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Expendable Bathythermograph Data on Subsurface Thermal Structure in the Eastern North Pacific Ocean

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By

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ABSTRACT

This report contains reproductions of original temperature-depth traces, two temperature sections, and synoptic weather observations taken between San Francisco and Honolulu in November-December 1965, using an expendable bathythermograph system aboard a merchant ship. A third temperature section derived from closely spaced observations shows the complicated temperature structure with temperature maximums and minimums over a distance of about 45 nautical miles (85 km.) across the outer boundary of the California Current.

INTRODUCTION

Knowledge of the mechanisms by which the environment may affect the abundance and availability of commercial fishes and the application of oceanographic and fishery forecasting will depend upon the collection of oceanographic data well distributed in space and time, both at the surface of the ocean and below the surface. Near-surface water temperatures collected as a part of the marine weather observations are numerous from the middle latitudes of the northern hemisphere where shipping is dense. Instrument programs are underway in the Bureau of Commercial Fisheries, the Navy Oceanographic Office, and the Weather Bureau to improve the quality of the water temperature observations that are now generally obtained by reading commercial grade mercury-in-glass thermometers mounted in the ship's sea-water intake system in the engineroom and that contain numerous errors (Saur, 1963; Sette, 1965).

The cost of obtaining the weather observations (including the sea temperatures) aboard merchant ships is low compared with the cost of oceanographic observations by research vessels. The greatest overhead cost, the operation of the ship, is already absorbed because the ship has another primary mission. From the point of view of oceanographic or meteorological observations, a merchant ship is a "ship of opportunity".

Subsurface oceanographic observations are sparse in comparison with surface data. It seems feasible to improve greatly the time-space distribution of subsurface data by two methods: the use of anchored and drifting oceanographic buoys and the use of ships of opportunity. The latter depends upon instrument systems that can obtain the data without interfering with the normal operation of the ship, particularly without having to decrease the speed or change course. One of the first systems of this type to be developed is based on the expendable bathythermograph.

The Bureau of Commercial Fisheries Biological Laboratory, Stanford, Calif., with the cooperation of the Matson Navigation Company, has begun a pilot project to test the feasibility of using an XBT (expendable bathythermograph) system manufactured by the Sippican Corporation[1] aboard a ship of opportunity. George Hansen of the U.S. Fleet Numerical Weather Facility, Monterey, Calif., added a digitizer-encoder unit to the recorder and assisted with the preliminary tests of the system. The system has been placed aboard the SS CALIFORNIAN to obtain subsurface temperature data between Honolulu and San Francisco on approximately a biweekly basis. This project will provide experience to form plans for use of ships of opportunity to obtain

[1] The trade name referred to in this publication does not imply endorsement of the commercial product.

data on an oceanwide basis, and the temperature data will give information on the seasonal changes of the California Current.

This report presents the original data taken on round-trip voyage 105 of the SS CALIFORNIAN in November-December 1965. J. F. T. Saur made this trip to check the performance of the XBT system and to train the ship's personnel in its operation. The system was subsequently modified by the manufacturer to overcome deficiencies, some of which were diagnosed during this voyage.

INSTRUMENTATION

Expendable Bathythermograph System

The permanent shipboard components of the XBT system are the launcher (fig. 1) and the recorder (fig. 2) along with the connecting electric cables. These components are small enough and light enough to be easily moved from ship to ship. In figure 2, the recorder is shown mounted in a rack with a digitizer-encoder unit. A reperforator unit, which punches digitized data on a five-channel paper tape, is mounted on the top of the rack. Once permanent mounts for the rack have been fixed aboard a ship, the rack can be carried on board by two persons, secured, and checked out in 1 to 2 hours. The expendable component of the system is a canister that contains the expendable probe and wire (fig. 3).

The sensing element is a rapid-response thermistor wafer which is mounted in the nose of the probe in a manner that allows the water

Figure 1.--Placing an expendable thermograph canister in the loading breech of the launcher. The arrow is pointed at the lower end of the discharge tube.

Figure 2.--Reading the paper tape punched by the reperforator on top of the electronic rack which holds the recorder and digitizer encoder unit.

