

## REMEMBERING HUDSON-70

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### ABSTRACT

Hudson-70 was the last big multidisciplinary global oceanographic expedition. Organized by the Bedford Institute of Oceanography (BIO), based in Nova Scotia, this epic eleven-month voyage lasted from November 1969 to October 1970, involved 128 scientists from five countries, and traversed five oceans. Enroute, the CSS *Hudson* steamed 56,000 nautical miles and became the first ship to circumnavigate the Americas. A huge amount of new oceanographic information in all disciplines was collected in environments ranging from tropical to polar. Major highlights are summarized. General overviews of the expedition were published in three books and the results of individual studies were reported in over 50 scientific publications. Hudson-70 was a major Canadian oceanographic accomplishment, truly worthy of celebrating fifty years later.

### INTRODUCTION

In 1962, the Bedford Institute of Oceanography (BIO) opened on the shores of Bedford Basin in Dartmouth, NS. It soon grew into Canada's largest centre for ocean research. The following year marked the delivery of the CSS *Hudson*, a diesel-electric driven ship with a Lloyds Ice Class I hull to enable work in ice-infested waters, was built at Saint John Shipbuilding and Drydock in Saint John, NB. She was well equipped for multidisciplinary oceanographic research and could carry four hydrographic launches and a helicopter. Ninety meters in length, she had a displacement of 4793 tonnes, cruising speed of 13 knots, at-sea endurance of 50 days, and accommodation for 25 scientists. Well-designed for working in the North Atlantic and Eastern Arctic, she soon developed an international reputation as a superb platform for working under adverse weather conditions.

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She became the queen of the fleet and an icon for BIO. The many accomplishments over her long career have been summarized by Smith (2003). Without doubt, her most notable accomplishment was the Hudson-70 Expedition during which she became the first vessel of any kind to circumnavigate both North and South America.

### ORIGIN OF HUDSON-70

In 1967, BIO wished to extend its area of operations beyond the North Atlantic and Eastern Arctic. It was suggested by Dr. Cedric Mann, a physical oceanographer, that it would be worthwhile to measure the flow of water through the Drake Passage, between the southern tip of South America and Antarctica, which had not yet been quantified. There was also interest in studying the fjords of Chile, recording the gravity and magnetic fields along a south-north transit of the Pacific for calibrating oceanographic satellites, conducting geophysical surveys off the Queen Charlotte Islands (Haida Gwaii), surveying the little known Beaufort Sea and navigating the Northwest Passage.

Under the lead of Dr. Cedric Mann (Fig 1) and Dr. William Ford, Director of BIO, these ideas were assembled into a proposal for a major eleven-month oceanographic expedition following the summer around the Americas and completing the first ever circumnavigation. This proposal was subsequently approved by the Honourable Joe Greene, the Minister of Energy, Mines and Resources, and detailed planning proceeded which included adding additional projects as time and space permitted.



Fig 1 Dr. Cedric Mann, lead scientist for Hudson-70.



**Fig 2** Cruise track of Hudson-70.

## OVERVIEW

The Hudson-70 Expedition (Fig 2) took 330 days and was divided into nine legs. The total distance steamed in the North Atlantic, South Atlantic, South Pacific, North Pacific and Arctic oceans was 56,000 nautical miles. There were 128 participating staff from five countries (Canada, US, UK, Argentina and Chile), including scientists, technical support and graduate students. The majority came from BIO and Dalhousie University. A large number of agencies were involved: the Atlantic Oceanographic Laboratory (BIO), the

Marine Ecology Laboratory (BIO), the Canadian Wildlife Service (BIO), the Defense Research Establishment Atlantic (Dartmouth), the Marine Sciences Branch (Ottawa), the Geological Survey of Canada (Ottawa), the National Research Council (Ottawa), the National Museum of Natural Sciences (Ottawa), the Pacific Oceanographic Group (Nanaimo), the Institute of Oceanography (Dalhousie), the Institute of Oceanography (UBC), Queens University, University of Toronto, McGill University, Trent University, the Woods Hole Oceanographic Institution (US), the Scripps Institute of Oceanography (US), Oregon State University (US), University of Washington (US), the Royal Navy (UK), the Argentinian Navy and various Chilean universities. Research programs were carried out over a broad range of scientific disciplines including physical oceanography, chemical oceanography, biological oceanography, ornithology, marine geology, geophysics, geodesy, hydrography, and underwater acoustics.

