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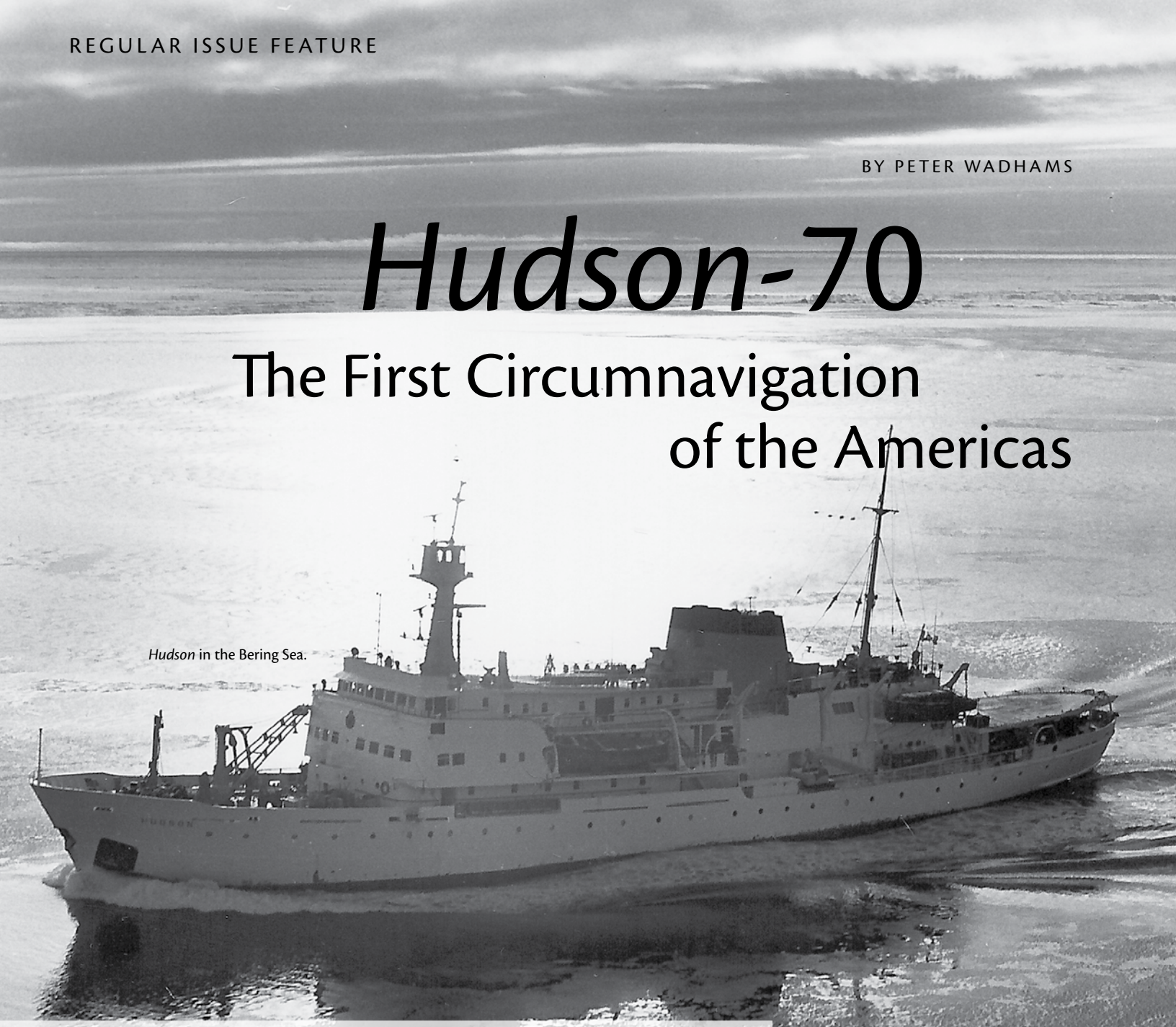
BY PETER WADHAMS

Hudson-70

The First Circumnavigation of the Americas



Hudson in the Bering Sea.

THIS YEAR MARKS the fortieth anniversary of the departure of one of the last of the great globe-spanning multidisciplinary oceanographic expeditions, a tradition that included the epic voyages of *Challenger*, *Meteor*, and *Albatross*. During an expedition lasting 11 months, the Canadian oceanographic ship CSS *Hudson* of the Bedford Institute of Oceanography (BIO), Dartmouth, Nova Scotia, accomplished the first, and still the only, circumnavigation of the Americas. The vessel worked in the South Atlantic, Antarctic, Pacific, and Arctic oceans and was only the sixth ship to transit the Northwest Passage. On November 17, 2009, CCGS *Hudson*, still an operational research ship of the Canadian Coast Guard, will host a party at BIO to celebrate the fortieth anniversary of the expedition, and a special exhibition is being mounted at BIO featuring films and photographs of the voyage.