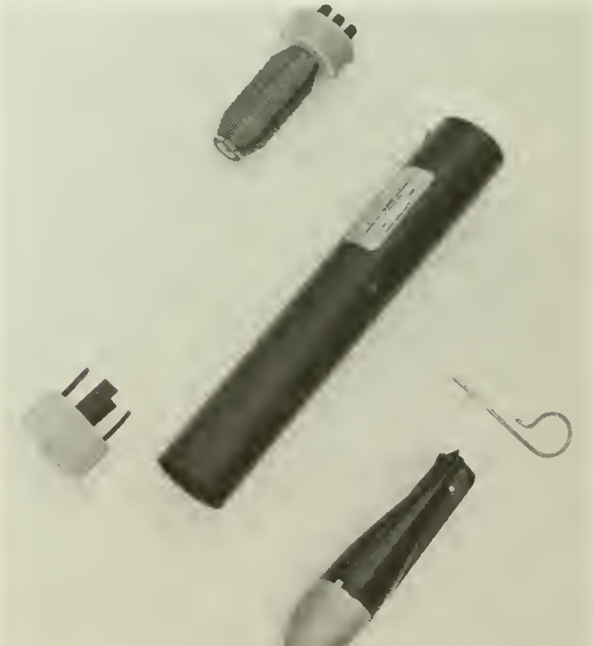

Figure 3.--Disassembled canister. The shipboard end of the fine wire pays off the spool (top center) in the canister (center) while the end connected to the thermistor pays from another spool inside the probe (lower right) through the finned end. Water enters the tube at the tip of the weighted nose of the probe, flows past the thermistor and out through the same orifice as the wire. The cap (left center), removed before loading into the launching tube, provides rubber cushioning to protect the thermistor during shipment and handling. The pin (right center), inserted through the holes in the canister and the hole in one fin of the probe, locks the probe in the canister. When the pin is pulled, the probe is released and slides out of the launch tube by gravity.

to flow past it as the probe drops through the water. This sensor is connected to the recorder through a hard-wire link. The wire is composed of three insulated conductors (Model T-3 probe), but it is very fine and has a breaking strength of about 8 oz. (227 g.). As the ship proceeds on course, a dual spooling system allows the wire to pay out freely from the canister in the launcher aboard ship while simultaneously the wire is payed out freely from the tail end of the ballistically shaped and finned probe as it falls vertically through the water. The temperature is recorded on the analog recorder which has a modified balancing bridge circuit. The probe has a calibrated rate of descent so that the depth is determined by the time interval from entry into the water.

The recorder operates automatically. The recording cycle starts when the probe enters the water. After a period of recording the temperature-depth analog trace, the cycle stops and the recorder returns to a standby condition.

The specifications of the system are as follows:

Temperature:	
Range:	28° to 95° F. (-2° - 35° C.)
Accuracy:	±0.36° F. (±0.2° C.)
Response time:	0.1 sec.
Depth:	
Range:	0 to 1,500 ft. (0 - 460 m.)
Accuracy:	±15 ft. (4.6 m.) or 2 percent of depth, whichever is greater
Time for deployment:	90 sec.
Ship's speed:	0 to 30 knots (0 - 15 m. per second)

NSRT (Near-Surface Reference Temperature) Unit

An NSRT unit is also being tested for accuracy and reliability during this project. The device is intended for use on merchant ships so that sea temperatures will not be read from mercury-in-glass thermometers in the intake system. The system consists of a thermistor probe installed in the ship's sea-water intake and a remote temperature-indicating meter. On the SS CALIFORNIAN the meter was installed near the XBT recorder so that the temperatures could be used as a subsurface (26 - 30 ft. or 8 - 9 m.) check against the XBT temperatures. Usually the meter would be installed on the bridge where the weather report is logged. The NSRT has an accuracy of ±0.15° C. over a total range of -2° C. to 40° C.; it uses four 12-degree overlapping scales.

Figure 4.--Position of launcher in relation to hull near vessel stern. For the purpose of the photograph the launcher was moved to its alternate mount on the starboard side at a location comparable to the portside mount used during the trip. The deck is between 25 and 30 ft. (8 - 9 m.) above the waterline.

Installations Aboard SS CALIFORNIAN

Aboard the SS CALIFORNIAN the launcher for the XBT system is mounted on the port rail of the main deck about 25 ft. (7.5 m.) from the stern. This is slightly aft of the point where the hull of the vessel begins to curve inward toward the stern so that the wire trails aft with little danger of contact against the side of the ship (fig. 4). The probe enters the water a few feet ahead of the wake. The XBT recorder and the NSRT indicator are installed one deck below the launcher in an area adjacent to the boatswain's locker. The distance from the XBT launcher to the recorder is about 45 ft. (14 m.). The distance from the NSRT sensor in the engineroom to the indicator aft is about 200 ft. (60 m.). The intake for the sea-water line in which the NSRT sensor is mounted is about 25 to 28 ft. (7 - 8 m.) below the surface, depending upon vessel loading.

OBSERVATIONS

The locations of the observations on the outbound leg from San Francisco to Honolulu are shown in figure 5. Numbers are not consecutive because all probe releases were numbered serially whether they were successful drops or failures. The XBT drops on the outbound leg were made by the senior author, and uneven spacing occurred while he was becoming familiar with the system and establishing a routine convenient for ship's personnel. Licensed officers of the SS CALIFORNIAN made most of the observations on the return

