MAY 1969

UnderSea Technology

THE INDUSTRY'S RECOGNIZED AUTHORITY FOR OCEANOGRAPHY, MARINE SCIENCES & UNDERSEA DEFENSE

**Ben Franklin's First Mission:
Probing the Gulf Stream**

Just what you've always wanted.

(And ready for you in the fall)

The Ben Franklin. Newest and largest civilian research submarine in the world. Fifty feet long and weighing about 130 tons. You can have it in the fall for survey work on the ocean bottom.

But first, in June, the Ben Franklin will take its designer, Jacques Piccard, the Grumman pilot, the engineering officer, two Navy oceanographic scientists and a NASA scientist, to begin its month-long undersea drift with the Gulf Stream from Florida to New England.

The Ben Franklin is big—3750 cubic feet—to provide the space, support, and comfort needed by this scientific team to carry out its mission.

The scientific instrumentation includes: stereo cameras; side-scan sonar for mapping; sonar to probe the Deep Scattering Layer; gravity meter; magnetometer; light meters; current meter; turbulence meter; sub-bottom profiler.

Grumman built the Ben big for extensive scientific projects. Its successors will be big and strong, too, enough for meaningful underwater work like drilling, salvage, mining . . .

Everybody talks about the new frontier in the ocean. But Grumman can build the hardware to do something about it.

If you are ready, contact our Ocean Systems Department.

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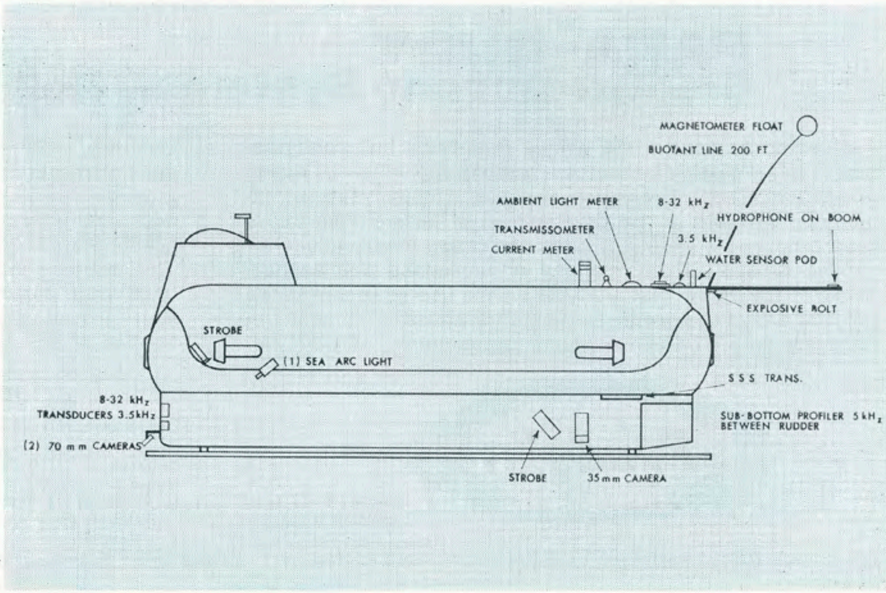
Bethpage, Long Island, N. Y. 11714

BEN FRANKLIN'S OCEANOGRAPHIC MISSION

Roswell F. Busby
U.S. Naval Oceanographic Office

The manned submersible *Ben Franklin* and its six-man crew is scheduled to descend to the ocean bottom off West Palm Beach, Fla., in June to begin a 30-day submerged cruise in the Gulf Stream.

From the oceanographic viewpoint, the purpose of this mission is manifold, and the coordination, instrumentation and planning is the most extensive ever for a manned submersible operation. We do not expect that the Gulf Stream Drift Mission will produce revolutionary new oceanographic findings. However, we are certain that the mission will yield valuable data, and that it may force us to think in different terms about the Gulf Stream, and the methods by which we investigate it and the world oceans in general. For reasons not entirely clear, many people have developed a peculiar attitude toward submersible operations. They seem to expect that every dive in a submersible will be a revelation — that scientists will return from these operations with the kind of information needed to re-write the oceanographic textbooks. The submersible is but one of many survey platforms available to ocean scientists, yet there



are those who think it should outperform all others in the quality of data recovered.

