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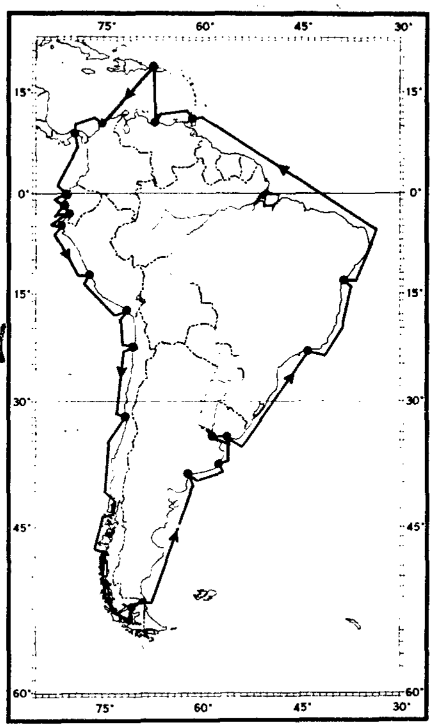
IR NO. 68-14

INFORMAL REPORT

OCEANOGRAPHIC CRUISE SUMMARY UNITAS VIII CRUISE AROUND SOUTH AMERICA AUGUST TO DECEMBER 1967



MARCH 1968

NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C. 20390

INFORMAL REPORT

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ABSTRACT

Oceanographic operations were conducted aboard U.S. Navy ships during the UNITAS VIII cruise around South America during the period 18 August to 9 December 1967. Nansen cast, bathythermograph, and bathymetric observations were made around the periphery of the continent. Thermal structure information was utilized for sonar range predictions during the cruise.

In the vicinity of the Gulf of Panama, mixed layers were generally shallow, and surface temperatures were below average. Mixed layers were deepest in the offshore waters in the Peru Current region. Upwelling occurred off Punta Pariñas and appeared to occur at 16° and 30°S. The water structure in the interisland region of Chile's southern coast indicated estuarine conditions. Conversely, the water column in the Strait of Magellan appeared to be well mixed.

Less data were collected on the Atlantic side than on the Pacific side of South America. Land-derived surface waters were observed off Argentina. In the region of confluence of the Brazil and Falkland Currents, water structure was quite variable. Farther north, the Brazil Current waters were characterized by high temperatures and salinities in the surface layers. In the Guiana and Caribbean Currents, water structures were relatively uniform in character; the mixed layer appeared to be restricted in vertical extent by Subtropic Underwater.

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This report has been reviewed and is approved for release as an UNCLASSIFIED Informal Report.

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FIGURES

I. INTRODUCTION

The waters contiguous to the South American continent are comprised of many types, and they range from Tropic to Polar in character. The hydro-geographic entities represented are the Caribbean Sea and the Atlantic and Pacific Oceans. The general oceanography around South America is well understood, but there remain many "holiday" regions in which sampling density has been insufficient to permit definitive description of oceanographic conditions. In the past few years, this situation has been alleviated to some extent by the increased number of oceanographic expeditions. The UNITAS VIII cruise of 1967 provided an excellent opportunity to collect additional data in South American waters.

II. PREVIOUS KNOWLEDGE OF THE REGION

It is impossible in a paper of this scope to adequately describe previous oceanographic investigations in an area as large as the one traversed during the UNITAS VIII cruise. The following short summary attempts to indicate some of the major studies.

Many oceanographic cruises have been made in the Equatorial and Peru Current regions of the eastern Pacific Ocean. Early investigations included those by Sverdrup (1930) and Gunther (1936); the latter work being the first thorough analysis of the Peru Current system. Fleming (1941) has described the oceanography of the Central American region including the Gulf of Panama.

In recent years, the increased utilization of fishery resources in Equatorial and eastern South Pacific waters has prompted an intensification of oceanographic investigations in these regions. Prominent among these investigations have been those of the Inter-American Tropical Tuna Commission and the EASTROPAC cruises; the latter being cooperative efforts conducted by various universities and governmental agencies of the South American countries and the United States. Many papers have resulted, including those by Wooster and others (1955, 1958, 1961), Posner (1957), Brandhorst (1959), Bjerknes (1961), and Cochrane (1967). These papers encompass a wide spectrum of subjects ranging from the physical properties and movements of the waters to factors affecting the plankton populations important to commercially valuable fishes.