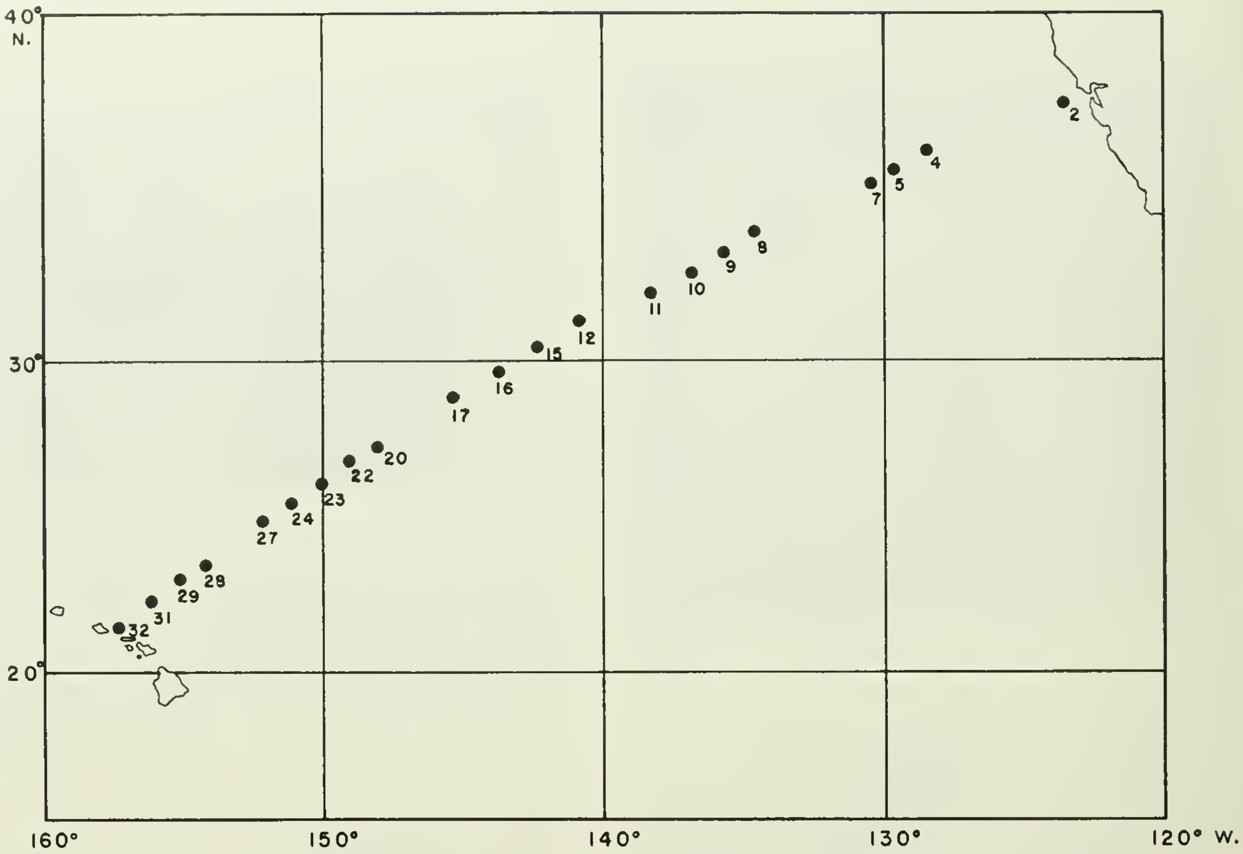

Figure 5.--Location of observations, SS CALIFORNIAN Voyage 105. Outbound from San Francisco to Honolulu.

leg from Honolulu to San Francisco. The locations are shown in figure 6. At locations 55 to 62 probes were dropped at closely spaced intervals by the senior author in the western boundary of the California Current.

The individual traces for the drops where good records were obtained are shown following table 13 and are identified by the observation number. Date, time, location, and NSRT temperature are shown also with each trace. Surface temperature and surface salinity are given when observed.

The U.S. Fleet Numerical Weather Facility, Monterey, Calif., has supported this project, and the observations were transmitted by radio (in BATHY report form) to that activity for use in its oceanographic services.

Selected portions of synoptic weather observations logged by ships' personnel for the U.S. Weather Bureau are given in tables 1 and 2. Tables 3 through 13 give the weather codes used in logging the weather observations (reproduced from the International Code for Radio Weather Reports from Ships, U.S. Dept. of Commerce, Weather Bur., Wash., D.C., 1960).

