geological Survey of Canada), Kenneth Hunkins (Lamont Geological Observatory), Susan Huntsman (Duke University Marine Laboratory), A.J. Faller (University of Maryland), A.G. Carey (Smithsonian Institution) and P.G. Sly (Inland Waters Branch).

1970

After five years of gestation, the proposal to create a graduate Department of Oceanography was finally ratified by the Faculty of Graduate Studies and the University Senate to become effective the summer of 1971. In the end, Ron Hayes voted in favour. The Institute would now have autonomy in professorial appointments and various administrative matters and not be dependent on the disciplinary departments. This was a huge victory for Gordon and fulfilled his dream of many years that was originally kindled while he was at Yale. If Yale had followed his advice and created its own Department of Oceanography, Gordon most likely would have never moved to Dalhousie for a new life in Canada.

Construction of the new oceanography building and associated sea water system was approximately on schedule and should be completed as planned in the summer of 1971.

Despite the recommendations of a Science Council report (Stewart and Dickie 1971) to double federal expenditures for marine science, the government was not listening and further growth was not possible under the restrained financial situation at the time. The security of the future stature of Canadian oceanography was dependent upon funding from the NRC and other agencies. Basic research in the pursuit of knowledge was needed not only for its own sake but also to discover what is relevant.

There were no faculty changes. However, John Field (Biology) and Ted Loder (Chemistry) arrived as postdoctoral fellows.

In response to the growing concern about environmental issues, students organized a successful seminar series on pollution and talks were given by students, faculty and invited speakers. The Institute felt it should be cautious in establishing its role in the study of environmental problems. Oceanography had never been an ivory tower science and much of its growth had been dependent upon the public need for oceanographic applications. Nevertheless, it was felt that the academic requirements of original research should not be compromised in the choice of problems to investigate. Faculty and students were conducting basic oceanographic studies in areas where there were threats of pollution and their findings would be useful in a practical way sooner or later. Routine monitoring programs, as necessary as they are, were not regarded as proper Institute functions. Recognizing the need for professionals to provide objective information to the public, Institute faculty became more active in providing advice to government and industry and in communications with the news media.

While limited by financial constraints, a start was made to use offshore drilling platforms in support of two projects and it was hoped that this program could be expanded in the future.

Research highlights (including students and PDFs):

- Several physical oceanographic studies were initiated including exploring the feasibility of using the SEDCO offshore drilling platform for measuring currents, theoretic studies of small features in the vertical distribution of temperature and salinity, the circulation of Petpeswick Inlet and spectral analysis of surface wave heights (Overstreet).
- Studies on the physical processes in coastal embayments continued with focus on St. Margaret's Bay, Halifax Harbour and Canso Strait (Trites).
- The first direct measurements of currents in the Drake Passage were made on the Hudson 70 Expedition (Mann).
- A cruise on CSS *Dawson* to Hudson Bay collected information on bathymetry, seismic profiles, magnetics, heat flow, sediments and plankton. In addition, work continued using tilt meters installed in mines to measure earth tides (Keen).
- Heat flow measurements in Baffin Bay and the Labrador Sea confirmed that there is no active seafloor spreading occurring in this region (Hyndman).
- Orphan Knoll was successfully nominated as a Deep Sea Drilling Project drill site, the first such site off Canada. Subsequent drilling by Glomar Challenger on Leg 12 confirmed it was a continental fragment (Ruffman).
- The igneous/metamorphic stratigraphy for the oceanic crust was determined and compared to seismic evidence (Aumento).
- Work was carried on the stratigraphy and paleoecology of sediment cores from the Mid-Atlantic Ridge (Medioli).
- Studies of surficial sediments continued at various locations including the Labrador continental margin, the Mid-Atlantic Ridge, the Laurentian Channel, the Bras d'Or Lakes and continental slope off Nova Scotia (Gees).
- A large number of faculty and students participated in the Antarctic and Pacific legs of the Hudson 70 Expedition and carried out numerous biological and chemical projects (Wangersky, Watt and Mills).
- Studies continued on the nutrition of deep-sea zooplankton, the distribution of dissolved and particulate organic matter in seawater and the formation of particles from dissolved organic matter (Riley).
- Work began investigating the visual properties of suspended organic matter in seawater using both light and scanning electron microscopy (Loder).
- The distribution of primary production in the Baie-des-Chaleurs was calculated using temperature, phosphate and oxygen data (Watt).
- Investigations on the soluble carbohydrates of chrysophycean algae continued (Craigie).
- The electronic zooplankton counter was used to study the small-scale spatial patterns of zooplankton in the Gulf Stream and Sargasso Sea (Boyd).

- Quantitative analyses of zooplankton samples collected at the Bermuda Biological Station hydrostation were completed (Deevey).
- In collaboration with BIO, several faculty and students were involved in the clean up operations and subsequent research following the *Arrow* oil spill in Chedabucto Bay (Riley).
- Benthic samples were collected off Cape Horn, in the Drake Passage and in the South Shetland Islands on the Hudson 70 Expedition to test the hypothesis that some animals have continuous distributions from the deep-sea into shallow water in high latitudes. Other studies investigated the properties and dynamics of benthic communities at various locations including the Gulf of St. Lawrence, Prince Edward Island, St. Margaret's Bay and Cape Cod Bay (Mills).

One MSc and six PhD degrees were awarded. Ten new students were admitted making the total number 40.

Out of town visitors giving seminars included Christopher Garrett (University of California at San Diego), Allan H. Lee (Great Lakes Institute, University of Toronto), Jaan Huus (University of Ottawa), Tuzo R.S. Wilson (Woods Hole Oceanographic Institution) and Thomas M. Church (Scripps Institution of Oceanography).

1971

This was a particularly eventful year for oceanography at Dalhousie. On 1 July, the Institute finally achieved full departmental status under the Faculty of Graduate Studies and soon after moved into its new building in the Life Sciences Centre along with the Departments of Biology and Psychology. The Centre also contained shared lecture space and a large common area with a canteen for the university as a whole. For the first time, the entire Dalhousie oceanography program was united under one roof. Gordon had now successfully accomplished his two major goals since coming to Dalhousie, but staffing and funding problems remained. As a departmental chair, he now faced an increasing burden of administrative details relating to settling into the new building and dealing the higher levels of university bureaucracy. The student body had nearly tripled since his arrival six years ago and, although biological oceanographic students were still the majority, other specialties were well represented. The new department had finally developed the nucleus of a viable oceanographic establishment.

The new Oceanography Building contained the Aquatron, a unique major running seawater facility which was much more advanced than those at the local FRB labs on Lower Water Street and at BIO. Carl Boyd, who had been promoting the concept of the Aquatron since his arrival at Dalhousie, was appointed as director and technical personnel were hired to run it. While administered by the Institute, this state-of-the-art experimental facility was expected to be used by the entire university community as well as visiting scientists. It consisted of a large pool tank, a large tower tank, a flume tank, a high-pressure facility and ten small labs with running seawater and environmental control. A pumping station on the shore of the Northwest Arm and connecting pipelines provided the seawater. This facility was funded by grants from NRC and the Atlantic

Development Board as well as a provincial loan. These funds also allowed for the purchase of a scanning electron microscope, atomic absorption spectrometer and electronic beam microprobe to be shared with other departments.

There were a lot of comments both pro and con about the general construction of the new building. The materials and external planning were the architect's choice and some people felt that the result was gray and dull. However, it was an economical kind of construction and anything fancier would have provided less space. Initially, there was more space than needed by oceanography and, until required, it was temporarily used by the Mathematics and Geology departments and later by the Trace Metal Analysis group.

There were three additions to the faculty. Bob Fournier returned after two years at the University of Hawaii to replace Walton Watt as a biological oceanographer. Bob Cooke, one of Pete Wangersky's students, was hired as a second chemical oceanographer and Chris Garrett joined as the second physical oceanographer. In addition, Chris Beaumont, a geophysicist, was hired as a lecturer on a one-year term to cover for Roy Hyndman while on sabbatical leave at UBC. Mike Keen left the faculty to become the Chair of the Department of Geology at Dalhousie but remained an associate. Neil North (Chemistry) arrived as a new postdoctoral fellow.

Research highlights (including students and PDFs):

- Physical oceanographic studies were carried out in Northwest Arm and wave height studies were conducted at the entrance to Halifax Harbour (Overstreet).
- Studies of tidal resonance in the Bay of Fundy were initiated and it was discovered building tidal barrages in the upper reaches could increase the tidal amplitude in the Gulf of Maine (Garrett).
- Internal wave experiments were conducted using a wave tank at BIO (Sandstrom).
- Geophysical studies in Baffin Bay and over the Mid-Atlantic Ridge continued in collaboration with BIO (Keen, Aumento, Loncarevic).
- Using CCS *Hudson*, heat flow measurements were made over the Mid-Atlantic Ridge and unexpectedly high concentrations of uranium were found (Hyndman).
- Work continued on measuring the elastic response of the earth's crust beneath the Maritime Provinces due to the macrotides in the Bay of Fundy (Beaumont).
- Work continued on ion solvation, water structure and the oceanic carbon cycle (Wangersky).
- Studies were initiated on the chemical behaviour of carbonate minerals in seawater, the distribution of nitrous oxide in the open ocean, the effects of pressure on ion proportions in interstitial water of marine sediments, the incorporation of nitrogen in near-surface water resulting from bubbles generated by surface turbulence and the solubility of sulphate, magnesium, calcium and carbonate ions in seawater (Cooke).
- Studies on the growth of deep-sea bacteria and their relations with particulate and dissolved organic matter continued. Other research included studies of phytoplankton, particulate organic matter and nutrients in Bedford Basin, population studies and feeding of deep-sea zooplankton and organic particle formation in seawater (Riley).

- Research on improving understanding of the biochemical composition and behaviour of marine algae continued (Craigie).
- In collaboration with BIO, a comparative study of zooplankton data collected with the electronic plankton counter and a Clark-Bumpus sampler was carried out in Bedford Basin (Boyd).
- Analysis of benthic samples taken during Hudson 70 continued. Different numerical models were evaluated for their suitability in the analysis of multispecies survey data. Field studies of a benthic community and its fish predators in St. Margaret's Bay was completed. In addition, a comparative study of the distribution, breeding and feeding of Great and Double-crested Cormorants in Cape Breton Island and Southwest Nova Scotia was initiated (Mills).

Two MSc and five PhD degrees were awarded. Fifteen new students were admitted bringing the total up to 42.

While most graduates continued to find jobs which utilized their oceanographic training, the placement situation was now more difficult than it was a few years ago. Neither the job situation nor the present operating budget warranted the kind of growth anticipated when the new building was planned so the Institute decided to maintain the student body at current level until additional funding was available.

Out of town visitors giving seminars included Peter Betzer (Graduate School of Oceanography, University of Rhode Island), Thomas W. Moon (University of British Columbia), Bruno d'Anglejan (Marine Sciences Centre, McGill University), R.P. Von Herzen (Woods Hole Oceanographic Institution), Walter H. Munk (Scripps Institution of Oceanography) and Peter H. Rich (Brookhaven National Laboratory).

1972

The Institute continued to settle into the new building and the additional space and new instrumentation expanded research capabilities considerably. Bob Fournier established an undergraduate survey course in oceanography which turned out to be very popular.

Gordon Riley and Bob Fournier compiled some statistics summarizing the academic progress of the Dalhousie oceanography program to date. Since the founding of the Institute in 1959, 33 MSc and 29 PhD degrees had been awarded. Six of the MSc graduates continued with their graduate studies and earned a PhD degree. Over half of the graduates were able to find suitable employment in Canada as follows:

Federal labs	16
Universities	11
Industry	5
Other	2
=====	
Total	34

The rest found employment outside Canada as follows:

US	12
Britain and Commonwealth	7
Other	3
=====	
Total	22

Even though some graduates were leaving the country, the Institute was clearly addressing its mandate of producing oceanographers for Canada. Because of the tightening of job opportunities in Canada, especially for non-Canadians, the admission policy continued to be to accept the best students available regardless of nationality. The current citizenship of students was as follows:

Canada	23
US	16
Other	6
=====	
Total	45

This was quite a change from just a few years ago when Canada was producing few oceanographers and was largely dependent on other countries for building up its oceanographic expertise. BIO could not have attained its present size and quality without extensive importation. It could be argued that Canada was paying a just debt if it trained and exported a few oceanographers to other countries.

The faculty of the Institute itself was very international. There were two native and one naturalized Canadians, all of whom got their PhDs abroad, three Americans educated in the US, one American with a Canadian PhD and two Britishers with degrees from the UK.

In the early days of the Institute, the student body was heavily weighted toward biological oceanography but with time a better interdisciplinary balance had been achieved and the distribution was now:

Biology	18
Chemistry	12
Physics	11
Geology	4

It was recognized that several other Canadian universities were producing marine biologists which could lead to a potential over supply. However, most of these were seashore types while Dalhousie was producing seagoing scientists with a considerable knowledge of the whole field of oceanography for which there continued to be considerable demand.

Roy Overstreet resigned to take up a job in the US with the Atomic Energy Commission. This left a huge hole in the physical oceanography program which was temporarily filled by Warren Forrester from BIO serving as an associate. Recruitment for a replacement

physical oceanographer started immediately. David Piper, a geologist, joined the faculty. Sandra Barr (Geology) and Werner Hirsbrunner (Chemistry) arrived as postdoctoral fellows.

University scholarship funds continued to be inadequate and the NRC scholarships awarded did not close the gap. As a result, the annual stipends for students were only \$2,800, a minimal amount which was not competitive with other universities. A substantial increase in scholarship funding was needed to maintain the viability of graduate studies in oceanography at Dalhousie.

Research highlights (including students and PDFs):

- Work continued on understanding tidal resonance in the Gulf of Maine-Bay of Fundy system and the potential impacts of constructing tidal barrages in the upper reaches (Garrett).
- A geological investigation of St. Margaret's Bay was initiated. In collaboration with BIO, geophysical data were collected on a cruise of the CSS *Hudson* on the continental margin of Nova Scotia and off the Grand Banks (Keen).
- Heat flow measurements continued to be made over the Mid-Atlantic Ridge as well as in British Columbia, Nova Scotia and the Indian Ocean as part of Leg 26 of the Deep Sea Drilling Project. Geomagnetic data from Atlantic Canada was processed and a theory developed that described the origin of subduction zones which considered the motion of lithospheric plates relative to the underlying mantle (Hyndman).
- A new program was initiated to investigate how silts and clays are distributed and deposited in deep water (Piper).
- In collaboration with BIO, water samples were collected between Halifax and Bermuda to investigate the heterogeneity of particulate organic carbon in seawater. Other projects included the effect of air bubbles on the incorporation of gases into seawater, the organic decomposition in seawater under anoxic conditions, the solubility of major ions in seawater, sedimentation in estuaries, measurement of volatile organic matter in seawater, the distribution of nitrous oxide in seawater and photochemical reactions at the sea surface (Wangersky).
- An investigation of the thermodynamics and kinetic behaviour of calcite and aragonite in seawater continued. Other projects included pressure-dependent relationships of ion-pair formation, chemical kinetics of calcite dissolution and the effect of pressure on the silicate system in siliceous sediments (Cooke).
- Studies continued on the role of bacteria in the deep sea with particular reference to their capability to flocculate small particles into larger packages of suitable size for copepods and other small organisms to feed on. Other projects included a study of nutrient chemistry and phytoplankton in the Northwest Arm and experimental studies of phytoplankton in Bedford Basin (Riley).
- In collaboration with BIO, water samples were collected on a seasonal series of cruises between Halifax and Bermuda to assess the concentration of olive-green cells. In addition, a sampling program was started in the Northwest Arm and weekly observations were made of phytoplankton, nutrients and dissolved and particulate organic carbon (Fournier).

- Using the electronic plankton counter, it was demonstrated that aggregations of zooplankton can be associated with thermal microstructures in offshore waters. A version of the electronic plankton counter was developed for measuring air bubbles and assessing their role in the transfer of gases across the air-sea interface (Boyd).
- Detailed sorting and counting of benthic animals from the Antarctic leg of the Hudson 70 Expedition continued. Work began on deep-water amphipod crustaceans from the western North Atlantic. In collaboration with the Scripps Institution of Oceanography, deep-water benthic samples were collected in the Pacific Ocean between San Diego and Tahiti. A study looking at the interactions between winter flounder and benthic communities in St. Margaret's Bay was completed and work continued on the bathymetric distribution of mollusc assemblages in the St. Lawrence Estuary. In addition, a study of faunal changes in a seasonally anoxic basin in Petpeswick Inlet was completed. Various seabird studies were carried out (Mills).
- Several attempts were made to sample mesopelagic fish in slope water but were thwarted by bad weather and gear problems (Dickie).

Five MSc and seven PhD degrees were granted but only four new students were admitted so the total student enrolment stood at 45. Due to financial restrictions, there was no opportunity to expand enrolment in the near future.

Out of town visitors giving seminars included Egon Degens (Woods Hole Oceanographic Institution), Carl Wunsch (Massachusetts Institute of Technology), Theodore Smayda (Graduate School of Oceanography, University of Rhode Island), A.C. Heron (CSIRO, Australia), Ralph Brinkhurst (St. Andrews Biological Station) and John Allen (Memorial University).

1973

This was another year of major changes. In October, at the age of 62, Gordon Riley resigned as Director of the Institute and Chair of the Department of Oceanography but continued as professor. He had considered staying on for a few more years until retirement but then realized he was burned out as an administrator and that it was best to step aside and turn the reins over to a fresh pair of hands. To his great satisfaction, he had attained the goals he had set when he came to Dalhousie. In the eight years of his tenure as director, the Department of Oceanography was created and, from a scattering of little groups tucked away in various corners of the university campus, the Dalhousie oceanography program had come together to become a coherent faculty housed in its own building. It was most fitting that this year he elected as a Fellow of the Royal Society of Canada.



Peter J. Wangersky
Director 1973-1974, 1977-1978, 1979-1980

Pete Wangersky took over as director from Gordon on an acting basis and a search committee was formed to find a new permanent director. There were no other faculty changes this year but R.M. MacDonald (Chemistry) arrived as a postdoctoral fellow. Consideration was given to developing a new program in fisheries oceanography. The Institute was now reasonably settled into the new building although some design deficiencies and construction oversights remained to be corrected.

The graduate student stipend was increased to \$3,200 but was still considered inadequate. As usual, the difference between the amount needed and amount furnished by the university was made up from NRC institutional and operational grants. It was recognized that this practice could not continue and, unless other sources of funding could be found, it might be necessary to reduce the number of incoming students. This would be regrettable for excellent applications continued to come in and the demand for well-trained oceanographers remained high. Only the top 10-20% of applicants were being accepted and 35% of the current students held NRC fellowships.

Most of the graduate students and many of the faculty participated in a month-long cruise on CSS *Hudson* to Newfoundland and Labrador which was designed to provide training in sea-going research for new students. In addition, a series of lectures was organized to commemorate the 100th anniversary of HMS *Challenger's* visit to Halifax in 1873 at the start of her famous around the world expedition.

This year also marked the founding of the Dalhousie School of Resource and Environmental Studies (SRES) under the lead of Ron Hayes. In addition, it marked the publication of Ron's book entitled *The chaining of Prometheus: evolution of a power struggle for Canadian science* (Hayes 1973). This book pointed out the vicissitudes of government policy which he had observed during his five years in Ottawa.

Research highlights (including students and PDFs):

- On a cruise of the CSS *Hudson*, an offshore tide gauge was deployed near Sable Island and physical oceanographic data were collected in Nain and Tikkoatokak

- Inlets, Labrador and in slope water off Nova Scotia. Other projects included determining the effects of bottom topography on ocean currents, studying internal waves on the continental slope, temporal and spatial variations in slope water, investigating Langmuir circulation using photography, measurements of seiches in Northwest Arm, long-shore currents and sand transport at Martinique Beach, developing numerical models to compute tidal currents in the Minas Channel and Basin at the head of the Bay of Fundy and using remote sensing data to measure the growth and movement of ice in the Gulf of St. Lawrence (Garrett).
- Further heat flow measurements were carried out off Bermuda, the Azores and on the continental margin off Nova Scotia and Newfoundland using CSS *Hudson*. Seismic velocities of oceanic basalts were measured in the laboratory and a study was initiated to examine the opening of the Labrador Sea (Hyndman).
 - Studies of the deposition of terrestrial sediments in the deep-sea continued which included participating in Leg 28 of the Deep Sea Drilling Project to Antarctica. Geological studies of the development of St. Margaret's Bay continued (Piper).
 - Studies of the small-scale distribution of particulate organic carbon in seawater continued and microscopic observations indicated that zooplankton were associated with high concentrations (Wangersky).
 - Laboratory studies of the carbonate system in seawater continued. Other projects included investigating the effect of pressure on the solubility of silica and clays in seawater, the ionic composition of seawater as a function of exposure to clays, the pressure-volume-temperature relationships of apatites and phosphorites in seawater, the fate of natural and pollutant hydrocarbons in the sediments of Halifax Harbour, the physical chemistry of bubble nucleation, the flux of transition metals across the air-sea interface, photochemical reactions in sea surface films, the measurement of volatile organic carbon in seawater and estuarine sedimentation (Cooke).
 - Experiments continued exploring the interactions of bacteria with dissolved and particulate organic matter in seawater. A study of phytoplankton growth and phosphate balance in Bedford Basin was completed (Riley).
 - Work continued on studying the phytoflagellates in the phytoplankton community of the Northwest Arm. Primary productivity and standing stock measurements of phytoplankton were made in Nain Fjord, Labrador, plus attempts were made to culture local phytoflagellates for comparison with Northwest Arm assemblages (Fournier).
 - Work continued on studying the aggregation of zooplankton in layers of thermal microstructure using the electronic plankton counter on a CSS *Hudson* cruise off Newfoundland and Labrador. Other projects included studies of the neuston assemblage in the Sargasso Sea and zooplankton/phytoplankton associations along 5,000 km transects (Boyd).
 - Analysis of benthic samples from the Antarctic leg of Hudson 70 Expedition continued and the results compared with data from St. Margaret's Bay. A major study of molluscs in the St. Lawrence Estuary was completed. Studies of the physiological ecology of the gastropod *Nucula* and a systematic ecological study of meiofauna in sediments along the Nova Scotian coast were begun (Mills).

Four MSc and seven PhD degrees were awarded. Twenty-five new students were admitted which brought the total up to 44.

