Maritime Sediments, Vol. 4, No. 2, August, 1968, pp. 69-72.

The Submersible PISCES Feasibility Study in the Canadian Arctic*

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During a six-week period in August and September of 1968, the submersible PISCES, owned and operated by Hydrodynamics International of Vancouver, Canada, made a series of dives in the waters of the Canadian Arctic Archipelago (Fig. 1) to assess the feasibility of using this vehicle to undertake geological research, exploration, and mapping of the sea floor. The operations were carried out from the CCGS LABRADOR of the Canadian Department of Transport and were in concert with programs of the Johns Hopkins University, Maryland, the Defence Research Establishment Pacific and the Pacific Oceanographic Group of the Fisheries Research Board of Canada, both located on Vancouver Island, British Columbia, and the Atlantic Oceanographic Laboratory at the Bedford Institute, Dartmouth, Nova Scotia.

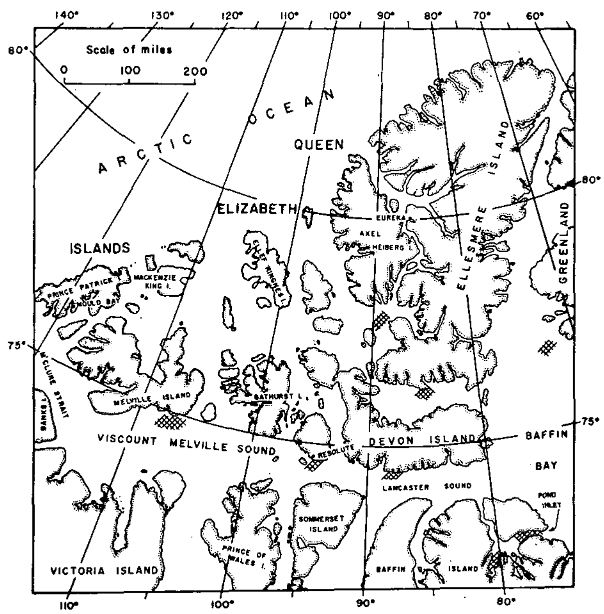

Figure 1 Map of Arctic Islands, Diving locations are shown in cross-hatched areas.

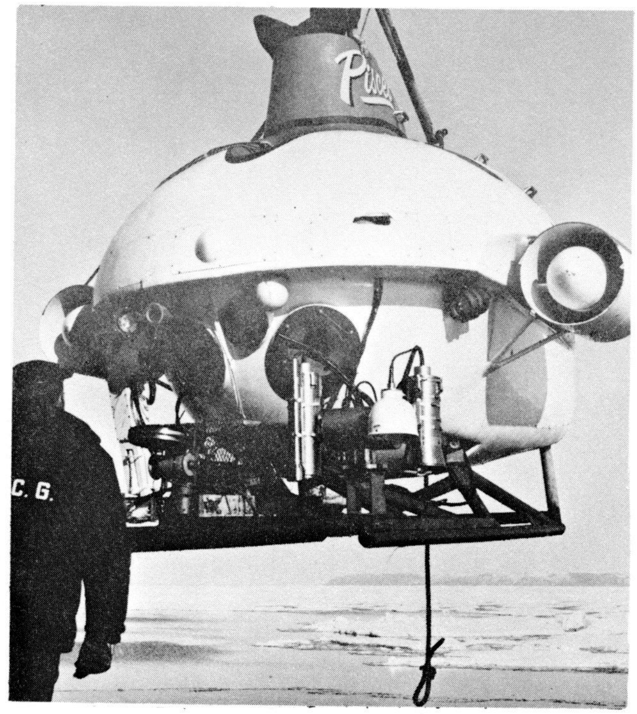

Figure 2 PISCES-1 being swung over the side from CCGS LABRADOR in western Viscount Melville Sound. Note location of motors on either side; hydraulic manipulating claw and arm on left; sample basket in front centre; television and camera on right. Viewing ports are located in front near centre. Photo by Dept. of National Defence.