Among the first oceanographic ships to visit the western South Atlantic were METEOR (Germany) and DISCOVERY (England). Defant, Wüst, and Deacon utilized the data acquired by these ships to publish numerous papers describing oceanographic features of the regions. Sverdrup et al (1942) have summarized much of this information.

More recently, United States institutions (e.g., Woods Hole Oceanographic Institution (WHOI) and Lamont Geological Observatory) and South American nations have extended previous studies in the western South Atlantic. During the period of the International Geophysical Year, surveys were conducted in the South Atlantic as a cooperative, concentrated effort by several nations.

The Caribbean Sea was first investigated by the U.S. Coast and Geodetic Survey during the latter 1800's. Agassiz (1888) contributed one of the earliest oceanographic analyses of the area. With the improvement of analytic methods in the early 1900's, investigators were able to more accurately describe the distribution of salinity and temperature; BACHE (U.S.A.) data were the first precise measurements from the Caribbean.

Oceanographic investigations in the Caribbean have been greatly intensified since World War II. The southern Caribbean region has been extensively sampled by WHOI, to a lesser extent by Lamont Geological Observatory, and by others.

To describe the stratification and circulation in the Caribbean region, Wüst (1964) made an extensive study using much of the data taken during the years 1873 to 1961. He also evaluated the quality of the various observational data.

III. OBJECTIVES OF THE CRUISE

Oceanographic operations during the 1967 UNITAS VIII cruise were intended to assist in the conduct of ASW exercises by providing information relevant to sonar detection of submarines. These operations also were intended to yield data applicable to various oceanographic studies, especially in regions where available data are sparse. Sampling was to include temperature, salinity, nutrient, trace metal, and bathymetric data collection.

IV. NARRATIVE OF OPERATIONS

The UNITAS VIII cruise began on 18 August 1967 with the deployment of USS NORFOLK (DL 1), USS GYATT (DD 712), USS GLENNON (DD 840), and USS SENNET (SS 408) from San Juan, Puerto Rico. Figure 1 shows the ships' itinerary during the ensuing weeks.

Because of mechanical difficulties, GYATT left the operation at Panama. The USS MULLINEX (DD 944) replaced GYATT, joining the cruise at Valparaiso, Chile.

Nansen stations were occupied by GLENNON, which was equipped with a portable oceanographic winch. All four ships collected bathymetric data during the course of the voyage. NORFOLK, GLENNON, and SENNET collected bathythermograms (BT's).

The cruise concluded on 9 December at San Juan.