Out of town visitors giving seminars included Nelson Hogg (Massachusetts Institute of Technology), Holger Jannasch (Woods Hole Oceanographic Institution), Arthur de Vries (Scripps Institution of Oceanography), Max Dunbar (McGill University), J.J. McCarthy (Johns Hopkins University), Martin Angell (National Institute of Oceanography, UK), Tony Bowen (Institute of Coastal Oceanography and Tides, UK), Bruce Warren (Woods Hole Oceanographic Institution), Richard W. Eppley (Scripps Institution of Oceanography), Gilbert Rowe (Woods Hole Oceanographic Institution), Luigi Provasoli (Haskins Laboratories), Walter H. Munk (Scripps Institution of Oceanography), Thomas Osborn (University of British Columbia), Robert Clutter (Scripps Institution of Oceanography), Ramon Margalef (Instituto de Investigaciones Pesqeras, Spain), John Gould (Institute of Oceanographic Sciences, UK), Wendell Brown (University of California), Timothy Parsons (University of British Columbia), Dean R. Uffen (Queens University), Fred Newman (Massachusetts Institute of Technology), S.S. Voyt (Institute of Oceanography, USSR) and Frank Daiber (University of Delaware).

1974

The new oceanography building, including the Aquatron, was formally opened in March by Henry Hicks at a special convocation with a series of invited lectures. The Dalhousie oceanography program was now fifteen years old. There was a strong feeling of accomplishment and it was agreed that the primary functions should continue to be training of graduate students and oceanographic research.

Lloyd Dickie arrived from BIO to become the new Director of the Institute of Oceanography as well as Chair of the Department of Oceanography. He also became the Director of the newly created Dalhousie School of Resource and Environmental Studies. A fisheries scientist, Lloyd had previously been the founding director of the Marine Ecology Laboratory at BIO and one of his goals in moving to Dalhousie was to establish a graduate program in fisheries oceanography.



Lloyd M. Dickie
Director 1974-1977

Tony Bowen and David Huntley also joined the faculty. Both were physical oceanographers with interests in the coastal zone. With these two additions, the Institute was now self reliant in physical oceanography and no longer dependent on BIO associates for teaching and supervision. Eric Mills departed on a sabbatical to Cambridge University. R.T. Guza (Physics) and Fred E. Wells (Biology) arrived as postdoctoral fellows.

There was continuing concern over the contraction of research funds. The size of grants was not keeping up with the costs of research, especially in chemistry. There seemed to be a lack of coordination between government policy and the funding of universities. Ministers talked about need for ocean resource managers but did not seem to recognize that these take several years for universities to produce. This situation was being reviewed by both the NRC and CCO. On the bright side, the university provided funding to complete the Aquatron so it finally became fully operational. One third of the students had either NRC or Killam scholarships while the rest were supported by university funds and research grants. The annual student stipend had now increased to \$3600.

Research highlights (including students and PDFs):

- A general theory of tides in gulfs was completed which clarified the relative importance of direct and oceanic forcing, the energy balance and type of boundary conditions appropriate for numerical models. Work continued on internal wave problems. Other studies included the analysis of tidal variations in current meter and temperature data from BIO moorings, seiches in the Northwest Arm, measuring the water flow between the Arctic Ocean and Baffin Bay using temperature, salinity and current meter data, the dynamic causes of windrows on the sea surface, modelling the tidal currents and residual circulation in the Minas Channel and Basin, developing a numerical model of ice formation and movement in the Gulf of St. Lawrence, the formation of slope water in the Laurentian Fan area and upwelling offshore of Yarmouth (Garrett).
- A broad look at the beaches of Nova Scotia was undertaken as part of a study on beach maintenance. A series of measurements of the long shore current velocities and wave conditions were made along Martinique Beach (Bowen).
- Plans were made for a new program to measure water movements in the near-shore zone and on beaches (Huntley).
- The study of the opening of the Labrador Sea continued. A summary was prepared on the geological development of the continental margin of Atlantic Canada. Five deep crustal drill holes were drilled on the crest of the Mid-Atlantic Ridge. The electrical resistivity of oceanic basalts from Bermuda, the Azores and Iceland were examined in the laboratory at various pressures and temperatures and heat flow measurements in the basaltic crust were made at three holes drilled on Leg 37 of the Deep Sea Drilling Project (Hyndman).
- A cruise on CCS *Hudson* provided a large number of new sediment cores and much bathymetric data from the Scotian Slope, Laurentian Fan and the continental margin of the Grand Banks. Depositional valleys in the Laurentian Fan were mapped in detail. Magnetic, seismic and sediment data were used to

- map the subsurface distribution of bedrock and tills in St. Margaret's and Mahone bays (Piper).
- Using CSS *Dawson*, work continued on measuring the fine scale variability of particulate organic carbon in seawater and the contribution of inorganic materials to organic aggregates formed by bubble collapse (Wangersky).
 - Work continued on examining the calcite-seawater system. Other projects addressed the photochemistry of amino acids at the sea surface, the reactions of surface trace metal ions, the size spectrum of bubbles in surface waters, the effects of pressure on opal and silica concentrations in seawater, the adsorption of organically-bound transition metals by biogenic silica, improved techniques for the measurement of particulate, dissolved and volatile organic carbon and the role and flux of carboxylic acids in algal metabolism (Cooke).
 - A new program was established to explore problems of nutrient balance and physical factors that control biological productivity in the Gulf of St. Lawrence, along the Nova Scotian coast and in Long Island Sound. A study of tintinnids in the Northwest Arm continued as well as a study of phytoplankton production in varying light conditions (Riley).
 - A new long-term program was launched to develop a better understanding of the qualitative and quantitative properties of plankton on the Scotian Shelf. In addition, the study of plankton in the Northwest Arm continued (Fournier).
 - Using the electronic plankton counter, the spatial distribution of zooplankton was examined as part of an international upwelling study off West Africa. Soon after the counter was equipped with a fluorometer to simultaneously measure phytoplankton. In addition, a study of the growth and feeding of three local ctenophore species was completed, work of the scale and causation of plankton patchiness continued, methods were developed to measure zooplankton feeding rates using fluorescence analysis of gut contents and a study of the neuston community off Bermuda was completed (Boyd).
 - A comparison was made of the general features of the benthic communities in the South Shetland Islands, Antarctica, and Nain Bay, Labrador. The study of the benthic infaunal molluscs in the St. Lawrence Estuary was completed while studies of the protobranch bivalve mollusc *Nucula* continued. An ecological study of meiofauna in the West Lawrencetown marsh was initiated as well as a project documenting the early history of marine science in the UK (Mills).
 - Research continued to centre on elements of species interaction with particular reference to comparative study of natural predator-prey links and those represented by fisheries. In addition, study of the growth and productive capacity of blue mussels in Nova Scotian waters was completed (Dickie).

Three MSc and six PhD degrees were awarded. Sixteen new students were admitted so the total remained at 44 despite a 50% increase in applications.

Out of town visitors giving seminars included Jeanne Sauvé (MOSST), Gerald Middleton (McMaster University), Elijah Swift (Graduate School of Oceanography, University of Rhode Island), Sir Edward Bullard (Cambridge), S.A. Thorpe (Institute of Oceanographic Sciences, UK), Colin W. Clark (University of British Columbia), Sir George Deacon

(Institute of Oceanographic Sciences, UK), Arvid Pardo (Malta), Peter Wiebe (Woods Hole Oceanographic Institution), A. Niedoroda (University of Massachusetts), John Kanwisher (Woods Hole Oceanographic Institution), T. Bannister (University of Rochester), Thomas Malone (City College of New York), Kenneth Gold (Osborn Laboratories) and J. Edmonds (Massachusetts Institute Technology).

1975

After being on the faculty since 1966, Roy Hyndman departed to take up a position at the Victoria Geophysical Observatory in British Columbia. He was replaced by Chris Beaumont, a former graduate student in the Institute who had been working with the Earth Physics Branch in Ottawa. Joe Wroblewski, a biologist with expertise in ecosystem modelling, also joined the faculty. In addition, Norval Balch, also a former graduate, was hired as the manager of the Aquatron while Carl Boyd departed on sabbatical leave to the Station Zoologique at Villefranche-sur-Mer, France. Sharon L. Smith (Biology) arrived from Duke as a new postdoctoral fellow.

Further improvements, funded by the university, were made to the Aquatron and a proposal for long-term funding was submitted to NRC. Due to a general economic slowdown, there was increasing concern about employment opportunities for new graduates. Despite continuing demand, it was becoming increasingly difficult to place students. Due in part to the new federal Make and Buy policy, an increasing number of graduates were going into industry. Others were going into the environmental and natural resource fields which often involved planning, administering and operating the new government management organizations being created. Fewer were able to move into an oceanographic research environment. It was recognized that training in oceanography had to be linked more closely to the needs of Canadian society which posed a difficult challenge.

The department now offered the following courses:

- Introductory Oceanography (Fournier)
- Introduction to Geological Oceanography (Piper, Beaumont)
- Introduction to Physical Oceanography (Huntley)
- Introduction to Chemical Oceanography (Wangersky)
- Introduction to Biological Oceanography (Riley, Mills)
- Time Series Analysis in Oceanography (Huntley, Platt)
- Advanced Physical Oceanography (Bowen)
- Biology of Phytoplankton (Fournier)
- Marine Geology and Geophysics (Keen)
- Advanced Chemical Oceanography (Wangersky)
- Benthic Ecology (Mills)
- Zooplankton (Boyd)
- Biological Dynamics of Fisheries (Dickie)
- Advanced Chemical Oceanography (Cooke)
- Fluid Dynamics (Garrett)

- Physiology of Marine Plants (Craigie)

Research highlights (including students and PDFs):

- A new theory on the generation of Langmuir cells was developed and work continued on refining tidal models for the Bay of Fundy. The later involved installing offshore tide gauges on the continental shelf. In addition, a project on residual currents in the Minas Channel and Basin was completed, as were projects measuring the transport of water, heat and salt from the Arctic Ocean to Baffin Bay through Nares Strait and on slope water. New projects were initiated to study the front between Labrador Slope Water and Warm Slope Water in order to elucidate the mechanisms maintaining the front and explaining the high biological activity and to formulate models to understand ice formation and movement in the Gulf of St. Lawrence (Garrett).
- Studies of nonlinear wave interactions in shallow water continued, including the measurement of long-shore currents at Martinique Beach, and a general survey of the condition of beaches in Nova Scotia was completed. Preliminary calculations of sediment transport parameters in the Minas Basin were made with a numerical tidal model (Bowen).
- A new experimental system was developed for measuring near-shore wave velocities and elevations in the field and the high frequency turbulent motion in the near-field velocity field was investigated. The properties of beaches at Martinique and Inverness were compared and a study of the Labrador Current was begun (Huntley).
- A stratigraphy for the deep-water continental margin going back to 700,000 B.P. was developed. Major sources and transport paths of clay minerals on the continental margin were delineated and work on the geological history of St. Margaret's and Mahone bays continued. In addition, a project was initiated to examine damage to benthic foraminifera resulting from ingestion by invertebrates (Piper).
- Studies were carried out to determine the retention of particulate organic carbon by different kinds of filters. Analysis of samples collected during the Hudson 70 Expedition indicated that the distribution of particular organic carbon is essentially the same in both the Atlantic and Pacific oceans (Wangersky).
- Research on sedimentary carbonates continued. Other projects addressed the photolytic degradation of amino acids in seawater, the effect of fluvial organic materials in particle behaviour in estuaries, the phase relationships between seawater and phosphorites and apatites of various types, the fractionation and chemical behaviour of transition metals at the air-sea interface, the flux of saccharides near coasts, the size spectrum of bubbles in seawater, the chemical aspects of heterotrophy in algae, the organic budget of seawater and phase composition and transition metal co-precipitation in ferro-manganese oxides (Cooke).
- Problems of biological productivity in the Gulf of St. Lawrence and continental shelf waters from Nova Scotia to southern New England were addressed. Other studies included tintinnids in the Northwest Arm, phytoplankton productivity in

- relation to varying light intensity and the effects of zooplankton excretion on phytoplankton growth (Riley).
- The Scotian Shelf program designed to investigate nutrient dynamics expanded and four seasonal cruises were run along the Halifax section. Plankton biomass, primary productivity, nutrients, ATP, chlorophyll and dissolved and particulate organic carbon were measured at seven stations (Fournier).
 - A study of the degradation of amino acids was completed. A project was established to explore the feasibility of using sulphate metabolism to study growth rates and physiological status of marine plankton and special chamber was developed for studying photosynthesis in macrophytes (Craigie).
 - Work on the small-scale spatial patterns of zooplankton continued. A taxonomic key to marine copepods found near Halifax was completed and work continued on the spectral analysis of chlorophyll, temperature and zooplankton data collected along long transects (Boyd).
 - The development of British marine biology during the period of 1840 and 1870 was studied. In addition, work continued on the ecological study of meiofauna in the West Lawrencetown marsh and the feeding and food selection of the bivalve *Nucula*. Also a study of the food sources of a polychaete worm in the subtidal sediments of St. Margaret's Bay was initiated (Mills).
 - In collaboration with the School of Resource and Environmental Studies, a new project was launched to construct bioeconomic management models relevant to east coast fisheries. In addition, projects continued on the feeding and bioenergetics of mackerel in the Gulf of St. Lawrence and the production of the Gulf of St. Lawrence herring population while new projects were initiated on using acoustic tools to measure demersal fish populations and examining the interactions between resource availability and economic benefits (Dickie).

Six MSc and four PhD degrees were awarded and twenty new students were admitted.

Out of town visitors to the Institute giving seminars included Robert Guillard (Woods Hole Oceanographic Institution), Robert Duce (Graduate School of Oceanography, University of Rhode Island), Edward Carpenter (Woods Hole Oceanographic Institution), Johan Hellebust (University of Toronto), J.J. O' Brien (Office of Naval Research, USA), M.P. Lanleben (McGill University), John Tietjen (City College of New York), Walter H. Munk (Scripps Institution of Oceanography), Michael Pilson (Graduate School of Oceanography, University of Rhode Island), Charles Yentsch (Bigelow Laboratory for Ocean Science), Howard Freeland (Woods Hole Oceanographic Institution), Clinton Winant (Scripps Institution of Oceanography), N.S. Baxter (University of Glasgow), Arthur E. Collin (Fisheries and Marine Service, Environment Canada), Byron Morris (Bermuda Biological Station), H. Eric Sadler (Defence Research Establishment), Kirk Bryan (National Oceanic and Atmospheric Administration), Angus McEwan (Commonwealth Scientific and Industrial Research Organization, Australia), Michael Whitfield (Plymouth Laboratory, UK), R.D. Hamilton (Fisheries and Marine Service, Environment Canada), Oliver Zafiriou (Woods Hole Oceanographic Institution) and G.N. Somero (Scripps Institution of Oceanography).

1976

On the national level, there was continuing concern over science policy and funding. It was felt that this was a critical time because Canadian research funding was falling behind other nations. A major reorganization of the federal funding councils was underway.

Gordon Riley retired and was appointed Professor Emeritus. He also was awarded the prestigious Rosenstiel Award in Ocean Sciences by the University of Miami in recognition of his lifetime achievements in oceanography. Chris Garrett was awarded an NRC Steacie Memorial Fellowship. R.W. Houghton and J.G. Richman arrived as postdoctoral fellows.

Under the lead of Lloyd Dickie, the proposed fisheries oceanography program began to take shape and the Dalhousie Faculty of Graduate Studies and Senate approved an MSc option in fisheries oceanography.

Two new courses were added to the curriculum:

- Marine Geology and Geophysics (Peirce)
- Physics of the Earth (Beaumont)

Research highlights (including students and PDFs):

- A study of the coupling between a coastal tidal model and the deep ocean was completed. The role of tides in determining stratification, secondary circulation and other general oceanographic characteristics was explored to elucidate the potential effects of tidal power development in the Bay of Fundy. A numerical model was developed to describe the response of ice in the Gulf of St. Lawrence to wind stress, currents and internal forces between ice flows. Studies continued on the front between Warm Slope Water and Labrador Slope Water and problems associated with surface water interactions were studied. A model was developed to use satellite altimeter data to compute tides and the shape of the geoid in Hudson Bay. In addition, the effects of tidal mixing on vertical profiles of temperature and density in coastal waters were investigated (Garrett)
- In collaboration with the Scripps Institution of Oceanography, research on nonlinear wave interactions and sediment transport in shallow water continued as was a study of sediment transport by tidal and residual currents in the Minas Basin (Bowen).
- Work on near-shore long-period wave motion continued with experiments at Queensland, Martinique and Inverness beaches. In addition, physical oceanographic measurements were made between the edge of the Labrador Current and offshore waters on a cruise of CSS *Hudson* (Huntley).
- Studies on subsidence and isostatic adjustment in sedimentary basins continued and experimental work on the electrical properties of oceanic basalts was completed. Models of recent vertical movements of Atlantic Canada were developed to place limits on the viscosity distribution in the Earth's mantle and

- the possible effects of potential tidal power barrage construction on regional seismicity was studied in the Bay of Fundy (Beaumont).
- Work continued on refining the sediment stratigraphy on the margin of the Grand Banks, in the Laurentian Fan and in Baffin Bay. Research continued on the late Quaternary history of coastal bays southwest of Halifax, including St. Margaret's Bay, Mahone Bay, Lunenburg Bay and the La Have estuary. In addition, a review of turbidite muds and silts in deep sea fans and abyssal plains was completed (Piper).
 - Work began on developing a nephelometer for measuring particles in seawater. The continuous flow dissolved organic carbon analyzer was rebuilt and calibrated (Wangersky).
 - Phase relationships in carbonate sediments at sea-floor pressures continued to be studied. A study on transition metal behaviour at the air-sea interface was completed, as was a study of adsorption of organic materials by inorganic particles in estuaries. Other studies included the transition-metal coprecipitation in ferro-manganese oxides, phase interactions in marine phosphorites, the sorptive characteristics of marine clays in relation to several trace metals, the transport of heavy metal ions from near-shore sediments to deeper water as a result of dredging, the distribution and dissolution behaviour of bubbles in the ocean and the chemical and seismic characteristics of methane bubbles in highly organic muds (Cooke).
 - The investigation of plankton biology on the Scotian Shelf continued on four CSS *Dawson* cruises. The sorption, uptake and subcellular distribution of cadmium in selected species of marine phytoplankton were also investigated (Fournier).
 - Projects investigated the role played by fixed nitrogen nutrients in the growth strategy of seaweeds, the production and biosynthesis of carrageenans and phenolic constituents of brown seaweeds, nitrogen regeneration during amino acid degradation in local plankton communities and the effects of physiological factors on photosynthesis in dulse (Craigie).
 - The electronic plankton counter continued to be used to study the spatial patterns of zooplankton and their interactions with phytoplankton. Other projects included feeding by different stages and species of calanoid copepods, a zoographic study of the distribution and ecology of *Acantharia* in the North Atlantic and the behavioural and physiological patterns of diel vertical migration, feeding and metabolism (Boyd).
 - A study of benthic communities along the Halifax Section across the Scotian Shelf was begun and methods for measuring organic carbon in sediments were compared. Work continued on documenting the history of dredging in Great Britain during the 1860s. Other studies included ammonia release by benthos along a transect across the Scotian Shelf, the feeding of the mollusc *Nucula* and a deposit feeding polychaete worm and harpacticoid copepods in a Nova Scotian estuary (Mills).
 - A DSS contract on bioeconomic models of east coast fisheries was completed. The study of relationships between growth and mortality in the common mussel continued while a study on the feeding and production of mackerel in the Gulf of St. Lawrence was completed. An analysis was done on the relative impacts of

long-line and otter-trawl fisheries of Southwest Nova Scotia on cod and haddock populations. Work continued on using dual beam echo sounders to estimate the abundance of fish populations. In addition, CIDA funded a proposal for a cooperative anchovy project with Peru (Dickie).

Five MSc and two PhD degrees were awarded. Fourteen new students were admitted.

Out of town visitors giving seminars included A. Aitsam (Baltic Sea Section, Institute of Thermal and Electrophysics), Peter Vanicek (University of New Brunswick), Tom Sanford (Woods Hole Oceanographic Institution), Thomas A. Newbury (Marine Biological Laboratory), James Quinn (Graduate School of Oceanography, University of Rhode Island), G.R. Lopez (Stony Brook), Jack Mathias (University of British Columbia), J.W.M. Rudd (Freshwater Institute), Sallie Chisholm (University of California at San Diego), J.S. Wroblewski (Florida State University), Brian Shuter (University of Toronto), R. Jones (Fisheries Laboratory, Aberdeen), Robert Houghton (University of Ghana), Chris Mooers (University of Delaware), Neils Daan (Netherlands Institute for Fisheries Investigations), Donald Rhoads (Yale University), Joseph Ramus (Yale University) and Norman Sleep (Northwestern University).

1977

On the national front, Canada declared a 200-mile limit and exclusive economic zone which covered most of the continental shelf. This bold action implied an increased demand for graduates trained in fisheries management but it was discouraging that increases in university funding to meet this demand were not visible on the horizon.

After serving three years, Lloyd Dickie stepped down as the Director of the Institute and Chair of the Department but continued on faculty as a professor. For the second time, Pete Wangersky stepped back up to the plate and assumed these duties on an acting basis.

Bob Moore, a chemical oceanographer from the University of Southampton specializing in trace metals, joined the faculty along with James Richman, a physical oceanographer. Chris Garrett departed on sabbatical leave to Australia and was also elected to the Royal Society of Canada.

While there was continuing concern about the funding of graduate students and research, there was now some hope for the future. The NRC was setting up a two-year program of supplemental grants and oceanography was one of the fields selected. Proposals were prepared and submitted which would be reviewed by a panel of marine scientists.

The Institute was informed that the Canadian International Development Agency (CIDA) had accepted a proposal by the Peruvian Government for a joint Canadian-Peruvian expedition to study the relation between the Peruvian anchovy and its environment with the objective of improving the precision of the prediction systems used by fisheries managers.