ORIGIN OF THE IDEA

The Bedford Institute of Oceanography (BIO), whose largest part was known as the Atlantic Oceanographic Laboratory (AOL), was founded in 1960 by the Canadian government to investigate the waters of the North Atlantic and Baffin Bay. The institute's ships initially worked in the Arctic seas of Canada, the Denmark Strait, the North Atlantic out to the Mid-Atlantic Ridge, and the warmer waters of the Gulf Stream and the Caribbean. By 1967, AOL wished to extend its horizons, and Ced Mann, head of the physical oceanography group, thought that it would be worthwhile to measure the great eastward flow of water through the Drake Passage, which had not yet been monitored successfully.

Legend has it that this idea evolved into a circumnavigation plan in the bar of *Hudson*, BIO's newest (1963) and largest (4660 tons) ship, while she was stormbound off the east coast of Greenland in February 1967. Ced Mann, William Ford (Director of BIO), and the ship's captain were wedged together against the roll of the ship. Mann brought out his Drake Passage idea; the captain topped it by saying that he would like to take *Hudson* through the Northwest Passage. Ford already knew that the marine geophysicists at BIO wanted to work off the Queen Charlotte Islands on Canada's Pacific coast, where there was thought to be a "triple junction"—a place where three of Earth's tectonic plates meet. He also knew that there was a need to study the unknown Beaufort Sea in the western Arctic, which even then was believed to have offshore oil potential. The Beaufort Sea is accessible from the west—round the north of Alaska—early in the summer, while the Northwest Passage is not open until later in the summer. Finally, Ford also knew that the fjord oceanographers of the University of British Columbia would love to be able to study Chile's unknown fjords and compare them with their own waters. Why not combine all of these ideas in one sequential expedition: Drake Passage—Chilean fjords—Queen Charlotte Islands—Beaufort Sea—Northwest Passage, following the summer around the Americas and accomplishing a circumnavigation?

An additional boost to the idea came from William Von Arx of Woods Hole Oceanographic Institution, who pointed out how valuable it would be to do a long northward transit of the Pacific, recording the gravity and magnetic fields to serve as a calibration line for an oceanographic satellite, Seasat, due to be launched a few years later. Firm plans were in place by the autumn of 1968. *Hudson* would take a year to circumnavigate the Americas, working in the Southern Hemisphere from December to April and then reaching the Arctic for August and September. This circumnavigation would be the greatest single effort that Canada had ever made in oceanography.

The cost of the expedition, however, outstripped BIO's resources. The shortfall

was modest by today's standards—a mere $25,000 for extra fuel. Ford had to take the proposal to the government, in fact to Joe Greene, Minister of Energy, Mines, and Resources. Greene had just rejected science proposals for a telescope and a linear accelerator, each of which would have cost $100 million, and found the *Hudson* project an attractive and cheap alternative to support. He was due to announce approval for the project in the House of Commons in November 1968, but suffered a heart attack the day before. Planning for "*Hudson*-70" had to stop until he recovered. The vital speech was made in February 1969 and was received enthusiastically by the opposition parties as being "the sort of thing that Canada should be doing in the world." The voyage was approved.

LEG 1. HALIFAX TO RIO DE JANEIRO

November 19–December 14, 1969

Hudson sailed from BIO on November 19 and ran down to the equator at 30°W, carrying out along-track geophysics (gravity, magnetics, precision bathymetry) and acoustic reverberation research. At 0°, 30°W she began a line of stations at 2.5° (150-nautical-mile) intervals down the 30°W meridian as far as 55°S, reaching 25°S on the first leg. Each station included shallow and deep Knudsen bottle casts with onboard oxygen and nutrient analyses on collected waters; Niskin bottles were added to the casts for particulate organic carbon (POC) analyses. These casts were followed by an auxiliary cast to 2500 m using the Bathysonde, an "STD" (forerunner of the conductivity-temperature-depth [CTD] profiler), which at the time was too inaccurate to be used as the primary measuring device. Normal for the period, but extraordinary to remember today, was the time taken for a full station—up to 12 hours, mostly a product of the shallow and deep casts. The time required necessitated a large spacing between stations even though the region was almost virgin as far as previous station work was concerned.

Orest Bluy (front) and George Gill (Defence Research Establishment, Atlantic) recording acoustic data.

There was also an assumption that oceanic conditions were stable so that the results could be entered into oceanographic atlases. An oxygen section from this and the next leg (Duedall and Coote, 1972) was long regarded as a standard result.

Other work done at every station included a deep-scattering-layer study using one-pound charges, an Isaacs-Kidd mid-water trawl for one hour at 3 kts, and a vertical plankton tow. At night, on passage between stations, a Neuston net would be deployed to catch surface fish and zooplankton. Whenever whales were seen, the ship would be stopped to take acoustic recordings; minke whales were common, with occasional pods of fin whales and one blue whale.