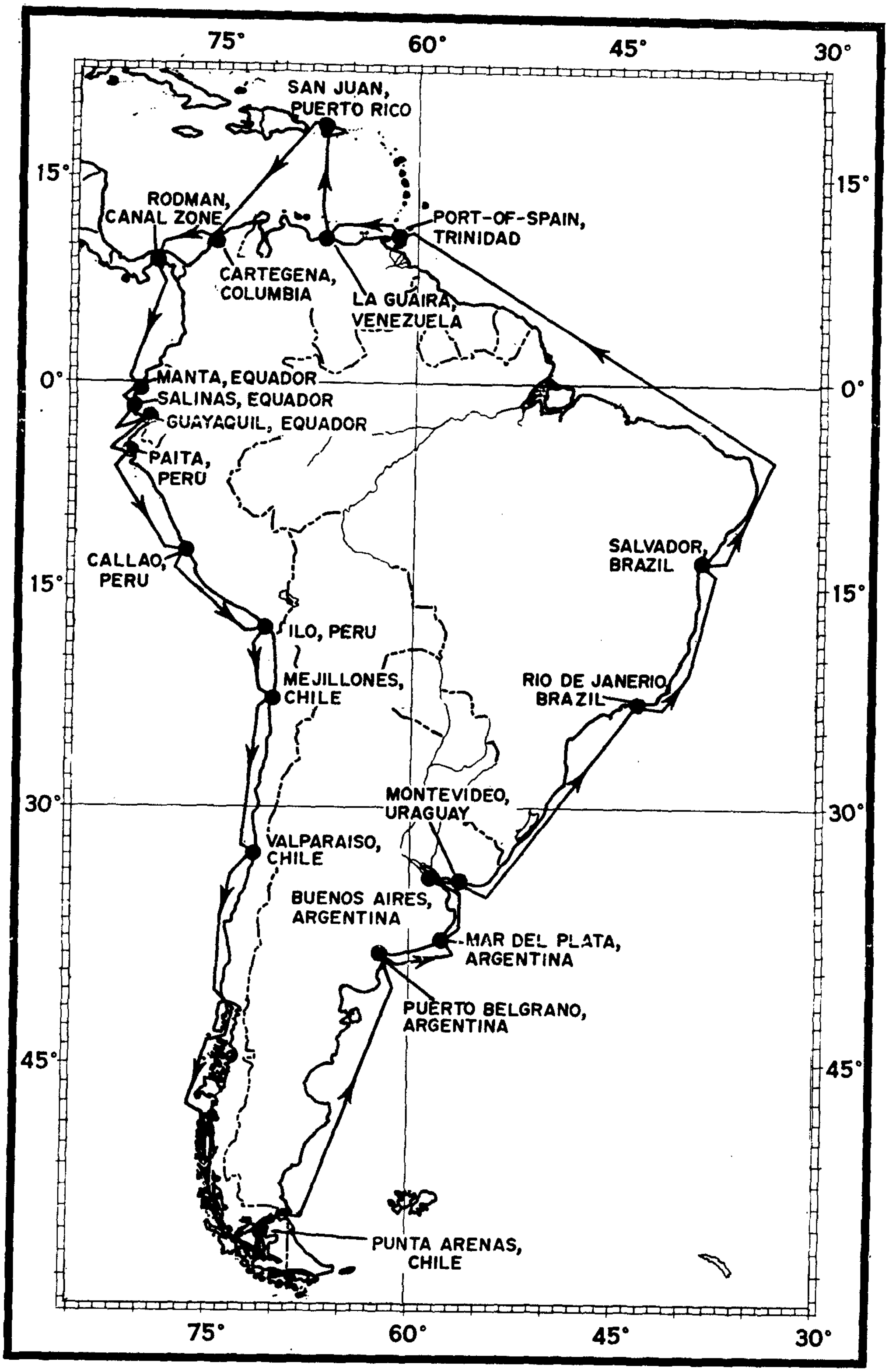

FIGURE 1. UNITAS VIII ITINERARY

V. RESULTS

During the UNITAS VIII cruise, 18 oceanographic stations were occupied (Fig. 2). At these stations, 178 temperature observations were made, and 177 salinity, nutrient, and trace metal samples were collected. A combined total of over 250 BT observations was taken by NORFOLK, GLENNON, and SENNET. The BT observations were comprised of mechanical, submarine, and expendable (XBT) types. Figure 3 shows the 2-degree squares in which BT's were collected, giving the number of observations, the average observed surface temperature, and the average layer depth. Several hundred miles of bathymetric sounding data were obtained.

VI. METHODS OF COLLECTION AND ANALYSIS

A. Physical Oceanography.

1. Temperature. Paired protected reversing thermometers were employed on Nansen bottles to measure water temperatures from the surface to a maximum depth of 1300 feet (400 meters). Standard depth bottle spacing was employed on each Nansen cast. Below 650 feet (200 meters), unprotected reversing thermometers were used to obtain thermometric depths of bottle reversal.

NORFOLK took XBT's, and GLENNON and SENNET took mechanical BT's. The XBT's have a depth capability of 1500 feet (460 meters) and the mechanical BT's have a maximum depth capability of 900 feet (275 meters).

B. Chemical Oceanography.

1. Salinity. Salinity samples were drawn into either glass citrate bottles or 6-ounce (176 ml) capacity polyethylene bottles. These samples were analyzed at NAVOCEANO with an inductive salinometer and should be accurate to ± 0.01 ‰.