Research highlights (including students and PDFs):

- An 18.6-year cycle in the surface temperature of shallow seas was found to be due to variations in tidal mixing. Further work on tidal modelling explored the separation of well-mixed and stratified water in the Bay of Fundy and Gulf of Maine and how it might be affected by tidal barrages. In addition, the role of internal waves and other processes of oceanic mixing was re-examined (Garrett).
- Research on nonlinear wave interactions in shallow water continued in collaboration with the Scripps Institution of Oceanography and the interactions between waves and near shore topography were investigated. A study on the sedimentation of the Scotian Margin and Laurentian Fan led to the development of a model on the flow and deposition of turbidity currents (Bowen).
- A study of the effect of bottom stresses and mean currents responsible for them on mobile offshore sand bars was carried out in collaboration with BIO at Tracadie, PEI. A similar study was conducted in Prince Inlet, SC (Huntley).
- Measuring benthic boundary layer currents were made as part of the BIO Shelf Break Experiment and estimates were made of mixing rates in the upwelling area off Peru (Richman).
- Models of the development of sedimentary basins on elastic lithospheres were developed and the dynamics of long-term isostatic adjustment as it related to the rheology of the lithosphere were studied. Numerical models of sea level variation in Atlantic Canada since the end of the last ice age were developed and the electrical conductivity of oceanic basalts and gabbros was determined. In addition, tilt observations of earth tides and the loading effect of the ocean tides were made at Springhill and Shelburne (Beaumont).
- Studies of the Late Quaternary stratigraphy and sedimentology continued at several regions of the eastern continental margin including the Laurentian Fan, the Grand Banks, Baffin Bay and Orphan Basin. The late- and post-glacial development of coastal bays along the South Shore was studied to understand the processes leading to the present distribution of sediment. Work on Holocene marine palynology continued (Piper).
- Work continued on the development of a continuous high temperature dissolved organic carbon analyzer and a report on analytical methods for organic materials in seawater was prepared for the NRC. Other studies included developing a carbohydrate budget for Fink Cove, NS, investigating the photochemistry of surface seawater, the effects of nutrient stress on the uptake and release of organic compounds by phytoplankton, C^{12}/C^{13} ratios of particulate matter in Baffin Bay, the distribution of man-made surface-active compounds in Northwest Arm, the development of a high intensity UV dissolved organic carbon analyzer, the effects of particulates on rates of nutrient regeneration and the feeding of zooplankton on dissolved and particulate matter (Wangersky).
- The solubility behaviour of several natural aragonites in seawater was determined and the movement of calcium carbonate from more soluble polymorphs to less soluble ones in sediment was investigated. Research began to investigate how CO_2 liberated by burning fossil fuels and forest clearing enters the ocean and is transported to deep water and sediments. Other work included experiments on the role of bubbles in gas exchange and particle production in coastal waters, the

- binding of transition metals by organic ligands and the physical distribution, chemical controls and microbiological factors important in generating methane bubbles in sediments (Cooke).
- The Scotian Shelf Project, studying plankton dynamics, continued with particular interest in the upwelling area off Yarmouth at the entrance to the Bay of Fundy. Other studies examined the effects of cadmium on phytoplankton growth and the occurrence and distribution of zooplankton around the deep chlorophyll maximum found on the Scotian Shelf (Fournier).
 - Investigations continued on the assimilation sulphate by marine phytoplankton and the effects of nitrogen fertilizers on the physiology of large seaweeds (Craigie).
 - A deck-mounted plankton system was used on the Peru cruise to obtain horizontal transects of temperature, chlorophyll and zooplankton concentrations. Work began to study the swarming behaviour and feeding of the euphausiid *Meganyctiphanes*. Other studies underway included the diel activity cycles in marine zooplankton, the distribution of Acantharia between Halifax and Bermuda and the horizontal spatial variability of marine phytoplankton and zooplankton (Boyd).
 - Benthic studies continued on the Scotian Shelf and slope in parallel with phytoplankton studies and methods for measuring sediment organic carbon were compared. Research on the history of UK marine biology focussed on events leading up to the famous HMS *Challenger* expedition. Other studies included nutrient release from marine sediments, the small scale spatial distribution of benthic animals on the Scotian Shelf and slope and the ecology of meiobenthic harpacticoids in West Lawrencetown (Mills).
 - Studies on the effects of genetics on the growth and mortality of mussels continued as did studies of the effects of economic and management factors on production indices of commercial fish populations. Bioeconomic models of east coast fisheries were evaluated. The distribution and abundance of ichthyoplankton were investigated on the Peru cruise while surveys of anchoveta were conducted using acoustics. Other studies included comparing the catchability and distribution of long-line and otter trawl fishing gears used in Southwest Nova Scotian, examining the metabolic activity of mussels in relation to tidal rhythms, the effects of oil pollution on eggs and larvae of cod and mackerel and small fish predation on cod and mackerel larvae (Dickie).
 - Along with BIO scientists, numerous faculty and students participated in a most successful CIDA-funded cruise to Peru on the CSS *Baffin* to study the anchovy fishery and supporting oceanographic processes (Dickie).

Nine MSc and seven PhD degrees were awarded. Twenty-two new students were admitted bringing the total up to 48, the highest ever.

Out of town visitors giving seminars included Robert Beardsley (Woods Hole Oceanographic Institution), Pat Lohman (Woods Hole Oceanographic Institution), Richard Dugdale (Bigelow Center for the Ocean Sciences), Phil Richardson (Woods Hole Oceanographic Institution), Dick Peltier (University of Toronto), Ramon Margalef

(University of Barcelona), Derek Spencer (Woods Hole Oceanographic Institution), Richard Stolzberg (New England Aquarium), Robert Byrne (University of Rhode Island), Robert Moore (University of Southampton), William Graham (University of Rhode Island), Dennis Waslenchuk (Skidaway Institute of Oceanography), Gustav-Adolf Paffenhöfer (Skidaway Institute of Oceanography), Jim Clark (Cornell University), Howard Sanders (Woods Hole Oceanographic Institution), Peter Friend (Cambridge University), Robin Pingree (Institute for Oceanographic Sciences), Allan Clarke (Massachusetts Institute of Technology), Rod Zikta (University of Miami), Peter Brewer (Woods Hole Oceanographic Institution), Peter Le B. Williams (University of Southampton) and David Feigenbaum (Woods Hole Oceanographic Institution).

1978

The Natural Sciences and Engineering and Research Council of Canada (NSERC) was created and replaced NRC as the major source for funding Canadian university research. This resulted in the phasing out of the block grants which had been an important source of funding for the Institute since its creation. However, beginning the previous year, these had been replaced with a new program of supplementary grants in key areas of national interest and one of these was oceanography. The proposals submitted last year on the first round were quite successful with awards totalling \$200,000 which provided some temporary relief from financial woes. It was hoped that this program would continue.

The new MSc program in fisheries management was formally approved by the Maritime Provinces Higher Education Commission and the search for a new faculty member to lead it was begun.

Pete Wangersky stepped down as acting director and chair and was replaced by Tony Bowen. Soon after, he departed on a sabbatical to the Institutt for Marin Biokjemi at the University of Trondheim, Norway and the Istituto Italiano di Idrobiologia at Pallanza, Italy. Jim Richman departed to take up a position at Oregon State University. David Piper went on sabbatical leave to the University of Patras, Greece.



Anthony J. Bowen
Director 1978-1979, 1984-1986

It was noted that support for university research and training of graduate students oscillates on a four to seven year cycle with the general economy. The average residence time for graduate students approximates the economic cycle so that the supply of graduates tends to get out of phase with demand making it difficult to find funds to support new students at the bottom of the cycle. This year there was a sharp drop in applications but it was felt that career prospects in oceanography remained high because of the declaration of the 200-mile limit which was expected to increase the demand for trained ocean resource managers.

The following courses were now offered:

- Introductory Oceanography (Fournier)
- Introduction to Geological Oceanography (Beaumont/Piper)
- Introduction to Physical Oceanography (Huntley)
- Introduction to Chemical Oceanography (Moore)
- Introduction to Biological Oceanography (Mills/Wroblewski)
- Time Series Analysis (Huntley/Beaumont)
- Advanced Physical Oceanography (Bowen/Richman/Hendry/Garrett)
- Biology of Phytoplankton (Fournier)
- Biology of Zooplankton (Boyd)
- Biological Dynamics of Fisheries (Dickie)
- Advanced Chemical Oceanography (Bewers/Jones/Levy/Pocklington/Smith/Tan/Yeats)
- Fluid Mechanics (Garrett)
- Techniques of Biological Oceanography (Boyd/Wroblewski/Mills)
- Benthic Ecology (Mills)
- Marine Geology and Geophysics (Peirce/Reid)
- Physiology of Marine Plants (Craigie)
- Marine Modelling (Wroblewski/Garrett)
- Advanced Topics in Geophysics (Beaumont)
- Physics of the Earth (Beaumont)

Research highlights (including students and PDFs):

- A study of relationship between the tidal mixing parameter H/U^3 and summer stratification in the Bay of Fundy and Gulf of Maine was completed. Work was commenced to investigate the reasons for the substantial variations in tidal amplitude and phase observed along the edge of the continental shelf at the entrance to the Gulf of Maine (Garrett).
- Research on nonlinear interactions in shallow water continued but the main focus has been shifting towards problems involving sediment transport. Work also began on investigating the transport of sediment across the shelf break into deep water (Bowen).
- The CSS *Dawson* was used to measure bottom boundary layer turbulence in the strong tidal flow regime in the upper Bay of Fundy. Improvements were made to

- field instrumentation and the telemetry system can now be turned on and off remotely from the shore and transmit over 10 nm (Huntley).
- Work continued on defining ice margins, sea level, water mass distribution and sedimentation processes over the past 100,000 years in selected regions on the continental margin from Baffin Bay to Nova Scotia. Work also continued on mapping and interpreting coastal sediments along the south shore of NS. In addition a cruise on CSS *Dawson* to obtain seismic reflection profiles of the Quaternary sequence on the Laurentian Fan (Piper).
 - Modelling of the development of sedimentary basins on elastic and viscoelastic lithospheres progressed. Variations in postglacial relative sea level around Atlantic Canada were also modelled and work continued on studying creep mechanisms in rocks at the microscopic level. In addition, more work was done on tilt observations of earth tides and the loading effect of the ocean tides at Springhill and Shelburne (Beaumont).
 - Work continued on the distribution of particulate organic carbon in seawater and it was found that the concentrations measured depend upon the type of filter used. A new project was initiated to examine the effects of particle surface area on the regeneration rate of inorganic nutrients using a turbidostat (Wangersky).
 - Work continued on unraveling the details of the carbonate system in seawater. In addition, work also continued on studying methane in carbon-rich coastal sediments and the roll of bubbles in marine processes near the air-sea interface. Also, equipment was designed to determine the rates of degradation of particulate organic matter at different depths of the ocean (Cooke).
 - Research was initiated to explore the factors governing the distribution of trace metals in the ocean (Moore).
 - Studies of plankton dynamics and nutrient enrichment on the Scotian Shelf continued with two more cruises on CSS *Dawson* to the shelf-break front. The results indicated the importance of large internal tides with vertical excursions of 20-30. Other related studies included the interactions between phytoplankton and bacteria and phytoplankton-zooplankton interactions in the region of the chlorophyll maximum (Fournier).
 - Work continued on the physiological and biochemical responses of large algae to fixed nitrogen supplies and the biosynthesis and distribution of algal polysaccharides (Craigie).
 - Work continued on the feeding patterns of zooplankton off the coast of Peru and a new project was started examining the mouthparts of the euphausiid *Meganyctiphanes* using a scanning electron microscope. Other work included experimental studies on diel vertical migration, the abundance of copepods in waters of the Scotian Shelf and Slope and the feeding of the copepod *Calanus finmarchicus* off Labrador (Boyd).
 - Quantitative study of the mechanisms which produce the faunal and floral provinces in the sea was initiated. In addition, another new project investigated the role of herbivore grazing in shaping the spectra of particle sizes in the ocean (Wroblewski).
 - Work continued on determining the abundance and production of benthic organisms across the Scotian Shelf into the slope water region. Analysis of the

results allowed a comparison to be made between the fish production systems on the Scotian Shelf and the North Sea. Factors controlling the zonation of attached animals and plants in the rocky intertidal zone near Halifax were investigated. Work on the history of marine science focused on the background of benthic ecology before the HMS *Challenger* expedition. Other studies included the effects of competition, predation and food supply on the small scale spatial distribution of benthic animals, the ecological energetics of feeding by lobster in kelp forests and the distribution of seabirds on the Scotian Shelf in relation to environmental factors (Mills).

- Work continued on understanding the reasons for the differences observed in the growth and mortality of different mussel populations. Other studies included a bioeconomic analysis of Gulf of St. Lawrence fisheries and further development of acoustic methods for estimating fish populations (Dickie).

Six MSc and three PhD degrees were awarded. Only six new students were admitted so enrolment dropped slightly to 46.

Out of town visitors giving seminars included Dana Kester (Graduate School of Oceanography, University of Rhode Island), H. Thomas Rossby (Graduate School of Oceanography, University of Rhode Island), John Edmond (Massachusetts Institute of Technology), Jeremy Jackson (Johns Hopkins University), Akira Okubo (State University of New York), J. Rudi Strickler (University of Ottawa), Ian Morris (Bigelow Laboratory for Ocean Sciences), Scott W. Nixon (Graduate School of Oceanography, University of Rhode Island GSO), John H. Dearborn (University of Maine), Peter Wiebe (Woods Hole Oceanographic Institution), Lowell Sick (University of Delaware), Michael Mullin (Scripps Institution of Oceanography), Michael McIntyre (Cambridge University), J. Bishop (Lamont-Doherty Geological Observatory of Columbia University), Laurence McCrone (University of Washington), John Farrington (Woods Hole Oceanographic Institution), Richard Bray (University of California, Santa Barbara), R. Zingmark (Bigelow Laboratory for Ocean Sciences), D. Gardiner (Occidental College), Louis Legendre (Université Laval), Frederick T. Mackenzie (Northwestern University), Richard Haedrich (Woods Hole Oceanographic Institution), W.C. Clarke (University of British Columbia), N. Hogg (Woods Hole Oceanographic Institution), A. Gordon (Lamont-Doherty Geological Observatory of Columbia University), Creighton D. Wirick (Brookhaven National Laboratory), Scott Aikenhead (Fisheries Laboratory, St John's), Loren G. Hepler (University of Lethbridge) and David Farmer (Institute of Ocean Sciences, Patricia Bay).

1979

Perhaps biggest and most welcomed event of the year was the announcement of sharply increased funding for NSERC and its grants programs. It was expected that this would help to alleviate the perennial problems of student support and instrumentation replacement. However, since the Institute policy was to maintain an international mix of students, the problem finding funding for non-Canadian students remained. Another

increasing source of funding was contract research which by now amounted to about one quarter of the total oceanography budget.

Tony Bowen stepped down as acting director and chair and Pete Wangersky took over the reins for the third time after returning from his sabbatical. Barbara (Hendry) Goodman, the long-time Administrative Assistant, transferred to the English Department and was replaced by Elizabeth Tidmarsh from the Biology Department. Tony Koslow, a fisheries biologist from the Scripps Institution of Oceanography, joined the faculty to spearhead the new fisheries oceanography program. David Huntley departed on sabbatical to the Scripps Institution of Oceanography. P.E. Holloway (Physics) and Patricia Stoffin-Egli (Chemistry) arrived as postdoctoral fellows.

Research highlights (including students and PDFs):

- A review of the physical oceanography of Passamaquoddy Bay was prepared and the dynamical oceanography of the Strait of Belle Isle was investigated. Other studies included the interactions of surface waves with weak current jets, the forcing mechanisms of the observed clockwise gyre around Georges Bank and the physical dynamics of St. Georges Bay (Garrett).
- Work continued on several aspects of near shore oceanography and the development of turbidity currents. Other work included processing physical data collected on the CSS *Baffin* cruise to Peru (Bowen).
- A field experiment investigated the nature of waves and long shore currents over the undulating near-shore bottom at Malpeque, PEI (Huntley).
- Work on modelling the development of sedimentary basins continued. Significant advances were also made in understanding the post glacial rebound of the Earth's crust in eastern Canada since the end of the Wisconsinan glaciation. Tidal tilt measurements at Shelburne were completed and the results used to develop models of ocean tides and the structure of the Nova Scotian crust (Beaumont).
- Work continued on defining ice margins, sea level, water mass distribution and sedimentation processes over the last 200,000 years in selected regions of the continental margin from Baffin Bay to Nova Scotia. Methods were developed for dating foraminifera and used to correlate marine and land stratigraphies in the Baffin Island area. Work continued on mapping and interpreting coastal sediments on the South Shore of Nova Scotia. A general model for sedimentation in a Labrador fjord was developed and sedimentation processes on the Nova Scotian slope were investigated (Piper).
- Further improvements were made to the turbidostat, a device for maintaining cultures of diatoms at constant population density over long periods of time. Other studies included exploring the carbon flux in planktonic systems, laboratory experiments on the adsorption and biodegradation of anthropogenic surface-active materials and working out procedures for collecting surface-active organic matter using a bubble scavenging mechanism (Wangersky).
- Experiments were conducted to compare the relative behaviour of aragonite and calcite in seawater of increasing carbon dioxide concentrations and decreasing pH and more work was done on exploring the effects of bubble dissolution on organic

- matter. Other studies included investigating the chemical dynamics of anaerobic conditions in Halifax Harbour muds, a study of the carbonate system in the Arctic Ocean from an ice island as part of Lomonosov Ridge Experiment and determining the factors affecting the solubilization of polycyclic hydrocarbons in seawater (Cooke).
- A number of radioactive tracers were measured in the water column of the Arctic Ocean during the Lomonosov Ridge Experiment (LOREX) to measure vertical and horizontal mixing. In addition, ice cores were taken to define recent temporal changes in the tritium content of surface waters (Moore).
 - Research continued on the physical mechanisms which promote phytoplankton production on the Scotian Shelf including interactions with bacteria and zooplankton and the effects of bottom topography on production. Other studies included the importance of zooplankton in the subsurface chlorophyll maximum and the importance of particles on bacterial activity (Fournier).
 - Research on the physiology of large marine algae in high density cultures continued for potential application to the developing mariculture industry. In addition, the uptake and distribution of radiosulfate by a planktonic diatom was investigated (Craigie).
 - The deck-mounted planktonic counting system was redesigned so that signals could be processed, displayed and recorded in real time and the system could now be easily attached to a seawater line on a ship of opportunity. Other work included studying the feeding behaviour and resource partitioning of three copepod species in the Peruvian upwelling system, the modification of copepod behaviour as induced by feeding, the ecology of cladocerans in Bedford Basin, feeding of copepods, excretion of ammonia by microzooplankton, the swarming behaviour of euphausiids and a zoogeographic study of copepods on the Scotian Shelf, the Slope and fringes of the Gulf Stream (Boyd).
 - Models of the food webs supporting fisheries on the Scotian Shelf and slope were tested by using stable carbon isotopes to estimate trophic levels and transfer efficiencies. Invertebrates in the fresh water ponds on Sable Island were investigated with the aim to document the occurrence of amphipod crustaceans in as many habitats as possible. Further studies on the history of marine science focused on establishing the sequence of events between 1890 and 1935 that led to a well-articulated theory of plankton dynamics. Other work investigated the structure of subtidal benthic communities in Nain Bay, Labrador, the effect of oceanographic variables on the distribution of seabirds in Cabot Strait, the small scale spatial distribution of invertebrates along a transect across the Scotian Shelf and slope and the ecological energetics of lobster and their food (Mills).
 - Work continued on modelling the distribution of zooplankton in the sea as well as examining the plankton dynamics in warm core Gulf Stream rings. A new project was begun to investigate factors governing recruitment in fisheries, especially the relationship between mixing in the upper layer of the ocean, phytoplankton and zooplankton production and fish larvae survival. The new large grazing chamber was constructed to assess the role of herbivore grazing in shaping the spectrum of particle sizes in the ocean was test on a CSS *Dawson* cruise to Sargasso Sea (Wroblewski).

- Work continued on evaluating the genetic control of production parameters in mussels. Two cruises on MV *Prince* were conducted to evaluate the use of the acoustic systems being developed for studying the behaviour of fish aggregations. A final workshop was held to discuss the results of the highly successful 1977 CSS *Baffin* cruise to Peru which was organized in cooperation with Peruvian scientists investigate the production of anchoveta an upwelling ecosystem. Other studies include experimental measurements of food uptake, growth and activity of juvenile cod and the analysis of the economic and biological factors affecting fisheries production in the Gulf of St. Lawrence (Dickie).

Two MSc and three PhD degrees were awarded. Ten new students were admitted bringing the total up to 55, a new record.

Out of town visitors giving seminars included Edward Bousfield (National Museum of Canada), Mel Briscoe (Woods Hole Oceanographic Institution), Bradford Butman (US Geological Survey), W.B. Clarke (McMaster University), Manfred Ehrhard (Institut für Meereskunde, Germany), Paul Falkowski (Brookhaven National Laboratories), Charles Hall (Cornell University), Richard Harbison (Woods Hole Oceanographic Institution), Peter Hendrikson (University of Kiel, Germany), Tony Koslow (Scripps Institution of Oceanography), F. Mantoura (Woods Hole Oceanographic Institution), Geoff Millward (Plymouth Polytechnic, UK), Brian Nakashima (McGill University), Barry Parsons (Massachusetts Institute of Technology), Brian Riddell (McGill University), Frank Rigler (McGill University), Gary D. Sharp (FAO, Rome), Joel Sohn (Museum of Comparative Anatomy), Derek Spencer (Woods Hole Oceanographic Institution), Rudi Strickler (University of Ottawa), A.V. Tyler (Oregon State University), Tony Watts (Lamont-Doherty Geological Observatory), Mark Wimbush (Graduate School of Oceanography, University of Rhode Island) and Val Worthington (Woods Hole Oceanographic Institution).

1980

The new Strategic Grants Program was announced by NSERC and one of the panels created focused on ocean research. This was expected to be an important source of funding for the indefinite future. Several faculty members later served on the panel adjudicating research proposals from university marine labs across Canada.

Henry Hicks, a long time supporter of the Dalhousie oceanography program and the one responsible for hiring Gordon Riley, retired as university president and was placed by Andrew MacKay.



Robert O. Fournier
Director 1980-1984

Bob Fournier was appointed as full time director and chair, thereby relieving Tony Bowen from these duties, who then departed on sabbatical leave to Oregon State University. Chris Beaumont was awarded a prestigious Steacie Memorial Fellowship by NSERC and departed on sabbatical leave in New Zealand. Gordon Riley was selected by the US National Academy of Science to co-chair their panel on petroleum in the marine environment. Three new faculty positions in oceanography were approved by the university, two in geology and one in physical oceanography, and recruiting for suitable candidates was initiated.

The Scientific Committee for Oceanic Research (SCOR), an international non-governmental non-profit organization under the International Council of Scientific Unions (ICSU), moved its secretariat from England to Dalhousie. Elizabeth Tidmarsh, administrative assistant in the Institute, was appointed as Executive Secretary. This move was expected to increase the involvement of Dalhousie in international oceanography. In collaboration with BIO, preparations were immediately begun to organize the next Joint Oceanographic Assembly (JOA) to be held in Halifax in 1982. This event, organized by SCOR and held every six years, was the world's largest inter-disciplinary gathering of oceanographers.