### **Leg 1 – Halifax to Rio de Janeiro**

19 November to 14 December 1969

Dr. C.R. Mann (BIO), Chief Scientist

After sendoff speeches, including the Honorable Joe Greene, the Minister of Energy, Mines and Resources, the freshly painted and fully provisioned *Hudson* departed BIO on 19 November 1969 for her eleven-month voyage around the Americas (Fig 3). She proceeded south in the North Atlantic conducting gravity, magnetic and bathymetric surveys and acoustic reverberation research.



**Fig 3** *Hudson* departing BIO.

Upon reaching the Equator at 30°W, she began a line of oceanographic stations down the 30°W meridian in the South Atlantic. Water samples throughout the water column were collected for the determination of temperature, salinity, oxygen, nutrients and organic carbon. Other work included a deep scattering layer study using one-pound explosive charges, Isaacs-Kidd mid-water trawls and vertical plankton tows. Measurements of primary production were also carried out. On the passage between stations at night, a neuston net was deployed to catch surface fish and zooplankton. Whenever whales were spotted, the ship stopped to take acoustic recordings. Upon reaching 25°S, *Hudson* proceeded to Rio de Janeiro.

### **Leg 2 – Rio de Janeiro to Buenos Aires**

20 December 1969 to 16 January 1970

Dr. C.R. Mann (BIO), Chief Scientist

Upon departing Rio, the *Hudson* resumed the line of stations southward along 30°W. The station routine was the same as Leg 1 with the exception that piston cores of seafloor sediment were collected at each station. Christmas Day was spent at 32.5°S and New Year's Eve occurred at 47.5°S with suitable celebrations. At the southern limit of the transect, 55°S, *Hudson* encountered icebergs, albatrosses, penguins, a full spectrum of other Antarctic birds as well as fin and pilot whales. Turning to the northwest, she investigated a gap in the Scotia Ridge which was thought to be a northward route for Antarctic Bottom Water and then sailed for Buenos Aires.

### **Leg 3 – Buenos Aires to Punta Arenas**

22 January to 23 February 1970

Dr. C.R. Mann (BIO), Chief Scientist

From Buenos Aires, the *Hudson* sailed southward toward Cape Horn, making seabird observations on the way. She then entered Magellan Strait, made a call at Punta Arenas, Chile, and threaded through the Beagle Channel to make another port call in Puerto Williams, Chile, the southernmost settlement in the world. Here, some biologists left the ship for a month to study coastal and beach fauna using a survey launch. After conducting some bottom sled stations and plankton tows off the Wollaston Islands, *Hudson* then proceeded south. After passing Cape Horn in under unusually calm conditions, she entered the Drake Passage and sought out areas of

level seabed suitable for deploying a line of current meter moorings, one of the original justifications for the expedition. Once suitable sites were located, four moorings were deployed. Each mooring consisted of a railway wheel at the bottom, a subsurface float at the top and Braincon current meters at depths of 150 m and 1,500 m, as well as 100 m above the bottom (Fig 4). Each current meter was fitted with a thermograph and a depth gauge. Standard oceanographic stations were carried out at each location.

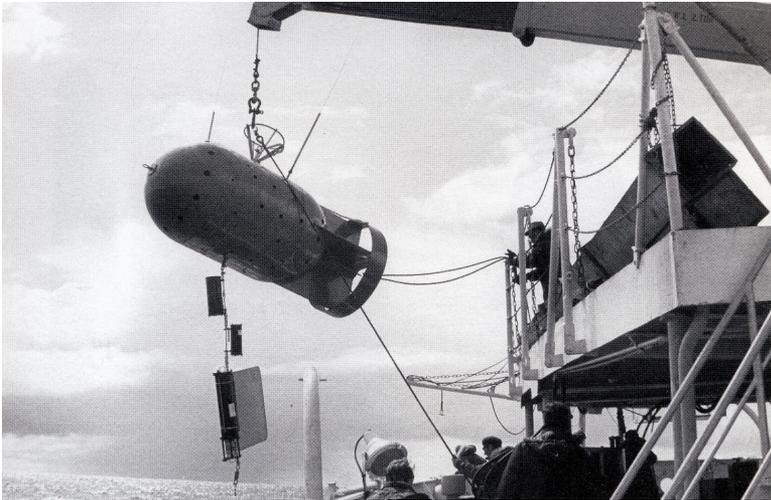


Fig 4 Deploying a current meter mooring the Drake Passage.

