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Frederick B. Dent, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Robert M. White, Administrator

NATIONAL MARINE FISHERIES SERVICE

Robert W. Schoning, Director

Oceanic Conditions During the Joint Investigation of the Southeastern Tropical Atlantic (JISETA)— February, April, and September-December 1968

STEVEN K. COOK, JAMES F. HEBARD, MERTON C. INGHAM,
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Data Report 82

SEATTLE, WA.

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CONTENTS

	Page
Introduction	1
Station patterns and cruise schedules	1
Data acquisition	2
Data processing	3
Literature cited	5
Appendix 1	5

Figures

1. General location of the Joint Investigation of the Southeastern Tropical Atlantic (JISETA)	6
2. Temperature-salinity relationships obtained by RV <i>Undaunted</i> , RV <i>Goa</i> , and USCGC <i>Rockaway</i> at intercalibration station located at 12°20'S and 13°00'E	7
3. Temperature-oxygen relationships obtained by RV <i>Undaunted</i> and USCGC <i>Rockaway</i> at intercalibration station located at 12°20'S and 13°00'E	8
4. Locations of stations 2-45; <i>Undaunted</i> 6801, phase I; 18-25 February 1968 ...	9
5- 29. Vertical distributions of temperature, salinity, density, oxygen, and phosphate for <i>Undaunted</i> 6801, phase I	10-34
30. Locations of stations 46-105; <i>Undaunted</i> 6801, phase II; 8-16 March 1968	35
31- 69. Vertical distributions of temperature, salinity, density, oxygen, and phosphate for <i>Undaunted</i> 6802, phase II	36-74
70. Locations of stations 114-144; <i>Undaunted</i> 6801, phase III; 15-21 April 1968 ...	75
71- 95. Vertical distributions of temperature, salinity, density, oxygen, and phosphate for <i>Undaunted</i> 6801, phase III	76-100
96. Locations of stations 18-35; <i>Undaunted</i> 6802, phase I; 19-23 September 1968	101
97-105. Vertical distributions of temperature, salinity, density, oxygen, and phosphate for <i>Undaunted</i> 6802, phase I	102-110
106. Locations of stations 1-61; <i>Goa</i> , phase II; 12-25 October 1968	111
107-136. Vertical distributions of temperature, salinity, and density for <i>Goa</i> , phase II ...	112-141
137. Locations of stations 50-99; <i>Undaunted</i> 6802, phase II; 15-29 October 1968 ...	142
138-191. Vertical distributions of temperature, salinity, density, oxygen, and phosphate for <i>Undaunted</i> 6802, phase II	143-196
192. Locations of stations 6-166; <i>Rockaway</i> , phase II; 15-20 October 1968	197
193-255. Distributions of temperature, salinity, density, oxygen, and phosphate for <i>Rockaway</i> , phase II	198-260
256. Locations of stations 170-274; <i>Rockaway</i> , phase III; 11-21 November 1968	261
257-276. Vertical distributions of temperature, salinity, density, oxygen, and phosphate for <i>Rockaway</i> , phase III	262-281
277. Locations of stations 1-29; <i>Goa</i> , phase III; 12-17 November 1968	282
278-316. Vertical distributions of temperature, salinity, and density for <i>Goa</i> , phase III ...	283-321
317. Locations of stations 276-338; <i>Rockaway</i> , phase IV; 25 November-2 December 1968	322
318-353. Vertical distributions of temperature, salinity, density, oxygen, and phosphate for <i>Rockaway</i> , phase IV	323-358

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Tables

1	A summary of sampling activities conducted on the vessels participating in the various cruises of JISETA	3
2	Methods used by participating agencies for quality control of data collected on JISETA cruises	4

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Oceanic Conditions During the Joint Investigation of the Southeastern Tropical Atlantic (JISETA)—February, April, and September-December 1968

STEVEN K. COOK,¹ JAMES F. HEBARD,¹ MERTON C. INGHAM,¹
ELLSWORTH C. SMITH,² and CARLOS AFONSO DIAS³

ABSTRACT

Oceanic conditions in the upper 1,000 meters in the water column off tropical western Africa are portrayed. The portrayal is comprised of vertical sections of temperature, salinity, sigma- t , oxygen, and phosphate. A description of methods of sampling, analysis, data processing and quality control is presented.

INTRODUCTION

The Joint Investigation of the Southeastern Tropical Atlantic (JISETA) was conceived in 1967 at the Tropical Atlantic Biological Laboratory (now Southeast Fisheries Center) of the Bureau of Commercial Fisheries (BCF), U.S. Department of Interior (now the National Marine Fisheries Service, U.S. Department of Commerce) in Miami, Fla. The investigation was planned as an extension of a broad study of the tropical Atlantic tunas and their ecology. Of particular interest to JISETA was the relationship between the distribution of surface-schooling tunas and seasonal changes in their environment. Specific oceanic features along the coast of western Africa between the equator and 17°S (Fig. 1) thought to influence tuna distribution were fronts, upwelling areas, and the effluent plume of the Congo River.

It soon became apparent that the investigation of this area was too much for one vessel, BCF's RV *Undaunted*, and assistance was requested from various U.S. and foreign laboratories. Two organizations agreed to participate, the Missao de Estudos Bioceanologicos e de Pescas de Angola, with the RV *Goa*, located in Lobito, Angola, and the U.S. Coast Guard Oceanographic Unit, located in Washington, D.C., which agreed to send the USCGC *Rockaway*.

This report is a compilation of the physical and chemical data collected by the three ships in the various phases of JISETA, portrayed in a series of vertical sections corresponding with transects of stations occupied during the investigation. The report is not intended to be the sole publication resulting from JISETA, but instead is intended to serve as a source of physical and chemical data which should be utilized in further research in fisheries ecology or oceanography. Although biological data were collected during JISETA also, there are no similar portrayals of these data planned; they will be utilized in research papers instead.

STATION PATTERNS AND CRUISE SCHEDULES

The station patterns occupied during the various phases of JISETA are shown in Figures 4, 30, 70, 96, 106, 137, 192, 256, 277, and 317. The cruises comprising the investigation were conducted according to the following schedules:

Undaunted 6801:

14-25 February—phase I (2-11°S)
8-16 March —phase II (15-19°S)
15-21 April —phase III (2°S-5°N,
Northeastern Gulf of Guinea)

Undaunted 6802:

19-23 September—phase I (1°N-6°S)
15-29 October —phase II (6-12°S)
11-22 November —phase III (12-17°S,
results not included)

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Goa

- 19-24 September—phase I (5-12°S, results not included)
- 12-25 October —phase II (12-17°S)
- 12-17 November —phase III (12-17°S)

Rockaway:

- 29 September-3 October —phase I (Angola Dome survey, results not included here)
- 15-30 October —phase II (0-6°S)
- 11-21 November —phase III (11-17°S)
- 25 November-2 December—phase IV (0-4°S)

During phase II of the cruises in October-December 1968 the three ships were at sea simultaneously, occupying stations along onshore-offshore transects 100-120 nm (185-200 km) in length in the area from the equator to 17°S. Goa covered the southern portion (12-17°S), *Undaunted* the central portion (6-12°S), and *Rockaway* the northern portion (0-6°S).