Research highlights (including students and PDFs):

- Circulation and mixing on continental shelves was a major interest this year. Tidal mixing and rectification were investigated with particular reference to the Georges Bank region of the Gulf of Maine. A time dependent numerical model of the Bay of Fundy was developed to better understand horizontal diffusivity. A two-layer baroclinic numerical model was developed for St. Georges Bay. In addition, studies were continued in the Strait of Belle Isle and a study of sea level variability over the whole North Atlantic was initiated (Garrett).
- Theoretical and experimental work on beach profiles continued. This included using a vertical array of flow meters at Queensland Beach to investigate

hydrologic input for sediment transport and the development of a model depicting the growth and effects beach cusps. Work also continued on a number of problems related to sedimentation on shelf edge and upper slope and the dynamics of turbidity currents on the continental slope (Bowen).

- Near shore waves and currents continued to be the main area of research. A model was developed for the long period waves generated when alternating groups of high and low waves break at the shoreline (Huntley).
- Research continued on earth-tides and secular tilting of the Earth. A thermal stretching model was used to explore the development of Atlantic-type continental margins. Other studies addressed post-glacial rebound and sea level change in eastern Canada and the isostatic adjustment of viscous and viscoelastic earth models (Beaumont).
- The study of sedimentary and late Quaternary history of the south shore of Nova Scotia was completed. Other work included developing a sedimentation-acoustic stratigraphy model for Makkovik Bay, Labrador, establishing a late Quaternary stratigraphy for Baffin Bay and using marine palynomorphs for developing paleo-oceanographic stratigraphies (Piper).
- Further improvements were made to the turbidostat so that it could be used to explore the effects of nutrient stress on the release of organic materials in unialgal cultures. Other work included studying the effects of inorganic particles on regeneration of nutrients in seawater and the use of particulate organic matter by microzooplankton (Wangersky).
- Experiments investigating chemical processes in the marine carbonate system continued, most of which involved high pressure reactions. One project was examining the bacterial mediation of redox reactions in sediments and the effect of pressure on the growth kinetics of manganese-precipitating bacteria (Cooke).
- Analyses of trace metals in water samples from the Arctic Ocean were completed and the resulting distributions reflected a number of important oceanographic features including well-defined horizontal advection, low biological productivity and a large freshwater contribution to the surface layer. In addition, work began on developing a method for measuring dissolved iron in seawater (Moore).
- Capping four years of concerted effort, additional cruises were carried out to further understanding of the various processes which contribute to primary production on the Scotian Shelf. This included another cruise to the Laurentian Channel-Cabot Strait to examine the effects of bottom topography on surface production which utilized an *in situ* fluorometer which permitted rapid profiling of chlorophyll. In addition, chlorophyll degradation rates were studied as a means of estimating rates of delivery of phytoplankton to sediment (Fournier).
- Work on the Peruvian upwelling system was completed. A new study commenced on examining the secondary production of zooplankton in the Gulf of Maine and will involve collecting data on a weekly basis from the ferry running between Yarmouth and Portland, Maine. Other studies included developing a new method for calculating zooplankton production, examining resource partitioning by copepods on the Scotian shelf, determining the importance of ammonia regeneration with respect to the availability and utilization of nutrients by phytoplankton in Bedford Basin, the swarming of krill off Brier Island, NS, in

- relation to feeding, tidal currents and other factors and differences in copepod communities in the major water masses off Nova Scotia (Boyd).
- The energy balance of chaetognaths in Bedford Basin was investigated and in collaboration with BIO a trap system for studying the vertical migration of zooplankton was developed and tested in St. George's Bay (Pearre).
 - In collaboration with BIO, work continued using stable carbon isotopes to unravel the links in the food webs supporting both pelagic and demersal fisheries on the Scotian Shelf. Continuing research on the history of marine science focused on the development of plankton dynamics between about 1890 and the 1940s. Studies of the subtidal benthos of Nain Bay, Labrador neared completion as did studies of the distribution of seabirds in Cabot Strait in relation to water temperature and feeding patterns. Other projects addressed the effects of fishing regulations on the herring fishery in southwestern Nova Scotia as seen by commercial fishermen and the food resources of lobsters in southwestern Nova Scotia (Mills).
 - A model was developed which addressed the survival of fish larvae during the critical period after yoke sac depletion when first feeding must occur. Theoretical work was completed that described the influence of predation on shaping the spectrum of particle sizes in the marine ecosystem (Wroblewski).
 - Research was initiated toward understanding the ecology of the recruitment process and the role of fish populations within marine ecosystems. A field program was planned for 1981 to study the interactions between hydrography, primary and secondary production and the distribution and feeding of herring stocks off southwest Nova Scotia (Koslow).
 - The behaviour of squid in a stratified water column was studied in the tower tank (Balch)

Six PhD degrees were awarded. Fifteen new students were admitted bringing the total up to an all time high of 60.

1981/ 1982

In collaboration with BIO, the Institute co-hosted the highly successful Joint Oceanographic Assembly (JOA) in Halifax during August 1982. This major international event was attended by more than 800 marine scientists from around the world and solidified the importance of the Halifax/Dartmouth area as a leading international centre for marine research. This year also marked the passing of Ron Hayes, the founder and first director of the Institute. Funds left over from the JOA were used to establish the F. Ronald Hayes International Scholarship to be awarded annually to the most deserving student in oceanography from a third world country.

David Piper resigned and moved to BIO to join the Atlantic Geoscience Centre (AGC) of the Geological Survey of Canada (GSC). However, three new scientists joined the faculty. Barry Ruddick, a physical oceanographer, arrived from the Australian National University. Keith Loudon, a geophysical oceanographer, arrived from Cambridge University, while Larry Mayer, another geophysical oceanographer, arrived from the

Graduate School of Oceanography at the University of Rhode Island. These arrivals increased the faculty to sixteen, the highest yet. Hence, the oceanography program continued to expand and assume a progressively higher profile in the international oceanographic community. In 1981, Chris Garrett departed on sabbatical leave at Cambridge University while Eric Mills departed on sabbatical leave at the University of Edinburgh. Hans Jochim Kumpel, Jeffrey Runge, Jerry Cheney and Jonathan Grant arrived as postdoctoral fellows.

There continued to be a shortage of graduate students in physical oceanography, both nationally and internationally, despite the fact that there were many important problems to tackle and job opportunities were good.

To honour the outstanding scientific career of Gordon Riley, his Dalhousie colleagues produced a volume of his most influential scientific publications which were reprinted in their entirety (Wroblewski 1982). Many of these papers were classics and as relevant as they were when first published. This wonderful tribute included a foreword by Henry Hicks and essays by Evelyn Hutchinson, Eric Mills, Robert Fournier, Peter Wangersky and Edward Deevey.

In 1982, Chris Garrett won the prestigious A.G. Huntsman Award. Administered by BIO, this international award is presented annually by the Royal Society of Canada to a marine scientist of any nationality in recognition of the excellence of research and outstanding contributions to marine sciences.

Research highlights (including students and PDFs):

- Theoretical and observational studies of the physical oceanography of straits continued with focus on the Strait of Belle Isle. In response to proposals for disposing of low-level nuclear wastes in the deep sea, models of the effects of bioturbation and sinking particles on seabed pollutants were developed. Other studies continued to examine the physical oceanography of St. Georges Bay and Gulf of St. Lawrence, using satellite altimeter data to study deep-sea tides, developing models of tidal rectification on the sides of banks and the effects of changing wind stress on monthly mean sea levels in the North Atlantic (Garrett).
- Theoretical and experimental work on near shore dynamics continued on several fronts. A study of the coastline east of Halifax done under contract with the Nova Scotia Department of Lands and Forests led to a useful overview of the processes that control breaches and other coastal formations. In addition, studies of the dynamics of turbidity currents were completed and applied to the study of turbidite deposits (Bowen).
- Near-shore processes continued to be a major focus of research. It was demonstrated that variable height breaking waves can generate long period oscillations with a seaward propagating long period wave beyond the breaking point. Research began on examining turbulence and stresses in the benthic boundary layer and their implications for sediment transport on the continental shelf. A model of the Canadian Archipelago was developed to study the response of the system to disturbances in tidal periods. In addition, the exchange

- and mixing of water near the entrance to Bedford Basin and their influence on phytoplankton were investigated (Huntley).
- CSS *Dawson* was used to study warm core rings of the Gulf Stream (Ruddick).
 - Work continued on studying the geodynamic processes that determine the geology of ocean basins, continental margins and continental interiors. Tidal tilt studies investigated whether there were large-scale changes in the properties of the crust that were related to the earthquake cycle. Relative sea level change in Atlantic Canada and around Baffin Island were interpreted in terms of a global model of rebound since the last deglaciation. In addition, the rheological implications of a cooling plate model of ocean lithosphere were investigated and a number of projects examined the formation and evolution of sedimentary basins. (Beaumont).
 - Several new geophysical projects began which addressed the history and structure of ocean basins and margins. These included seismic investigations of oceanic crust, the thermal structure of ocean basins and margins and isostatic compensation of oceanic topography (Louden).
 - A new program was begun to develop new, quantitative, high resolution seismic profiling techniques and apply them to study marine sediments. A new hydraulic piston corer was used in Leg 85 of the Deep Sea Drilling Program in the central equatorial Pacific (Mayer).
 - Using turbidostats, studies of the effects of nutrient stress on exudation of dissolved organic matter by phytoplankton continued and the results strongly suggested that nutrient stress is a major factor in the production of extracellular organic matter. Other studies included construction of a battery-powered continuously recording backscatter turbidimeter for measuring the distribution of particulate matter in seawater, the isolation and partial chemical characterization of bubble transportable organic matter in seawater, the weathering of oil spills on sandy beaches, the chemistry of lipids of biogenic origin and the effect of dissolved organic matter on the solubility and accommodation of polyaromatic hydrocarbons in seawater (Wangersky).
 - Experimentation on high-pressure reactions, marine carbonate chemistry, the physics and chemistry of small bubbles and the effects of high temperatures and pressures on clay sediments in the marine abyss continued (Cooke).
 - Attention continued to be focused on processes of addition and removal of trace metals in seawater, in particular aluminum. Natural radio-isotope disequilibria were used to determine the removal rates of elements with relatively short residence times in the Arctic Ocean. In addition, a gas chromatographic method was developed for measuring Freon 11 and 12 in seawater (Moore).
 - Investigations continued on the role of physical factors in controlling biological productivity on the Scotian Shelf, with recent attention directed to the region off southwest Nova Scotia which is the most productive portion of the shelf. Nitrate and ammonium assimilation by phytoplankton were studied as was the subsurface chlorophyll maxima in coastal waters with emphasis on the delimitation of zooplankton co-occurrence. Other projects addressed chlorophyll and its breakdown products, relationship between bacteria and phytoplankton and the

interrelationships between light and nutrient utilization by phytoplankton (Fournier).

- The Yarmouth to Portland ferry was used as a sampling platform for measuring secondary production in the Gulf of Maine. Using a container laboratory, water was collected from a through-hull fitting while the vessel was underway and passed through a series of electronic sensors that measured time, temperature, chlorophyll and zooplankton. Two crossings were made each week for 15 months. In cooperation with Poland, a study of the mechanisms and rate of feeding of Antarctic krill was carried out. In addition, studies were also conducted on the metabolic costs borne by copepods feeding on phytoplankton, the distribution of copepods on the Scotian Shelf, the feeding and reproductive rates of ciliate microzooplankton, the retention of food particles by euphausiids and the fitness of hake larvae in the Gulf of St. Lawrence (Boyd).
- Work continued on the feeding ecology of chaetognaths and, in collaboration with BIO, the production and vertical migration of zooplankton in St. Georges Bay (Pearre).
- Work on phenomena associated with Gulf Stream eddies continued which included investigating the entrainment of fish larvae. In addition, research was underway to improve the ecological basis for management of fisheries (Wroblewski).
- Work continued on studies of the structure of the Scotian Shelf food web supporting fisheries using stable carbon isotopes as tracers and it was found that the length of the food chain from phytoplankton to demersal fish was no more than five steps. Other studies included the relationship between bottom currents, sediment texture and food availability for benthic animals, the subtidal benthos of Nain Bay, Labrador, the distribution of food resources for lobster in and out of sea urchin dominated barrens, laboratory flume studies examining how bottom roughness can affect the supply of organic matter to the seabed, developing a new technique to separate biologically-significant natural particles from sediment so that their food value could be determined and the relationship between food input and patch size of benthic invertebrates (Mills and Grant).
- Several cruises off southwest Nova Scotia examined the relationships between the distribution and production of zooplankton and herring in relation to topography, hydrology and phytoplankton. Predation by adult mackerel on ichthyoplankton in the Gulf of St. Lawrence was examined to determine the importance of fish predation on larval fish mortality. A statistical study of climate and marine ecology in the North Atlantic was carried out through analysis of time series of air pressure, air and sea temperature, salinity, plankton abundance and fisheries recruitment. Other projects included the physical-biological interactions and their effect of fishery recruitment in Atlantic Canada, the incidence of parasites on larval herring in the Bay of Fundy and the energetics and growth of cod based on experimental work in the pool tank (Koslow).
- The reproductive biology and early life history of oceanic squid were studied in pool tank (Balch).

Nine MSc and six PhD degrees were awarded during this two-year period. Twenty new students were admitted bringing the total to an all time high of 66.

1983/1984

After serving for four years, Bob Fournier stepped down as director and chair in June 1984 and was replaced by Tony Bowen. Marlon Lewis, a biological oceanographer, and Keith Thompson, a physical oceanographer, joined the faculty. Bob Moore departed for a sabbatical at the University of Otago, New Zealand, and the Institute for Marine Environmental Research, UK. Bob Cooke departed on sabbatical at the University of Alberta and Carl Boyd departed on sabbatical to New Caledonia. Glen Stockmal, Louise Royer, Dan Hanes and John Middleton arrived as postdoctoral fellows.

The 25th anniversary of the Institute was quietly celebrated. It had come a long way since it was created in 1959. Key people since departed were fondly remembered for their contributions to the growth and development of the Institute.

Research highlights (including students and PDFs):

- A new program was initiated to investigate iceberg trajectories off the coast of Labrador using data collected by the oil and gas industry with the goal of providing an optimal statistical forecasting scheme. Work on flow through the Strait of Belle Isle continued and the experience gained was applied to studying seasonal changes in the flow through the Strait of Gibraltar. Further work on tidal modelling in the Bay of Fundy was conducted to improve earlier predictions of tidal power impacts. It was recognized that understanding the role of the oceans in climate was a topic that would become increasingly important in the future. Therefore, another new program began to use the extensive meteorological and oceanographic data sets collected for many years at weather station Bravo in the Labrador Sea to learn more about air-sea exchange and deep convection (Garrett).
- Work continued on turbidity currents, shelf dynamics, near shore processes and sediment transport. Contributions were made to the Canadian Coastal Sediment Study, sponsored by a number of government departments, and field work was conducted in both New Brunswick and Prince Edward Island (Bowen).
- Work continued on near shore processes and continental shelf bottom boundary layers. This included participating in the Canadian Coastal Sediment Study. An instrumented platform for measuring flow within one meter of the seabed was developed and deployed successfully in the field at depths ranging from 10 to 270 m (Huntley).
- The intrusion of a tongue of cold shelf water into a warm-core Gulf Stream ring was traced using Batfish data. Laboratory and theoretical work addressed the effects of double-diffusion ocean mixing mechanisms and the action of friction on the Gulf Stream was examined (Ruddick).
- The influence of Ekman pumping over the North Atlantic on the transport of the Labrador Current was investigated. Also, in collaboration with BIO, the spatial scale of monthly sea surface temperatures from Cape Hatteras to Cape Farewell and their relationship to climate and fish recruitment was examined (Thompson).

- Research addressed large-scale oceanic diffusion problems and turbulence (Middleton).
- Research continued to address the kinematic and dynamic understanding of both long term and short term processes that determine the character of the geology of the ocean basins, continental margins and continental interiors. This work included the development and application of various numerical models and results could be used for assessing hydrocarbon potential (Beaumont).
- Marine geophysical research continued using a diverse set of measurement techniques to investigate the structure and history of ocean basins and margins. It included heat flow measurements in Sohm abyssal plain and off Labrador, conducting seismic studies of the ocean crust using a newly developed ocean bottom seismometer and gravity measurements across continental margins (Louden).
- Research continued on developing new high-resolution seismic profiling techniques to address specific geological and acoustic problems. These were used in field programs conducted in Narragansett Bay, RI, the Laurentian Fan, off Cape Hatteras and in the equatorial Pacific during Leg 85 of the Deep Sea Drilling Program. Preparations were being made for a major expedition to the Kane Fracture Zone along the Mid-Atlantic Ridge (Mayer).
- Work on the cage-culture turbidostat continued and four units were now available for experiments with diatom cultures to determine the effects of nutrient, light and heavy metal stress on the rate of production of organic exudate. A battery powered recording back-scatter turbidity meter was built to measure particulate matter in seawater. In addition, an *in situ* pump sampler was developed to collect water for chemical analysis from ships of opportunity. Other studies included the collection of trace metals on particles created by the solution and breaking of bubbles in seawater, the lipid composition of copepods and the biogeochemical cycle of copper in seawater. (Wangersky).
- Research continued on various aspects of the marine carbonate system. In addition, work was carried out on calculating the partial molal volumes of important anions and cations in seawater (Cooke).
- Water samples were collected for metal scavenging, freon and natural radioactive isotopes studies from an ice island in the Arctic Ocean as part of the Canadian Expedition to study the Alpha Ridge (CESAR). A newly-constructed submersible pump was used to collect water samples down to depths of 1500 m. Research continued on the distribution of dissolved chlorofluoromethanes in Arctic waters (Moore).
- Investigations continued on biological processes off southwestern Nova Scotia, a region of unusually high productivity that supports a large and active fishery, with an emphasis on the winter months. Other projects included exploring the functional interrelationships between bacteria and phytoplankton and the analysis of phytoplankton pigments using high-pressure liquid chromatography (Fournier).
- In collaboration with BIO, theoretical, experimental and observational studies were initiated on various interactions between biological and physical oceanographic processes. The influence of different wavebands on natural populations of phytoplankton was measured for the first time (Lewis).

- The field program measuring secondary production in the Gulf of Maine using the Yarmouth to Portland ferry was completed after 57 consecutive weekly crossings. Other studies underway included the feeding of copepods on toxic dinoflagellates, culturing of marine ciliates, developing a method to estimate the volume of oil sacs in copepods, feeding of euphausiid shrimps, the flux of zooplankton feces to the benthic environment, using acoustics to estimate the biomass of herring schools and the mixing of copepods between the Scotian Shelf and the Sargasso Sea (Boyd).
- Numerous projects were underway exploring the growth and reproductive processes of the copepod *Calanus finmarchicus* (Runge).
- A literature survey was carried out to examine the size frequency of prey consumed by field-caught fish and it was found that the feeding niche width stays approximately the same as fish grow (Pearre).
- An instrumented flume system was constructed for studies of biological and physical processes in the benthic boundary layer in order to help assess the amount of food material available to the benthos. Other studies included investigating the effect of diatom mats on the transport of intertidal sediments, the vertical gradients of particle flux above natural sediments and the patchiness of polychaete worms (Mills and Grant).
- Work exploring the relationships between marine climate, ecology and fishery recruitment continued. Other studies included assessing the influence of advection on the early life history of haddock off southwest Nova Scotia, the feeding selectivity and foraging behaviour of Atlantic mackerel, the retention of water on Flemish Cap and its implications for zooplankton populations and larval redfish, the feeding, energy storage and energetics of cod, the development of zooplankton communities off southwest Nova Scotia, parasitism in larval herring from the Bay of Fundy and Gulf of St. Lawrence and the effects of density-dependence and age-structure on the reproductive effort in fish and their implications for fish population dynamics (Koslow).
- Further experimental work using the Aquatron on the early life history of oceanic squid led to the discovery of an important spawning area along the shoreward edge of the Gulf Stream between Cape Hatteras and Miami (Balch).

One MSc and two PhD degrees were awarded. Fourteen new students were admitted during 1983 and 1984 bringing the total number down to 61.

1985

After a long battle with cancer, Gordon Riley passed away and his ashes were spread in his beloved woods at Coxs Lake. Fitting tributes to his life and career were written by G. Evelyn Hutchinson (Hutchinson 1986) and Lloyd Dickie (Dickie 1987). In his memory, the Department of Oceanography created the Riley Lecture which is given annually by a prominent oceanographer selected by graduate students. The private road leading to his Coxs Lake cottage was later named Riley Road by the County of Halifax.

Five MSc and nine PhD degrees were awarded.

1986

Bruce Johnson, a graduate of the Institute, joined the faculty thereby strengthening the chemical oceanography program. Tony Koslow departed on sabbatical leave at the University of the West Indies in Jamaica while David Huntley departed on sabbatical leave at the Southampton University, UK.

Financial constraints on oceanographic research continued in the universities as well as in government and industry. The news was mostly bad. In particular, the federal Department of Fisheries and Oceans was undergoing substantial financial cuts and a major re-organization was having huge impacts on BIO (Gordon 2021). Both the Atlantic Oceanographic Laboratory (AOL) and the Marine Ecology Laboratory (MEL), which had been close associates of the Institute for over twenty years, were disbanded. AOL staff were able to continue their most important programs under the new organization with minimal disruption while, with the exception of the Biological Oceanography Division, MEL staff were split asunder and integrated into the more applied fisheries divisions of the department. This resulted in a huge protest within the Canadian marine scientific community, and Institute faculty, led by Eric Mills, came to the defense of MEL and advocated for reversing these decisions. Unfortunately, these arguments fell on deaf ears and there was no going back. Staff morale at BIO plummeted.

Despite the difficult times, graduates continued to do well with placement and most continued to be involved in oceanographic research. However, a major concern continued to be the number, quality and disciplinary mix of applicants which was quite variable year to year. In general, there was a shortage of qualified applicants but nevertheless nineteen new students were admitted from Canada, Brazil, Chile, China, France, Italy, New Zealand, Nigeria, Spain and the US, a truly international mix.