Once the moorings were deployed, *Hudson* sailed further south and began a sampling program among the South Shetland Islands off the Antarctic Peninsula. This included plankton tows, rock dredge sampling, epibenthic sled tows and grab sampling. Shore parties explored several interesting sites. This program was interrupted when it became necessary to return to Puerto Williams to drop off a technician whose son had just died. While there, the biologists conducting inshore surveys in the launch were reprovisioned. *Hudson* then headed south again to pick up the current meter moorings and carry out a line of closely spaced oceanographic stations across the Drake Passage. All were relieved when the moorings were recovered in good order. *Hudson* then returned to the South Shetland Islands for some further sampling before returning to Puerto Williams to recover the launch party and steaming to Punta Arenas.

**Leg 4 – Punta Arenas to Valparaiso**

1 March to 7 April 1970

Dr. George Pickard (UBC), Chief Scientist

This leg was run by the Institute of Oceanography, University of British Columbia, and included a contingent of Chilean scientists. The purpose was to study the oceanography of the little known Chilean fjords. Seabird observations were also made. Heading northward, *Hudson* made her way through an intricate web of fjords and conducted surveys in 32 of them. Many were surveyed for the first time. *Hudson* then sailed westward into the open Pacific Ocean to visit Juan Fernandez Island and carry out a short transect of stations before steaming to Valparaiso.

**Leg 5 – Valparaiso to Tahiti**

15 April to 12 May 1970

Mr. R.C. Melanson (BIO), Chief Scientist

Departing Valparaiso, *Hudson* sailed southwest toward 65°S 150°W. On the way, she passed over a previously unknown underwater peak (seamount) and deep trough. These were subsequently named after *Hudson* and are now shown as such on international charts. Unfortunately, a high concentration of icebergs was encountered before reaching 65°S so the ship was forced to turn north at 63°S 150°W to begin the longest south-north transect of continuous oceanographic sampling ever completed. Gravity data were collected to allow the calibration of a radar altimeter about to be launched by satellite. Oceanographic stations were also made along the way and the sampling program was similar to that followed in the South Atlantic. At 16°30'S, sampling operations ceased and the ship headed to Tahiti (Fig 5).

**Leg 6 – Tahiti to Vancouver**

16 May to 12 June 1970

Dr. W.M. Cameron (MSB, Ottawa), Chief Scientist

Upon leaving Tahiti, *Hudson* returned to where sampling had ceased on the previous leg and resumed the sampling program of continuous gravity measurements and periodic oceanographic stations, while heading north along 150°W toward Alaska. At the oceanographic stations, data were collected on temperature, salinity, oxygen, nutrients and organic carbon throughout the water column.



Fig 5 *Hudson* at anchor in Tahiti.

A variety of plankton tows continued to be made. Planktonic foraminifera were collected at pre-programmed depths with a new sampler. In addition, detailed measurements were made on the size distribution of particles in surface water. Crossing the Equator marked the end of six months working in the Southern Hemisphere. The sampling program along  $150^{\circ}\text{W}$  was terminated over the Aleutian Trench at  $57^{\circ}30'\text{N}$ . This marked the end of an unprecedented 7,200 nautical mile south to north sampling transect in the Pacific Ocean. From here, the ship proceeded to Vancouver, the first Canadian port since departing Halifax eight months earlier. Upon arrival, *Hudson* was warmly welcomed and hosted an open house. The ship then moved to Esquimalt, just outside Victoria, for engine repairs that took almost a month to complete (Fig 6).

### **Leg 7 – Victoria to Victoria**

12 July to 5 August 1970

Dr. C.D. Maunsell (BIO), Chief Scientist

This leg was devoted to conducting geophysical surveys in the region west of the Queen Charlotte Islands (Haida Gwaii), the northern termination of the Juan de Fuca Ridge and the area surrounding the Explorer Trench. This area was of special interest to geophysicists studying plate tectonics for it marks the location where the American, Juan de Fuca, and Pacific plates meet at a 'triple junction'. The program, conducted with the assistance of the CNAV *Endeavour*, involved bathymetric, gravity and magnetic surveys as well as seismic reflection profiling.



Fig 6 *Hudson* departing Vancouver.