Many of the seagoing scientists were still graduate students, and because *Hudson* was equipped with state-of-the-art instrumentation, the combination of young and senior scientists was a memorable experience for many, a formative influence on their careers. Two of the youngest and most junior on the scientific staff were Roger Smith, then a student at Queen's University, Kingston, Ontario, with an interest in sediments and plankton, and myself, just graduated from Cambridge University and taken on as Assistant to the Senior Scientist to perform general duties. We were both on board for all or most of the voyage, and after 40 years, we are helping to

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organize the celebrations, being among the few "*Hudson*-70" scientists still in full-time employment.

LEG 2. RIO DE JANEIRO TO BUENOS AIRES

December 20, 1969–January 16, 1970

During the stay in Rio de Janeiro, Brazil, the cetacean researcher on board, Peter Beamish, went hunting in Guanabara Bay and brought back a *Sautelia brasiliensis*, a Brazilian dolphin, which was cut up and kept in the ship's freezer. Each port call was also the occasion for a partial change of scientific personnel. In this case, Carol Lalli and Georgiana Deevey (McGill University) joined to study zooplankton, the only women until the Arctic legs.

Hudson sailed on December 20 and returned to the 30°W line. Stations from 27.5°S to 47.5°S were done at 2.5° intervals; then, approaching the Antarctic Convergence, the station interval was dropped to 1.5° from 49°S to 55°S. The last station of the line was done slightly further east, at 29°30'W, so as to be over the South Sandwich Trench in 7900 m of water. The station routine was similar, but with a piston core added to each station. Christmas Day was spent at 32.5°S, with suitable celebrations. New Year's Eve occurred during Station 20 at 47.5°S and coincided with the beginning of the International Decade of Ocean Exploration (1970–1980). In fact, probably the first sampling in IDOE was an expendable bathythermograph (XBT) that I launched at 00.01 GMT—and which got caught in the Bathysonde wire.

At the southern limit of the line, *Hudson* encountered icebergs, albatrosses (sooty, black-browed, and wandering), Adélie penguins, and the full spectrum of other Antarctic birds—Cape pigeons, Wilson's storm petrels, sooty shearwaters, and fulmars—as well as fin whales and pilot whales.

The Bosun easing a current meter down the slipway.

After completing the 30°W line, *Hudson* sailed to 40°W to do a line of five stations between 51°30'S and 47°S to investigate a gap in the Scotia Ridge that was thought to be a northward route for Antarctic bottom water. *Hudson* then sailed for Buenos Aires, Argentina, where the ship was opened to the public.

LEG 3. BUENOS AIRES TO PUNTA ARENAS

January 22–February 23, 1970

From Buenos Aires, *Hudson* sailed southward toward Magellan Strait, but was forbidden by Argentina from doing research in areas that were claimed to be Argentinian continental shelf (200 nm from the coast). A hydrographic officer, Lt. Roberto Rebaudi, was put aboard to enforce the claim. Therefore, there was no oceanographic research during the southward transit, although research on seabird populations was carried out by Eric Mills (Dalhousie University), Fred Cooke (Queen's University), and Bob Hessler (Scripps Institution of Oceanography). On January 26, *Hudson* entered Magellan Strait, calling at Punta Arenas to drop a steward whose brother was ill, then threaded through the Beagle Channel to reach Puerto Williams, a small Chilean port that, excepting Antarctic bases, is the southernmost settlement in the world. Here, a reception was held and *Hudson* dropped a pair of biologists, Ed Bousfield (then National Museum of Canada, now at the University of British Columbia) and Jim Markham (National Research Council), to carry out a month of independent work among the far southern islands from the ship's survey launch *Redhead*, studying coastal and beach fauna. During this survey, Bousfield discovered a new species of beach flea on a Fuegan shoreline.

Hudson carried out bottom-sled stations and plankton tows off Wollaston Island near Cape Horn, and then continued south, passing Cape Horn in very calm conditions. There, scientists started to search for areas of level seabed to deploy a line of four current meter moorings across Drake Passage, one of the original justifications for the expedition. The first mooring was 120 nm south-southwest of Cape Horn at

Deploying current meters in Drake Passage—the subsurface float and the topmost current meter enter the water.

57°49'S, 68°20'W. A bottle cast was done at each current meter site, including the use of large, 30-liter Niskin bottles and a nephelometer to study POC.

The second and third moorings were each a further 120 nm southward, and the final mooring was at 63°26'S, 67°06'W. The taut-wire mooring chain consisted of a railway wheel at the bottom and a subsurface float at the top, with Braincon current meters at 150-m depth, 1500-m depth, and 100 m above the bottom. A thermograph and a depth gauge accompanied each current meter.