Research highlights (including students and PDFs):

- The study of iceberg trajectories was completed and operational models for forecasting impacts on oil rigs were developed. Work on flows through the Strait of Belle Isle and Strait of Gibraltar continued. A model was developed for predicting the dispersion of decaying radioactive wastes at a deep-sea dump and was used by the US Atomic Energy Commission to establish regulations. Work on the wind driven circulation of St. George's Bay was completed and satellite IR imaging was used to study upwelling and cross-shelf mixing off Nova Scotia (Garrett).
- Work on near shore dynamics focused on wave evolution during shoaling, wave-wave interactions, long waves and wave driven currents. Boundary layer research addressed processes of physical, geological and engineering interest operative on beaches and the continental shelf and slope, particularly the factors involved in the modelling of sediment transport. The dynamics of turbidity currents on the continental slope and in the deep ocean were also investigated. Expanding

- offshore oil and gas exploration was increasing the need to understanding both near shore and offshore sediment transport (Bowen).
- Research on near shore processes and continental shelf bottom boundary layers continued. This included further processing of data collected during the Canadian Coastal Sediment Study and a study of waves and rip currents at a pocket beach in Jamaica. In addition, a new technique was developed for estimating bottom stress from turbulence measurements (Huntley).
 - The mechanisms and effects of ocean mixing continued to be studied. In collaboration with BIO, the dissipation of a lens of Mediterranean Sea water was successfully tracked using acoustic SOFAR floats. Work on double diffusive ocean mixing continued and satellite imagery was used to quantify the mixing between the Grand Banks and surrounding waters (Ruddick).
 - The study of North Atlantic sea level and its relationship to changes in ocean circulation was completed. A new project was started to develop models useful in interpreting the oceanographic data collected on the Scotian Shelf during the Canadian Atlantic Storms Program (Thompson).
 - Investigations continued on deformation processes of the lithosphere and their consequences for the large-scale geological features of the Earth. These included rifting and the formation of passive continental margins, lithospheric compression, the development of orogens and their associated sedimentary basin and earth tides, tectonic stress and earthquakes (Beaumont).
 - Investigations continued on the structure and history of ocean basins and margins. These included heat flow in the basins and margins of eastern and northern Canada and seismic studies of oceanic crust (Louden).
 - Broad-beam seismic deep-towed profiling systems were used to determine quantitative sediment properties, an analytical system for measuring sound wave speed and attenuation in laboratory samples was developed to verify field sonar records, seismic modelling was used to examine the origin of a series of regionally correlatable seismic reflectors in the equatorial Pacific, using a deep-towed system a detailed sidescan sonar survey of the Mid Atlantic ridge was conducted in order to select drill sites for the Ocean Drilling Project and studies were conducted of the 1929 earthquake south of the Grand Banks and resultant turbidity current (Mayer).
 - Work continued on investigating the nature and distribution of particulate matter in the ocean. This included the development of a recording backscatter photometer which was incorporated into a CTD to provide the real time simultaneous measurements of salinity, temperature, backscatter and oxygen. A 200 l cage culture turbidostat was constructed for the mass culture of diatoms (Wangersky).
 - Using several approaches, the general problem of carbon dioxide distribution between calcareous marine sediments, the oceans and the atmosphere continued to be investigated (Cooke).
 - A study of chemical and physical processes in arctic shelf environments was initiated with the Institute of Ocean Sciences in Southampton, UK, with focus on the Beaufort Sea. Other work included trace element scavenging in the Arctic

- Ocean, the dynamics of suspended particles in the ocean and the use of freon for studying mixing processes in the Arctic Ocean (Moore).
- Laboratory and field studies on the distribution and settling behaviour of particulate materials in the ocean continued. A back scatter camera system for determining the distribution and morphologies of suspended particulate materials was successfully used on four cruises on the Scotian Shelf. Studies on floatation and surface coagulation continued and included field studies at Niagara Falls (Johnson).
 - Theoretic, experimental and observational studies of various interactions between biological and physical oceanographic processes continued. The implications for using remote sensing of phytoplankton production in the sea were investigated as was the role of the ocean as a sink for atmospheric carbon dioxide through photosynthesis. Algae that inhabit the underside of Arctic ice were also studied (Lewis).
 - Four months were spent at the US Palmer Station in the Antarctic studying the feeding of krill and further work was done on processing the data collected from ferry program in the Gulf of Maine. Other studies included examining the feeding of krill feeding in the tower tank, prey selectivity by krill, the feeding of ciliates on phytoplankton, the impacts of toxic algae on copepods and the carbon/nitrogen ratio of fecal pellets in relation to food ingested (Boyd).
 - Research continued investigating the relationship of trophic niche width to predator size in predators which swallow their prey whole as well as, in collaboration with BIO, the vertical migration of zooplankton in St. Georges Bay (Pearre).
 - Work continued on the relationships between climate, oceanography and fisheries in the northwest Atlantic and the ecology and management of Caribbean reef fisheries. It was demonstrated that recruitment of cod and haddock is linked to regional climatic indicators. Other studies included the feeding, energy storage and energetics of cod feeding selectivity and foraging behaviour of mackerel and their possible influence on larval behaviour, and retention of water on the Flemish Cap and its implications for zooplankton populations and larval redfish mortality (Koslow).
 - Research continued on assessing the role of near bottom flows in affecting and controlling the supply of food to benthic invertebrates using the instrumented flume system previously built. In addition, field research on particle fluxes and their role as food for benthic animals continued. The research submarine Pisces was used in St. Margaret's Bay to investigate the organic quality of marine snow and resuspended sediments. Other studies included determining the metabolic efficiency and production of marine microfaunal animals, the ecological genetics of the sea scallop, and the food resources of lobsters. And finally, the long term project on the history of plankton dynamics was completed and a book manuscript prepared (Mills and Grant).
 - Studies on squid continued and included experiments in the Aquatron and two cruises on the RV *Needler* were made to spawning areas along the western edge of the Gulf Stream between Cape Hatteras and Miami (Balch).

Three MSc and four PhD degrees were awarded. Thirty-five new students were admitted over 1985 and 1986 bringing the total to an all time high of 79.

Up to 1984, the annual or biennial reports of the Dalhousie oceanography program had been issued under the name of the Institute of Oceanography, a tradition started from its founding in 1959. In 1971, all functions except the Aquatron were incorporated into the new Department of Oceanography but the tradition of the Institute preparing the reports continued. However, in 1986, the ghost of the Institute was finally laid to rest as part of a university-wide rationalization of centres and institutes. This closure marks the end of this history. Hopefully, some time in the future someone else will step forward to document the history of the Department from 1986 to the present.

SUMMARY

Three people are largely responsible for the creation of the Department of Oceanography as it is known today. The first was Ron Hayes. In the late 1940s, it was proposed that a university institute of oceanography be created somewhere in Canada and the University of British Columbia (UBC), McGill and Dalhousie expressed interest in hosting such an institute (Mills 1994). After considering many factors, the Joint Committee on Oceanography (JCO) selected UBC and the UBC Institute of Oceanography (IOUBC) was thereby created in 1949. However, soon after IOUBC was established, Ron Hayes began to lobby for the creation of a similar institute at Dalhousie. At first he was not successful in convincing the JCO of the need for a second academic oceanographic institute in Canada but he persisted and in 1959 they decided to create the Institute of Oceanography at Dalhousie (IODal). Ron Hayes was appointed as Director and led the development of the Institute over the first five years.

The second was Henry Hicks who was the President of Dalhousie from 1963 to 1980 and led the transformation of Dalhousie from the tiny "College By the Sea" into a leading national research university. During his tenure, the university underwent a complete transformation as new facilities and programs were built or expanded for all areas of the university, including research. He was particularly interested in developing the fledgling Institute of Oceanography into a major centre of international renown and gave his full support to developing the Department of Oceanography and building the Oceanography Building with the Aquatron.

The third, and most important, was Gordon Riley. Dalhousie University was extremely fortunate to have landed him. He was upset that Yale University refused to create the department of oceanography that he desired and, as a result, was looking for a new home. And just by chance at the same time, the Institute of Oceanography was looking for a new director. It was a perfect fit with perfect timing. When he arrived in 1965 he had a clear vision of what he wanted to do. Under his leadership, with the full support of Henry Hicks, the Institute developed into a full graduate Department of Oceanography with an expanded multidisciplinary teaching and research program. He also led the development of the Life Sciences Centre that included the Oceanography wing and the

Aquatron. Working from this foundation, the Department developed into a major international centre for oceanographic research and education, a feather in the cap for Dalhousie University and the Canadian oceanographic community.

It is interesting to note the indirect influence of G. Evelyn Hutchinson on the development of the Institute. He was a leading limnologist and ecologist at Yale University who, over his long career, supervised a large number of graduate students who came to Dalhousie including Gordon Riley, Edward Deevey, Peter Wangersky, Ian McLaren, Eric Mills and Roger Doyle. By the early 1970s, the greatest number of branches on the Hutchison family tree, including second generation students, had sprouted in Halifax/Dartmouth (Kohn 1971).

The Institute was most fortunate to be located across the harbour from the Bedford Institute of Oceanography (BIO) which was opened in 1962. From the very beginning, both institutes promoted collaboration. Gordon Riley and Bill Ford were good friends who had worked together at the Woods Hole Oceanographic Institution in the 1940s. BIO provided free ship time on major vessels, many staff served as associates who taught and supervised students and numerous collaborative projects were established. In exchange, many graduates found employment at BIO, especially in the early years when federal oceanographic programs were expanding.

The personnel in the Institute from 1959 to 1986 was heavily male dominated. Only a few women were admitted as students, few were appointed as associates or postdoctoral fellows and none were appointed to faculty positions. This significant imbalance, a product of the times, was fortunately corrected in later years

While the BIO oceanographic research program today is only a fraction of what it used to be, the Dalhousie Department of Oceanography fortunately continues to thrive. The current 2021 web site lists 21 faculty members (including 8 women), 7 emeritus scientists, 7 adjunct staff, 37 research staff and 61 graduate students. Research is carried out in all the oceanographic disciplines, much of it as part of national and international programs. The traditions established during the founding years of the Institute continue. However, one major recent change has been the introduction of a four-year undergraduate program in oceanography.

ACKNOWLEDGEMENTS

First and foremost I thank Eric Mills for his encouragement throughout this project and the loan of his collection of the Institute annual/biennial reviews. I thank the directors for ensuring that these indispensable documents were prepared on a regular basis. I also thank my many colleagues who provided information and comments on earlier drafts that improved this history considerably. These included Eric Mills, Carl Boyd, Bob Cook, Lloyd Dickie, Bosko Loncarevic, Alan Ruffman, Barry Hargrave, Tim Lambert and Paul Hill. Sharon Bellefontaine kindly assisted in providing some photographs. I especially want to thank Gordon Riley for bringing me along with him as a graduate student when

he moved to Dalhousie in 1965, a move which changed my life forever. And finally, I thank the COVID-19 pandemic for allowing me to ‘stay the blazes home’ to prepare this history.

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APPENDIX 1

DALHOUSIE INSTITUTE OF OCEANOGRAPHY 1959-1986

BOARD OF DIRECTORS AND SCIENTIFIC ADVISORY COMMITTEE

1959

Board of Directors

President of the University (Chair)
Chair of the University Board of Governors
Vice-Chair of the University Board of Governors
Dean of the Faculty of Arts and Science
Dean of the Faculty of Graduate Studies
Director of the Institute of Oceanography (Secretary)

Scientific Advisory Committee

Chair: Dr. F.R. Hayes
Prof. I. McT. Cowan, University of British Columbia
Prof. J.T. Wilson, University of Toronto
Dr. W.M. Cameron, Director of Oceanographic Research, Department of Mines and
Technical Surveys
Dr. J.L. Kask, Chair of the Fisheries Research Board of Canada
Dr. G.O. Langstroth, Chief Superintendent, Naval Research Establishment, Dartmouth,
NS
Dr. H.D. Smith, President, Nova Scotia Research Foundation
Prof. W.J. Chute, Department of Chemistry, Dalhousie University
Prof. C.G.I. Friedlander, Department of Geology, Dalhousie University
Prof. E.W. Guptill, Department of Physics, Dalhousie University

1960

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Prof. C.G.I. Friedlander, Department of Geology, Dalhousie University
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Dr. K.E von Maltzahn, Department of Biology, Dalhousie University

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Dean of the Faculty of Graduate Studies
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Prof. C.G.I. Friedlander, Department of Geology, Dalhousie University
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Dr. K.E von Maltzahn, Department of Biology, Dalhousie University

1968

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Dean of the Faculty of Graduate Studies
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Mines and Resources
Dr. F.R. Hayes, Chair of the Fisheries Research Board of Canada
Prof. W.J. Chute, Department of Chemistry, Dalhousie University
Prof. E.W. Guptill, Department of Physics, Dalhousie University
Dr. K.E von Maltzahn, Department of Biology, Dalhousie University

Both of these bodies were dissolved in 1968.

APPENDIX 2

DALHOUSIE INSTITUTE OF OCEANOGRAPHY 1959-1986

DIRECTORS AND PERIOD OF TENURE

F. Ronald Hayes	1959-1964
Ewart Blanchard	1964-1965
Gordon A. Riley	1965-1973
Peter J. Wangersky	1973-1974
Lloyd M. Dickie	1974-1977
Peter J. Wangersky	1977-1978
Anthony J. Bowen	1978-1979
Peter J. Wangersky	1979-1980
Robert O. Fournier	1980-1984
Anthony J. Bowen	1984-1986

APPENDIX 3

DALHOUSIE INSTITUTE OF OCEANOGRAPHY 1959-1986

FACULTY, ASSOCIATED STAFF, POSTDOCTORAL FELLOWS, DEGREES AWARDED, INCOMING STUDENTS AND ADMINISTRATIVE AND TECHNICAL STAFF

1959

Faculty

F. Ronald Hayes (Biology) (Director)
Elmer H. Anthony (Biology)
Alan A. Mills (Chemistry)
John M. Teal (Biology)

Associated Staff

Neil J. Campbell¹ (Physics)
Robert W. Stewart² (Physics)
Ronald W. Trites¹ (Physics)
¹Atlantic Oceanographic Group, Fisheries Research Board
²Defence Research Board

Incoming Students (Advisor in parentheses)

Kevin Halcrow (Teal)
Peter W. Hochachka (Hayes)

Administrative Staff

Barbara A. Hendry

1960

Faculty

F. Ronald Hayes (Biology) (Director)
Elmer H. Anthony (Biology)
Alan A. Mills (Chemistry)
Dirk J.G. Nota (Geology)
John M. Teal (Biology)

Associated Staff

Neil J. Campbell¹ (Physics)
Robert W. Stewart² (Physics)
Ronald W. Trites¹ (Physics)
¹Atlantic Oceanographic Group, Fisheries Research Board
²Defence Research Board

Incoming Students (Advisor)

William B. Bailey (Stewart)
Sheila L. Duff (Teal)
Glen H. Geen (Hayes)

W.G. MacIntyre (Trost)
D. Tsernoglou (Anthony)
Walton D. Watt (Hayes)
R.R. Weiler (Mills)
Administrative Staff
Barbara A. Hendry

1961

Faculty

F. Ronald Hayes (Biology) (Director)
Elmer H. Anthony (Biology)
Michael J. Keen (Geology)
Alan A. Mills (Chemistry)
Dirk J.G. Nota (Geology)
John M. Teal (Biology) (Departed in September)

Associated Staff

Neil J. Campbell¹ (Physics)
Ronald W. Trites¹ (Physics)
¹Atlantic Oceanographic Group, Fisheries Research Board

Postdoctoral Fellows

H. Hirata (Biology)
D. Prakash (Biology)
F. Uyeno (Biology)

Degrees Awarded

Peter W. Hochachka (MSc)

Incoming Students (Advisor)

Anthony E. Cok (Nota)
J.M. Pezzetta (Nota)
G.M. Telford (Phillips)
T. Wyatt

Administrative Staff

Barbara A. Hendry

1962

Faculty

F. Ronald Hayes (Biology) (Director)
Elmer H. Anthony (Biology)
Carl M. Boyd (Biology)
Michael J. Keen (Geology)
Alan A. Mills (Chemistry)
Dirk J.G. Nota (Geology)

Associated Staff

Neil J. Campbell¹ (Physics)
Cedric R. Mann² (Physics)
Ronald W. Trites¹ (Physics)
¹Atlantic Oceanographic Group, Fisheries Research Board (BIO)

²Department of Mines and Technical Surveys (BIO)

Postdoctoral Fellows

J. David George (Biology)

F. Uyeno (Biology)

Degrees Awarded

Sheila L. Duff (MSc)

Kevin Halcrow (MSc)

J.M. Pezzetta (MSc)

D. Tsernoglou (MSc)

Walton D. Watt (MSc)

Incoming Students (Advisor)

Donald L. Barrett (Keen)

Edward Batoosingh (Anthony)

Roger W. Doyle (Boyd)

Douglas R. Grant (Nota)

W.G. MacIntyre (Hayes/Platford)

Keith Manchester (Keen)

Sifford Pearre (Boyd)

K.C. Shan

R. Thomasson

Administrative and Technical Staff

Barbara A. Hendry

Dorothy P. Jeffrey

N. Honig

1963

Faculty

F. Ronald Hayes (Biology) (Director)

Elmer H. Anthony (Biology)

Carl M. Boyd (Biology)

Michael J. Keen (Geology)

Alan A. Mills (Chemistry)

Dirk J.G. Nota (Geology) (Departed in March)

Associated Staff

Neil J. Campbell¹ (Physics)

A. Earlston Doe² (Physics)

Cedric R. Mann² (Physics)

Ronald W. Trites¹ (Physics)

¹Atlantic Oceanographic Group, Fisheries Research Board (BIO)

²Department of Mines and Technical Surveys (BIO)

Postdoctoral Fellows

J. David George (Biology)

F. Uyeno (Biology)

Degrees Awarded

Donald L. Barrett (MSc)

Douglas R. Grant (MSc)

Incoming Students (Advisor)

Anthony (Tony) E. Cok (Keen)
Robert H. Cook (Boyd)
Anton M. Dainty (Keen)
Gerry N. Ewing (Keen)
R.A. McHardy (Boyd)
Stuart G. Miles (McInerney)

Administrative and Technical Staff

Barbara A. Hendry
Judith A. Barlow
Dorothy P. Jeffrey
O.D. Kennedy
J.L.A. Earl

1964

Faculty

F. Ronald Hayes (Biology) (Director) (Departed in July)
J. Ewart Blanchard (Physics) (Acting Director from July)
Elmer H. Anthony (Biology)
Carl M. Boyd (Biology)
Michael J. Keen (Geology)
Alan A. Mills (Chemistry)
Daniel J. Stanley (Geology)
Donald J.P. Swift (Geology)

Associated Staff

A. Earlston Doe¹ (Physics)
Arthur Levin (Engineering Physics)
Bosko D. Loncarevic¹ (Geology)
Cedric R. Mann¹ (Physics)
Ronald W. Trites² (Physics)

¹Department of Mines and Technical Surveys (BIO)

²Atlantic Oceanographic Group, Fisheries Research Board (BIO)

Postdoctoral Fellows

J. David George (Biology)

Degrees Awarded

Edward Batoosingh (MSc)
Keith Manchester (MSc)

Incoming Students (Advisor)

George Drapeau (Stanley)
Noel P. James (Stanley)
James A. Miller (Swift)
Donald L. Peer
Alan S. Ruffman (Keen)
C.F. Tsong (Blanchard)
Gustaf B. Vilks (Anthony)

Administrative and Technical Staff

Barbara A. Hendry
Judith A. Barlow
Dorothy P. Jeffrey
Georgette A. Cok
O.D. Kennedy
J.L.A. Earl

1965

Faculty

J. Ewart Blanchard (Physics) (Acting Director until July)
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Arthur Levin (Engineering Physics)
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Cedric R. Mann¹ (Physics)
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Postdoctoral Fellows

Franco Medioli (Geology)
Walton D. Watt (Biology)

Degrees Awarded

Robert H. Cook (MSc)
Gerry N. Ewing (MSc)
W.G. MacIntyre (PhD)
Sifford Pearre (MSc)
R.R. Weiler (PhD)

Incoming Students (Advisor)

Norval Balch (Boyd)
Anton M. Dainty (Keen)
Donald C. Gordon (Riley)
Glen W. Johnson (Boyd)
Anthony (Tony) Lambert (Keen)
A.H. Lee (Keen)
Roger Pocklington (Wangersky)
Joshua R. Ramsammy (Boyd)
James L. Warner (Levin)

Administrative and Technical Staff

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Georgette A. Cok
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J. David Ardill (Dickie)
Theresa M. Allen (Wangersky)
Sandra J. Blunden (Keen)
Chung I. Choi (Riley)
Robert C. Cooke (Wangersky)
Gareth C. Harding (Riley)
Ronald F. Macnab (Loncarevic)

Zinntae Zo (Riley)
Administrative and Technical Staff
Barbara A. Hendry
Gloria J. Profit
Ruth A. Manuel
D.R. Turner
R.R. Janc
Barbara D. Keshwar

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Arthur Levin (Engineering Physics)
Bosko D. Loncarevic³ (Geology)
Cedric R. Mann³ (Physics)
Ronald W. Trites² (Physics)

¹Nova Scotia Research Foundation

²Dartmouth Laboratory, Fisheries Research Board (BIO)

³Department of Mines and Technical Surveys (BIO)

Postdoctoral Fellows

Stephen P. Baig (Chemistry)

Degrees Awarded

Edward Batoosingh (PhD)
Anton M. Dainty (PhD)
Stuart G. Miles (PhD)

Incoming Students (Advisor)

Shirley A.M. Conover (Watt)
Sandra J. Blundon
Iver W. Duedall (Wangersky)
F. Colin Duerden (Watt)
David P. Krauel (Trites)
Louis Legendre (Watt)
Alan D. Michael (Mills)
James C. MacKinnon (Dickie)
Alan K. Pease (Conover)
H. Eric Sadler

Jonathon H. Sharp (Riley)
Martin L.R. Thomas (Mills)
Administrative and Technical Staff
Barbara A. Hendry
Gloria J. Profit
Ruth A. Manuel
D.R. Turner
R.R. Janc
Barbara D. Keshwar

1968

Faculty

Gordon A. Riley (Biology) (Director)
Carl M. Boyd (Biology)
Rudolf A. Gees (Geology)
Roy D. Hyndman (Geology)
Michael J. Keen (Geology)
Franco Medioli (Geology)
Eric L. Mills (Biology)
Peter J. Wangersky (Chemistry)
Walton D. Watt (Biology)

Associated Staff

J. Ewart Blanchard¹ (Physics)
Lloyd M. Dickie² (Biology)
A. Earlston Doe³ (Physics)
Arthur Levin (Engineering Physics)
Bosko D. Loncarevic³ (Geology)
Cedric R. Mann³ (Physics)
George T. Needler³ (Physics)
Helmut Sandstrom³ (Physics)
Ronald W. Trites² (Physics)
¹ Nova Scotia Research Foundation
² Marine Ecology Laboratory (BIO)
³ Atlantic Oceanographic Laboratory (BIO)

Postdoctoral Fellows

Elizabeth Alloit (Biology)
F. Barbieri (Geology)
Robert O. Fournier (Biology)
Manu C. Raheja (Chemistry)

Degrees Awarded

J. David Ardill (MSc)
Robert H. Cook (PhD)
Donald C. Gordon (PhD)
Ronald F. Macnab (MSc)

Incoming Students (Advisor)

Edward P. Anderson (Conover)