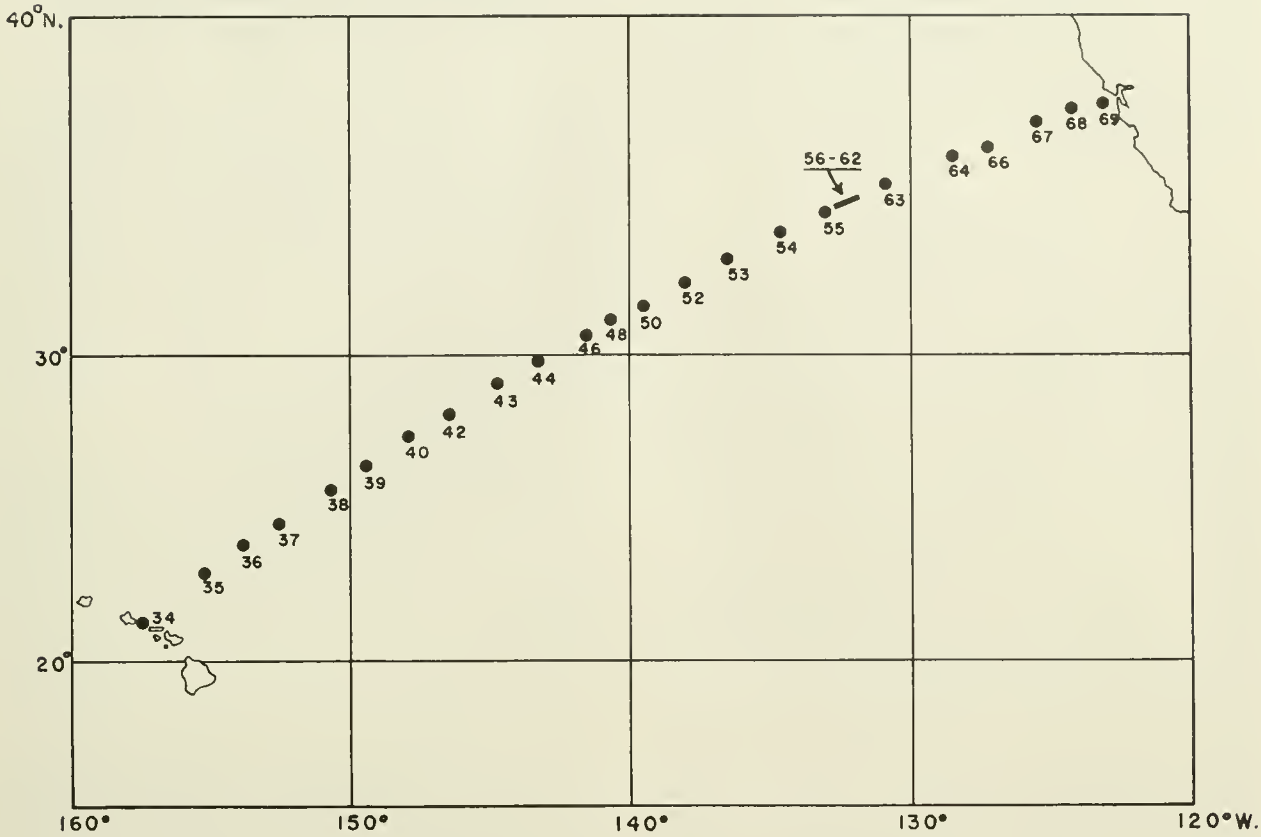

Figure 6.--Location of observations, SS CALIFORNIAN Voyage 105. Inbound from Honolulu to San Francisco. The bar labeled 56-62 gives location of six closely spaced observations (fig. 9).

PROBLEMS WITH INSTRUMENTATION

During the trip a number of problems were encountered with the Model T-3 XBT system, which gave rise to errors in some of the traces and to a few outright failures. Subsequently, design and engineering changes have been made in the circuitry, recorder, and probes. The systems now in use are Model T-4. In spite of the problems, many valid data were obtained. The paragraphs which follow in this section are devoted to a discussion and diagnosis of these instrumental problems with regard to the interpretation of the data presented.

Temperature Errors

When compared with the NSRT temperature or a surface bucket temperature, a number of XBT traces showed near-surface temperature error greater than the specified design tolerances of ±0.2° C. Comparison of temperatures at 1,500 ft. (460 m.) indicated that these same traces generally were in poor agreement with adjacent observations. These data, along with tests that our Laboratory made in the Hawaii area in 1965, indicated that the temperature correction for traces having an "offset" is not constant. The error appears as if a constant resistance were added into one side of the balancing bridge circuit or the other, and because of the nonlinear relation of temperature to resistance, the error (or correction) changes with temperature. Such errors occurred in eight of the observations published in this report: 7, 12, 15, 17, 22, 27, 58, and 64.

The temperature corrections shown with the curves were applied in preparing the temperature sections (figs. 7, 8, and 9). The individual observations published in this report are direct tracings, as recorded. If data are taken from these traces, temperature corrections should be applied.

Failures

Total failure to obtain any valid data with a given probe was evidenced in two ways. Wild oscillations of the pen (temperature spikes in the trace) probably indicated electrical leakage due to insulation defects in the wire link. If the wire breaks in the water, the electrical short causes the pen to move to the high-temperature side of the recorder and remain there. In 71 releases, two failures appeared to result from insulation defects and six from wire breaks.