With the moorings deployed, *Hudson* began a program of stations among the South Shetland Islands in Antarctica. Stations included plankton tows, dredge sampling, epibenthic sled tows, and Smith-McIntyre grab sampling. Work among the islands began on February 5 at South Bay, Livingston Island, and continued in Discovery Bay, Greenwich Island, then in Marion Cove, King George Island, and finally in Admiralty Bay, King George Island, where we visited the abandoned British Base G of Falkland Islands Dependencies Survey.

Plans for further sampling were abandoned when it became necessary to return to Puerto Williams to drop off a technician whose son had just died. The two biologists dropped off earlier were also resupplied. *Hudson* then headed south again to pick up the current meter moorings and to carry out a line of closely spaced oceanographic stations across Drake Passage. Accompanying work included the lowering of a 2000-liter giant bag to collect a large water sample to filter for POC.

We now know that the duration of the current meter measurements was too short to obtain a good average for the flow, given the very large fluctuations due to eddy activity. In fact, during the experiment, the near-surface meters showed the expected strong eastward flow, but the mid-depth meters recorded little net flow, while the bottom meters recorded a net flow from east to west. The overall net water flux was negligible. One of the chief values of this surprising result was to stimulate further work, and very extensive flow measurements were made later in the 1970s by the International Southern Ocean Studies program, yielding the more familiar large eastward flow (150 Sv) that we use today.

With all the moorings successfully recovered, *Hudson* visited the crater of Deception Island on February 15 and did a station in Telefon Bay. The scientists visited the wreckage of the Chilean base Presidente Aguirre Cerda, which had been destroyed in a 1969 volcanic eruption. The area was still extremely active. Another sled haul was done in deep water (2560 m) off Elephant Island, and then two further bottle stations were conducted as we steamed north, making a total of 47 so far. On February 19, we reentered Beagle Channel from the east, anchored at Puerto Williams, and recovered *Redhead* and her crew and scientists.

At this point, the presence of the Argentine hydrographer caused a problem with the Chilean authorities who insisted that he was a spy and that we could not return to Punta Arenas through Beagle Channel as he might inspect their defenses; at the time, there was a boundary dispute in the Beagle Channel between Chile and Argentina (later settled by the Pope). Therefore, we sailed through Le Maire Strait, up the east coast of Tierra del Fuego, and entered Magellan Strait again at the eastern end. We took on fuel at Puerto Percy, with a shore excursion to sample intertidal fauna, then docked at Punta Arenas on February 23.

LEG 4. PUNTA ARENAS TO VALPARAISO

March 3–April 7, 1970

Leg 4 was run by the Institute of Oceanography, University of British Columbia, with George Pickard as chief scientist and Brian Bary as chief biologist, and with a contingent of seven Chilean

scientists on board.[1] The purpose was to study the oceanography of the Chilean fjords, a region untouched in many cases since the survey voyage of HMS *Beagle* in the 1830s (R. FitzRoy, commander; C. Darwin, naturalist). The ship started in the southern fjords such as Seno Almirantazgo and Whiteside Channel that lead off Magellan Strait into the mountainous interior of Tierra del Fuego. These fjords tended to carry loose ice blocks from tidewater glaciers. Then, *Hudson* threaded an intricate web of fjords running northward, starting with Seno Otway. The ship exited the Magellan Strait at Cap Pilar and visited the small settlement of Puerto Natales which lay at the head of a complex set of inlets; the innermost, Estero Ultima Esperanza, offered the impressive mountain scenery of the Torres del Paine National Park.