### Leg 8 – Victoria to Resolute

13 August to 22 September 1970

Dr. B.R. Pelletier (BIO), Chief Scientist

Departing Victoria, *Hudson*, now equipped with a helicopter for ice reconnaissance, sailed westward toward the Aleutian Islands. She was now accompanied by the CCS *Baffin* which had sailed from BIO by way of the Panama Canal to assist with work in the Beaufort Sea and the transit through the Northwest Passage. In addition, the newly commissioned CSS *Parizeau* from Victoria accompanied them to participate in the Beaufort Sea program. At Unimak Island, *Hudson* entered the Bering Sea. Soon after, a generator exploded which decommissioned one of her four engines for the duration of the voyage. After crossing the Arctic Circle, heavy pack ice was first encountered off Point Barrow which necessitated some backing and ramming. However, after crossing US-Canada boundary, the pack ice was located much further offshore and this allowed the first intensive oceanographic study of the southern Beaufort Sea to be carried out as planned. The only previous oceanographic work in this part of the Beaufort Sea was a few stations done from the Royal Canadian Mounted Police schooner *St. Roch* during her transit of the Northwest Passage in 1940. Gathering oceanographic information from this region was high priority at the time for the

Canadian Government because of active hydrocarbon exploration by industry and a successful oil find at Atkinson Point in the Mackenzie Delta in 1969.

A survey grid of parallel lines was established running northward from the coast out to the edge of the pack ice, along which seismic profiling and echo sounder, gravity and magnetics measurements were made. In addition, a sidescan sonar fish was deployed to examine seabed features. *Hudson* stopped periodically for hydrocasts, sediment cores, and seabed photography. Extensive seabed scouring by ice was observed out to depths of 100 m. Numerous underwater pingos were discovered similar to those observed on land in the Mackenzie Delta. These ice-cored mounds, looking like small conical volcanoes, rise as much as 70 m from the seabed and can be a hazard to shipping. Fortunately, the oil tanker SS *Manhattan* did not encounter any while passing through this area on her controversial passage through the Northwest Passage the previous year.

At the end of the survey, scientific personnel were exchanged by helicopter at Tuktoyaktuk and *Hudson*, still accompanied by *Baffin*, set off to navigate the Northwest Passage along the northerly route through Prince of Wales Strait and Parry Channel.

Heavy pack ice was encountered part way through and the Department of Transport icebreaker CCGS *John A. Macdonald* had to be called from Resolute, on Cornwallis Island, to break a channel (Fig 7). Some hydrocasts and bottom grabs were made along the way as conditions allowed. Polar bears were frequently observed. Once completed, the successful passage through the Northwest Passage was duly celebrated. The final port of call was Resolute.

### **Leg 9 – Resolute to Halifax**

30 September to 16 October 1970

Dr. D.I. Ross (BIO), Chief Scientist

Before leaving Resolute, a plaque commemorating Hudson-70, made by the bosun, was installed on a rock outcrop at nearby Cape Martyr (Fig 8). This plaque was revisited in 2002 and, except for a few bullet holes, was found in good condition.

The final leg of Hudson-70 was a geophysical survey of northern Baffin Bay involving two-ship seismic refraction work. *Hudson* served as the listening ship and the United States Coast Guard icebreaker USCGC *Edisto* served as the shooting ship. This survey



Fig 7 Traversing the Northwest Passage with *Baffin*.

demonstrated that underlying rocks in this region are oceanic rather than continental in origin. Once this survey was completed, the ship headed for home. At first it was planned to pass through the Straits of Belle Isle, inside Newfoundland, but then it was recognized that *Hudson* should pass outside Newfoundland over the Grand Banks so that it could be truly said that she circumnavigated the Americas.

On 16 October 1970, the *Hudson*, accompanied by *Baffin*, returned to BIO escorted by a fireboat and other water craft while coming up the harbour. It was a most fitting welcome home after an absence of almost a year. Many willing hands ashore were willing to catch her lines (Fig 9).



Fig 8 Bosun Joe Avery and Dr. Bernie Pelletier installing plaque outside Resolute.



Fig 9 Looking somewhat worse for wear, *Hudson* returns to BIO.

A large crowd had gathered on the quay. A podium had been constructed and after the lines were secure, there were welcoming speeches by Dr. William Ford, the Honourable Joe Greene and others (Fig 10). The Honourable Joe Greene also presented Captain David Butler with a commemorative plaque celebrating the successful completion of the expedition.



**Fig 10** Dr. William Ford, Director of BIO, presenting his welcome home speech. Sitting behind him on the podium are the Honourable Joe Greene, Minister of Energy, Mines and Resources, and Captain David Butler. The commemorative plaque is in front of the podium.