2. Nutrient Samples. Seawater samples were drawn into 6-ounce capacity polyethylene bottles and frozen immediately after collection. These samples were returned to NAVOCEANO in a frozen state for subsequent analysis of reactive phosphorus, nitrate, and reactive silicate contents. The reactive phosphorus analyses will be performed in accordance with the method described by Murphy and Riley (1962), and the nitrate and reactive silicate analyses will be performed following the methods described by Strickland and Parsons (1960).

3. Trace Metal Samples. Samples for trace metal analysis were drawn into 6-ounce capacity polyethylene bottles. The analyses will be performed at NAVOCEANO using atomic absorption spectrophotometric techniques.

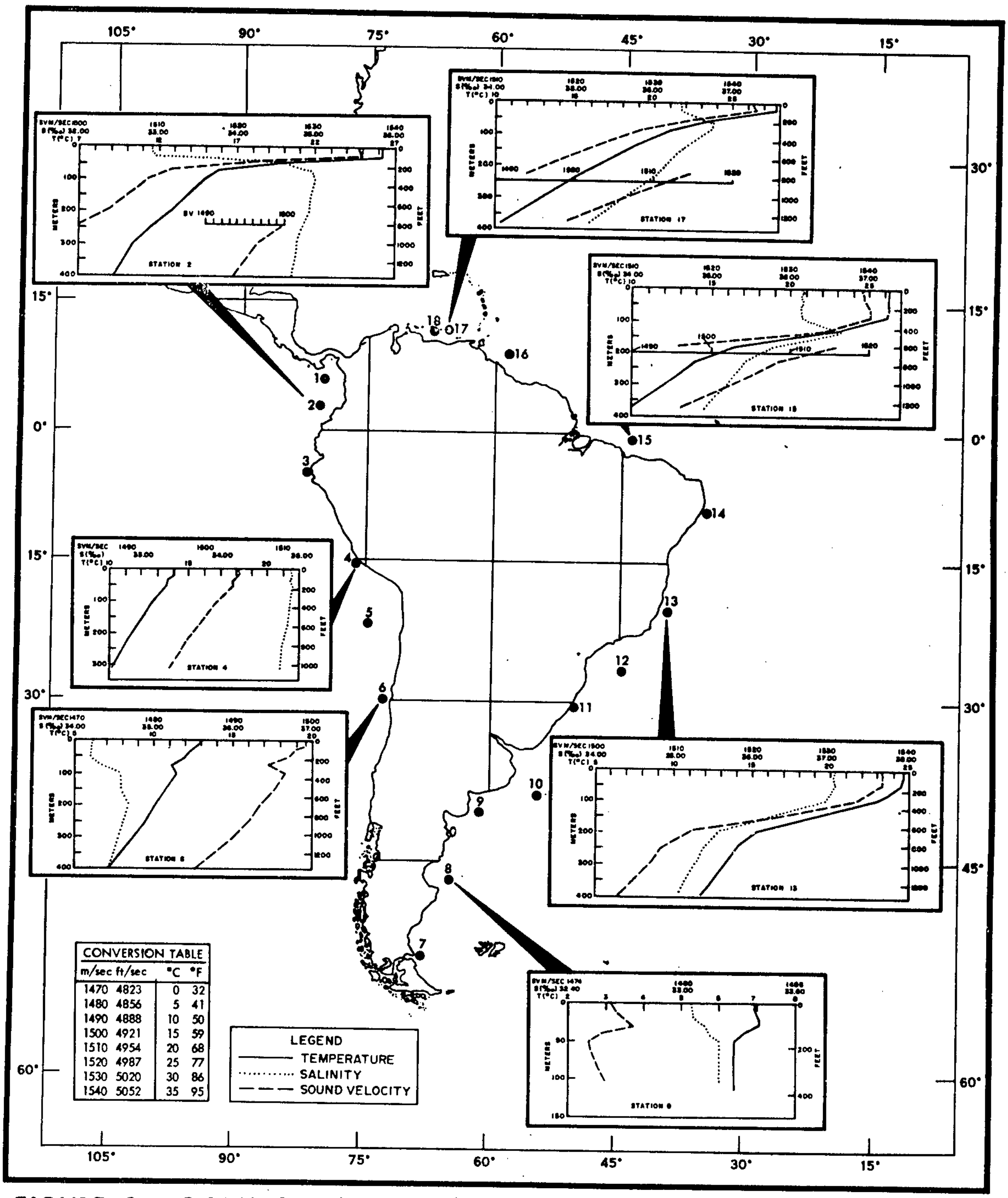

FIGURE 2. OCEANOGRAPHIC STATION LOCATIONS WITH REPRESENTATIVE PROFILES

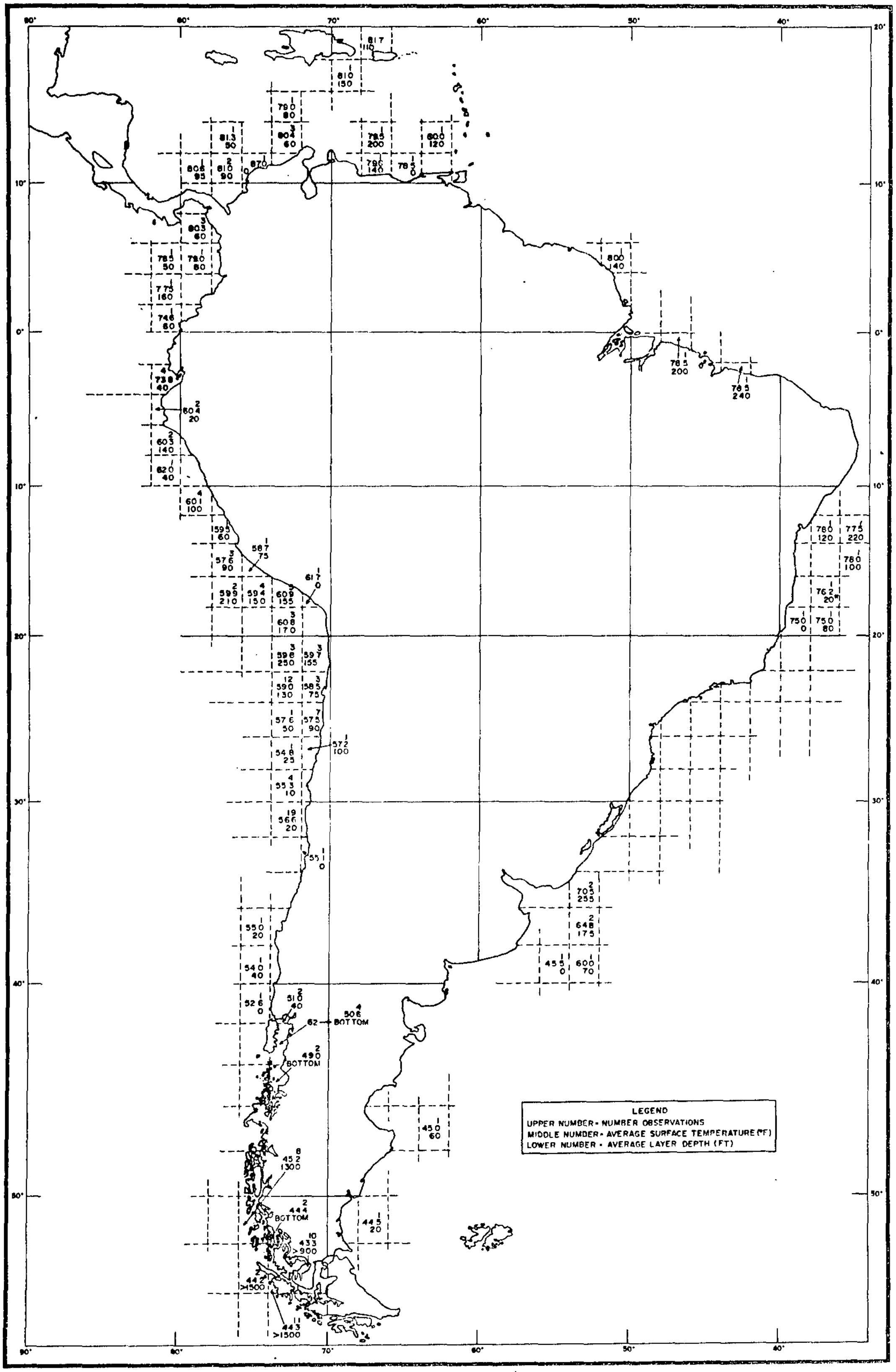

FIGURE 3. BT OBSERVATIONS BY 2-DEGREE SQUARES

C. Bathymetric Data.

Bathymetric data were collected in accordance with H.O. Pub. 606-b, using UQN depth recorders. The data will be evaluated at NAVOCEANO.

VII. DISPOSITION OF DATA

Processing of the BT and oceanographic station data into a finished form for submission to the National Oceanographic Data Center (NODC) is in progress. Computer processing of the oceanographic station data will yield temperature, salinity, sigma-t, and sound velocity values at both standard and observed depths. Specific volume and dynamic depth anomalies will be determined at standard depths.

The original results of nutrient and trace metal analyses will be filed at NAVOCEANO. Nutrient data will be included in the NODC oceanographic station data listings.