During phase III, the ships worked together in an area from 11° to 17°S in an effort to describe the anticipated southward movement of an oceanic front along the Angola coast. The *Rockaway* occupied stations along four long north-south transects, while the *Goa* and *Undaunted* worked along a sawtooth track in the same area.

During phase IV, only the *Rockaway* gathered data, while reoccupying stations between 4°S and the equator.

DATA ACQUISITION

Water Temperature

Water temperature was measured by reversing thermometers, expendable or mechanical bathythermographs (XBT or BT), in situ salinity-temperature-depth recording systems (STD), recording thermographs, and bucket thermometers.

Salinity

Salinity was measured in situ by means of an STD or by shipboard or laboratory analysis of water samples collected from casts of Niskin or Nansen bottles.

Dissolved Oxygen Content

A modified Winkler titration (Strickland and Parsons, 1965) was used on board the *Undaunted* and *Rockaway* to determine the concentration of dissolved oxygen in water samples collected with Nansen or Niskin bottles.

Inorganic Phosphate Content

Samples of seawater were analyzed for their content of dissolved inorganic phosphate either on board the research vessel (*Rockaway*) or in the laboratory after preservation by freezing (*Undaunted*). The shipboard analysis generally followed methods prescribed by Strickland and Parsons (1965). The laboratory method used on preserved water samples from *Undaunted* 6801 was a modification of a dual reductant analysis (Van Landingham, 1958) involving color formation and stabilization by a stannous chloride-hydrazine sulfate reducing agent. Preserved water samples from *Undaunted* 6802 were analyzed according to the procedure specified by Strickland and Parsons (1968) using a Beckman DU spectrophotometer.

Primary Productivity

Estimates of primary productivity were made each day on board the *Rockaway* and *Undaunted* by measuring the amount of carbon fixed during 24 hr in incubation of seawater samples inoculated with C-14 carbonate. The water samples were collected at local apparent noon at selected light-extinction levels. They were placed in deck mounted incubators, fitted with filters to simulate the extinction levels, in a bath of running seawater at ambient sea surface temperature. After incubation the samples were filtered and residues desiccated and frozen until subsequent analysis in a laboratory ashore.

Zooplankton

Double oblique tows of 1-m plankton nets fitted with flow meters and bathythermographs were made in the upper 200 m (water depth permitting) to capture representative samples of zooplankton. Biomass estimates, per unit volume of water filtered, were obtained by the displacement method described by Tashiro and Hebard (1969).

Nekton

Near-surface tows of a 6-ft Isaacs-Kidd midwater trawl were made on selected stations from the *Undaunted* in an attempt to sample the forage organisms available to surface-schooling tunas.

Tunas

Samples (up to 100 individuals) were collected by hook and line from surface schools of tuna whenever possible from the *Undaunted*. Samples of muscle tissue, gonads, blood, and eyes were taken from the fish after they were measured, weighed, and sexed.

Navigation

Ships' positions were determined by celestial fixes and dead reckoning. When near enough to shore, radar was used to identify landmarks as a supplementary means.

A summary of sampling activities conducted on the vessels participating in the various cruises of JISETA is presented in Table 1.

Table 1.—Sampling activities on the Joint Investigation of the Southeastern Tropical Atlantic.

Sampling activity	<i>Undaunted</i> 6801	<i>Undaunted</i> 6802	<i>Goa</i>	<i>Rockaway</i>
Bottle casts for temperature and salinity	X	X	X	X
STD ¹	X			X
XBT ²		X		X
Mechanical bathythermograph		X	X	
Thermograph	X	X	X	
O ₂ concentration	X	X		X
PO ₄ concentration	X	X		X
Productivity	X	X		X
Zooplankton	X	X	X	X
Nekton		X		
Tuna spotting	X	X	X	X
Tuna sampling	X	X		

¹Salinity-temperature-depth recording systems.

²Expendable bathythermograph.

Intercalibration

During October, each vessel participating in JISETA occupied a station near 12°20'S, 13°00'E, off Lobito, Angola, for the purpose of intercalibration of physical and chemical measurements. The results of these occupations are presented as comparative plots of temperature vs. salinity and temperature vs. oxygen (Fig. 2 and 3). The surface and near-surface values were not plotted because of scatter in these data due to real changes in the upper waters during the interval of 10 days between the first and last occupation of the station.

Determinations of temperature and salinity on the three vessels were closely comparable; the T-S envelope width (Fig. 2) was 0.07‰ and 0.3°C at its widest point. Oxygen determinations on the *Rockaway* and *Undaunted* were not as comparable. In warmer water (>9°C) above 150 m the determinations were widely different, possibly because of real changes in concentration; the depth of the oxycline varied widely in space in the vicinity of the intercalibration station. However, the oxygen determinations were closely comparable in cooler water (<9°C) in and below the oxygen minimum.

Quality Control and Processing of Data

Each agency participating in JISETA was independently responsible for shipboard and laboratory quality control of the data it collected, using the methods listed in Table 2.

DATA PROCESSING

The vertical sections presented in this report were produced from data derived from bottle casts and STD instrument lowerings. All data obtained were reduced and quality controlled by the participants. Final processing and quality control were completed by the U.S. National Oceanographic Data Center (NODC). The data were archived by NODC and are available to interested persons from NODC under the following identification:

Vessel	Dates	NODC Cruise Number
<i>Goa</i>	10-12-68/10-25-68	AN 001
<i>Goa</i>	11-12-68/11-17-68	AN 002
<i>Rockaway</i>	10-13-68/12- 2-68	318058
<i>Undaunted</i>	2-14-68/ 4-25-68	318100
<i>Undaunted</i>	9-15-68/11-20-68	318161

Standard depth interpolation for temperature, salinity, and oxygen was based upon a 3-point Lagrange interpolation equation (Scarborough, 1958). Details of this interpolation method are available from NODC.

Following interpolation, the data were edited and anomalous data were examined for validity by comparison with data acquired at nearby stations as well as with historical data from the same region. When validity was doubtful, data were flagged. In the preparation of this report, data of doubtful validity were not used for development of the vertical sections.

Several stages in the process by which the JISETA data were impressed into the standard NODC format may be of interest to anyone concerned with application of the final product. These stages are described below.

All data were subjected to the standard NODC station data compute program. In this program, values of temperature, salinity, and oxygen were interpolated at standard depths between the observed values, using the routine shown in Appendix 1.

All data were subjected to edit programs which flag anomalies such as impossible ship-location/time sequences and improbable or unprocessable parameter values, to be corrected in the next stage by an oceanographer/monitor. More significantly, when the value of sigma-t (both observed and standard-depth values) was less than the value at the depth immediately above by an amount exceeding 0.02 sigma-t units, it was flagged.

Table 2.—Methods used by participating agencies for quality control of data collected on the Joint Investigation of the Southeastern Tropical Atlantic cruises.