NEAR-SURFACE IRREGULARITIES IN THE TRACE

The rated response time of the thermistor sensor is about 0.1 sec. Thus, it takes 0.3 sec. for the thermistor to respond to 95 percent of a step change in temperature and during this time the probe descends about 9 to 10 ft. (3 m.). When the cycle starts as the probe enters the water, the thermistor is responding to change from its ambient temperature in the launcher to water temperature. For most of the observations a small curve appears in the trace between the surface and 10 ft. (3 m.), which is a result of the thermistor response time. No attempt should be made to utilize the record of temperature for depths less than 10 ft. (3 m.).

In 12 observations included in this report, the temperature trace exhibited a gradient from the surface to a depth of 20 ft. (6 m.) or greater which was not believed to be valid. This conclusion was reached for several reasons. A large storm had moved through the area preceding the voyage, and the weather remained windy with cooling at the surface, which would create a well-mixed layer. Excellent agreement between the bucket (surface) temperature and the NSRT temperature (8 - 9 m. below the surface) verified the isothermal condition in the surface layer. Thus, the near-surface gradient appearing in the trace was judged to be instrumental. In tests made by the manufacturer in probes of the same model (T-3), a few also failed to have the proper response. Since the evidence is not conclusive that the apparently erratic trace was due to the instrument system, the traces are shown as they were recorded, but the doubtful portion (according to our judgment) has been hachured to draw attention to it. These doubtful gradients occurred at observations 8, 9, 10, 11, 12, 15, 17, 28, 29, 31, 52, and 64. We feel that the trace for these observations should be vertical through the hachured portion to connect with the vertical line just below the hachured layer, portraying an isothermal water layer.

CHARACTERISTICS OF TEMPERATURE SECTIONS

The temperature section derived from the observations on the outbound leg is shown in figure 7 and that for the inbound leg in figure 8. The isotherms for every 2° F. show the gross features of the temperature structure. The pronounced mixed layer is evident across the entire section, but it becomes progressively shoaler from about long. 140° W. toward the California coast. Similarly the isotherms rise more rapidly in the eastern half of the sections. Both features are evidence of more rapidly moving southward flow, normal to the section, in the eastern part which is occupied by the California Current.

On the outbound section (fig. 7), the isotherms show a steep rise at mid-depths at observation 22. This feature is worth noting because a similar rise in the isotherms occurs at observation 39 on the return section (fig. 8). Although the gradients were small at these depths and a slight temperature error could cause such a feature, it seems that this temperature ridge may well be a real feature. Time series sections, such as those planned for this pilot project, should reveal much information on features like this which heretofore might well have been viewed with suspicion as instrumental or observational error.

Because a temperature inversion appeared at observation 55, a special series of closely spaced observations was begun. The temperature structure from the closely spaced XBT observations over a distance of about 45 nautical miles (85 km.) reveals a complex structure of maximums and minimums (fig. 9).

Robert P. Brown of the BCF Tuna Resources Laboratory, La Jolla, Calif., has previously noted (unpublished data and personal communication) that similar complicated vertical temperature structure was observed about 500 nautical miles (930 km.) west of Los Angeles. He found this structure was associated with the boundary between the outer edge of the California Current and the Eastern North Pacific Central Water Mass. Roden (1964) has also described the occurrence of temperature maximums in mechanical bathythermograph observations from the Northeast Pacific Ocean. It appears that such structure is characteristic of the outer boundary of the California Current for distances of at least several hundred miles parallel to the California coast.