It is true that the submersible has certain advantages over the surface ship. Being able to observe the geological, biological and other oceanic variables first hand permits more precise scientific assessment. However, not many scientists have had the opportunity to use a submersible for their investigations, and we still have much to learn about equipping and operating them for scientific purposes.

The Gulf Stream Drift Mission in the *Ben Franklin* is but one more step forward in this learning process. Our oceanographic plans for the drift mission may prove overly ambitious in terms of the operating realities, but we intend to try as many things as possible, so that future missions like it can receive the maximum benefits from our experiences. Not one, not five, possibly not 500 missions of this kind will tell us all we want to know about the Gulf Stream. Yet, this cooperative undertaking by Grumman Aircraft Engineering Corp., which funded the design and development of the submersible, and the Naval Oceanographic Office is an important beginning.

Oceanographic Objectives

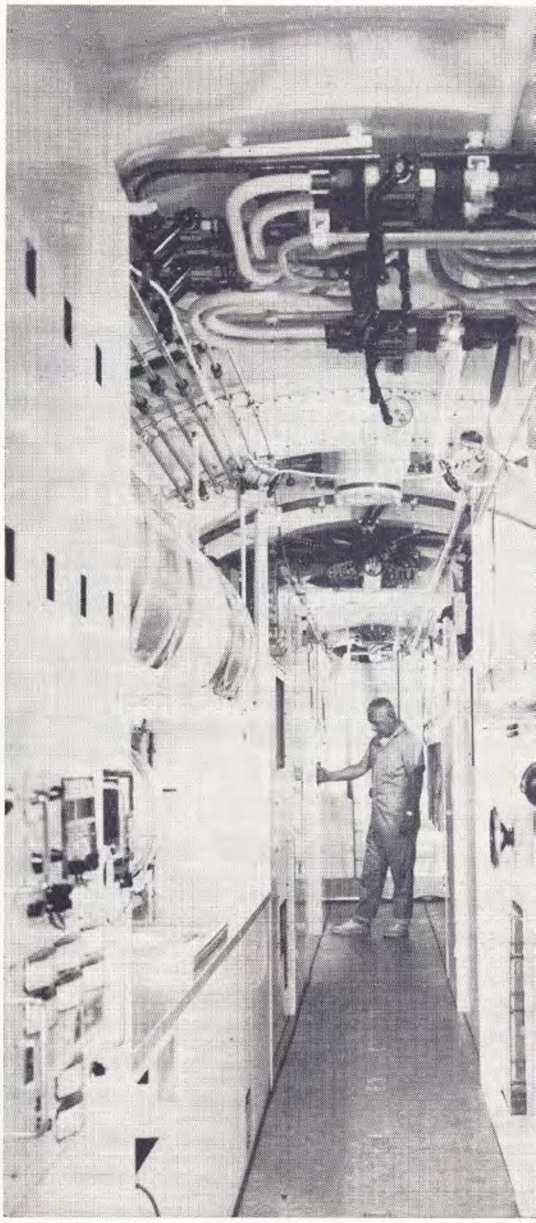
Of primary oceanographic interest is the nature of the currents in the Gulf Stream. After years of investigation, there is still no authoritative documentation of these currents. Quite naturally, most of the work to date has concentrated on the surface currents, and the subsurface currents are all but unknown.

The work of Dr. William Richardson and his collegues at Nova University has supplied the only actually observed measurements of the Gulf Stream, which have been used in planning the drift mission.