	BCF ¹	USCG ²	BIOPESCA ³
Temperature	<p>STD⁴ data compared with reversing thermometers at top and bottom of cast</p> <p>Performance of reversing thermometers monitored on each cast. Values averaged if difference for pair $\leq 0.03^{\circ}\text{C}$</p>	<p>STD data compared with reversing thermometers on full bottle casts on stations</p> <p>Performance of reversing thermometers monitored on each cast. Values averaged if differences for pair $\leq 0.04^{\circ}\text{C}$</p>	<p>Performance of reversing thermometers monitored on each cast</p> <p>Values averaged if difference for pair $\leq 0.04^{\circ}\text{C}$</p>
Salinity	<p>STD data compared with laboratory analysis of water samples collected at top and bottom of cast</p> <p>Samples analyzed in duplicate by inductive salinometer</p>	<p>STD data compared with on-board analysis of water samples from Nansen casts on station</p>	<p>Duplicate determinations of salinity by inductive salinometer on shore.</p>
Sampling depth	<p>STD compared with thermometric depth</p> <p>Monitored performance of protected and unprotected thermometers and reviewed L-Z curves</p>	<p>STD compared with thermometric depth</p> <p>Monitored performance of protected and unprotected thermometers and reviewed L-Z curves</p>	<p>Monitored performance of protected and unprotected reversing thermometers and reviewed L-Z curves</p>
Dissolved oxygen	<p>Replicate titrations on first and last sample from each station. If first replicates differed by more than ± 0.02 ml of titer, duplicates were run on all samples. Special precautions were taken to reduce errors caused by volatilization of iodine.</p>	<p>Replicate titrations of first and last sample from each station. If first replicates differed by more than 0.02 ml of titer duplicates were run on all samples. Special precautions were taken to reduce errors caused by volatilization of iodine.</p>	<p>Variable not measured</p>
Inorganic phosphate	<p>Standardized against known concentration of potassium dihydrogen phosphate at beginning and end of cruise. Single determination with O_2PO_4 relationship for quality control (Van Landingham, pers. comm.).</p>	<p>Standardized against known concentration of potassium dihydrogen phosphate at beginning and end of cruise. Duplicate determination.</p>	<p>Variable not measured</p>

¹Bureau of Commercial Fisheries

²U. S. Coast Guard

³Missao de Estudos Bioceanologicos e de Pescas de Angola

⁴Salinity-temperature-depth recording systems

The data listout was reviewed by an oceanographer/monitor, who examined the flagged sigma- t anomalies to determine the source of error. When in the monitor's judgment the depth, temperature, or salinity was of doubtful validity, the value was flagged with the suffix "P". This flag was carried through the process to the permanent file and final listing.

As a guide to judging, if the value retains a flag, a decrease (with depth) of 0.05 sigma- t units was tolerated at depths between 100 and 300 m, and 0.2 from the surface to 100 m. Values identified as being doubtful by the originator were flagged with the suffix "O".

When either temperature or salinity had been flagged, sigma- t also was flagged.

After the data were quality controlled and processed to the stage of archival by NODC, the observed values of temperature, salinity, density, oxygen, and phosphate were plotted versus depth and contoured to yield the vertical sections in this report. Data from the *Goa*, *Rockaway*, and *Undaunted* 6802 were plotted and contoured by a computer-controlled drafting machine utilizing the Coast Guard Oceanographic Unit's HYDROGRAPH computer program. The data from *Undaunted* 6801 were plotted and contoured by

hand. All contoured sections were reviewed and smoothed by hand before final drafting

The *Rockaway* data involved an STD lowering and a Nansen bottle cast on each station. Separate numbers were assigned the lowerings and casts on the same stations, so the oxygen and phosphate sections bear different station numbers, but the positions are the same.

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APPENDIX 1

Station Data Compute Program Equations

Standard Depth Interpolation Routine

The following 3-point Lagrange interpolation equation (Scarborough, 1958:74-75) is used to interpolate temperature, salinity, and oxygen at standard depths:

$$X = \frac{(d-d_2)(d-d_3)}{(d_1-d_2)(d_1-d_3)} X_1 + \frac{(d-d_1)(d-d_3)}{(d_2-d_1)(d_2-d_3)} X_2 + \frac{(d-d_1)(d-d_2)}{(d_3-d_1)(d_3-d_2)} X_3$$

where d = standard depth in question

d_1 = observed depth #1

d_2 = observed depth #2

d_3 = observed depth #3

X = parameter at standard depth

X_1 = observed parameter at depth d_1

X_2 = observed parameter at depth d_2

X_3 = observed parameter at depth d_3 .

However, there is one case where linear interpolation

$$X = X_1 + \frac{d-d_1}{d_2-d_1} (X_2-X_1)$$

is used. That is where the 3-point interpolated value does not lie within the interval between the valid observed values immediately above and below; if there

are additional interpolated values within this interval, a new value is also computed (by linear interpolation) for these standard depths.

The observed values used to interpolate at a given standard depth are normally chosen as one above the required standard depth and two below. However, if there are standard depths between the last two observed depths for a station then the values are chosen as two above and one below for the required standard depths. No doubtful data are used for interpolation. Doubtful data are bypassed until valid data are encountered.

If there is no valid observation at the surface, the surface interpolated value is made equal to the observed value at d_1 , if $d_1 \leq 9$ m. If $d_1 > 9$ m. then no standard depth interpolations are computed until $d \geq d_1$.

In addition, no interpolation for temperature, salinity, and/or oxygen is performed where the following conditions are encountered:

1) The first depth (d_1) with a valid observed value (card type 3, 4) is 400 m or less and the next depth (d_2) with a valid observed value is greater than $d_1 + 200$ m.

2) d_1 exceeds 400 m but not greater than 1,200 m and d_2 is greater than $d_1 + 400$ m.

When d_1 exceeds 1,200 m, interpolation proceeds according to normal procedure.

Figure 1.—General location of the Joint Investigations of the Southeastern Tropical Atlantic (JISETA).

Figure 2.—Temperature-salinity relationships obtained by RV *Undaunted*, RV *Goa*, and USCGC *Rockaway* at intercalibration station located at 12°20'S and 13°00'E.

Figure 3.—Temperature-oxygen relationships obtained by RV *Undaunted* and USCGC *Rockaway* at intercalibration station located at 12°20'S and 13°00'E.

Figure 4.—Locations of stations 2-45; *Undaunted* 6801, phase I; 18-25 February 1968.

Figure 5.—Vertical distribution of temperature (°C) for *Undaunted* 6801, phase I; stations 2-5; 18-19 February 1968.

Figure 6.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase I; stations 2-5; 18-19 February 1968.

Figure 7.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase I; stations 2-5; 18-19 February 1968.

Figure 8.—Vertical distribution of temperature (°C) for *Undaunted* 6801, phase I; stations 5-9; 19 February 1968.

Figure 9.—Vertical distribution of salinity (‰) for *Undaunted 6801*, phase I; stations 5-9; 19 February 1968.

Figure 10.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase I; stations 5-9; 19 February 1968.

Figure 11.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6801, phase I; stations 5-9; 19 February 1968.

Figure 12.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase I; stations 9-13; 19-20 February 1968.

Figure 13.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase I; stations 9-13; 19-20 February 1968.

Figure 14.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase I; stations 9-13; 19-20 February 1968.

Figure 15.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase I; stations 15-20; 20-21 February 1968.

Figure 16.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase I; stations 15-20; 20-21 February 1968.

Figure 17.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase I; stations 15-20; 20-21 February 1968.

Figure 18.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase I; stations 25-29; 22 February 1968.

Figure 19.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase I; stations 25-29; 22 February 1968.

Figure 20.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase I; stations 25-29; 22 February 1968.