Larry P. Atkinson (Wangersky)
Howard J. Freeland (Hyndman)
W.J. Iams (Keen)
Byron F. Morris (Boyd)
John R. Wheeler (Riley)
Tadashi Yoshinari (Wangersky)
Administrative and Technical Staff
Barbara A. Hendry
Dolores A. Billard
D.R. Turner
R.R. Janc

1969

Faculty

Gordon A. Riley (Biology) (Director)
Carl M. Boyd (Biology)
Rudolf A. Gees (Geology)
Roy D. Hyndman (Geology)
Michael J. Keen (Geology)
Franco Medioli (Geology)
Eric L. Mills (Biology)
Roy Overstreet (Physics)
Peter J. Wangersky (Chemistry)
Walton D. Watt (Biology)

Associated Staff

Fab Aumento (Geology)
J. Ewart Blanchard¹ (Physics)
James S. Craigie² (Biology)
Georgiana B. Deevey (Biology)
Lloyd M. Dickie³ (Biology)
A. Earlston Doe⁴ (Physics)
Arthur Levin (Engineering Physics)
Bosko D. Loncarevic⁴ (Geology)
Cedric R. Mann⁴ (Physics)
George T. Needler⁴ (Physics)
Helmut Sandstrom⁴ (Physics)
Ronald W. Trites³ (Physics)
James L. Warner⁵ (Physics)
¹ Nova Scotia Research Foundation
² Atlantic Regional Laboratory (NRC)
³ Marine Ecology Laboratory (BIO)
⁴ Atlantic Oceanographic Laboratory (BIO)
⁵ Nova Scotia Technical College

Postdoctoral Fellows

Robert O. Fournier (Biology)
Manu C. Raheja (Chemistry)

Degrees Awarded

Sandra J. Blundon (MSc)
David P. Krauel (MSc)
Anthony (Tony) Lambert (PhD)
Joshua R. Ramsammy (PhD)
Zinntae Zo (MSc)

Incoming Students (Advisor)

J.K. Caldwell (Conover)
Leslie A. Foster
M. Gatien (Overstreet)
Colin D. Levings (Mills)
Norman A. Lyttle (Clarke)
M.W. MacCutcheon
C.R. McKay
Bryon Morris (Boyd)
Corry C. Norenburg (Riley)
C.F. Stehman
Paul E. Vandall (Overstreet)
Joan D. Willey (Wangersky)

Administrative and Technical Staff

Barbara A. Hendry
Dolores A. Gratton
D.R. Turner
R.R. Janc
P.V. Keenan

1970

Faculty

Gordon A. Riley (Biology) (Director)
Carl M. Boyd (Biology)
Rudolf A. Gees (Geology)
Roy D. Hyndman (Geology)
Michael J. Keen (Geology)
Franco Medioli (Geology)
Eric L. Mills (Biology)
Roy Overstreet (Physics)
Peter J. Wangersky (Chemistry)
Walton D. Watt (Biology)

Associated Staff

Fab Aumento (Geology)
J. Ewart Blanchard¹ (Physics)
James S. Craigie² (Biology)
Georgiana B. Deevey (Biology)
Lloyd M. Dickie³ (Biology)
A. Earlston Doe⁴ (Physics)
Arthur Levin (Engineering Physics)

Bosko D. Loncarevic⁴ (Geology)
Cedric R. Mann⁴ (Physics)
George T. Needler⁴ (Physics)
Helmut Sandstrom⁴ (Physics)
Ronald W. Trites³ (Physics)
James L. Warner⁵ (Physics)
¹ Nova Scotia Research Foundation
² Atlantic Regional Laboratory (NRC)
³ Marine Ecology Laboratory (BIO)
⁴ Atlantic Oceanographic Laboratory (BIO)
⁵ Nova Scotia Technical College

Postdoctoral Fellows

John G. Field (Biology)
Theodore C. Loder (Chemistry)

Degrees Awarded

Chung I. Choi (MSc)
Anthony E. Cok (PhD)
Allan H. Lee (PhD)
Sifford Pearre (PhD)
Roger Pocklington (PhD)
Martin L.H. Thomas (PhD)
James L. Warner (PhD)

Incoming Students (Advisor)

Kathleen Bidleman
Raymond E. Cranston (Wangersky)
Douglas N. Gregory (Overstreet)
Paul G. Harrison
Howard R. Hume (Keen)
James S. Johnson (Keen)
Janet A. Macintosh (Boyd)
Brian D. Petrie (Overstreet)
Ginette Robert (Mills)

Administrative and Technical Staff

Barbara A. Hendry
Krista L. Page
D.R. Turner
R.R. Janc
P.V. Keenan

1971

Faculty

Gordon A. Riley (Biology) (Director)
Christopher Beaumont (Geology)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Robert O. Fournier (Biology)

Christopher J.R. Garrett (Physics)
Rudolf A. (Geology)
Roy D. Hyndman (Geology)
Michael J. Keen (Geology)
Franco Medioli (Geology)
Eric L. Mills (Biology)
Roy Overstreet (Physics)
Peter J. Wangersky (Chemistry)
Walton D. Watt (Biology) (Departed)

Associated Staff

Fab Aumento (Geology)
J. Ewart Blanchard¹ (Physics)
James S. Craigie² (Biology)
Lloyd M. Dickie³ (Biology)
A. Earlston Doe⁴ (Physics)
Arthur Levin (Engineering Physics)
Bosko D. Loncarevic⁴ (Geology)
Cedric R. Mann⁴ (Physics)
George T. Needler⁴ (Physics)
Helmut Sandstrom⁴ (Physics)
Ronald W. Trites³ (Physics)
James L. Warner⁵ (Physics)

¹Nova Scotia Research Foundation

²Atlantic Regional Laboratory (NRC)

³Marine Ecology Laboratory (BIO)

⁴Atlantic Oceanographic Laboratory (BIO)

⁵Nova Scotia Technical College

Postdoctoral Fellows

John G. Field (Biology)
Neil A. North (Chemistry)

Degrees Awarded

Theresa M. Allen (PhD)
Norval Balch (PhD)
Robert C. Cooke (PhD)
Georges Drapeau (PhD)
James S. Johnson (MSc)
Louis Legendre (PhD)
Murray W. MacCutcheon (MSc)

Incoming Students (Advisor)

D.L. Backus (Boyd)
Donald S. Bezanson (Levin)
J.E. Carrière (Overstreet)
Louise Cooke
L.A. Foster (Mann)
H.R. Hume (Keen)
Patricia L. Johanson (Fournier)

David L. Mackas (Boyd)
Michael D. MacKinnon (Cooke)
J.A. Mackintosh (Boyd)
Stewart Malloy (Riley)
V.J. Stukas (Reynolds)
S.R. Waddell (Levin)
Rodney G. Zika (Cooke)

Administrative and Technical Staff

Barbara A. Hendry
Eileen T. Dowling
D.R. Turner
R.R. Janc
P.V. Keenan
C.I. Choi
A.K. Hanson
Ed Officia

1972

Faculty

Gordon A. Riley (Biology) (Director)
Christopher Beaumont (Geology)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Robert O. Fournier (Biology)
Christopher J.R. Garrett (Physics)
Rudolf A. Gees (Geology)
Roy D. Hyndman (Geology)
Michael J. Keen (Geology) (Departed but became an associate)
Franco Medioli (Geology)
Eric L. Mills (Biology)
Roy Overstreet (Physics) (Departed in August)
David J.W. Piper (Geology)
Peter J. Wangersky (Chemistry)

Associated Staff

Fab Aumento (Geology)
J. Ewart Blanchard¹ (Physics)
James S. Craigie² (Biology)
Lloyd M. Dickie³ (Biology)
A. Earlston Doe⁴ (Physics)
Warren Forrester⁴ (Physics)
Arthur Levin (Engineering Physics)
Bosko D. Loncarevic⁴ (Geology)
Cedric R. Mann⁴ (Physics)
George T. Needler⁴ (Physics)
Helmut Sandstrom⁴ (Physics)
Ronald W. Trites³ (Physics)

James L. Warner⁵ (Physics)

¹ Nova Scotia Research Foundation

² Atlantic Regional Laboratory (NRC)

³ Marine Ecology Laboratory (BIO)

⁴ Atlantic Oceanographic Laboratory (BIO)

⁵ Nova Scotia Technical College

Postdoctoral Fellows

Sandra Barr (Geology)

Werner Hirsbrunner (Chemistry)

Degrees Awarded

Larry P. Atkinson (PhD)

Leslie A. Foster (MSc)

Gareth C. Harding (PhD)

Howard R. Hume (MSc)

Colin D. Levings (PhD)

Norman A. Lyttle (MSc)

James C. MacKinnon (PhD)

Janet A. Mackintosh (MSc)

Allan D. Michael (PhD)

Jonathan H. Sharp (PhD)

Paul E. Vandall (MSc)

John R. Wheeler (PhD)

Incoming Students (Advisor)

Bruce D. Johnson (Cooke)

Clive MacGregor (Wangersky)

Scott MacKnight (Wangersky)

Mary O'Brien

Administrative and Technical Staff

Barbara A. Hendry

Eileen T. Dowling

D.R. Turner

R.R. Janc

P.V. Keenan

C.I. Choi

A.K. Hanson

Ed Officia

1973

Faculty

Gordon A. Riley (Biology) (Director) (Resigned in July)

Peter J. Wangersky (Chemistry) (Acting Director from July)

Anthony J. Bowen (Physics)

Carl M. Boyd (Biology)

Robert C. Cooke (Chemistry)

Robert O. Fournier (Biology)

Christopher J.R. Garrett (Physics)

Roy D. Hyndman (Geology)
Eric L. Mills (Biology)
David J.W. Piper (Geology)

Associated Staff

Fab Aumento (Geology)
J. Ewart Blanchard¹ (Physics)
James S. Craigie² (Biology)
Kenneth L. Denman³ (Physics)
Lloyd M. Dickie³ (Biology)
A. Earlston Doe⁴ (Physics)
Daniel Kamykowski (Biology)
Michael J. Keen (Geology)
Arthur Levin (Engineering Physics)
Bosko D. Loncarevic⁴ (Geology)
Franco Medioli (Geology)
Cedric R. Mann⁴ (Physics)
George T. Needler⁴ (Physics)
Helmut Sandstrom⁴ (Physics)
Ronald W. Trites³ (Physics)
James L. Warner⁵ (Physics)

¹ Nova Scotia Research Foundation

² Atlantic Regional Laboratory (NRC)

³ Marine Ecology Laboratory (BIO)

⁴ Atlantic Oceanographic Laboratory (BIO)

⁵ Nova Scotia Technical College

Postdoctoral Fellows

Sandra Barr (Geology)
Werner Hirsbrunner (Chemistry)
R.M. MacDonald (Chemistry)
Neil A. North (Chemistry)

Degrees Awarded

Donald D. Adams (PhD)
Donald S. Bezanson (MSc)
J.B. Carrière (MSc)
Iver W. Duedall (PhD)
F. Colin Duerden (PhD)
Howard J. Freeland (PhD)
Douglas N. Gregory (MSc)
Alan K. Pease (PhD)
V.J. Stukas (MSc)
Gustav B. Vilks (PhD)
Tadashi Yoshinari (PhD)

Incoming Students (Advisor)

Kathleen A. Agosta (Cooke)
Keith P. Appleton (Hyndman)
Osmundo J. Betancourt (Wangersky)

Louis J. Blinn (Keen)
Richard Bohrer (Boyd)
Gary L. Bugden (Garrett)
Jacqueline DeMestral
Malcolm J. Drury (Hyndman)
Janet M. Dunbrack
Kenneth R. Freeman (Mann)
M. Germaine Gatian (Garrett)
John T. Hoff (Cooke/Wangersky)
Timothy J. Hollibaugh (Craigie)
Edward P. Horne (Garrett)
Martin Horwitz (Cooke)
J. Robert Keeley (Garrett)
John F. Lewis (Hyndman)
Stewart Malloy (Riley)
John F. Marra (Riley)
Georges Merinfeld (Boyd)
Doreen Newhouse (Dickie)
Phillip D. Rice (Ade-Hall)
Kevin G. Sellner (Wangersky)
Dario Stucchi (Garrett)
Kim-Tai Tee (Garrett)

Administrative and Technical Staff

Barbara A. Hendry
Eileen T. Dowling
Sheila C. Byers
Lea Dawson
Loretta Levesque
Diane Young
D.R. Turner
R.R. Janc
P.V. Keenan
C.I. Choi
A.K. Hanson
Ed Officia
G. Wilson

1974

Faculty

Peter J. Wangersky (Chemistry) (Acting Director to July)
Lloyd M. Dickie (Biology) (Director beginning July)
Anthony J. Bowen (Physics)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Robert O. Fournier (Biology)
Christopher J.R. Garrett (Physics)

David A. Huntley (Physics)
Roy D. Hyndman (Geology)
Eric L. Mills (Biology)
David J.W. Piper (Geology)
Gordon A. Riley (Biology)

Associated Staff

Fab Aumento (Geology)
J. Ewart Blanchard¹ (Physics)
James S. Craigie² (Biology)
Kenneth L. Denman³ (Physics)
A. Earlston Doe⁴ (Physics)
Daniel Kamykowski (Biology)
Michael J. Keen (Geology)
Arthur Levin (Engineering Physics)
Bosko D. Loncarevic⁴ (Geology)
Cedric R. Mann⁴ (Physics)
Franco Medioli (Geology)
George T. Needler⁴ (Physics)
Helmut Sandstrom⁴ (Physics)
Ronald W. Trites³ (Physics)
James L. Warner⁵ (Physics)

¹ Nova Scotia Research Foundation

² Atlantic Regional Laboratory (NRC)

³ Marine Ecology Laboratory (BIO)

⁴ Atlantic Oceanographic Laboratory (BIO)

⁵ Nova Scotia Technical College

Postdoctoral Fellows

Sandra Barr (Geology)
R.T. Guza (Physics)
F.E. Wells (Biology)

Degrees Awarded

Edward Anderson (PhD)
Shirley Conover (PhD)
Raymond E. Cranston (MSc)
Kenneth R. Freeman (MSc)
Paul Harrison (PhD)
Glenn Johnson (PhD)
Stewart Malloy (MSc)
Brian D. Petrie (PhD)
Ginette Robert (PhD)

Incoming Students (Advisor)

Stephen S. Bates (Riley)
Louis Binn (Keen)
Glenn F. Cota (Wangersky)
Blaine E. Hall (Piper)
Alan V. Hincks (Wangersky)

Robert A. Holman (Bowen)
William K.W. Li (Fournier)
Camille Mageau (Walker)
Serge Parent (Huntley)
Phillip D. Rice (Ade-Hall)
Jonathan V. Robbins (Craigie)
Jerome Smith (Huntley)
Patrick Stewart (Mills)
Yuan-Erh Tsai (Garrett)
Denis Wiesenburg (Cooke)
Administrative and Technical Staff
Barbara A. Hendry
Eileen T. Dowling
Cedella Morse
Ginette Robert
Lea Dawson
Mary van Det
Franzika Knips
P.V. Keenan
A.K. Hanson
Ed Officia
G. Wilson

1975

Faculty

Lloyd M. Dickie (Biology) (Director)
Christopher Beaumont (Geology)
Anthony J. Bowen (Physics)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Robert O. Fournier (Biology)
Christopher J.R. Garrett (Physics)
David A. Huntley (Physics)
Roy D. Hyndman (Physics)
Eric L. Mills (Biology)
David J.W. Piper (Geology)
Gordon A. Riley (Biology)
Peter J. Wangersky (Chemistry)

Associated Staff

Fab Aumento (Geology)
Norval E. Balch (Aquatron Manager)
J. Ewart Blanchard¹ (Physics)
James S. Craigie² (Biology)
Kenneth L. Denman³ (Physics)
A. Earlston Doe⁴ (Physics)
Daniel Kamykowski (Biology)

Michael J. Keen (Geology)
Arthur Levin (Engineering Physics)
Bosko D. Loncarevic⁴ (Geology)
Franco Medioli (Geology)
Cedric R. Mann⁴ (Physics)
George T. Needler⁴ (Physics)
Helmut Sandstrom⁴ (Physics)
Ronald W. Trites³ (Physics)
James L. Warner⁵ (Physics)
¹ Nova Scotia Research Foundation
² Atlantic Regional Laboratory (NRC)
³ Marine Ecology Laboratory (BIO)
⁴ Atlantic Oceanographic Laboratory (BIO)
⁵ Nova Scotia Technical College

Postdoctoral Fellows

R.T. Guza (Physics)
Sharon L. Smith (Biology)
F.E. Wells (Biology)

Degrees Awarded

Louis J. Blinn (MSc)
Germaine Gatien (MSc)
Robert J. Keeley (MSc)
John F. Lewis (MSc)
Clive D.R. MacGregor (MSc)
Byron Morris (PhD)
Eric Sadler (PhD)
Dario J. Stucchi (MSc)
Kim-Tai Tee (PhD)
Joan D. Willey (PhD)

Incoming Students (Advisor)

Ali E. Aksu (Piper)
Arthur A. Allen (Huntley)
J. Richard Birch (Garrett)
Mark G. Carls (Dickie)
David DeWolfe (Garrett)
J.J. Michel Gagnon (Wangersky)
Katherine Gartner
Blaine R. Hall (Keen)
J. Murray Hartwell (Cooke)
Kathryn Jung Holman (Cooke)
Robert A. Holman (Huntley/Bowen)
Steven J. Keir (Huntley)
Paul E. Kepkay (MSc)
Daniel A. Lesso
Ulrich Lobsiger
John W. Loder (Bowen)

Jonathan Robbins (Craigie)
Mary Rebecca Rohrbacher (Riley)
Paul Sherwood
Lung-Fa Ku (Garrett)
Ross Shotton (Dickie)
Administrative and Technical Staff
Barbara A. Hendry
Eileen T. Dowling
Cedella Morse
Susan L. MacDonald
S.R. Waddell
A.K. Hanson
Mary van Det
Sheila Byers
P.E. Donovan
S.A. Gibb
Ed Officia
J.T. MacMillan
F. Walsh
Franzika Knips

1976

Faculty

Lloyd M. Dickie (Biology) (Director)
Christopher Beaumont (Geology)
Anthony J. Bowen (Physics)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Robert O. Fournier (Biology)
Christopher J.R. Garrett (Physics)
David A. Huntley (Physics)
Roy D. Hyndman (Geology) (Departed)
Eric L. Mills (Biology)
David J.W. Piper (Geology)
Gordon A. Riley (Biology)
Peter J. Wangersky (Chemistry)
Joseph S. Wroblewski (Biology)

Associated Staff

Norval Balch (Aquatron Manager)
James S. Craigie¹ (Biology)
Niels Daan (Biology)
Fred W. Dobson² (Physics)
Barry T. Hargrave³ (Biology)
Michael J. Keen (Geology)
Charlotte Keen (Geology)
Arthur Levin (Engineering Physics)

Sifford Pearre (Biology)
J.W. Peirce (Geology)
Trevor C. Platt³ (Biology)
Cedric R. Mann² (Physics)
George T. Needler² (Physics)
William L. Silvert (Biology)
Stuart D. Smith² (Physics)
Ronald W. Trites³ (Physics)
¹Atlantic Regional Laboratory (NRC)
²Atlantic Oceanographic Laboratory (BIO)
³Marine Ecology Laboratory (BIO)

Postdoctoral Fellows

R.W. Houghton
Sharon L. Smith (Biology)
J.G. Richman

Degrees Awarded

Gary Bugden (MSc)
Louise Cooke (MSc)
Blaine R. Hall (MSc)
James T. Hollibaugh (PhD)
Martin R. Horwitz (MSc)
Patricia L. Johansen (PhD)
Jonathon V. Robbins (MSc)

Incoming Students (Advisor)

Thomas A. Clair (Mills)
Kenneth F. Drinkwater (Garrett)
Malcolm J. Drury (Beaumont)
Robert M. Gershey (Wangersky)
Dolores C. Gottenburg
Joan Kean (Dickie)
Christopher Majka (Mills)
Leonard S. Mukai (Craigie/Fournier)
Jean Painchaud (Boyd)
Garry M. Quinlan (Beaumont)
Scott Wilson (Boyd)
Chia-Hsian Su (Huntley)

Administrative and Technical Staff

Barbara A. Goodman
Cedella Morse
Susan L. MacDonald
S.R. Waddell
A.K. Hanson
Mary van Det
Sheila Byers
Ed Officia
F. Walsh

G.P. Myers
J.T. MacMillan

1977

Faculty

Lloyd M. Dickie (Biology) (Director until July)
Peter J. Wangersky (Chemistry) (Acting Director from July)
Christopher Beaumont (Geology)
Anthony J. Bowen (Physics)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Robert O. Fournier (Biology)
Christopher J.R. Garrett (Physics)
David A. Huntley (Physics)
Eric L. Mills (Biology)
Robert M. Moore (Chemistry)
David J.W. Piper (Geology)
J.C. Richman (Physics)
Gordon A. Riley (Biology)
Joseph S. Wroblewski (Biology)

Associated Staff

Norval Balch (Aquatron Manager)
James S. Craigie¹ (Biology)
Fred W. Dobson² (Physics)
Barry T. Hargrave³ (Biology)
Michael J. Keen (Geology)
Charlotte Keen (Geology)
Cedric R. Mann² (Physics)
George T. Needler² (Physics)
J.W. Peirce (Geology)
Sifford Pearre (Biology)
Trevor C. Platt³ (Biology)
William L. Silvert (Biology)
Stuart D. Smith² (Physics)
¹Atlantic Regional Laboratory (NRC)
²Atlantic Oceanographic Laboratory (BIO)
³Marine Ecology Laboratory (BIO)

Postdoctoral Fellows

Sharon L. Smith (Biology)

Degrees Awarded

Ali E. Aksu (MSc)
Malcolm J. Drury (PhD)
Alan V. Hincks (MSc)
John T. Hoff (PhD)
Kathryn Holman (MSc)
Paul E. Kepkay (MSc)

David L. Mackas (PhD)
Michael D. MacKinnon (PhD)
Ca Scott D. MacKnight (PhD)
Camille M. Mageau (MSc)
John F. Marra (PhD)
Doreen S. Newhouse (MSc)
Phillip Rice (MSc)
Paul E. Shaw-Wood (MSc)
Patrick L. Stewart (MSc)
Rodney G. Zika (PhD)

Incoming Students (Advisor)

Bjorn Bjornsson (Dickie)
Hein DeBaar (Wangersky/Moore)
Chi Keung Chong (Dickie)
Donald J. Douglas (Fournier)
Katherine E. Gartner (Dickie)
N. Brent Hargreaves (Fournier)
J. Murray Hartwell (Cooke)
Mark E. Huntley (Boyd)
Paul Kepkay (Cooke)
Malcolm G. Lowings (Cooke)
Bryan J. Michaud (Mills)
Leonard S. Mukai (Craigie)
Jean Painchaud (Wangersky)
Ingrid K. Peterson (Dickie)
Gary M. Quinlan (Beaumont)
Gaye Gerald Sims (Wangersky)
Michael W. Stacey (Bowen)
Jerome A. Smith (Garrett/Bowen)
Graham Symonds (Huntley)
Barry W. Towill (Richman)
Bernard Vézina (Dickie)
David W. Welch (Dickie)