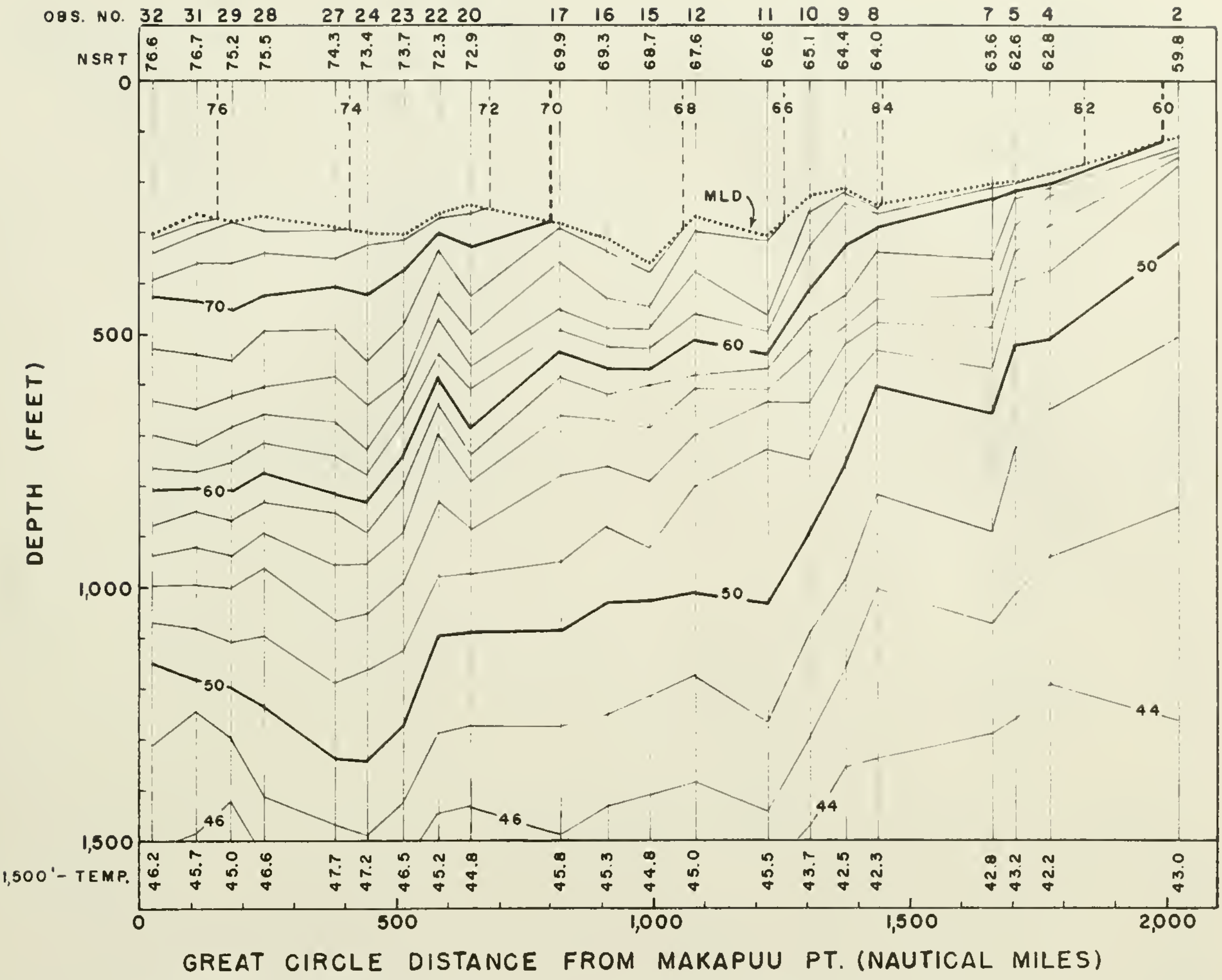

Figure 7.--Temperature-depth section derived from observations taken during the outbound leg (Nov. 22 - 27, 1965). Mixed layer depth is designated by MLD. The near surface reference temperature (NSRT) is in degrees Fahrenheit.