The PISCES weighs 7 tons and is propelled at four knots by two battery-powered, D. C. motors situated externally on port and starboard sides approximately at midships (Fig. 2). It has 2 ports to permit observers in a prone position to observe features both ahead of and below the vehicle. A hydraulically filled oil bladder and steel-sphere reservoir serve as the chief buoyancy mechanism and, by pumping oil from bladder to sphere, the vessel is able to submerge; by reversing the process the vessel ascends. Forward tilting to dive down or up, while cruising, is accomplished by shifting the batteries on a track fore and aft respectively.

Although the submersible is capable of withstanding the hydrostatic stress that occurs at a depth of 12, 000 feet, the maximum operational depth is 1, 800 feet with a duration of more than 8 hours. The writer made nine dives to a maximum depth of 1, 520 feet, and up to 4 hours duration. These dives, and the others in the series, are the furthest north for a submersible of this class, and the one to a depth of 1, 520 feet is its deepest working dive to date. Because of drifting ice cover it was necessary to terminate some of the dives early, thereby avoiding the problems of maneuvering and emerging from beneath the ice (Fig. 3). An externally mounted television camera equipped with a pan-and-tilt unit provided aid in this operation.

*Manuscript received December 4, 1968; B. I. Contribution No. 140

Figure 3 **PISCES** maneuvering in ice field before submerging. Submarine was tethered for traverses beneath ice cover but otherwise was free-diving. Photo by Dept. of National Defence.

The PISCES was carried on the main deck of LABRADOR on the port side about midship in a heated hut that was specially constructed for the Arctic voyage. She was handled over the side by means of a 12-ton crane which hooked onto lifting cables attached to the submarine. This operation, as well as the recovery operation, called for close co-ordination of the LABRADOR's deck crew, particularly when the ship maneuvered to minimize the pendulum effect of the suspended vessel caused by conditions of moderate swell. Before the crane is swung over the submarine, the observer enters and the hatch is closed after him. The submarine operator, standing on the hatch, rides with his vessel while it is lowered into the water and then unhooks the crane (Fig. 4). Because of her buoyancy the submersible floats fairly low, but yet permits the operator to enter and secure the hatch while alfoat. He then submerges his vessel and makes his descent to the survey area.

In the submarine, a carbon dioxide breather system purifies the air, and tanks containing compressed air replenish the exhausted supply. Temperature is maintained at 55 degrees Fahrenheit without the aid of internal heaters although preheating is carried out. Much of the heat is obtained during the dive from electrical converters and various electronic appliances. Pressure is fairly constant at 30.5 inches of mercury, with slight discomfort felt at the time of opening the hatch when operations are terminated at the surface. Work can be carried out comfortably without the need of heavy clothing. Quarters are fairly commodious and a wide range of equipment can be installed for internal use, together with special external sensors connected through the hull for the purpose of recording within the diving chamber.

To carry out the geological sampling program, the vessel was equipped with a hydraulic hammer for breaking bedrock, an electrohydraulic manipulating arm and claw for retrieving the sample, a hydraulically powered clam-shell bottom grabber for obtaining large blocks and boulders up to 200 pounds in weight, and a steel basket for receiving the samples and carrying them to the surface (Fig. 2). More than 20 samples of sedimentary bedrock were collected from the sea floor and submarine scarps that form some of the walls of the Arctic channels. This system of channels had earlier been described as an ancient submerged fluvial system (Fortier and Morley, 1956) which was later modified by the scouring action of Pleistocene valley glaciers (Pelletier,

Figure 4 Submarine operator standing on closed hatch and unhooking crane prior to submerging. Photo by Dept. of National Defence.

1966). Certainly the evidence of glaciation in the fiords and inlets is obvious, particularly the occurrence of the submerged rolling morainal ridges and boulder beds near the mouths of presumed submerged tributaries.