Bathymetric data will be incorporated into future charts.

VIII. PRELIMINARY ANALYSES

A. Pacific Coast.

The waters off the west coast of South America are comprised of several natural regions, each characterized by distinctive oceanographic features or processes. Discussion of conditions in the near-surface waters (to 1500 feet) observed during the UNITAS VIII cruise will be in terms of three such regions.

1. Panama to Punta Pariñas. The surface waters in the Gulf of Panama and the region southward to Punta Pariñas ($\approx$ 4°S latitude) can be considered tropical waters. Little seasonal alteration of the surface layers occurs. This stability is related to high heating throughout the year and to the large amount of rainfall which maintain strong thermoclines and haloclines in the near-surface layers (see station 2, Fig. 2). These two factors combine producing a rapid increase of density at approximately 100 to 200 feet (30 to 60 meters) below the surface. The strong stratification restricts mixing to the uppermost waters.

In this region, observed surface temperatures generally were 1° to 2°F (0.6° to 1.2°C) lower than the 12-year average for September given by Renner (1963). Layer depths usually were less than 100 feet (30 meters). Comparison of observed nearshore temperatures off Punta Pariñas with those observed during the previous southern hemisphere summer and fall (Cochrane, 1967) shows a temperature decrease greater than 10°F (6°C). This temperature decrease is an indication of increased upwelling off Punta Pariñas in late winter 1967.