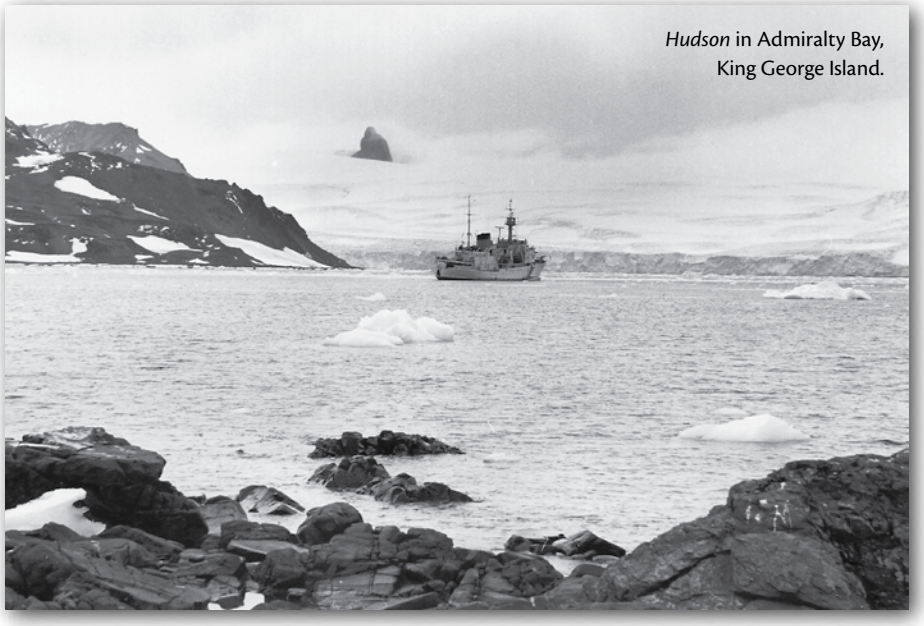
The first set of fjords, some of them fed by ice from the inland ice sheet, was followed by a stretch of open ocean, the Gulf of Peñas, and then a further set of intricate fjords. Here, many place names recall Darwin, FitzRoy, and the survey ships *Beagle* and *Adventure*, and some go even further back. We encountered Canal Cheap, Wager Bay, and Bahia Anna Pink. Cheap was the captain of HMS *Wager*, a ship in Anson's Royal Naval squadron of 1741, which was intended to circumnavigate the world. The ship was wrecked in Wager Bay, and the shipwrecked crew mutinied and sailed off, leaving the captain and his officers to their own devices; *Anna* was a supply ship ("pink") in the same squadron. *Hudson* visited the small settlement of Puerto Aysen, then ended the survey at the town of Puerto Montt, the southernmost point of rail and continuous road transport in Chile. Many of the 32 fjords surveyed had never had oceanographic measurements made in them, and this led to an important paper (Pickard, 1971). Most of the fjords were fully oxygenated and had a standard estuarine circulation and a two-layer system.

From Puerto Montt, *Hudson* sailed out westward into the open Pacific to visit Juan Fernandez Island, former home of the castaway Alexander Selkirk. The ship then carried out a short northward dogleg of stations before reaching Valparaiso, Chile, on April 7.

LEG 5. VALPARAISO TO TAHITI
April 15–May 12, 1970

From Valparaiso, *Hudson* sailed southwest into the high-latitude Pacific to begin a northward line. It was intended to be the longest line of oceanographic stations ever completed, with the aim of providing a north-south transect of temperature-salinity structure and gravity data (collected with Bill Von Arx's vibrating string accelerometer) that could be used to calibrate Seasat's altimeter. It turned out that Seasat was not launched until 1978 and then only lasted three months, but the long survey line remains as validation data for later altimeter-equipped satellites such as Envisat.

The line's start point was meant to be 65°S, 150°W, but a high concentration of icebergs in the area dictated that, for safety, the line began at 63°S—to the disappointment of Von Arx, who pointed out the need for as long a northward line as possible. We crossed the Antarctic Convergence at 59°S. Stations were more widely spaced than in the Atlantic, carried out at 5° intervals (apart from the first at 63°S and the second at 60°S), with the same set of observations at each one as in the South Atlantic. Many of the same scientists were back on board, as well as Von Arx himself;



Hudson in Admiralty Bay, King George Island.

[1] Hector Inostroza, University of Concepçion; Bernardo Uccelletti and Riccardo Montaner, Hydrographic Institute of Valparaiso; Nelson Silva, Catholic University of Valparaiso; Chano Chuecas and Ramon Ahumada, University of Concepçion; Francisco Rey, University of Chile, Valparaiso. After the Pinochet coup in 1973, Francisco Rey fled to Norway and is now an oceanographer with the Institute of Marine Research, Bergen.

Chief Scientist was Russ Melanson (BIO). The first South Sea island to be spotted was Tubuai, at 23°S, 149°W, and the last station was done at 20°S, 150°W, very close to Tahiti, although the gravity line was carried up to 16°30'S before the ship turned for Papeete.

During the voyage from Valparaiso to the far south, it was later found, by analysis of the geophysical records, that at 54°19'S, 94°33'W *Hudson* had crossed an underwater peak that stood 1500 m above its fellows, rising to 2920 m from the surface. Then, only 60 km later, at 54°38'S, 95°12'W, the track crossed a very deep trough extending down deeper than 6103 m. These bathymetric features were named after the ship—Hudson Peak and Hudson Deep—and appear on maritime charts.

LEG 6. TAHITI TO VANCOUVER

May 16–June 12, 1970

After a visit to Tahiti, where the most junior research assistant and author of this article celebrated his twenty-second birthday on Moorea, *Hudson* returned to the 150°W line and continued stations northward from 15°S at 5° intervals. The line was meant to extend as far as the continental shelf on the Gulf of Alaska, to connect with the Alaskan Geophysical Survey. Chief Scientist was Bill Cameron (BIO).