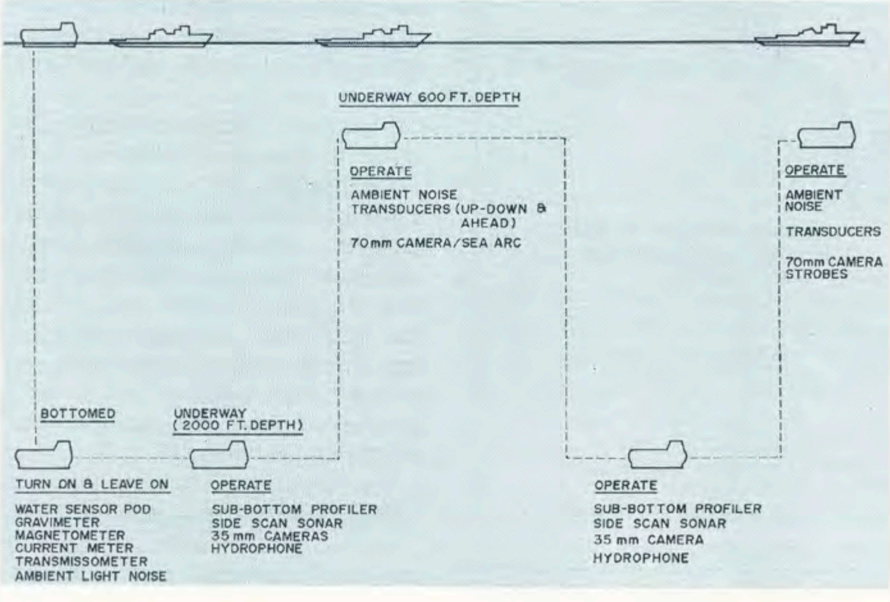
One of the most difficult questions to answer regarding the drift mission is where will we surface after drifting along for 30 days. Our objective, of course, is to stay within the high velocity core of the Gulf Stream. To help us achieve this, an ASWEPS aircraft equipped with an airborne radiation thermometer (ART) will fly over our position every three days. The ART will pinpoint the thermal center of the Gulf Stream.

The anticipated *Ben Franklin* drift includes regular drift operations at depths of about 600 ft. and bottom excursions to 2,000 ft. depths. The bottom excursions will require greater power expenditures, but they are essential to achieving important oceanographic objectives. According to the limited data available, the currents at 600 ft. depths vary from 1.3 knots off Cape Hatteras to 2.7 knots in the northern Florida Straits.

Depicting the *Ben Franklin's* route as a straight line from point to point is misleading, although necessary for graphic representation. Since the current twists and bends as it moves northward, the submersible will be taking a very circuitous route. The sub could travel several miles in



Interior of the Ben Franklin, where the six crew members will live and work during the 30-day drift project. The illustration at the extreme left shows the location of the sub's scientific instruments, the companion sketch — how they will be deployed at various depths.



making good one mile on its intended northern course. Consequently, it is impractical to predict how far *Ben Franklin* will travel (considering also the scant knowledge about current velocity) during the 30-day mission.

Imperfect knowledge about the currents could, of course, alter all of our oceanographic objectives. If, for example, it requires more propulsive energy than anticipated to maintain *Ben Franklin's* position in the mainstream, our power budget for the oceanographic sensors will no longer apply. If that eventuality should develop, decisions involving trade-offs between mission length and data recovery will be required.

Another related concern is that the *Ben Franklin* could be caught in one of the numerous eddies that split off from the Gulf Stream and then drift undetected for many miles from its intended path. A precious amount of electrical energy would then have to be expended to get the sub back into the mainstream. Perhaps one of our greatest fears is drifting to the northern wall and then proceeding north while turning in circles, similar to a dead whale that was observed from an ASWEPS aircraft.

The primary purpose of the bottom excursion is to gather geological data. Several investigations of the Blake Plateau sediments have been conducted through surface-oriented techniques. In one case, what had been thought to be coral reefs turned out on visual inspection from the *Alvin* to be large dunes capped by coral.

Ben Franklin is scheduled to conduct visual and photo acoustical surveys in selected areas of the plateau to determine the nature of both constituents and relief. Such excursions serve scientific objectives and help to further determine the submersible's best role in oceanography—i.e., whether it be purely research, surveying or engineering activities.