Figure 21.—Vertical distribution of temperature (°C) for *Undaunted* 6801, phase I; stations 35-39, 24 February 1968.

Figure 22.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase I; stations 35-39; 24 February 1968.

Figure 23.—Vertical distribution of density (σ_t) for *Undaunted* 6801, phase I; stations 35-39; 24 February 1968.

Figure 24.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6801, phase I; stations 35-39; 24 February 1968.

Figure 25. —Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6801, phase I; stations 35-39, 24 February 1968.

Figure 26.—Vertical distribution of temperature (°C) for *Undaunted* 6801, phase I; stations 41-45; 25 February 1968.

Figure 27.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase I; stations 41-45; 24 February 1968.

Figure 28.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase I; stations 41-45; 25 February 1968.

Figure 29.—Vertical distribution of oxygen (ml/liter) for *Undaunted 6801*, phase I; stations 41-45; 25 February 1968.

Figure 30.—Locations of stations 46-105; *Undaunted* 6801, phase II; 8-16 March 1968.

Figure 31.—Vertical distribution of temperature (C) for *Undaunted 6801*, phase II; stations 49-55; 9-10 March 1968

Figure 32.—Vertical distribution of salinity (‰) for *Undaunted 6801*, phase II; stations 49-55; 9-10 March 1968.

Figure 33.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase II; stations 49-55, 9-10 March 1968.

Figure 34.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6801, phase II; stations 49-55; 9-10 March 1968.

Figure 35.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6801, phase II; stations 49-55; 9-10 March 1968.

Figure 36.—Vertical distribution of temperature (°C) for *Undaunted* 6801, phase II; stations 56-62; 10-11 March 1968.

Figure 37.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase II, stations 56-62; 10-11 March 1968

Figure 38.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase II; stations 56-62; 10-11 March 1968.

Figure 39.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6801, phase II; stations 56-62, 10-11 March 1968.

Figure 40.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$ - for *Undaunted* 6801, phase II; stations 56-62; 10-11 March 1968.

Figure 41.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase II; stations 63-70; 11-12 March 1968.

Figure 42.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase II; stations 63-70; 11-12 March 1968.

Figure 43.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase II; stations 63-70; 11-12 March 1968.

Figure 44.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6801, phase II; stations 63-70; 11-12 March 1968.

Figure 45.—Vertical distribution of inorganic phosphate (μ g-at./liter) for *Undaunted* 6801, phase II; stations 63-70; 11-12 March 1968.

Figure 46.—Vertical distribution of temperature (°C) for *Undaunted* 6801, phase II: stations 71-78, 12 March 1968.

Figure 47.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase II; stations 71-78; 12 March 1968.

Figure 48.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase II; stations 71-78; 12 March 1968.

Figure 49.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6801, phase II; stations 71-75; 12 March 1968.

Figure 50.—Vertical distribution of inorganic phosphate (μ g-at./liter) for *Undaunted* 6801, phase II; stations 71-75; 12 March 1968.

Figure 51.—Vertical distribution of temperature (°C) for *Undaunted* 6801, phase II; stations 81-87, 13-14 March 1968.

Figure 52.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase II; stations 81-87; 13-14 March 1968.

Figure 53.—Vertical distribution of density (σ_t) for *Undaunted* 6801, phase II; stations 81-87; 13-14 March 1968.

Figure 54.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6801, phase II; stations 81-87; 13-14 March 1968.

Figure 55.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6801, phase II; stations 81-87; 13-14 March 1968.

Figure 56.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase II; stations 88-94; 14-15 March 1968.

Figure 57 —Vertical distribution of salinity (‰) for *Undaunted* 6801, phase II; stations 88-94 14-15 March 1968.

Figure 58.—Vertical distribution of density (σ_t) for *Undaunted* 6801, phase II; stations 88-94; 14-15 March 1968.

Figure 59.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6801, phase II; stations 88-94; 14-15 March 1968.

Figure 60.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase II; stations 95-100; 15 March 1968.

Figure 61.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase II, stations 95-100; 15 March 1968.

Figure 62.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase II; stations 95-100; 15 March 1968.

Figure 63 — Vertical distribution of oxygen (ml/liter) for *Undaunted* 6801, phase II, stations 95-100, 15 March 1968.

Figure 64.—Vertical distribution of inorganic phosphate (g-at./liter) for *Undaunted* 6801, phase II; stations 95-100; 15 March 1968.

Figure 65.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase II; stations 101-105; 16 March 1968.

Figure 66.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase II; stations 101-105; 16 March 1968.

Figure 67.—Vertical distribution of density (σ_t) for *Undaunted* 6801, phase II, stations 101-105; 16 March 1968.

Figure 68.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6801, phase II, stations 101-105; 16 March 1968.

Figure 69.—Vertical distribution of inorganic phosphate (μ g-at. liter) for *Undaunted* 6801, phase II; stations 101-105; 16 March 1968.

Figure 70.—Locations of stations 114-144, *Undaunted 6801*, phase III; 15-21 April 1968.

Figure 71.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase III, stations 114-117, 15 April 1968.

Figure 72.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase III; stations 114-117; 15 April 1968.

Figure 73.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase III, stations 114-117, 15 April 1968.

Figure 74.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted 6801*, phase III; stations 118-123; 16 April 1968.

Figure 75.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase III, stations 118-123; 16 April 1968.

Figure 76.—Vertical distribution of density (σ_t) for *Undaunted 6801*, phase III; stations 118-123; 16 April 1968.

Figure 77.—Vertical distribution of oxygen (ml/liter) for *Undaunted 6801*, phase III; stations 118-123; 16 April 1968.

Figure 78.—Vertical distribution of inorganic phosphate (μ g-at./liter) for *Undaunted 6801*, phase III; stations 118-123; 16 April 1968.

Figure 79.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase III, stations 124-134, 17-19 April 1968.

Figure 80.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase III; stations 124-134, 17-19 April 1968.

Figure 81.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase III, stations 124-134, 17-19 April 1968.

Figure 82.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6801, phase III; stations 124-134; 17-19 April 1968.

Figure 83.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6801, phase III; stations 124-134, 17-19 April 1968.

Figure 84.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase III; stations 130-133; 18-19 April 1968.

Figure 85.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase III, stations 130-133, 18-19 April 1968.

Figure 86.—Vertical distribution of density (sigma-t) for *Undaunted* 6801, phase III; stations 130-133; 18-19 April 1968.

Figure 87.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase III; stations 133-136; 19 April 1968.

Figure 88.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase III; stations 133-136; 19 April 1968.

Figure 89.—Vertical distribution of density (σ_t) for *Undaunted* 6801, phase III; stations 133-136; 19 April 1968.

Figure 90.—Vertical distribution of temperature (°C) for *Undaunted* 6801, phase III, stations 136-140; 19-20 April 1968.

Figure 91.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase III; stations 136-140; 19-20 April 1968.

Figure 92.—Vertical distribution of density (σ_t) for *Undaunted* 6801, phase III; stations 136-140; 19-20 April 1968.

Figure 93.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6801, phase III, stations 140-144; 20-21 April 1968.

Figure 94.—Vertical distribution of salinity (‰) for *Undaunted* 6801, phase III; stations 140-144; 20-21 April 1968.