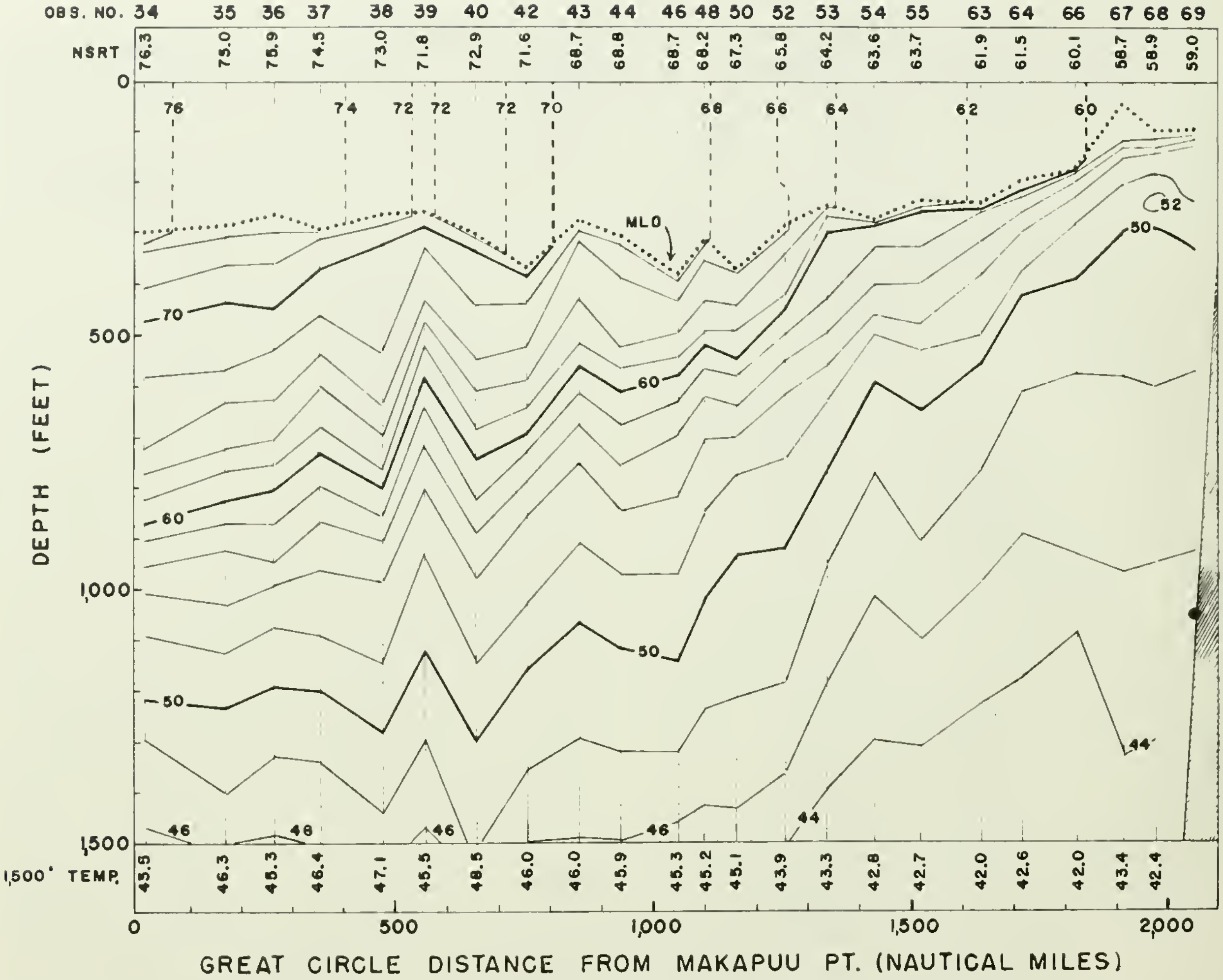

Figure 8.--Temperature-depth section derived from observations taken during the inbound leg (Nov. 28 to Dec. 3, 1965), omitting observations 56-62 giving details of boundary region shown in figure 9. Mixed layer depth is designated by MLD. The near surface reference temperature (NSRT) is in degrees Fahrenheit. Shaded area is the sea floor. Observation 69 (see trace) may have hit rising continental slope at 1,070 ft. (326 m.), indicated by the black dot.