Administrative and Technical Staff

Barbara A. Goodman
Cedella Morse
Susan L. MacDonald
Mary S. Wyman
S.R. Waddell
D.G. Mason
A.K. Hanson
Mary van Det
M. Spencer
Ed Officia
F. Walsh
G.P. Myers

1978

Faculty

Peter J. Wangersky (Chemistry) (Acting Director to July)
Anthony J. Bowen (Physics) (Acting Director from July)
Christopher Beaumont (Geology)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Robert O. Fournier (Biology)
Christopher J.R. Garrett (Physics)
David A. Huntley (Physics)
Eric L. Mills (Biology)
Robert M. Moore (Chemistry)
David J.W. Piper (Geology)
J.C. Richman (Physics)
Gordon A. Riley (Biology) (Emeritus)
Joseph S. Wroblewski (Biology)

Associated Staff

Norval Balch (Aquatron Manager)
Robert J. Conover¹ (Biology)
James S. Craigie² (Biology)
Lloyd M. Dickie¹ (Biology)
Fred W. Dobson³ (Physics)
Barry T. Hargrave¹ (Biology)
Ross M. Hendry (Physics)
Michael J. Keen⁴ (Geology)
Charlotte Keen⁴ (Geology)
Stephen J. Kerr¹ (Biology)
Cedric R. Mann³ (Physics)
George T. Needler³ (Physics)
James A. Novitsky (Biology)
Sifford Pearre (Biology)
J.W. Peirce (Geology)
Trevor C. Platt¹ (Biology)
William L. Silvert (Biology)
Stuart D. Smith³ (Physics)
Daniel M. Ware¹ (Biology)
¹ Marine Ecology Laboratory (BIO)
² Atlantic Regional Laboratory (NRC)
³ Atlantic Oceanographic Laboratory (BIO)
⁴ Atlantic Geoscience Centre (BIO)

Postdoctoral Fellows

Sharon L. Smith (Biology)

Degrees Awarded

Richard J. Birch (MSc)
Mark G. Carls (MSc)

Janet M. Dunbrack (MSc)
Katherine E. Gartner (MSc)
J. Murray Hartwell (MSc)
Edward P.W. Horne (PhD)
William K.W. Li (PhD)
Mary Rebecca Rohrbacher-Carls (MSc)
Kevin G. Sellner (PhD)
Incoming Students (Advisor)
Marjorie A. Bousfield (Mills)
Richard J. Geider (Fournier)
Dian J. Gifford (Boyd)
Barbara-Ann Juszko (Wroblewski/Garrett)
Julie LaRoche (Boyd)
Stephen Nicol (Boyd)
Administrative and Technical Staff
Barbara A. Goodman
Cedella Morse
Mary S. Wyman
A.K. Hanson
D.G. Mason
Mary van Det
Rosslyn Whitney Ernst
Alison C. Mitchell
M. Spencer
B.J. Toulany
Ed Officia
F. Walsh
G.P. Myers
L. Almeida

1979

Faculty

Anthony J. Bowen (Physics) (Acting Director to July)
Peter J. Wangersky (Chemistry) (Acting Director from July)
Christopher Beaumont (Geology)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Robert O. Fournier (Biology)
Christopher J.R. Garrett (Physics)
David A. Huntley (Physics)
J. Anthony (Tony) Koslow (Biology)
Eric L. Mills (Biology)
Robert M. Moore (Chemistry)
David J.W. Piper (Geology)
Gordon A. Riley (Biology) (Emeritus)
Joseph S. Wroblewski (Biology)

Associated Staff

Norval Balch (Aquatron Manager)
Robert J. Conover¹ (Biology)
James S. Craigie² (Biology)
Lloyd M. Dickie¹ (Biology)
Fred W. Dobson³ (Physics)
Barry T. Hargrave¹ (Biology)
Ross M. Hendry (Physics)
Charlotte Keen⁴ (Geology)
Stephen J. Kerr¹ (Biology)
Cedric R. Mann³ (Physics)
George T. Needler³ (Physics)
James A. Novitsky (Biology)
Sifford Pearre (Biology)
J.W. Peirce (Geology)
Peter C. Smith³ (Physics)
Stuart D. Smith³ (Physics)
Francis C. Tan³ (Chemistry)
Daniel M. Ware¹ (Biology)
¹ Marine Ecology Laboratory (BIO)
² Atlantic Regional Laboratory (NRC)
³ Atlantic Oceanographic Laboratory (BIO)
⁴ Atlantic Geoscience Centre (BIO)

Postdoctoral Fellows

P.E. Holloway (Physics)
Patricia Stoffn-Egli (Chemistry)

Degrees Awarded

Arthur A. Allen (MSc)
Stephen S. Bates (PhD)
Robert A. Holman (PhD)
Bruce D. Johnson (PhD)
Jean Painchaud (MSc)

Incoming Students (Advisor)

Peter B. Bayley (Dickie/Koslow)
William P. Cochlan (Fournier)
Robert C. Courtney (Beaumont)
Ambekar E. Eknath (Koslow)
Anne F. Fullerton (Boyd)
Donald C. Lowdon (Huntley)
Maureen E. McInerney (Koslow)
Debra L. Roberts (Mills)
Suzanne Roy (Fournier)
Brian Whitehouse (Wangersky)

Administrative and Technical Staff

Barbara A. Goodman
Elizabeth R. Tidmarsh

Cedella Morse
Mary S. Wyman
A.K. Hanson
D.G. Mason
Ed Officia
F. Walsh
D. Lawrence
R. Boutilier
Rosslyn Whitney Ernst
B.D. Johnson
R. McCullen
Alison C. Mitchell
B. Munroe
Ingrid Peterson
Karin Pittman
Donald Plasse
Harriet Rueggeberg
M. Spencer
B.J. Toulany
Mary van Det

1980

Faculty

Peter J. Wangersky (Chemistry) (Acting Director to July)
Robert O. Fournier (Biology) (Director from July)
Christopher Beaumont (Geology)
Anthony J. Bowen (Physics)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Christopher J.R. Garrett (Physics)
David A. Huntley (Physics)
J. Anthony (Tony) Koslow (Biology)
Eric L. Mills (Biology)
Robert M. Moore (Chemistry)
David J.W. Piper (Geology)
Gordon A. Riley (Biology) (Emeritus)
Joseph S. Wroblewski (Biology)

Associated Staff

Norval Balch (Aquatron Manager)
Robert J. Conover¹ (Biology)
James S. Craigie² (Biology)
Lloyd M. Dickie¹ (Biology)
Fred W. Dobson³ (Physics)
Roger W. Doyle (Biology)
Barry T. Hargrave¹ (Biology)
Ross M. Hendry (Physics)

Bruce D. Johnson (Chemistry)
Charlotte Keen⁴ (Geology)
Stephen J. Kerr¹ (Biology))
George T. Needler³ (Physics)
James A. Novitsky (Biology)
Sifford Pearre (Biology)
John Peters (Geology)
J.W. Peirce (Geology)
Peter C. Smith³ (Physics)
Stuart D. Smith³ (Physics)
Francis C. Tan³ (Chemistry)
Daniel M. Ware¹ (Biology)
Daniel Wright³ (Physics)
¹ Marine Ecology Laboratory (BIO)
² Atlantic Regional Laboratory (NRC)
³ Atlantic Oceanographic Laboratory (BIO)
⁴ Atlantic Geoscience Centre (BIO)

Postdoctoral Fellows

Patricia Stoffn-Egli (Chemistry)

Degrees Awarded

Michel J. Gagnon (PhD)
Mark E. Huntley (PhD)
Paul E. Kepkay (PhD)
John W. Loder (PhD)
Leonard S. Mukai (PhD)
Jerome A. Smith (PhD)

Incoming Students (Advisor)

E. Bedell
P. Hill
J. Letson
Christopher N. Milley (Cooke)
Peta J. Mudie
Dwight K. Muschenheim (Mills)
C. Parrish
R. Peters
A. Rosenburg
P. Rouleau
G.G. Sims
R. Stephenson
Peter M. Strain (Wangersky)
Douglas W. Wallace (Moore)
Filip Volckaert (Mills)

Administrative and Technical Staff

Elizabeth R. Tidmarsh
Jean Page
Mary S. Wyman

Beth Garside
A.K. Hanson
D.G. Mason
Ed Officia
Fred Walsh
Don Lawrence
R. Boutilier
Rosslyn Whitney Ernst
Neil Hamilton
Ingrid Peterson
Karin Pittman
Harriet Ruedeberg
Mendel Spencer
B.J. Toulany
Mary van Det

1981 and 1982

Faculty

Robert O. Fournier (Biology) (Director)
Christopher Beaumont (Geology)
Anthony J. Bowen (Physics)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Christopher J.R. Garrett (Physics)
David A. Huntley (Physics)
J. Anthony (Tony) Koslow (Biology)
Keith E. Loudon (Geology)
Larry A. Mayer (Geology)
Eric L. Mills (Biology)
Robert M. Moore (Chemistry)
Gordon A. Riley (Biology) (Emeritus)
Barry R. Ruddick (Physics)
Peter J. Wangersky (Chemistry)
Joseph S. Wroblewski (Biology)

Associated Staff

Norval Balch (Aquatron Manager)
Robert J. Conover¹ (Biology)
Terry Chriss (Physics)
James S. Craigie² (Biology)
Lloyd M. Dickie¹ (Biology)
Fred W. Dobson³ (Physics)
Roger W. Doyle (Biology)
Barry T. Hargrave¹ (Biology)
Ross M. Hendry (Physics)
W. David Jamieson (Chemistry)
Bruce D. Johnson (Chemistry)

Charlotte Keen⁴ (Geology)
Stephen J. Kerr¹ (Biology)
Rick Marsden (Physics)
George T. Needler³ (Physics)
James A. Novitsky (Biology)
Sifford Pearre (Biology)
John Peters (Geology)
Brian D. Petrie³ (Physics)
J.W. Peirce (Geology)
Michael M. Sinclair⁵ (Biology)
Peter C. Smith³ (Physics)
Stuart D. Smith³ (Physics)
Francis C. Tan³ (Chemistry)
Keith Thompson (Physics)
Daniel Wright³ (Physics)
¹ Marine Ecology Laboratory (BIO)
² Atlantic Regional Laboratory (NRC)
³ Atlantic Oceanographic Laboratory (BIO)
⁴ Atlantic Geoscience Centre (BIO)
⁵ Halifax Fisheries Research Laboratory

Postdoctoral Fellows

Jerry Cheney (Biology)
Jonathan Grant (Biology)
Hans Joachim Kumpel (Geology)
Jeffrey Runge (Biology)
Patricia Stoffn-Egli (Chemistry)

Degrees Awarded

Peter B. Bailey (PhD)
Marjorie A. Bousfield (MSc)
Chi K. Chong (MSc)
William P. Cochlan (MSc)
Robert C. Courtney (MSc)
Robert M. Gershey (PhD)
N. Brent Hargreaves (PhD)
Barbara-Ann Juszko (MSc)
Joan Kean (MSc)
Julie LaRoche (MSc)
Garry M. Quinlan (PhD)
Debra L. Roberts (MSc)
Michael W. Stacey (PhD)
Graham Symonds (PhD)
Kathryn E. Thomas (MSc)

Incoming Students (Advisor)

Scott Akenhead
Jodine C. Dugas (Koslow)
P. Franks

J. Hallisey
J. Haines
D. Hebert
D. Issler
John D. Ives (Boyd)
Chang-Shuk Kim (Bowen)
Lung-Fa Ku (Garrett)
L. MacDonald
S. McClatchie
Fred Page
A. Parsons
Pierre Pepin (Koslow)
N. B. Sharp
Michael W. Stacey (Bowen)
G. Symonds
Bechara Toulany (Garrett)
Administrative and Technical Staff
Elizabeth R. Tidmarsh
K. Sawler
C. Smith
I. Mann
A.K. Hanson
M. Gourd
T. Parsons
Ed Officia
Fred Walsh
K. Harvey
R. Boutilier
S. Brault
J. Covill
Rosslyn Ernst
Neil Hamilton
G. Leger
R. Maas
B. Schofield

1983 and 1984

Faculty

Robert O. Fournier (Biology) (Director to June 1984)
Anthony J. Bowen (Physics) (Director from July 1984)
Christopher Beaumont (Geology)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Christopher J.R. Garrett (Physics)
David A. Huntley (Physics)
J. Anthony (Tony) Koslow (Biology)

Marlon R. Lewis (Biology)
Keith E. Louden (Geology)
Larry A. Mayer (Geology)
Eric L. Mills (Biology)
Robert M. Moore (Chemistry)
Gordon A. Riley (Biology) (Emeritus)
Barry R. Ruddick (Physics)
Keith Thompson (Physics)
Peter J. Wangersky (Chemistry)
Joseph S. Wroblewski (Biology)

Associated Staff

Norval Balch (Aquatron Manager)
Terry Chriss (Physics)
Robert J. Conover¹ (Biology)
James S. Craigie² (Biology)
Lloyd M. Dickie¹ (Biology)
Fred W. Dobson³ (Physics)
Roger W. Doyle (Biology)
James E. Elliott³ (Physics)
Robert M. Gershey (Chemistry)
Jonathan Grant (Biology)
Barry T. Hargrave¹ (Biology)
W. David Jamieson² (Chemistry)
Bruce D. Johnson (Chemistry)
Charlotte Keen⁴ (Geology)
Stephen J. Kerr¹ (Biology)
George T. Needler³ (Physics)
James A. Novitsky (Biology)
Sifford Pearre (Biology)
John Peters (Geology)
Brian D. Petrie³ (Physics)
David J.W. Piper (Geology)
Michael M. Sinclair⁵ (Biology)
Peter C. Smith³ (Physics)
Francis C. Tan³ (Chemistry)
¹ Marine Ecology Laboratory (BIO)
² Atlantic Regional Laboratory (NRC)
³ Atlantic Oceanographic Laboratory (BIO)
⁴ Atlantic Geoscience Centre (BIO)
⁵ Halifax Fisheries Research Laboratory

Postdoctoral Fellows

Dan Hanes (Physical)
Hans Joachim Kumpel (Geology)
John Middleton (Physics)
Louise Royer (Physics)
Jeffery Runge (Biology)

Glen Stockmal (Biology)

Degrees Awarded

Richard N. Bohrer (PhD) (1983)
Glenn F. Cota (PhD) (1983)
Jodine C. Dugas (MSc) (1983)
Peter J.S. Franks (MSc) (1984)
Anne Francesca Fullerton (MSc) (1983)
Richard J. Geider (PhD) (1984)
Ku Lung-Fa (PhD) (1983)
Christopher M. Milley (MSc) (1983)
Pilip Volckaert (MSc) (1983)
D.W. Welch (PhD) (1984)
Brian G. Whitehouse (PhD) (1983)

Incoming Students (Advisor)

Y. Andrade
M. Bormans
J. Braun
D. Brew
David Brinkman
Gary Bugden
Clair E.A. Carver
John Hughes-Clark
J. Hamilton
G. Napolitano
Sherry Niven
Robert Pett
Rao Tatavarti
X. Zhou

Administrative and Technical Staff

Elizabeth R. Tidmarsh
G. Hammer
C. Smith
C. Turgeon
I. Mann
A.K. Hanson
M. Gourd
T. Parsons
Ed Officia
Fred Walsh
K. Harvey
D. Lawrence
K. Sawler
R. Boutilier
S. Brault
Rosslyn Ernst
J. Hamilton

D. Hazen
G. Leger
R. Maas
F. Majaess
J. Manual
B. Schofield
A. Sharma

1985 and 1986

Faculty

A. J. Bowen (Physics) (Director)
Christopher Beaumont (Geology)
Carl M. Boyd (Biology)
Robert C. Cooke (Chemistry)
Robert O. Fournier (Biology)
Christopher J.R. Garrett (Physics)
David A. Huntley (Physics)
Bruce D. Johnson (Chemistry)
J. Anthony (Tony) Koslow (Biology)
Marlon R. Lewis (Biology)
Keith E. Louden (Geology)
Larry A. Mayer (Geology)
Eric L. Mills (Biology)
Robert M. Moore (Chemistry)
Gordon A. Riley (Biology) (Emeritus)
Barry R. Ruddick (Physics)
Keith Thompson (Physics)
Peter J. Wangersky (Chemistry)

Associated Staff

Norval Balch (Aquatron Manager)
Terry Chriss (Physics)
Robert J. Conover¹ (Biology)
James S. Craigie² (Biology)
Lloyd M. Dickie¹ (Biology)
Fred W. Dobson³ (Physics)
Roger W. Doyle (Biology)
James E. Elliott³ (Physics)
Paul Galbraith (Meterology)
Robert D. Gershey (Chemistry)
Jonathan Grant (Biology)
Robert Guza (Physics)
Dan Hanes (Physics)
Barry T. Hargrave¹ (Biology)
W. Glen Harrison¹ (Biology)
Ross M. Hendry³ (Physics)
P.E. Holloway (Physics)

W. David Jamieson² (Chemistry)
M. Jonass (Chemistry)
Charlotte Keen⁴ (Geology)
Stephen J. Kerr¹ (Biology)
Rick Marsden
John Middleton (Physics)
George T. Needler³ (Physics)
James A. Novitsky (Biology)
Sifford Pearre (Biology)
John Peters (Geology)
Brian D. Petrie³ (Physics)
David J.W. Piper⁴ (Geology)
J.W. Peirce (Geology)
Trevor C. Platt¹ (Biology)
Louise Royer (Physics)
Young-Ho Seung (Physics)
Michael M. Sinclair⁵ (Biology)
Peter C. Smith³ (Physics)
Stuart D. Smith³ (Physics)
Robert L. Stephenson (Biology)
Francis C. Tan³ (Chemistry)
Keith Thompson (Physics)
B. Whitehouse (Chemistry)
Daniel Wright³ (Physics)
¹ Marine Ecology Laboratory (BIO)
² Atlantic Regional Laboratory (NRC)
³ Atlantic Oceanographic Laboratory (BIO)
⁴ Atlantic Geoscience Centre (BIO)
⁵ Halifax Fisheries Research Laboratory

Postdoctoral Fellows

Robert Courtney (Geology)
Herbert McQueen (Geology)
John Middleton (Physics)
H.J. Price (Biology)

Degrees Awarded

Bjorn Bjornsson (PhD) (1985)
David Scott Brew (MSc) (1986)
Claire E.A. Carver (MSc) (1985)
Ambekar Eshwar Eknath (PhD) (1985)
Dian J. Gifford (PhD) (1985)
John David Ives (MSc) (1985)
Dan Kelly (PhD) (1986)
Chang-Shik Kim (MSc) (1985)
Sam McClatchie (PhD) (1985)
Bryan Michaud (PhD) (1986)
Carmen E. Morales (MSc) (1986)

Dwight K. Muschenheim (PhD) (1986)
Guillermo E. Napolitano (MSc) (1986)
Christopher C. Parrish (PhD) (1986)
Pierre Pepin (PhD) (1985)
Suzanne Roy (PhD) (1986)
Ross Shotton (PhD) (1985)
Peter M. Strain (PhD) (1985)
Bechara Toulany (MSc) (1985)
Sherman R. Waddell (PhD) (1985)
Douglas W. Wallace (PhD) (1985)
Derek Wallace (MSc) (1985)
Incoming Students (Advisor)
M. Anderson
Kimiko Azetsu
Rodney Bradford
M.E. Carr
Carla Caverhill
J. Chandler
P. Currie
J. Doering
A. Eisnor
C. Emerson
D. Gilbert
D. Grylicki
N. Hoepffner
N. Kuring
G. Leger
S. Lepage
S. Levesque
M. Lewis
M. MacNeil
J. Matthews
M.E. McInerney-Northcott
T. Minchington
Kate Moran
J. Muelbert
J. Osler
G. Pearson
M.A. Pena
S. Perissinotto
F. Schwing
D. Shurland
D. Slauenwhite
B. Tang
R. Tatavarti
J. Umoh

Administrative and Technical Staff

E.D. Crouse
G. Hammer
I. Rodgers
L.H. Burgess
Elizabeth R. Tidmarsh
I. Mann
A.K. Hanson
M. Gourd
J. Hurst
Ed Officia
Fred Walsh
K. Harvey
D. Lawrence
K. Sawler
T. Hoskins
N. Hamilton
D. Hazen
P. Bugden
J. Hamilton
T. Hoskins
G. Leger
R. Maass
F. Majaess
R. Palmer
B. Schofield
A. Sharma

APPENDIX 4

DALHOUSIE INSTITUTE OF OCEANOGRAPHY 1959-1986

STUDENT DATA

New students, total students and graduates by year. The numbers do not always balance because of dropouts or transfers. Approximately 70% of the admitted students earned degrees.

Year	New Students	Total Students	Graduates
1959	2	2	0
1960	7	9	0
1961	4	12	1
1962	10	?	5
1963	6	15	2
1964	7	?	2
1965	8	21	5
1966	10	25	5
1967	11	34	3
1968	7	36	4
1969	13	44	5
1970	10	40	7
1971	16	42	8
1972	4	?	12
1973	25	44	11
1974	16	44	9
1975	21	?	10
1976	14	?	7
1977	22	48	16
1978	6	46	9
1979	10	55	5
1980	15	60	6
1981/82	20	66	15
1983/84	14	61	11
1985/86	35	79	21

APPENDIX 5

DALHOUSIE INSTITUTE OF OCEANOGRAPHY 1959-1986

STUDENT THESES

Includes both MSc and PhD degrees. Supervisors are shown in parentheses.

1961

Hochachka, Peter W. Fish metabolic pathways in relation to temperature compensation and performance (MSc) (Hayes).

1962

Duff, Sheila L. Some aspects of ecosystem stability in salt marsh soils (MSc) (Teal).

Halcrow, Kevin. Acclimation to temperature in two marine crustacea (MSc) (Teal).

Pezzetta, J.M. Recent sediments of the Scotian Shelf (MSc) (Nota).

Tsernoglou, D. Contribution to the study of the structure and microbiology of marine and freshwater sediments (MSc) (Anthony).

Watt, Walton D. Tracer study of the phosphorus cycle in seawater (MSc) (Hayes).

1963

Barrett, Donald L. Seismic crustal studies in Eastern Canada: Atlantic coast of Nova Scotia (MSc) (Keen).