Other equipment used in the feasibility study included the following: a Hydro Products closed-circuit underwater television system provided with video tape re-play; a 70-mm Shipek camera equipped with strobe lighting for external photography; forward-and upward-ranging sonar together with a gyroscopic compass to assist navigation; and various inside cameras such as movie, polaroid and a variety of miniature types were carried to obtain a photographic record of the underwater studies. A transducer was mounted on the skid frame to investigate back-scattering from the underside of the ice cover, and a conductivity bridge was installed internally and connected through the hull for the purpose of measuring the conductivity and temperature of the water for any part of the water mass traversed by the submarine.

Experiments on underwater navigation were carried out to demonstrate the feasibility of mapping the bottom from a fixed reference point on the sea floor. In this study, carried out in Pond Inlet, a grounded iceberg was used as the reference mark and a 360 degree rectangular traverse was closed at several hundred yards around it. A bathymetric chart was available and this was of considerable help in the experiment. With a suitable number of reflecting beacons serving as bench marks on the sea floor, mapping the sea floor either topographically or geologically with the submarine is a distinct possibility. Add to this the successful use of acoustical devices such as side-looking sonar, echo-sounders and seismic profilers, and the geological and topographic mapping of the sea floor and the sub-bottom can be carried out on a practical basis. Because of good visibility, sites for dredging and drilling can be carefully selected and such operations actually observed and in some cases assisted.

The use of hull-mounted transducers and other energy sources for both sounding and seismic surveys is neither new, impossible nor impractical. Certainly a variety of geophysical equipment could be towed by the vehicle at given depths with miniature graphic recorders or tapes maintained within the diving chamber. During the present experiments hull-mounted equipment was used with short cables connected to recorders inside by means of through-the-hull connectors.

Other experiments involved marine biological and oceanographic observations. Animal noises such as those made by the seal, walrus and whale were recorded on magnetic tape by means of hydrophones placed beside the submarine; all observers soon learned how noisy the sea can be. Counts of animals were made, particularly at their feeding grounds, and the various types were recorded in notes and films. In addition to the oceanographic observations previously made, marker dyes were placed in the water to observe the shearing effect between various water layers particularly near the mouths of streams. Studies of sea floor sediments, their texture and structures in particular, were made in connection with the study of hydrodynamics of the environment. Current measurements were not made, although this would be possible, but observations on the sedimentary environment were supported with the use of both internal and external underwater photography.

In conclusion, the deep diving submersible offers considerable potential for a variety of studies in the Arctic which could also be carried out in waters at lower latitudes. It appears that in its present stage of development, the submersible is at a point similar to the helicopter's development about 20 years ago, when wide demand created immediate need for innovation and improvement. The future looks fairly good both for the submersible program and sea-floor exploration, and it seems that both will grow together. The need for more intensive study of the sea floor is bound to encourage the development of the deep diving submersibles with increased capability for carrying out this kind of underwater investigation, perhaps in concert with two or more of these submarines.

Acknowledgements

The writer expresses his deep thanks to Captain Paul Tooke, Master of the CCGS LABRADOR, and to her officers and men who assisted with interest and desire on all occasions. Many thanks are given to the co-ordinator of the cruise, Alan Milne, of the Defence Research Establishment Pacific who planned the PISCES program and innovated this study in the Canadian Arctic, and who did much of the acoustical work on the voyage; to Richard Herlinveaux of the Pacific Oceanographic Group who carried out oceanographic observations, assisted on the geological sampling program, and who made a successful underwater navigational study with the submarine; to Carleton Ray and Ray Harmon of the Johns Hopkins University who undertook the study of sea noises produced by marine vertebrates; and finally to the submarine crew consisting of Alan Trice, Scratch MacDonald and Merle Wilson all of whom worked unstintingly to provide amiable, competent service and proffer a wealth of excellent advice on the most efficient and productive use of submarine PISCES. Thanks are also extended to the writer's associates C. T. Schafer and G. Smith of the Bedford Institute and to his editorial colleague L. Ferguson of Mount Allison University for their many helpful suggestions and their critical review of the manuscript.

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