We crossed the equator on May 21, ending six months of work in the Southern Hemisphere. Beyond 10°N, station spacing was stretched to 6° to accommodate a request from BIO for two extra stations off Queen Charlotte Islands. We crossed the Tropic of Cancer on May 28, and the furthest north station was carried out at 57°30'N on June 7. This station gave us a 7000-mile north-south gravity line, but unfortunately, for operational reasons, the line was finished slightly too early, while the ship was still over the Aleutian Trench. The ship arrived at Vancouver on June 12.

LEG 7. QUEEN CHARLOTTE ISLANDS SURVEY

July 12–August 5, 1970

Hudson hosted the necessary parties and open houses in Vancouver and was then sent to the dockyard at Esquimalt for engine repairs, which lasted four weeks. On July 12, the ship sailed for a purely geophysical survey of a region to the west of Queen Charlotte Islands. Chief Scientist was Charlie Maunsell (BIO), and the BIO group mainly conducted geophysical work. Seismic refraction work was done with CNAV *Endeavour* as shooting ship. Other work included seismic reflection profiling, crustal anisotropy, and seabed heat flow. One heat flow measurement—16 microcal $cm^{-2}s^{-1}$—was then a record for heat flow measurements made at sea in the era before hydrothermal vents were discovered. Important insight was gained into the area where the American, Juan de Fuca, and Pacific plates meet at a "triple junction."

LEG 8. VICTORIA TO TUKTOYAKTUK

August 13–September 22, 1970

Hudson sailed from Esquimalt Harbor on August 13 and headed for Unimak Pass in the Aleutians, arriving on August 19. The ship carried out along-track geophysical watchkeeping and daily stations. Chief Scientist was Bernie Pelletier (BIO). The ship was now equipped with a Bell-206 helicopter for ice reconnaissance.

The ship's first station was at 50°N, 130°W; then, on August 18, we ran into the worst storm of the voyage, which toppled a bottom drill tied to the foredeck. This incident happened over the Aleutian Trench, just before the ship reached Unimak Pass. Entering the Bering Sea, the port-side generator exploded, igniting a fire; this event did not incapacitate the ship but left only

Bob Hessler (left) and Eric Mills (right) with the epibenthic sled.

three of *Hudson*'s four engines operating. At this time, we came across a dead bowhead whale with a flag embedded in it; we were never able to determine whether it was the work of a Japanese or an Inuit whaler. Later, we moored in the shelter of St. Lawrence Island to cover the sonar transducers with protective plates, and sighted another dead abandoned whale on the beach, this time a humpback.

On August 22, the ship transited Bering Strait and crossed the Arctic Circle, encountering pack ice the next day off the northwest coast of Alaska. There was a pause while we helped search for three Inuit who had disappeared in a boat off Wainwright on a hunting trip. Then, we moved toward Point Barrow, finding heavy pack ice close in to the coast, which necessitated backing and ramming. It was the first heavy pack ice ever encountered by *Hudson*, and contrasts with recent summers in the Arctic when the sea ice has retreated almost as far as the North Pole. As we moved east, and crossed the United States-Canada boundary, we found the sea ice lying further back from the coast, leaving a slot up to 150-nm wide in the southern Beaufort Sea, an exceptionally open (for 1970) situation that permitted an intensive oceanographic study of this region for the first time. The only recorded previous oceanographic work was a few stations done from the Royal Canadian Mounted Police schooner *St. Roch* during its transit of the Northwest Passage in 1940. But, the interest of the Canadian Government had been aroused in 1969 by a successful oil find at Atkinson Point on the Beaufort Sea coast, and so the *Hudson* survey was given high priority. We were given the BIO ship CSS *Baffin* (which had sailed through Panama) to assist us, and also the Pacific Oceanographic Group's smaller research ship CSS *Parizeau*. At Herschel Island, we took aboard more scientists, who were flown in by helicopter from Inuvik.

Hudson in the pack ice of the Beaufort Sea.

A survey grid was begun, consisting of parallel lines, 15 miles apart, running northward from the coast. We would set out on each line from the southern end, steering at 5 kts and carrying out seismic profiling as well as recording gravity and magnetic data and towing a side-scan sonar behind the ship. Every few miles we would stop for a hydrocast and a core; one 11-m core was by far the longest yet recovered from the Arctic Ocean. The line would end when we reached the ice edge, usually more than 100 miles off the coast. The positioning was to be controlled by a Decca Hi-Fix radio navigation system set up for the summer with a line of transmitting stations along the coast. Unfortunately, the ship's Decca receiver did not work, so we had to take a satellite fix at every station, which sometimes took two to four hours in those days before GPS.