2. Punta Pariñas to 40°S. Prominent oceanographic features of this region are the Peru Current and upwelling phenomena.

The Peru Current is a slow, fairly shallow current which transports Subantarctic Water northward along the South American coast. The current turns eastward at the approximate latitude of Punta Pariñas.

Upwelling, which occurs at several locations along the Peruvian and Chilean coasts, has been discussed by Gunther (1936) and others. Well known upwelling locations are found at approximately 16°S and 31°S. The magnitude and duration of upwelling are dependent on meteorological conditions, being most pronounced during the southern winter. Prolonged southeast winds induce upwelling, resulting in low temperatures in the surface waters near the coast.

The low surface temperatures at Nansen station 4, located near 16°S (Fig. 2), indicated that the upwelling process was active at the time of observation. At this station, both temperature and salinity decreased uniformly to the maximum observed depth. Apparently, upwelling was decreasing in intensity during this time because sonic layers in the upwelling region were generally rather shallow or, in some cases, absent.

Farther offshore, the temperature structure was characterized by an isothermal surface layer and a sharp negative gradient at approximately 200 to 300 feet (60 to 90 meters). Below this gradient, temperatures decreased uniformly to the observed depth of 1500 feet (460 meters). As a consequence of the deep isothermal mixed layer, conditions were favorable for long range sonar detections.