Figure 95.—Vertical distribution of density (σ_t) for *Undaunted* 6801, phase III; stations 140-144, 20-21 April 1968.

Figure 96.—Locations of stations 18-35; *Undaunted 6802*, phase I; 19-23 September 1968.

Figure 97.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6802, phase I; stations 18-21; 19-20 September 1968.

Figure 98.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase I; stations 18-21; 19-20 September 1968.

Figure 99.—Vertical distribution of density (σ_t) for *Undaunted* 6802, phase I; stations 18-21, 19-20 September 1968.

Figure 100.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6802, phase I; stations 24-31; 22 September 1968.

Figure 101.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase I; stations 24-31; 22 September 1968.

Figure 102.—Vertical distribution of density (σ_t) for *Undaunted* 6802, phase I; stations 24-31; 22 September 1968.

Figure 103.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted 6802*, phase I; stations 32-35; 22-23 September 1968.

Figure 104.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase I; stations 32-35, 22-23 September 1968.

Figure 105.—Vertical distribution of density (sigma-t) for *Undaunted* 6802, phase I; stations 32-35; 22-23 September 1968.

Figure 106.—Locations of stations 1-61; Goa, phase II; 12-25 October 1968.

Figure 107.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase II; stations 1-6; 12-13 October 1968.

Figure 108.—Vertical distribution of salinity (‰) for Goa, phase II; stations 1-6; 12-13 October 1968.

Figure 109.—Vertical distribution of density (sigma-t) for Goa, phase II, stations 1-6; 12-13 October 1968.

Figure 110.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase II; stations 7-12, 13-14 October 1968.

Figure 111.—Vertical distribution of salinity (‰) for Goa, phase II, stations 7-12; 13-14 October 1968.

Figure 112.—Vertical distribution of density (sigma-t) for Goa, phase II; stations 7-12; 13-14 October 1968.

Figure 113.—Vertical distribution of temperature (C) for Goa, phase II; stations 13-18; 14-15 October 1968.

Figure 114.—Vertical distribution of salinity (‰) for Goa, phase II; stations 13-18; 14-15 October 1968.

Figure 115 —Vertical distribution of density (σ_t) for Goa, phase II; stations 13-18; 14-15 October 1968.

Figure 116.—Vertical distribution of temperature (°C) for Goa, phase II; stations 19-24; 15-16 October 1968.

Figure 117.—Vertical distribution of salinity (‰) for Goa, phase II; stations 19-24, 15-16 October 1968.

Figure 118.—Vertical distribution of density (sigma-t) for Goa, phase II; stations 19-24; 15-16 October 1968.

Figure 119.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase II; stations 25-30; 18-19 October 1968.

Figure 120.—Vertical distribution of salinity (‰) for Goa, phase II; stations 25-30; 18-19 October 1968.

Figure 121.—Vertical distribution of density (σ_t) for Goa, phase II: stations 25-30; 18-19 October 1968.

Figure 122.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase II; stations 32-37; 20-21 October 1968.

Figure 123.—Vertical distribution of salinity (‰) for Goa, phase II, stations 32-37; 20-21 October 1968.

Figure 124.—Vertical distribution of density (σ_t) for Goa, phase II; stations 32-37; 20-21 October 1968.

Figure 125.—Vertical distribution of temperature (°C) for Goa, phase II; stations 38-43; 21-22 October 1968.

Figure 126.—Vertical distribution of salinity (‰) for Goa, phase II; stations 38-43; 21-22 October 1968.

Figure 127.—Vertical distribution of density (σ_t) for Goa, phase II; stations 38-43, 21-22 October 1968.

Figure 128.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase II; stations 44-49; 22-23 October 1968.

Figure 129.—Vertical distribution of salinity (‰) for Goa, phase II; stations 44-49; 22-23 October 1968.

Figure 130.—Vertical distribution of density (σ_t) for Goa, phase II; stations 44-49; 22-23 October 1968.

Figure 131.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase II; stations 50-55; 23-24 October 1968.

Figure 132.—Vertical distribution of salinity (‰) for Goa, phase II; stations 50-55; 23-24 October 1968.

Figure 133.—Vertical distribution of density (σ_t) for Goa, phase II; stations 50-55; 22-24 October 1968.

Figure 134.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase II; stations 56-61; 24-25 October 1968.

Figure 135.—Vertical distribution of salinity (‰) for Goa, phase II; stations 56-61, 24-25 October 1968.

Figure 136.—Vertical distribution of density (σ_t) for Goa, phase II; stations 56-61; 24-25 October 1968.

Figure 137.—Locations of stations 50-99; *Undaunted 6802*, phase II; 15-29 October 1968.

Figure 138.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted 6802*, phase II; stations 50-54; 15-17 October 1968.

Figure 139.—Vertical distribution of salinity (‰) for *Undaunted 6802*, phase II; stations 50-54, 15-17 October 1968.

Figure 140.—Vertical distribution of density (σ_t) for *Undaunted* 6802, phase II; stations 50-54; 15-17 October 1968.

Figure 141.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6802, phase II; stations 50-54, 15-17 October 1968.

Figure 142.—Vertical distribution of temperature (°C) for *Undaunted* 6802, phase II; stations 55-58; 17-18 October 1968.

Figure 143.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase II, stations 55-58; 17-18 October 1968.

Figure 144.—Vertical distribution of density (sigma-t) for *Undaunted* 6802, phase II; stations 55-58; 17-18 October 1968.

Figure 145.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6802, phase II; stations 55-58; 17-18 October 1968.

Figure 146.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6802, phase II; stations 55-58; 17-18 October 1968.

Figure 147.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6802, phase II; stations 59-62; 20-21 October 1968.

Figure 148.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase II, stations 59-62; 20-21 October 1968.

Figure 149.—Vertical distribution of density (sigma-t) for *Undaunted* 6802, phase II; stations 59-62; 20-21 October 1968.

Figure 150.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6802, phase II; stations 59-62; 20-21 October 1968.

Figure 151.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6802, phase II, stations 59-62; 20-21 October 1968.

Figure 152.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6802, phase II; stations 63-66; 21-22 October 1968.

Figure 153.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase II; stations 63-66; 21-22 October 1968.

Figure 154.—Vertical distribution of density (sigma-t) for *Undaunted* 6802, phase II; stations 63-66; 21-22 October 1968.

Figure 155.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6802, phase II; stations 63-66; 21-22 October 1968.

Figure 156.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6802, phase II; stations 63-66; 21-22 October 1968.

Figure 157.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6802, phase II; stations 67-71; 22-23 October 1968.

Figure 158.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase II; stations 67-71; 22-23 October 1968.

Figure 159.—Vertical distribution of density (σ_t) for *Undaunted* 6802, phase II; stations 67-71; 22-23 October 1968.

Figure 160.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6802, phase II; stations 67-71; 22-23 October 1968.

Figure 161.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted*, phase II; stations 67-71; 22-23 October 1968

Figure 162.—Vertical distribution of temperature (°C) for *Undaunted* 6802, phase II; stations 72-75; 24 October 1968.

Figure 163.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase II; stations 72-75; 24 October 1968.

Figure 164.—Vertical distribution of density (sigma-t) for *Undaunted* 6802, phase II; stations 72-75; 24 October 1968.