## SUMMARY

Hudson-70 was the last big multidisciplinary global oceanographic expedition, a tradition that began with the epic voyage of HMS *Challenger* in 1872. It established Canada's credentials in 'blue water' oceanographic research and was one of the most ambitious expeditions of its kind ever mounted by any nation. However, by 1970, the general features of the world ocean were relatively well known and future oceanographic cruises were more focused and regional in nature.

A huge amount of new oceanographic information was collected from five oceans in environments ranging from tropical to polar. Many regions traversed had not been studied before. Bathymetric,

gravimetric and magnetic data were measured continuously while the ship was underway. While stopped on station, data on temperature, salinity, oxygen, nutrients and organic carbon were collected throughout the water column. Seabed sediments were also sampled. Sampling of plankton, benthos and fish, as well as seabird observations, provided new fundamental information on the distribution of species in the world ocean.

The current meter moorings in the Drake Passage were the first direct measurements of water transport through this important part of the global ocean circulation and stimulated further studies by other nations. The Chilean fjord survey was the first and still the most thorough oceanographic survey of these unique fjords. A new seamount and trench, now named after *Hudson*, were discovered in the South Pacific. The 7,200 nautical mile transect up 150°W from the Antarctic to the Aleutians was unprecedented and provided critical geophysical information for calibrating satellite altimeters. Detailed studies of the size distribution of organic particles in surface water laid the basis for the development of the biomass size spectrum theory for analyzing pelagic ecosystems. The geophysical surveys off Haida Gwaii provided new information on the plate structure of the North Pacific. The extensive multidisciplinary survey of the Beaufort Sea was the first of its kind and provided information of immense value to the developing hydrocarbon industry and the defense of Canadian sovereignty. The *Hudson* was only the sixth ship to transit the Northwest Passage. The concluding geophysical survey provided new information on the crustal structure of Baffin Bay.

Full details of Hudson-70 operations are recorded in the BIO cruise reports. The scientific results have been reported in over 50 scientific publications, including peer-reviewed scientific journals, technical reports and graduate student theses. Honorary degrees were presented to Capt. David Butler by Brock University (1971) and Dr. Cedric Mann by the Nova Scotia Technical College (1972), in recognition of the critical roles that they played in the success of the expedition.

Three books have been written on Hudson-70. The first is *Voyage to the End of the World* (Edmonds 1973). Alan Edmonds was a journalist who did not participate in the expedition but interviewed key participants soon after it was completed. It is a very readable account of events with considerable insight into happenings behind

the scenes and interesting stories about the participants. The second is *The Great Ocean of Truth* (Wadhams 2009a). Peter Wadhams was a recent Cambridge University graduate who participated in the entire expedition as a technician looking after the geophysical equipment. As well as describing the general events, it also documents his personal memories and experiences, both at sea and onshore during port calls. The third book is *Getting Around the Americas: the Hudson-70 Expedition* (Schafer and Smith 2012). Both Charles Schafer and Roger Smith participated in certain legs of the expedition. It provides a thorough overview in words and pictures. In addition, two shorter overview articles have been written (Wadhams 2009b, 2014). As is certainly warranted, the Hudson-70 expedition has been very well documented for posterity.

Hudson-70 provided graduate students with marvellous training opportunities and formative experiences. In particular, Peter Wadhams was stimulated to pursue a PhD and is now the Head of Polar Ocean Physics Group at Cambridge. He became an expert on arctic ice and recently published a book on its gradual disappearance due to climate change (Wadhams 2017).

As testimony to her design and construction, *Hudson* is still afloat and in active use in 2020 at the advanced age of 57 years. This is quite remarkable for an oceanographic vessel. The only known research ship to surpass this number of years of service is the RV *Atlantis* which operated out of the Woods Hole Oceanographic Institution from 1930 to 1966 and then, renamed *El Austral*, carried out oceanographic research in Argentina up to 2006 for total of 76 years. *Hudson* will not surpass this record because a replacement vessel is planned and the keel is scheduled to be laid in the fall of 2020.

In 2009, BIO organized an event to celebrate the 40<sup>th</sup> anniversary of the departure of *Hudson* on Hudson-70. Over 50 of the original participants, including crew, attended and enjoyed presentations, receptions and a tour of the ship. Many old friendships were rekindled.

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