Upwelling also appeared to occur at approximately 30°S. Here, surface temperature distribution showed values of 55°F (12.8°C) near the coast and values of 58° to 60°F (14.4° to 15.60°C) offshore. During the period when BT's and Nansen stations were taken in the area, the prevailing winds were generally from the south or southeast and ranged from 10 to 18 knots (5.2 to 9.3 m/sec), reinforcing the supposition that upwelling was in progress.

Layer depths in the area were variable. Gunther (1936) observed that the temperature structure in the upwelling regions off the South American coast indicated alternating tongues of cold and warm surface waters. This type of temperature distribution could be responsible for the variations of layer depth observed since the warmer, less dense water would tend to overrun the cooler water, thereby producing shallow layers in the overrun areas.

At Nansen station 6 (Fig. 2), the temperature and salinity structures departed somewhat from those observed farther north. The lowest salinities occurred near the surface. At this latitude, mixing had not greatly altered the characteristic (34.2-34.4 ‰) salinity of the Subantarctic Water. An interesting feature of the thermal structure at this station was the temperature minimum found at 245 feet (75 meters). This minimum can probably be related to local winter cooling or possibly to advection of water from another area by the Peru Current.

3. <u>40°S to the Strait of Magellan</u>. Oceanographic stations were not occupied in the region south of Valparaiso, Chile. The UNITAS contingent proceeded by the sheltered inside passage during the greater portion of the transit to Punta Arenas. BT's were obtained during the transit and may be used to infer something about the oceanographic conditions in the interisland waters.

In the waters east of the Isla de Chiloe', BT traces indicated a relatively uniform composition from the surface to the generally shallow bottom. Similar conditions prevailed to about 46°S.

The interisland region, from 49°S to the Strait of Magellan, appears to be an estuarine environment similar to that observed along portions of the western North American coast. BT traces showed minimum temperature values at or near the surface. Temperatures generally increased to a maximum value at approximately 300 feet (90 meters) and then decreased at a slow uniform rate to the maximum depth sampled. Conditions such as these will cause degradation of sonar ranges. Multiple refractions and surface reflections of signals will increase attenuation, thereby shortening detection distances.

High precipitation along the southern Chilean coast maintains a low salinity surface layer. The strong density gradient, which exists between the dilute surface waters and the more saline underlying waters, causes a two-layer system in which interchange between the respective layers is inhibited. The existence of the low temperature strata in the surface layers observed during the UNITAS cruise was made possible by this two-layer system. The cold water probably originated mainly from glacial runoff.

In the Strait of Magellan, the temperature structure was almost isothermal. Several BT traces showed some evidence of the estuarine condition observed to the north. The majority of BT's, however, indicated that vigorous mixing contributed to the uniformity of structure with depth. BT's indicated that sonar conditions in the Strait of Magellan during the austral spring were quite good.

From approximately 50°S to the Strait of Magellan, the sonic layer was either bottom bounded or extended below the maximum depth sampled.

B. Atlantic and Caribbean Coasts.

Discussion of oceanographic conditions off the Atlantic and Caribbean coasts will follow the theme set forth previously, considering in turn several oceanic regions.

1. Falkland Current Region. Three oceanographic stations (Fig. 2) and several BT's were taken on the Argentine Shelf. Low surface salinities suggest that the surface waters are derived primarily from land runoff. Observed salinities ranged from less than 33 ‰ in the south to 33.75 ‰ farther north. Surface temperatures showed a similar increase, rising from 41.4° to 51.3°F (5.2° to 10.7°C). These alterations can be related to mixing and heating processes acting upon the waters as they are transported northward by the Falkland Current.

Layer depths displayed a correlation with salinity similar to that found in the interisland region of the Chilean coast. The subsurface halocline tended to restrict mixing to the uppermost layers.