Figure 165.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6802, phase II; stations 72-75; 24 October 1968.

Figure 166.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6802, phase II; stations 72-75; 24 October 1968.

Figure 167.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6802, phase II, stations 76-79, 25 October 1968.

Figure 168.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase II; stations 76-79; 25 October 1968.

Figure 169.—Vertical distribution of density (sigma-t) for *Undaunted* 6802, phase II; stations 76-79; 25 October 1968.

Figure 170.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6802, phase II; stations 76-79; 25 October 1968.

Figure 171.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted*, 6802 phase II; stations 76-79; 25 October 1968.

Figure 172.—Vertical distribution of temperature (°C) for *Undaunted 6802*, phase II; stations 80-84; 26 October 1968.

Figure 173.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase II; stations 80-84; 26 October 1968.

Figure 174.—Vertical distribution of density (sigma-t) for *Undaunted* 6802, phase II; stations 80-84; 26 October 1968.

Figure 175.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6802, phase II; stations 80-84, 26 October 1968.

Figure 176.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6802, phase II; stations 80-84; 26 October 1968.

Figure 177.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Undaunted* 6802, phase II, stations 85-89, 27 October 1968.

Figure 178.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase II; stations 85-89; 27 October 1968.

Figure 179.—Vertical distribution of density (sigma-t) for *Undaunted* 6802, phase II; stations 85-89; 27 October 1968.

Figure 180.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6802, phase II; stations 85-89; 27 October 1968.

Figure 181.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6802, phase II; stations 85-89; 27 October 1968.

Figure 182.—Vertical distribution of temperature (°C) for *Undaunted* 6802, phase II; stations 90-94; 28 October 1968.

Figure 183.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase II; stations 90-94; 28 October 1968.

Figure 184.—Vertical distribution of density (σ_t) for *Undaunted* 6802, phase II; stations 90-94; 28 October 1968.

Figure 185.—Vertical distribution of oxygen (ml/liter) for *Undaunted* 6802, phase II; stations 90-94; 28 October 1968.

Figure 186.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted 6802*, phase II; stations 90-94; 28 October 1968.

Figure 187.—Vertical distribution of temperature (°C) for *Undaunted 6802*, phase II; stations 95-99; 29 October 1968.

Figure 188.—Vertical distribution of salinity (‰) for *Undaunted* 6802, phase II; stations 95-99; 29 October 1968.

Figure 189.—Vertical distribution of density (sigma-t) for *Undaunted* 6802, phase II; stations 95-99; 29 October 1968.

Figure 190.—Vertical distribution of oxygen (ml/liter) for *Undanted* 6802, phase II; stations 95-99; 29 October 1968.

Figure 191.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Undaunted* 6802, phase II; stations 95-99; 29 October 1968.

Figure 192.—Locations of stations 6-166; *Rockaway*, phase II; 15-30 October 1968.

Figure 193.—Vertical distribution of temperature (°C) for *Rockaway*, phase II; stations 6-12; 15-16 October 1968.

Figure 194.—Vertical distribution of salinity (‰) for Rockaway, phase II; stations 6-12; 15-16 October 1968.

Figure 195.—Vertical distribution of density (σ_t) for Rockaway, phase II; stations 6-12; 15-16 October 1968.

Figure 196.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase II; stations 7-13; 15-16 October 1968.

Figure 197.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Rockaway, phase II; stations 14-24; 16-17 October 1968.

Figure 198.—Vertical distribution of salinity (‰) for Rockaway, phase II; stations 14-24; 16-17 October 1968.

Figure 199.—Vertical distribution of density (sigma-t) for *Rockaway*, phase II; stations 14-24; 16-17 October 1968.

Figure 200.—Vertical distribution of oxygen (ml/liter) for Rockaway, phase II; stations 15-25; 16-17 October 1968.

Figure 201.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Rockaway, phase II, stations 26-34; 17-18 October 1968.

Figure 202.—Vertical distribution of salinity (‰) for Rockaway, phase II; stations 26-34; 17-18 October 1968.

Figure 203.—Vertical distribution of density (sigma-t) for *Rockaway*, phase II; stations 26-34; 17-18 October 1968.

Figure 204.—Vertical distribution of temperature (°C) for Rockaway, phase II; stations 36-44; 18-19 October 1968.

Figure 205.—Vertical distribution of salinity (‰) for *Rockaway*, phase II; stations 36-44; 18-19 October 1968.

Figure 206.—Vertical distribution of density (σ_t) for Rockaway, phase II; stations 36-44; 18-19 October 1968.

Figure 207.—Vertical distribution of oxygen (ml/liter) for Rockaway, phase II; stations 37-45; 18-19 October 1968.

Figure 208.—Vertical distribution of temperature (°C) for *Rockaway*, phase II; stations 46-54; 19-20 October 1968.

Figure 209.—Vertical distribution of salinity (‰) for *Rockaway*, phase II; stations 46-54; 19-20 October 1968.

Figure 210.—Vertical distribution of density (sigma-t) for *Rockaway*, phase II, stations 46-54; 19-20 October 1968.

Figure 211.—Vertical distribution of oxygen (ml/liter) for Rockaway, phase II; stations 47-55; 19-20 October 1968.

Figure 212.—Vertical distribution of temperature (°C) for *Rockaway*, phase II; stations 58-66; 20-21 October 1968.

Figure 213.—Vertical distribution of salinity (‰) for Rockaway, phase II; stations 58-66; 20-21 October 1968.

Figure 214.—Vertical distribution of density (σ_t) for Rockaway, phase II; stations 58-66; 20-21 October 1968.

Figure 215.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase II; stations 59-67; 20-21 October 1968.

Figure 216.—Vertical distribution of temperature (°C) for *Rockaway*, phase II; stations 68-74; 21 October 1968.

Figure 217.—Vertical distribution of salinity (‰) for *Rockaway*, phase II; stations 68-74; 21 October 1968.

Figure 218.—Vertical distribution of density (σ_t) for *Rockaway*, phase II; stations 68-74; 21 October 1968.

Figure 219.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase II; stations 69-76; 21 October 1968.

Figure 220.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Rockaway*, phase II; stations 77-85; 22 October 1968.

Figure 221.—Vertical distribution of salinity (‰) for *Rockaway*, phase II; stations 77-85; 22 October 1968.

Figure 222.—Vertical distribution of density (σ_t) for *Rockaway*, phase II; stations 77-85; 22 October 1968.

Figure 223.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase II; stations 78-86; 22 October 1968.

Figure 224.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Rockaway*, phase II; stations 89-97; 23-24 October 1968.

Figure 225.—Vertical distribution of salinity (‰) for *Rockaway*, phase II; stations 89-97; 23-24 October 1968.

Figure 226.—Vertical distribution of density (σ_t) for *Rockaway*, phase II; stations 89-97, 23-24 October 1968.

Figure 227.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase II; stations 90-98; 23-24 October 1968.

Figure 228.—Vertical distribution of temperature (°C) for Rockaway, phase II; stations 100-105; 24 October 1968.

Figure 229.—Vertical distribution of salinity (‰) for *Rockaway*, phase II; stations 100-105; 24 October 1968.