The bottom excursions—six are planned for the mission—will be in areas designated as transition zones in bottom sediments. We will attempt during the 24-hour long missions along the bottom to more precisely define where one sediment facies ends and another begins. *Ben Franklin* will not carry equipment for collecting sediment samples, but constituent size and topographic features will be estimated or measured.

Visual observations will allow evaluation of the overall dynamics of the environment. Individual components such as sediment size, sediment features (ripple marks or current scour), currents, and biota can be seen at one time, and in the relationship of one to another. The combination of visual observations and instrument measurements allows comprehensive assessment and documentation of the dynamics of the environment.

The limited number of submersible dives in the deep scattering layer (DSL) have contributed significantly toward determining its composition and have thereby provided insight into its behavior. A major portion of *Ben Franklin's* efforts will be directed toward a greater understanding of the DSL's composition, its acoustic characteristics, and its relationship to light levels, temperature, salinity and pressure.

By cruising at constant depth (600 ft.), it is hoped to observe the DSL as it migrates to the surface and back down to greater depths.

The submersible will ping horizontally and vertically to the DSL at 3.5, 8, 12, 16 and 32 kHz, while a surface ship pings down into the layer at the same frequencies.

The DSL also will be photographed with two 70mm cameras mounted on the bow of the sub, which will provide 450 stereo pairs in the water column. A Sea Arc light, which throws a collimated beam—a light ray of almost constant intensity and diameter—will be turned on while these cameras are operating. Photographs of the organisms that appear in the Sea Arc ray should enable us to quantitatively measure both the number and types of organisms observed in the DSL.

One of our oceanographic objectives is unrelated to the collection of new data. It has to do with the development and refinement of the submersible platform for oceanographic research.

In one sense, the manned submersible is a sophisticated junction box, and the successful non-interfering integration of many oceanographic sensors is difficult to obtain. Shielded and balanced cables for the user's electronics are not common, and, even when they are, the close proximity of many wires where they penetrate the hull results in numerous problems. Degradation of sensor performance because of electronic interference is common in submersible operations.

It is therefore extremely important to integrate the electronics, so that all instruments can operate over long periods of time while subject to a variety of temperatures and pressures. If this can be accomplished during *Ben Franklin's* mission—and there has been significant preparation in this respect—a major step forward in multitask scientific missions for manned submersibles will be made.

Placement of the oceanographic sensors on a submersible vehicle is another difficult problem. It is not always possible to mount an instrument ideally for scientific purposes, since operational factors must take precedence. For example, an instrument cannot be mounted so that it obscures the pilot's vision or affects the trim of the sub. Much will be learned about the equipment/vehicle interface question from the mission.

Because it is an extended mission, the drift experiment also offers a unique opportunity to gather new data on the effects of marine fouling and corrosion on the vehicle, its viewports and oceanographic sensors.

Oceanographic Equipment

Since *Ben Franklin* is an unusually large submersible, it can carry a variety of oceanographic sensors and related equipment. The sub will have about the same inventory of oceanographic equipment as a standard Navy survey ship.

The human eye will be the most used and probably the most valuable sensor aboard. We plan to use every waking minute not required for operating and monitoring equipment to make visual observations through any of the *Ben Franklin's* 24 viewports. Several hand-held still and motion picture cameras will be available for photographic work from the interior of the sub.

The oceanographic equipment is being provided by the Naval Oceanographic Office as part of the agreement with Grumman. It includes instruments to measure the

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physical characteristics of the water, currents, light absorption, ambient light, gravity and magnetics. There are also a number of photographic and acoustic systems.

The following is a description of the equipment and its operational mission:

S-T-SV-D sensor—Designed especially for submersible applications by Bissett-Berman Corp., this sensor will be operated continuously throughout the mission. It measures salinity, temperature, sound velocity and pressure—and records these parameters with time in digital format on magnetic tape.