The first survey line yielded a fundamental discovery: using the side-scan sonar, we recorded seabed scouring by pressure ridges at the southern end of the line. As I wrote at the time, "we saw a complex array of long narrow troughs in the seabed, as if a drunken ploughman had been at work. It was a fascinating pattern of intersecting lines, some straight as a die and others curved round into circles and spirals." Each scour mark that crossed the ship's track showed up on the ordinary echosounder as a small indentation in the seabed, only 2–4-m deep. The marks were visible out to a water depth of 100 m, deeper than the deepest current pressure ridge, implying a periglacial origin for the deeper incisions when relative sea level was lower.

Further to the east, over the shallow Mackenzie Bay, we also discovered underwater pingos. Pingos on land are a well-known feature of the Mackenzie Delta, and we were already studying them by helicopter visits. They are basically ice-cored mounds, looking like small conical volcanoes and rising

starkly from the flat muskeg (bogland) landscape to a height of 70 m or more. Pingos are formed when a lake drains because of a change in the course of the streams that feed it. The deeper lakes on the muskeg do not freeze to the bottom during the winter, and their deep parts contain water at 4°C, its temperature of maximum density. This "warm" water melts the permafrost below and around the lake. When the lake disappears, the permafrost compensates for this sudden removal of heat by rising again, pushing up the soil above it. This mechanism cannot account for a pingo forming underwater. Their origin is still obscure, although their shape on the echo sounder resembles exactly that of pingos on land. We studied these newly discovered features using bottom-towed cameras and coring.

At the end of the survey, the scientific personnel were exchanged by helicopter at Tuktoyaktuk, then a small Inuit settlement on Kugmallit Bay, later to become a supply base for Beaufort Sea oil exploration. Three journalists joined the ship, including Dave Spurgeon of *Toronto Globe and Mail* and Ken Palka of CTV.

LEG 9. TUKTOYAKTUK TO DARTMOUTH

September 22–October 16, 1970

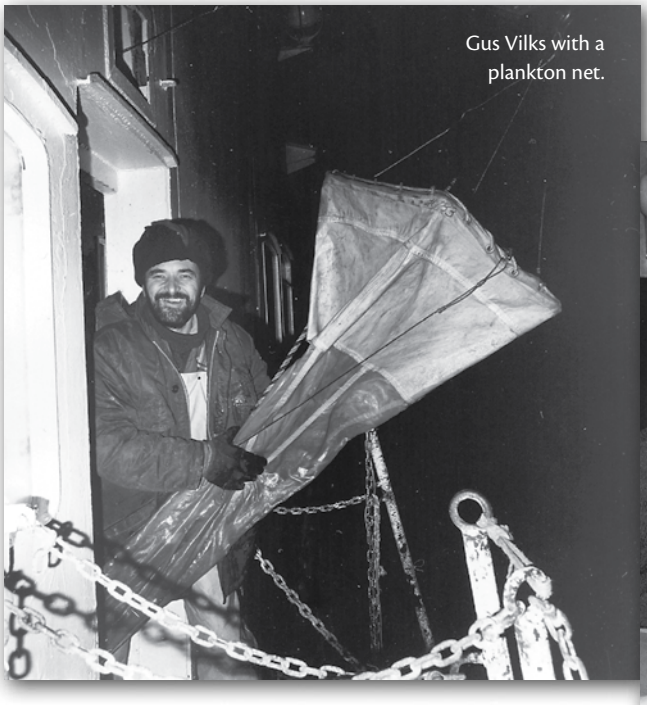
Hudson, accompanied by *Baffin*, now set off to navigate the Northwest Passage. The captain chose the direct, northerly route through Prince of Wales Strait and into Parry Channel, the course taken by *St. Roch* in 1950, the icebreaker *Labrador* in 1954, and the tanker *Manhattan* in 1968, but north of Amundsen's 1903–1906 passage through Peel Sound, Franklin Strait, and Coronation Gulf.

We began with oceanographic stations and a seismic line in Amundsen Gulf, ending under the cliffs of Cape Lambton on Banks Island. Then, we entered Prince of Wales Strait in open water, but encountered 100% pack ice near its northern end. The Department of Transport icebreaker *John A. Macdonald* was sent from Resolute to assist, and broke a channel that enabled *Hudson* to carry out a line of oceanographic stations through Parry Channel to Resolute at its eastern end. Hydrocasts and Van Veen bottom grabs were done at 100-km intervals. The ice was 100% first-year ice with pressure ridges, and populated by families of polar bears.

We reached Resolute on September 30, and a final exchange of scientists took place. The BIO geophysical group joined for a final survey in Baffin Bay, and a plaque commemorating *Hudson*-70, made by the bo'sun, was left behind, fastened to a rock near the settlement.

The final work of "*Hudson*-70" was a geophysical survey of northern Baffin Bay, involving two-ship seismic refraction work—*Hudson* was the listening ship and the wartime US Wind-class icebreaker *Edisto* was the shooting ship. Two seismic reflection lines were also run across the bay from west to east, and scientists aboard reached the conclusion that the underlying rocks were oceanic rather than continental, a question that up to then had been in doubt (Barrett et al., 1971).