Figure 230.—Vertical distribution of density (sigma-t) for *Rockaway*, phase II; stations 100-105; 24 October 1968.

Figure 231.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase II; stations 100-105; 24 October 1968.

Figure 232.—Vertical distribution of temperature (°C) for Rockaway, phase II; stations 109-117; 25 October 1968

Figure 233.—Vertical distribution of salinity (‰) for *Rockaway*, phase II; stations 109-117; 25 October 1968.

Figure 234.—Vertical distribution of density (sigma-t) for *Rockaway*, phase II; stations 109-117; 25 October 1968.

Figure 235.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase II; stations 110-118; 25 October 1968.

Figure 236.—Vertical distribution of temperature (°C) for *Rockaway*, phase II; stations 119-127; 25-26 October 1968.

Figure 237.—Vertical distribution of salinity (‰) for *Rockaway*, phase II; stations 119-127; 25-26 October 1968.

Figure 238.—Vertical distribution of density (sigma-t) for *Rockaway*, phase II; stations 119-127; 25-26 October 1968.

Figure 239.—Vertical distribution of oxygen (ml/liter) for Rockaway, phase II; stations 120-128; 25-26 October 1968.

Figure 240.—Vertical distribution of temperature (°C) for *Rockaway*, phase II; stations 127-135; 26-27 October 1968.

Figure 241.—Vertical distribution of salinity (‰) for *Rockaway*, phase II; stations 127-135; 26-27 October 1968.

Figure 242.—Vertical distribution of density (σ_t) for Rockaway, phase II; stations 127-135; 26-27 October 1968.

Figure 243.—Vertical distribution of oxygen (ml/liter) for Rockaway, phase II; stations 128-136; 26-27 October 1968.

Figure 244.—Vertical distribution of temperature (°C) for Rockaway, phase II; stations 137-145; 27-28 October 1968.

Figure 245.—Vertical distribution of salinity (‰) for Rockaway, phase II; stations 137-145; 27-28 October 1968.

Figure 246.—Vertical distribution of density (σ_t) for *Rockaway*, phase II; stations 137-145; 27-28 October 1968.

Figure 247.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase II; stations 138-146; 27-28 October 1968.

Figure 248.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Rockaway*, phase II; stations 147-155; 28-29 October 1968.

Figure 249.—Vertical distribution of salinity (‰) for *Rockaway*, phase II; stations 147-155; 28-29 October 1968.

Figure 250.—Vertical distribution of density (σ_t) for *Rockaway*, phase II; stations 147-155; 28-29 October 1968.

Figure 251.—Vertical distribution of oxygen (ml/liter) for Rockaway, phase II; stations 148-156; 28-29 October 1968.

Figure 252.—Vertical distribution of temperature (°C) for Rockaway, phase II; stations 157-165; 29-30 October 1968.

Figure 253.—Vertical distribution of salinity (‰) for Rockaway, phase II; stations 157-165; 29-30 October 1968.

Figure 254.—Vertical distribution of density (σ_t) for *Rockaway*, phase II; stations 157-165; 29-30 October 1968.

Figure 255.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Rockaway*, phase II; stations 158-166; 29-30 October 1968.

Figure 256.—Locations of stations 170-274; *Rockaway*, phase III; 11-21 November 1968.

Figure 257.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Rockaway*, phase III; stations 170-191; 11-13 November 1968.

Figure 258.—Vertical distribution of salinity (‰) for Rockaway, phase III; stations 170-191; 11-13 November 1968.

Figure 259.—Vertical distribution of density (σ_t) for *Rockaway*, phase III; stations 170-191; 11-13 November 1968.

Figure 260.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase III; stations 170-191; 11-13 November 1968.

Figure 261.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for Rockaway, phase III; stations 170-191; 11-13 November 1968.

Figure 262.—Vertical distribution of temperature (°C) for *Rockaway* phase III; stations 196-221; 14-16 November 1968.

Figure 263.—Vertical distribution of salinity (‰) for *Rockaway*, phase III; stations 196-221; 14-16 November 1968.

Figure 264.—Vertical distribution of density (sigma-t) for Rockaway, phase III; stations 196-221; 14-16 November 1968.

Figure 265.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase III; stations 196-221; 14-16 November 1968.

Figure 266.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for Rockaway, phase III; stations 196-221; 14-16 November 1968.

Figure 267.—Vertical distribution of temperature (°C) for Rockaway, phase III; stations 223-248; 16-19 November 1968.

Figure 268.—Vertical distribution of salinity (‰) for Rockaway, phase III; stations 223-248; 16-19 November 1968.

Figure 269.—Vertical distribution of density (sigma-t) for Rockaway, phase III; stations 223-248; 16-19 November 1968.

Figure 270.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase III; stations 223-248; 16-19 November 1968.

Figure 271.—Vertical distribution of inorganic phosphate (μ g-at./liter) for *Rockaway*, phase III; stations 223-248; 16-19 November 1968.

Figure 272.—Vertical distribution of temperature (°C) for Rockaway, phase III; stations 252-274; 19-21 November 1968.

Figure 273.—Vertical distribution of salinity (‰) for Rockaway, phase III; stations 252-274; 19-21 November 1968.

Figure 274.—Vertical distribution of density (σ_t) for Rockaway, phase III, stations 252-274, 19-21 November 1968.

Figure 275.—Vertical distribution of oxygen (ml/liter) for Rockaway, phase III; stations 252-274; 19-21 November 1968.

Figure 276.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for Rockaway, phase III; stations 252-274, 19-21 November 1968.

Figure 277.—Locations of stations 1-29; Goa, phase III; 12-17 November 1968.

Figure 278.—Vertical distribution of temperature (°C) for Goa, phase III; stations 1-3; 12 November 1968.

Figure 279.—Vertical distribution of salinity (‰) for Goa, phase III; stations 1-3; 12 November 1968.

Figure 280.—Vertical distribution of density (sigma-t) for Goa, phase III; stations 1-3; 12 November 1968.

Figure 281.—Vertical distribution of temperature (°C) for Goa, phase III; stations 3-5; 12-13 November 1968.

Figure 282.—Vertical distribution of salinity (‰) for Goa, phase III; stations 3-5; 12-13 November 1968.

Figure 283.—Vertical distribution of density (sigma-t) for Goa, phase III; stations 3-5; 12-13 November 1968.

Figure 284.—Vertical distribution of temperature (°C) for Goa, phase III; stations 5-7; 13 November 1968.

Figure 285.—Vertical distribution of salinity (‰) for Goa, phase III; stations 5-7; 13 November 1968.

Figure 286.—Vertical distribution of density (sigma-t) for Goa, phase III; stations 5-7; 13 November 1968.

Figure 287.—Vertical distribution of temperature (°C) for Goa, phase III; stations 7-9; 13 November 1968.

Figure 288.—Vertical distribution of salinity (‰) for Goa, phase III; stations 7-9; 13 November 1968.

Figure 289.—Vertical distribution of density (sigma-t) for Goa, phase III; stations 7-9; 13 November 1968.

Figure 290.—Vertical distribution of temperature (°C) for Goa, phase III; stations 9-11; 13-14 November 1968.

Figure 291.—Vertical distribution of salinity (‰) for Goa, phase III; stations 9-11; 13-14 November 1968.