Grant, Douglas R. Pebble lithology of the tills of southeast Nova Scotia (MSc) (Nota).

1964

Batoosingh, Edward. The bacteriology of marine pebbles (MSc) (Anthony).

Manchester, Keith S. Geophysical investigations between Canada and Greenland (MSc) (Keen).

1965

Cook, Robert H. The effects of anoxia on three crustaceans (MSc) (Boyd).

Ewing, Gerry N. Structural framework in the Gulf of St. Lawrence (MSc) (Keen).

MacIntyre, W.G. The temperature variation of the solubility product of calcium carbonate in seawater (PhD) (Platford).

Pearre, Sifford. Metabolic activity as an indicator of zooplankton abundance (MSc) (Boyd).

Weiler, R.R. A study of the surface structure on marine sediments by gas adsorption and related techniques (PhD) (Nota).

1966

Halcrow, Kevin. Some aspects of the respiration and nutrition of the marine amphipod *Gammarus oceanicus* Segerstrale (PhD) (Boyd).

James, Noel P. Sediment distribution and dispersal patterns on Sable Island and Sable Island Bank (MSc) (Stanley).

Miller, James A. The suspended sediment system in the Bay of Fundy (MSc) (Swift).

Ruffman, Alan S. Crustal seismic studies in Hudson Bay, Canada (MSc) (Keen).

Vilks, Gustaf B. Quantitative analysis of foraminifera in Bras d'Or Lakes (MSc) (Anthony).

1967

Batoosingh, Edward. The bacteriology of water masses in the North Atlantic Ocean (PhD) (Anthony).

Dainty, Anton M. Crustal studies in eastern Canada (PhD) (Keen).

Miles, Stuart G. The orientation of the adult American eel *Anguilla rostrata* (Le Seuer) (Garside).

1968

Ardill, J. David. Studies on the selective feeding of the American plaice *Hippoglossoides platessoides* F. of St. Margaret's Bay, Nova Scotia (MSc) (Dickie).

Cook, Robert H. Some biochemical and physiological consequences of induced anoxia in the marine amphipod *Gammarus oceanicus* Segerstrale (PhD) (Boyd).

Gordon, Donald C. Jr. Studies on the distribution and composition of non-living particulate organic matter in the North Atlantic Ocean (PhD) (Riley).

Macnab, Ronald F. Gravity computations on a spherical earth (MSc) (Loncarevic).

1969

Blundon, Sandra J. An attempt to obtain deep crustal reflections using a low level source (MSc) (Keen).

Krauel, David P. A physical oceanographic study of the Margaree and Cheticamp River systems (MSc) (Trites).

Lambert, Anthony (Tony). A tilt meter study of the response of the earth to ocean tide loading (PhD) (Keen).

Ramsammy, Joshua R. Energy flux and biosynthesis in a plankton community (PhD) (Boyd).

Zo, Zinntae. Observations on the natural population of *Sagitta elegans* in Bedford Basin, Nova Scotia (MSc) (Riley).

1970

Choi, Chung I. Phytoplankton production and extracellular release in Nova Scotia coastal and offshore waters (MSc) (Watt).

Cok, Anthony E. Morphology and surficial sediments of the eastern half of the Nova Scotia Shelf (PhD) (Gees).

Lee, Allen H. The T-S structure, circulation and mixing in the Slope Water region east of the Scotian Shelf (PhD) (Mann).

Pearre, Sifford. Light responses and feeding behaviour of *Sagitta elegans* Verrill (PhD) (Boyd).

Pocklington, Roger. Dissolved free amino-acids of North Atlantic Ocean waters (PhD) (Wangersky).

Thomas, Martin L.H. Studies on the benthos of Bidford River, Prince Edward Island (PhD) (Mills).

Warner, James L. Water movement on the Scotian Shelf (PhD) (Mann).

1971

Allen, Theresa M. A study of enzyme allele frequencies in herring (*Clupea harengus harengus* L.) sub-populations of the North Atlantic and application of numerical taxonomic techniques to the data (PhD) (Wangersky).

Balch, Norval. The role of living and non-living organic particles in copepod feeding (PhD) (Boyd).

Cooke, Robert C. The lysocline and calcium carbonate compensation depth in the sea (PhD) (Wangersky).

Drapeau, Georges. The sedimentology of the surficial sediments of the western portion of the Scotia Shelf (PhD) (Gees).

Johnson, James S. A contribution to the structure of northern Baffin Bay and Lancaster Sound (MSc) (Keen).

Legendre, Louis. Phytoplankton structures in Baie de Chaleurs (PhD) (Watt).

MacCutcheon, Murray W. Some aspects of a digital analysis of seismic refraction data (MSc) (Keen).

1972

Atkinson, Larry P. Air bubbles in an oceanic mixed layer: effect on gas concentrations and air-sea gas exchange (PhD) (Wangersky).

Foster, Leslie A. Current measurements in the Drake Passage (MSc) (Mann).

Harding, Gareth C. Ecological observations on North Atlantic deep-sea copepods (PhD) (Riley).

Hume, Howard R. The distribution of recent foraminifera in southeast Baffin Bay (MSc) (Keen).

Levings, Colin D. Temporal changes and fish predation in a marine benthic community (PhD) (Mills).

Lyttle, Norman A. Petrology and petrogenesis of basalts from the Olympic Peninsula, Washington (MSc) (Clark).

MacKinnon, James C. Production dynamics of a marine flatfish population: an energetic model (PhD) (Dickie).

Mackintosh, Janet A. A non-motivational model for the control of food intake in an intertidal amphipod *Marinogammarus obtusatus* Dahl (MSc) (Boyd).

Michael, Allen D. Studies on the benthic amphipoda of Cape Cod Bay, Massachusetts (PhD) (Mills).

Sharp, Jonathan H. The formation of particulate organic matter in seawater (PhD) (Riley).

Wheeler, John R. Some effects of solar levels of ultra-violet radiation on the dissolved organic constituents of surface waters (PhD) (Riley).

1973

Adams, Donald D. A laboratory model for plankton decomposition in anaerobic and aerobic seawater (PhD) (Wangersky).

Bezanson, Donald S. Cavitation due to reflection of shock waves at an interface between water and air (MSc) (Levin).

Carrière, J.E. A physical oceanographic study of The Havre and Baie de Gaspé (MSc) (Overstreet).

Duedall, Iver W. Seawater: an explanation of hydration and ion-water interactions in terms of differential isothermal compressibility measurements (PhD) (Wangersky).

Duerden, F. Colin. Aspects of phytoplankton production and phosphate exchange in Bedford Basin (PhD) (Riley).

Freeland, Howard J. The effects of topography on ocean currents: the splitting of the Gulf Stream (PhD) (Overstreet).

Gregory, Douglas N. A physical oceanographic study of the Northwest Arm of Halifax Harbour (MSc) (Overstreet).

Pease, Allan K. Uptake of radioactive substrates by cell suspensions of *Artemia salina* and their subsequent incorporation into protein and RNA (PhD) (Conover).

Stukas, V.J. $^{40}\text{Ar} - ^{39}\text{Ar}$ dating of the Long Range Dykes, Newfoundland (MSc) (Reynolds).

Vilks, Gustaf B. A study of *Globorotalia pachyderma* (Ehrenberg) in the Canadian Arctic (PhD) (Medioli).

Yoshiari, T. Nitrous oxide in the sea (PhD) (Wangersky).

1974

- Anderson, Edward. Feeding assimilation and growth in ctenophores (PhD) (Riley).
- Conover, Shirley. Nitrate, ammonium and urea as nitrogen sources for marine diatoms in culture and in spring blooms (PhD) (Riley).
- Cranston, Raymond E. Interactions between major cations, pH and suspended matter in coastal environments (MSc) (Wangersky).
- Freeman, Kenneth R. Growth, mortality and seasonal cycle of *Mytilus edulis* in two Nova Scotian embayments (MSc) (Mann).
- Harrison, Paul. Growth and detritus formation in a temperate seagrass (PhD) (Mann).
- Johnson, Glen W. On measuring zooplankton *in situ* using a resistive pulse technique (PhD) (Boyd).
- Malloy, Stewart. Some observations on chitin digesting bacteria from southern Nova Scotia and lobster shell disease (MSc) (Riley).
- Petrie, Brian. Surface and internal tides on the Scotian Shelf (PhD) (Garrett).
- Robert, Ginette. The sublittoral Mollusca of the St. Lawrence Estuary, east coast of Canada (PhD) (Mills).

1975

- Blinn, Louis J. A study of seismic surface waves on the Reykjanes Ridge (MSc) (Keen).
- Gatien, M. Germaine. A study in the Slope Water south of Halifax (MSc) (Garrett).
- Lewis, John F. Oceanic heat flow measurements over the continental margins of Eastern Canada (MSc) (Hyndman).
- MacGregor, D.R. Clive. Weathering of oil spilled on cold, oceanic water with particular reference to sulphur containing compounds (MSc) (Wangersky).
- Morris, Byron F. Ecology of the neuston in the North Atlantic (PhD) (Boyd).
- Sadler, H. Eric. Nares Strait (PhD) (Garrett).
- Stucchi, Dario J. Seiches in the Northwest Arm of Halifax Harbour (MSc).

Tee, Kim-Tai. Tide-induced residual currents in the Minas Channel and Minas Basin (PhD) (Huntley).

Willey, Joan D. Physical chemistry of silica in seawater and sediments (PhD) (Cooke).

1976

Bugden, Gary. Ice movement and modification in the Gulf of St. Lawrence (MSc) (Garrett).

Cooke, Louise. Ecological studies of the bivalve mollusc *Nucula delphinodonta* Mighels (MSc) (Mills)

Hall, Blaine R. Collection, reduction and interpretation of magnetic data from the Newfoundland Basin (MSc) (Keen).

Hollibaugh, James T. Nitrogen regeneration during amino acid degradation and the activity of bacteria in plankton communities of Halifax Harbour (PhD) (Craigie).

Horowitz, Martin R. An electrophoretic mobility study of suspended sediments in river and low salinity waters (MSc) (Cooke).

Johansen, Patricia L. A study of tintinnids and other protozoa in eastern Canada with special reference to tintinnid feeding, nitrogen excretion and reproduction rates (PhD) (Riley).

Robbins, Jonathan V. The photosynthetic and respiratory physiology of *Palmaria palmata* (L) Stackhouse, as affected by temperature, irradiance, total carbon dioxide, salinity and pH (MSc) (Craigie).

1977

Aksu, Ali E. The late Quaternary stratigraphy and sedimentation history of Baffin Bay (MSc) (Piper).

Drury, Malcolm J. The electrical properties of ocean crust and oceanic island basalts and gabbros: result and implications of a laboratory study (PhD) (Beaumont).

Hincks, Alan V. Seaweeds as a source of dissolved organic compounds in seawater (MSc) (Wangersky).

Hoff, John T. Evidence for chemical fractionation and non-conservative distribution of Fe, Mn, Cu and Zn in coastal seas (PhD) (Cooke).

Holman, Kathryn. An investigation into the solubility of copper, manganese and cobalt in seawater (MSc) (Cooke).

Kepkay, Paul E. Preliminary investigations of free gas as the control of a sub-bottom acoustic reflector in the fine-grained sediments of Halifax Harbour and St. Margaret's Bay, Nova Scotia (MSc) (Cooke).

Mackas, David L. Horizontal spatial variability and co-variability of marine phytoplankton and zooplankton (PhD) (Boyd).

MacKinnon, Michael D. The analysis of the total organic carbon in seawater (PhD) (Wangersky).

MacKnight, Scott D. An investigation into the solubility behaviour of phosphorite in seawater (PhD) (Cooke).

Mageau, Camille M. Foraminiferal test alterations resulting from ingestion by larger invertebrates (MSc) (Walker).

Marra, John F. Studies on the effect of short-term light intensity variation on photosynthesis in phytoplankton (PhD) (Riley).

Newhouse, Doreen S. The effects of prey size and fish size on some components of capture success behaviour in larval windowpane flounder (*Scophthalmus aquosus*) (MSc) (Dickie).

Rice, Phillip. The Bermuda Seamount - An investigation into the magnetic properties and the $^{40}\text{Ar}/^{39}\text{Ar}$ radiometric age of selected hydrothermally altered submarine flows (MSc) (Hall).

Shaw-Wood, Paul E. Halmyrolysis of montmorillonite with regard to some transition metals (MSc) (Cooke).

Stewart, Patrick L. Deposit-feeding of *Sternapsis scutata* (Annelid: Polychaeta) (MSc) (Mills).

Zika, Rodney G. An investigation in marine photochemistry (PhD) (Wangersky).

1978

Birch, J. Richard. Flood tide intrusions and their effects on the temperature of Little Narrows Pond (MSc) (Garrett).

Carls, Mark G. Some toxic and behavioural effects of No. 2 fuel oil on the eggs and larvae of *Scomber scombrus* L. and *Gadus morhua* L. (MSc) (Dickie).

- Dunbrack, Janet M. The effect of zooplankton excretion on phytoplankton productivity (MSc) (Riley).
- Gartner, Katherine E. Feeding and respiratory activities of *Mytilus edulis* in a continuous flow system (MSc) (Dickie).
- Hartwell, J. Murray. Organometallic associations in sediment-seawater systems (MSc) (Cooke).
- Horne, Edward P.W. The dynamics of the subsurface front in the slope water off Nova Scotia (PhD) (Garrett).
- Li, William K.W. Growth responses and physiological adaption of phytoplankton to cadmium stress (PhD) (Fournier).
- Rohrbacher-Carls, Mary Rebecca. Some sublethal effects of oiled sediment on a population of the marine amphipod *Pontoporeia femorata* (Krøyer, 1842) (MSc) (Riley).
- Sellner, Kevin C. Primary production and the flux of dissolved organic matter in several marine environments (PhD) (Wangersky).

1979

- Allen, Arthur A. Current variability at the offshore edge of the Labrador Current (MSc) (Huntley).
- Bates, Stephen S. Studies on the use of radiosulfate to determine the physiological state, growth rate and rate of protein synthesis by marine phytoplankton (PhD) (Craigie).
- Holman, Robert A. Infra-gravity waves on beaches (PhD) (Bowen).
- Johnson, Bruce D. The rate of organic particulate production resulting from bubble dissolution in the ocean (PhD) (Wangersky).
- Painchaud, Jean. The effect of particulate matter on nitrogen cycling and heterotrophic activity of marine bacteria (MSc) (Wangersky).

1980

- Gagnon, Michel J.J. The fate of anthropogenic surfactants in the marine system (PhD) (Wangersky).

Huntley, Mark E. Developing and testing a new method for estimating the production of marine zooplankton (PhD) (Dickie).

Kepkay, Paul E. Microbial and chemical controls of carbon cycling in marine sediments (PhD) (Cooke).

Loder, John W. Secondary tidal effects in tidally-energetic shallow seas with application to the Gulf of Maine (PhD) (Garrett).

Mukai, Leonard S. Cell wall chemistry and ultrastructure of diploid and haploid phases of the dimorphic alga *Prophyra tenera* (Kjellm) (PhD) (Craigie).

Smith, Jerome A. Waves, currents and Langmuir circulation (PhD) (Garrett).

1981/1982

Bailey, Peter B. Central Amazon fish populations: biomass, production and some dynamic characteristics (PhD) (Koslow).

Bousfield, Marjorie A. Species abundance, associations and zoogeography of invertebrate macrobenthos of a subarctic fjord, Nain Bay, Labrador (MSc) (Mills).

Chong, Chi K. Enzymatic activities as indicators of fish metabolism (MSc) (Dickie).

Hargreaves, N. Brent. Sub-surface chlorophyll maxima off Nova Scotia: relation to environmental distributions and zooplankton distributions (PhD) (Fournier).

Jusko, Barbara-Ann. The Strait of Belle-Isle: Physical aspects and biological implications of flow (MSC) (Garrett).

Kean, Joan C. Laboratory studies designed to investigate some aspects of predation on fish larvae (MSc) (Dickie).

LaRoche, Julie. Ammonium regeneration: its contribution to phytoplankton nitrogen requirements in a eutrophic environment (MSc) (Boyd).

Quinlan, Garry M. Numerical models of postglacial relative sea level change in Atlantic Canada and the eastern Canadian Arctic (PhD) (Beaumont).

Roberts, Debra L. Distribution of organic carbon and nitrogen in various natural particle types of a fine intertidal sediment (MSc) (Mills).

Stacey, Michael W. A theoretical study of density and turbidity currents (PhD) (Bowen).

Symonds, Graham. Long waves on beaches and the dynamics of surf zone forcing (PhD) (Huntley).

Thomas, Kathryn E. Seabird distribution in Cabot Straits: variability and associated oceanographic features (MSc) (Mills).

1983

Bohrer, Richard N. Diel activities cycles in marine copepods (PhD) (Boyd).

Cota, Glenn F. Carbon metabolism in planktonic systems (PhD) (Wangersky).

Dugas, Jodine C. Development of the zooplankton community in the Browns Bank Region between February and November 1983 (MSc) (Koslow).

Fullerton, Anne F. The response of a larval white hake population to the oceanographic regimes of 1974 and 1975 in St. George's Bay, Nova Scotia (MSc) (Dickie).

Ku, Lung-Fa. The computation of tides from GEOS-3 altimeter data (PhD) (Garrett).

Milley, Christopher M. Some effects of high temperatures and high pressures on Sohm Abyssal Plain sediments (MSc) (Cooke).

Volckaert, Filip. The spatial pattern of Polychaeta in soft sediments and the influence of food supply on their patchiness (MSc) (Mills).

Whitehouse, Brian G. The partitioning of polynuclear aromatic hydrocarbons into the dissolved phase of the aquatic environment (PhD) (Wangersky).

1984

Franks, Peter J.S. A coupled physical-biological model of a warm core ring (MSc) (Wroblewski).

Geider, Richard J. Light and nutrient effects on microalgal physiology (PhD) (Fournier).

Welch, D.W. A study of the effects of density dependence and age structure on the dynamics of marine fish populations (PhD) (Dickie).

1985

Bjørnsson, Bjørn. Bioenergetics of cod (*Gadus morhua* L.): a response to food intake with possible implications for fisheries management (PhD) (Dickie).

- Carver, Claire E. A. The contribution of the phototrophic picoplankton to the biomass and production of the phytoplankton: an evaluation of size-related principles (MSc) (Fournier).
- Eknath, Ambekar E. Intensity of selection on life history traits in cultivated fish populations (PhD) (Koslow).
- Gifford, Dian J. The impact of grazing by marine planktonic oligotrichs (Ciliophora, Oligotrichida) in laboratory culture and in the Northwest Arm of Halifax Harbour (PhD) (Boyd).
- Ives, John D. The influence of dinoflagellate toxicity on the grazing responses of small marine copepods: a laboratory study (MSc) (Boyd).
- Kim, Chang-Shik. Field observations of wave groups and long waves on sloping beaches (MSc) (Bowen).
- McClatchie, Sam. Feeding rates, selectivities and behaviour of euphausiid crustaceans (PhD) (Boyd).
- Pepin, Pierre. The influence of variations in food abundance on the foraging dynamics of Atlantic mackerel *Scomber scombrus* and its importance in modulating the impact of adult pelagic fish on larval fish survival and recruitment variability (PhD) (Koslow).
- Shotton, Ross. An analysis of the structure of herring schools (PhD) (Dickie).
- Strain, Peter M. The weathering of a light crude oil in a sandy beach (PhD) (Wangersky).
- Toulany, Bechara. The structure and dynamics of flow fluctuations in the Strait of Belle Isle (MSc) (Garrett).
- Waddell, Sherman R. Low frequency flow in the Canadian Arctic Archipelago (PhD) (Huntley).
- Wallace, Derek. Geothermal measurements on the Sohm Abyssal Plain, Northwest Atlantic (MSc) (Louden).
- Wallace, Douglas W. A study of the ventilation of Arctic waters using chlorofluoromethanes as tracers (PhD) (Moore).

1986

- Brew, David S. Seismic modelling at Deep Sea Drilling Project Site 603: the lower continental rise hills (MSc) (Mayer).

- Kelley, Dan. Oceanic thermohaline staircases (PhD) (Ruddick).
- Michaud, Bryan. Composition and production of macroinvertebrate communities and food resources of the American lobster *Homarus americanus* along the Atlantic coast of Nova Scotia (PhD) (Mills).
- Morales, Carmen E. Copepod faecal pellet composition: effects of food concentration acclimation and ingestion rates (MSc) (Boyd).
- Muschenheim, Dwight K. Hydrodynamics and the ecology of suspension feeding benthos (PhD) (Mills).
- Napolitano, Guillermo E. Studies on fatty acids of planktonic larvae of the European oyster *Ostrea edulis* (L) and their phytoplanktonic diet (MSc) (Wangersky).
- Parrish, Christopher C. Dissolved and particulate lipid classes in the aquatic environment (PhD) (Wangersky).
- Roy, Suzanne. Marine chloropigments: chromatographic measurement in phytoplankton and transformations in algal cultures and a spring bloom in a marine bay (PhD) (Fournier).

APPENDIX 6

DALHOUSIE INSTITUTE OF OCEANOGRAPHY 1959-1986

GRADUATES EMPLOYED AT THE BEDFORD INSTITUTE OF OCEANOGRAPHY

Donald L. Barrett (MSc) (1963)
Keith Manchester (MSc) (1964)
Gerry N. Ewing (MSc) (1965)
Alan S. Ruffman (MSc 1966)
Gustav Vilks (MSc) (1966), (PhD) (1973)
Robert H. Cook (PhD) (1968)
Donald C. Gordon (PhD) (1968)
Ronald F. Macnab (MSc) (1968)
David P. Krauel (MSc) (1969)
Roger Pocklington (PhD) (1970)
Martin L.H. Thomas (PhD) (1970)
Gareth C. Harding (PhD) (1972)
Paul E. Vandall (MSc) (1972)
Donald S. Bezanson (MSc) (1973)
Iver W. Duedall (PhD) (1973)
Douglas N. Gregory (MSc) (1973)
Raymond E. Cranston (MSc) (1974)
Kenneth R. Freeman (MSc) (1974)
Brian D. Petrie (PhD) (1974)
Ginette Robert (PhD) (1974)
Kim-Tai Tee (PhD) (1975)
Gary Bugden (MSc) (1976)
Paul E. Kepkay (MSc) (1977), (PhD) (1980)
Janet M. Dunbrack (MSc) (1978)
Edward P.W. Horne (PhD) (1978)
William K.W. Li (PhD) (1978)
Ingrid Peterson (MSc) (1979)
John W. Loder (PhD) (1980)
Robert C. Courtney (MSc) (1982), (PhD) (1985)
Ross Shotton (PhD) (1985)
Bechars Toulany (MSc) (1985)
Dwight K. Muschenheim (PhD) (1986)