After steaming 58,000 miles in 330 days, *Hudson* finally returned to



Gus Vilks with a plankton net.

Scientific conference in the Beaufort Sea. Left to right: Gus Vilks (BIO), Captain David Butler, Bernie Pelletier, Roy Gould (Navigator).

Halifax on October 16 to a welcome by fireboats, a ceremony on the quay, and a speech by Joe Greene.

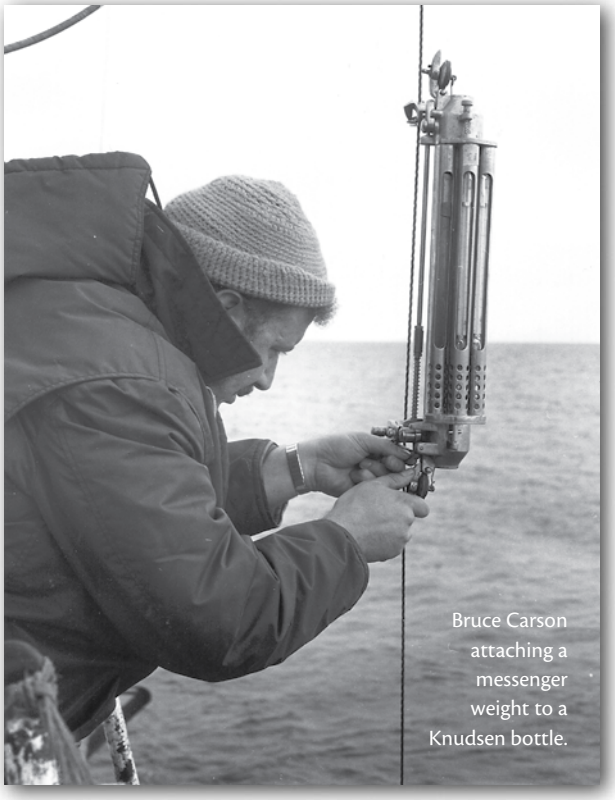
WHY WE CELEBRATE *HUDSON*-70

Why should we remember this expedition of 40 years ago?

First, it was the last of the big multidisciplinary global oceanographic expeditions that hacked out our basic knowledge of ocean structure, water masses, and currents during the nineteenth and twentieth centuries. The year 1970 was a turning point. Before that date, the ocean was still thought to be an unexplored expanse where any ship that sailed far enough afield and worked in sufficiently unfrequented waters could make fundamental discoveries about the nature of our planet. *Hudson*'s South Atlantic section at 30°W on the equator had never been done by another ship. From the 1970s on, it began to be accepted that the basic picture was now drawn, and new ocean expeditions tended to be short-term affairs, devoted to testing specific hypotheses about processes in a small piece of the ocean and ignoring the rest.

Second, *Hudson* used modern, effective methods for fundamental data collection, which was the rationale of the traditional big expedition. Geophysical monitoring was done using a gravimeter, towed magnetometer, and precision depth recorder (which today would be replaced by a multibeam sonar). The only old-fashioned technique used was a continued reliance on the Knudsen bottle cast for hydrographic stations, because the CTD (then called STD) was not yet reliable enough to be a primary data source. In that sense, *Hudson*-70 was a bridge from the classical to the modern ocean surveying world.

A third reason to celebrate was the variety of fundamental discoveries made in many different spheres and many different areas of the world. The Chilean fjord survey was the first, and still the most thorough, oceanographic survey of these fjords; the Drake Passage current meter moorings, despite their surprising results, were the first direct measurements of the Antarctic Circumpolar Current; a host of geoscience discoveries were made especially in northern waters—the structure of Baffin Bay, the ice scouring along the Beaufort Sea coast, the plate structure of the North Pacific; and the water structure of the Beaufort Sea was deciphered for the first time. *Hudson* scientists did the first proper multidisciplinary survey of the Beaufort Sea, and now that the sea ice is in full retreat, the results obtained so long ago gain value by showing us the conditions that prevailed in the era of complete ice cover before climate change wrought its massive changes.



Bruce Carson attaching a messenger weight to a Knudsen bottle.

For those of us who were lucky enough to take part, especially junior scientists like myself who stayed on for the whole voyage and performed "gofer" tasks in many spheres, it was a formative experience, the most perfect graduate-level field course that it is possible to imagine, and something that spoils one for the rest of one's life. We should celebrate *Hudson*-70 for that too, for daring to do great things in the ocean and thus to inspire the scientists on board to think great thoughts. It is wonderful that *Hudson* is still afloat at the advanced age of 46, and still doing valuable work in the waters around Canada.

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