2. Falkland Current-Brazil Current Confluence Region. The Falkland and Brazil Currents meet at approximately 35° to 40°S. The combined flows set eastward, forming the South Atlantic Current (Fairbridge, 1966). In the confluence region, complex and varied conditions may result due to the disparate natures of the water masses meeting there. Data from near the mouth of the Rio De La Plata exhibited two types of temperature and salinity structures. The southernmost observations in the confluence region resembled those observed on the Argentine Shelf, while the more northern observations exhibited subsurface temperature and salinity maxima. The salinity maximum (over 36 ‰) indicates that the water originated from the Brazil Current.

In waters that originated in the Brazil Current, the warm, saline subsurface strata promoted favorable sonar conditions; sonic layer depths as great as 300 feet (90 meters) were encountered. Shallow layers were found in the cool Falkland Current waters.

3. Brazil Current Region. Stations 11, 12, and 13 (Fig. 2) were located in the Brazil Current region where surface temperatures and salinities were high. At station 11, a subsurface salinity maximum was present, while stations 12 and 13 were characterized by high salinity (greater than 37 ‰) waters extending from the surface to a depth of 200 feet (60 meters).

Sonic layer depths were variable; the few Nansen and BT data available indicated that sonic layers ranged from 0 to 220 feet (0 to 70 meters) in thickness.

4. Guiana and Caribbean Currents Region. The quasi-isotropic properties of the waters observed at widely spaced Nansen stations in the Guiana and Caribbean Currents region reflect their common sources, i.e., the equatorial current systems. Stations 14 to 18 (Fig. 2) have similar features in their temperature, salinity, and sound velocity structures; the only differences are in the degree of development. All five stations had an isothermal surface layer ranging from 130 to 300 feet (40 to 90 meters) in thickness and

temperatures ranging from 78.8° to 82°F (26° to 28°C). A subsurface salinity maximum existed at each station between 200 and 500 feet (60 to 150 meters). This salinity maximum corresponds to the Subtropic Underwater defined by Wüst (1964). Maximum salinities in the core of the Subtropic Underwater are above 36.5 ‰.

A distinct relationship between sonic layer depth and the highly saline Subtropic Underwater was observed. That is, the maximum depth of the sonic layer was reached at, or slightly below, the interface between the more dilute surface water and the Subtropic Underwater. Evidently, the density increase occurring in the Subtropic Underwater is sufficient to preclude mixing very far into the high salinity stratum, even though relatively strong winds and currents may be operative.

IX. RECOMMENDATIONS FOR FUTURE WORK

Oceanographic station occupation during UNITAS cruises must be, of necessity, on a "not-to-interfere" basis; however, a flexible survey program conducted on this basis can yield highly useful information about existing oceanographic conditions. Besides temperature, salinity, and density data, the oceanographic station provides samples for nutrients, trace metals, and other analyses. Also, salinity and density data aid in analysis of BT's taken nearby.

Oceanographic stations should be occupied whenever possible, especially in regions where data are sparse.

In order to determine year-to-year variations, annual reoccupation of selected stations should be attempted.

The increased use of XBT's should be emphasized. XBT's provide an ideal means of measuring the bathythermal conditions in that: (1) a ship is not required to slow down, (2) the instrument has greater depth capability than a conventional mechanical BT, and (3) the temperature record is provided in a conveniently-used format. During forthcoming UNITAS cruises, XBT's should be collected at regular intervals, preferably every 2 to 3 hours, throughout the duration of the voyage. The improved spatial coverage provided by regular XBT collections would make analysis easier, more meaningful, and more reliable.

The feasibility of additional types of sampling should not be overlooked. Bottom sediment sampling, water visibility and color, and biological sampling could easily be incorporated in future UNITAS oceanographic programs.

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UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* U. S. NAVAL OCEANOGRAPHIC OFFICE	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

OCEANOGRAPHIC CRUISE SUMMARY UNITAS VIII CRUISE AROUND SOUTH AMERICA AUGUST TO DECEMBER 1967

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Informal Report 18 August to 9 December 1967

5. AUTHOR(S) *(First name, middle initial, last name)*

LAURIE E. JARVELA

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1968	13	17

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 202-02	IR 68-14
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Naval Oceanographic Office

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
OCEANOGRAPHIC CRUISE SUMMARY						
UNITAS VIII CRUISE						
USS NORFOLK (DL 1)						
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