Current sensor—A Hydro Products system will measure relative current speed and direction, displaying on taut-band meters and recording on strip chart recorders.

Transmissometer—It will measure the percentage of light absorbed by one meter of water, displaying and recording in the same manner as the current meter. Also Hydro Products equipment.

Ambient light meter—This equipment to measure the level of natural light was built by AC Electronics.

Gravity system—A LaCoste-Ronberg gravity sensor, platform control and recording electronics system will be aboard *Ben Franklin.*

Magnetometer—A proton-precession magnetic sensor built by the Barringer Corp. will be used to continuously measure and record the earth's magnetic field and local anomalies.

Bottom photography—To provide 3,300 stereo pair photographs of the sea floor, two 35mm cameras and two 250 w/sec. strobes built by EG&G will be used.

Biological photography—Two 70mm cameras and a 250 w/sec. strobe will produce 450 stereo pairs. This equipment was built by Hydro Products. The Birns & Sawyer Sea Arc light also will be used.

Side-scan sonar—This system is EG&G developed and will be used to acoustically map the sea floor when the sub is drifting near the bottom.

Sub-bottom profiler—An Ocean Research Equipment system will be employed to acoustically (5.5 kHz) determine the depth of the sub-bottom during bottom excursion missions.

Sound characteristics—Using equipment built by Edo, Gifft and Lockheed, measurements of bottom loss and volume reverberation will be conducted in the water column.

Operational Plans

The Gulf Stream Drift Mission is to be conducted in three phases—phase I being a rehearsal mission, phase II the actual mission and phase III the tow back to West Palm Beach at the termination of the mission.

The final decisions on the operational plan will not be made until the completion of the rehearsal mission, which is scheduled to begin May 5. A Naval Ship Systems Command team is in the process of certifying the sub for material adequacy. The rehearsal mission will continue for 10 days, ending on May 15.

Operations during phase I will be conducted in an area due east of West Palm Beach in water depths no greater than 2,000 ft. The rehearsal will involve a variety of tests related to the surface support ship, supporting divers, navigation equipment, vehicle performance and measurements, and instrument performance.

As noted earlier, *Ben Franklin's* scientific mission is wholly governed by the amount of electrical power required to maneuver the submersible into the core of the stream, and by the amount of air required to blow ballast to ascend from 2,000 ft. to the near-surface. Two hours daily are budgeted for the main propulsion, and six complete ascents and descents to 2,000 ft. are possible on one air charge. These estimates may prove inaccurate in the operational mission, so attempts will be made to establish techniques for recharging batteries and air tanks during the rehearsal mission.

The actual mission, slated to begin June 2 and continue until July 2, will commence at approximately 26°42′ N,79°44′W, where the water depth is 2,000 ft.

A chartered support ship will continuously track *Ben Franklin* during

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phase I and phase II. This ship will also serve as the towing platform and oral communications center. Communications with the sub can be continuous, but to conserve power a verbal contact will be made via a Straza underwater telephone every four hours throughout the mission.

An Alpine self-powered transponder (interrogates at 18 kHz and replies at 15 kHz) will provide range and bearing information. The transponder signal will be received on a baffled hydrophone carried by the support ship. A self-powered General Time 4 kHz pinger (2 sec. rep. rate) also mounted externally will provide a redundant tracking system. If required, the UQC can be used for tracking.

The geographic position of the surface support ship will be plotted continuously from Loran-C fixes, and the ship's position relative to Gulf Stream will be obtained from the ASWEPS aircraft.

A research vessel also will operate with the *Ben Franklin,* making a variety of measurements in conjunction with the submerged vehicle and the aircraft. ►

Roswell F. Busby, one of six men who will be aboard the Ben Franklin during the Gulf Stream Drift Mission, is a Navy scientist who believes firmly in the potential of manned submersibles as research and survey platforms. As the head of the Naval Oceanographic Office's Deep Ocean Survey Vehicle project, he has done pioneering work in using submersibles for scientific missions. Mr. Busby and his DOSV project group planned the oceanographic mission for the Ben Franklin.