Figure 292.—Vertical distribution of density (sigma-t) for Goa, phase III; stations 9-11; 13-14 November 1968.

Figure 293.—Vertical distribution of temperature (°C) for Goa, phase III; stations 11-13; 14 November 1968.

Figure 294.—Vertical distribution of salinity (‰) for Goa, phase III; stations 11-13; 14 November 1968.

Figure 295.—Vertical distribution of density (σ_t) for Goa, phase III; stations 11-13; 14 November 1968

Figure 296.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase III; stations 13-15; 14 November 1968.

Figure 297.—Vertical distribution of salinity (‰) for Goa. phase III; stations 13-15; 14 November 1968.

Figure 298.—Vertical distribution of density (σ_t) for Goa, phase III; stations 13-15; 14 November 1968.

Figure 299.—Vertical distribution of temperature (°C) for Goa, phase III; stations 15-17; 14-15 November 1968.

Figure 300.—Vertical distribution of salinity (‰) for Goa, phase III; stations 15-17; 14-15 November 1968.

Figure 301.—Vertical distribution of density (σ_t) for Goa, phase III; stations 15-17; 14-15 November 1968.

Figure 302.—Vertical distribution of temperature (°C) for Goa, phase III; stations 17-19; 15 November 1968.

Figure 303.—Vertical distribution of salinity (‰) for Goa, phase III; stations 17-19; 15 November 1968.

Figure 304.—Vertical distribution of density (sigma-t) for Goa, phase III; stations 17-19; 15 November 1968.

Figure 305.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase III; stations 20-22; 16 November 1968.

Figure 306.—Vertical distribution of salinity (‰) for Goa, phase III; stations 20-22; 16 November 1968.

Figure 307.—Vertical distribution of density (sigma- t) for Goa, phase III; stations 20-22; 16 November 1968.

Figure 308.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase III; stations 22-25; 16-17 November 1968.

Figure 309.—Vertical distribution of salinity (‰) for Goa, phase III; stations 22-25; 16-17 November 1968.

Figure 310.—Vertical distribution of density (sigma-t) for Goa, phase III; stations 22-25; 16-17 November 1968.

Figure 311.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase III; stations 25-27; 17 November 1968.

Figure 312.—Vertical distribution of salinity (‰) for Goa, phase III; stations 25-27; 17 November 1968.

Figure 313.—Vertical distribution of density (sigma-t) for Goa, phase III; stations 25-27; 17 November 1968.

Figure 314.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Goa, phase III; stations 27-29; 17 November 1968.

Figure 315.—Vertical distribution of salinity (‰) for Goa, phase III; stations 27-29, 17 November 1968.

Figure 316.—Vertical distribution of density (sigma-t) for Goa, phase III; stations 27-29, 17 November 1968.

Figure 317.—Locations of stations 276-338; *Rockaway*, phase IV; 25 November-2 December 1968.

Figure 318.—Vertical distribution of temperature ($^{\circ}\text{C}$) for *Rockaway*, phase IV; stations 276-282; 25-26 November 1968.

Figure 319.—Vertical distribution of salinity (‰) for Rockaway, phase IV; stations 276-282; 25-26 November 1968.

Figure 320.—Vertical distribution of density (σ_t) for *Rockaway*, phase IV; stations 276-282; 25-26 November 1968.

Figure 321.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase IV; stations 276-282; 25-26 November 1968.

Figure 322.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for Rockaway, phase IV; stations 275-281; 25-26 November 1968.

Figure 323.—Vertical distribution of temperature (°C) for *Rockaway*, phase IV; stations 283-289; 26-27 November 1968.

Figure 324.—Vertical distribution of salinity (‰) for *Rockaway*, phase IV; stations 283-289; 26-27 November 1968.

Figure 325.—Vertical distribution of density (sigma-t) for Rockaway, phase IV; stations 283-289; 26-27 November 1968.

Figure 326.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase IV; stations 283-289; 26-27 November 1968.

Figure 327.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Rockaway*, phase IV; stations 283-289; 26-27 November 1968.

Figure 328.—Vertical distribution of temperature (°C) for Rockaway, phase IV; stations 292-298; 27 November 1968.

Figure 329.—Vertical distribution of salinity (‰) for Rockaway, phase IV; stations 292-298; 27 November 1968.

Figure 330.—Vertical distribution of density (σ_t) for Rockaway, phase IV; stations 292-298; 27 November 1968.

Figure 331.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase IV; stations 292-298; 27 November 1968.

Figure 332.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for Rockaway, phase IV; stations 292-298; 27 November 1968.

Figure 333.—Vertical distribution of temperature (°C) for Rockaway, phase IV; stations 300-305; 28 November 1968.

Figure 334.—Vertical distribution of salinity (‰) for *Rockaway*, phase IV; stations 300-305; 28 November 1968.

Figure 335.—Vertical distribution of density (sigma-t) for Rockaway, phase IV; stations 300-305; 28 November 1968.

Figure 336.—Vertical distribution of temperature ($^{\circ}\text{C}$) for Rockaway, phase IV; stations 307-314; 28-29 November 1968.

Figure 337.—Vertical distribution of salinity (‰) for *Rockaway*, phase IV; stations 307-314; 28-29 November 1968.

Figure 338.—Vertical distribution of density (sigma-t) for *Rockaway*, phase IV; stations 307-314; 28-29 November 1968.

Figure 339.—Vertical distribution of oxygen (ml/liter) for *Rockaway*, phase IV; stations 307-313; 28-29 November 1968.

Figure 340.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Rockaway*, phase IV; stations 307-313; 28-29 November 1968.

Figure 341.—Vertical distribution of temperature (°C) for Rockaway, phase IV; stations 316-322; 29-30 November 1968.

Figure 342.—Vertical distribution of salinity (‰) for Rockaway, phase IV; stations 316-322; 29-30 November 1968.

Figure 343.—Vertical distribution of density (sigma-t) for *Rockaway*, phase IV; stations 316-322; 29-30 November 1968.

Figure 344.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Rockaway*, phase IV; stations 316-322; 29-30 November 1968.

Figure 345.—Vertical distribution of temperature (°C) for Rockaway, phase IV; stations 323-329; 30 November-1 December 1968.

Figure 346.—Vertical distribution of salinity (‰) for *Rockaway*, phase IV; stations 323-329; 30 November-1 December 1968.

Figure 347.—Vertical distribution of density (sigma-t) for *Rockaway*, phase IV; stations 323-329; 30 November-1 December 1968.

Figure 348.—Vertical distribution of oxygen (ml/liter) for Rockaway, phase IV; stations 323-329; 30 November-1 December 1968.

Figure 349.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Rockaway*, phase IV; stations 323-329; 30 November-1 December 1968.

Figure 350.—Vertical distribution of temperature (°C) for *Rockaway*, phase IV; stations 333-338; 1-2 December 1968.

DATA REPORT. NMFS. #82

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TITLE

Oceanic conditions during the

Figure 351.—Vertical distribution of salinity (‰) for Rock

Figure 352.—Vertical distribution of density (sigma-t) for Rockaway, phase IV, stations 333-338; 1-2 December 1968.

Figure 353.—Vertical distribution of inorganic phosphate ($\mu\text{g-at./liter}$) for *Rockaway*, phase IV; stations 333-338; 1-2 December 1968.