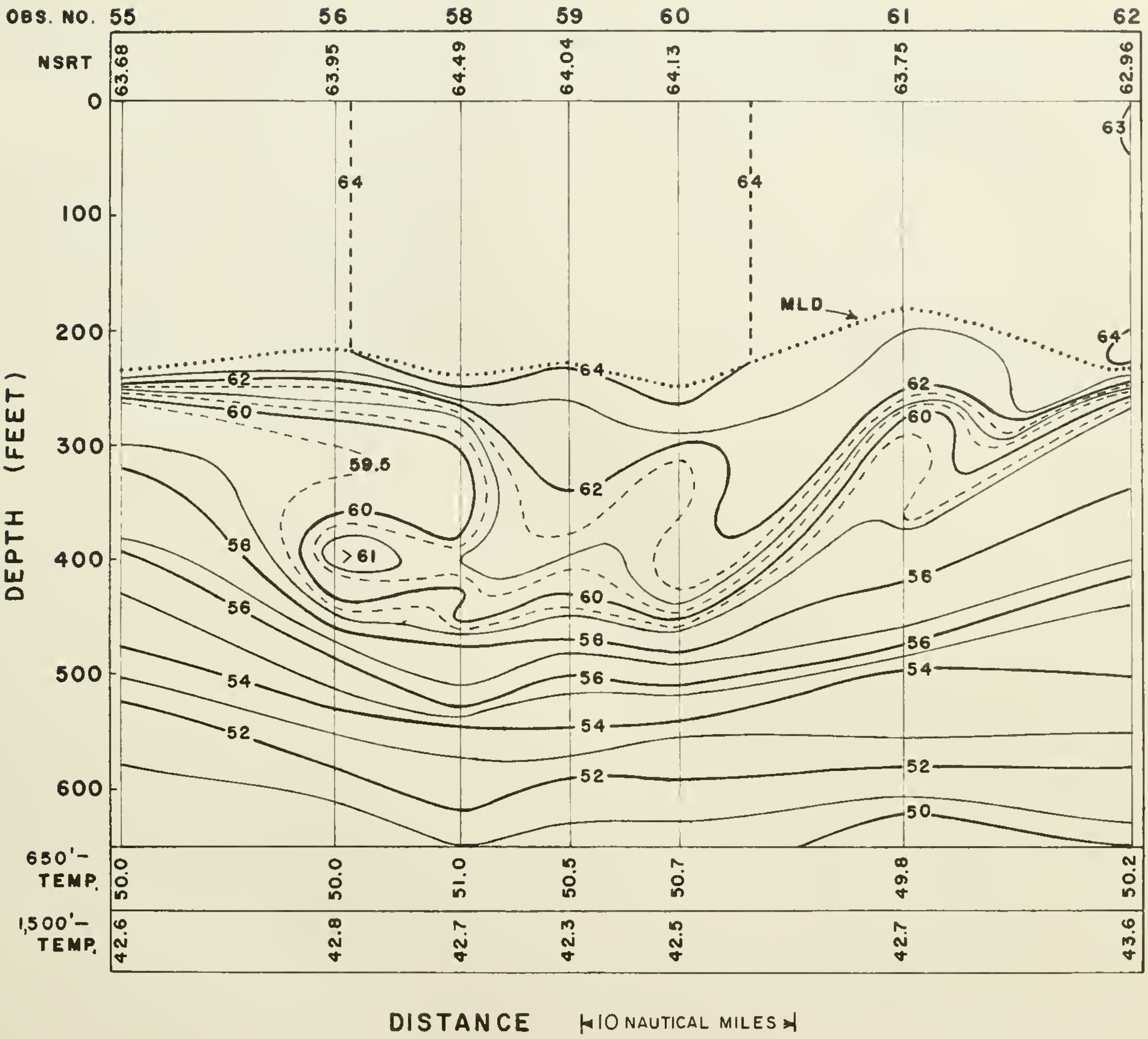

Figure 9.--Complex temperature structure over a distance of about 45 nautical miles (85 km.) in the western boundary of the California Current.

FURTHER DEVELOPMENTS

Subsequent to the shakedown cruise, the Sippican Corporation recalled the XBT system for re-engineering. The model T-4 probe was developed to improve the wire insulation and to assure better response of the thermistor at the time of water-entry.

The modified XBT system was installed aboard the SS CALIFORNIAN on June 1. By early November 1966 the ship had completed nine round trips. During this period observations were taken for 10 sections; 1 outbound and 8 inbound sections between San Francisco and Honolulu and 1 special outbound section from Los Angeles to Honolulu. The system was removed from the ship for one trip to repair the digitizer.

On the basis of preliminary analyses of these traces, the modified system is more reliable than that used on voyage 105. The defects causing the near-surface irregularities appear to have been remedied, so that the traces in almost every instance show rapid response of the system when the probe enters the water.

The percentage of total failures has been 8 percent as compared with 11 percent on voyage 105. A few of these failures may be attributed to poor insulation on the wire of the T-4 probes. Most failures occurred because the recorder did not trip and go through the cycle; a problem not encountered during the shakedown on voyage 105. Minor modifications still need to be made on the present system; however, the observations from the cruises made since June 1, 1966, demonstrate the capability of this unit to produce high quality data.

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Table 1. Synoptic weather observations, SS CALIFORNIAN Voyage 105. Outbound from San Francisco to Honolulu

Date, 1965	Hour (G.c.t.)	Latitude N.	Longitude W.	Wind		Weather		Pressure (mb.)	Temperature (° C.)			Clouds						Waves		
				Direction	Speed	Present	Past		Dry bulb	Wet bulb	Sea water	Total amount	Amount low	Type low	Height of low	Type middle	Type high	Direction	Period	Height
11/22	12	36.9°	125.7°	29	10	02	2	1012.5	14.0	11.3	15.0	5	5	4	4	0	0	29	2	1
11/22	18	36.3°	127.6°	05	12	02	2	1011.2	13.3	12.2	16.7	8	8	4	4	x	x	05	2	1
11/23	00	35.7°	129.6°	34	12	18	2	1007.8	15.8	13.0	16.7	8	8	4	4	x	x	34	2	2
11/23	06	35.0°	131.5°	35	12	02	2	1010.2	13.3	12.2	16.7	6	6	4	4	0	0	35	2	2
11/23	12	34.4°	133.3°	01	15	02	2	1012.5	14.5	10.0	17.8	5	5	4	4	0	0	01	2	2
11/23	18	33.6°	134.8°	35	30	02	2	1015.2	15.0	12.2	17.8	5	5	4	4	0	0	35	2	3
11/24	00	32.9°	136.5°	29	30	02	2	1016.3	16.0	12.0	17.8	4	4	4	4	0	0	29	3	3
11/24	06	32.1°	138.4°	29	15	02	1	1020.7	15.0	12.2	19.4	3	3	4	4	0	0	29	2	2
11/24	12	31.3°	140.2°	05	15	02	2	1023.4	17.0	13.8	19.4	4	4	4	4	0	0	05	2	2
11/24	18	30.6°	141.7°	36	30	02	2	1026.8	17.2	12.8	20.6	5	5	4	4	0	0	36	2	3
11/25	00	29.8°	143.3°	02	15	02	2	1026.8	18.7	13.2	20.6	5	5	4	4	0	0	02	2	3
11/25	06	29.0°	144.9°	03	15	02	2	1028.8	17.2	13.9	21.1	5	5	4	4	0	0	03	2	2
11/25	12	28.1°	146.6°	07	15	01	0	1028.4	19.5	15.0	21.1	0	0	0	9	0	0	07	2	2
11/25	18	27.2°	148.1°	09	15	02	2	1029.1	19.4	16.7	22.8	6	6	4	4	0	0	09	2	2
11/26	00	26.3°	149.8°	07	12	02	2	1026.8	22.2	18.4	22.8	8	8	4	4	x	x	07	2	2
11/26	06	25.4°	151.2°	11	15	02	2	1026.8	21.1	18.3	23.3	6	6	4	4	0	0	11	2	2
11/26	12	24.5°	152.8°	11	15	01	0	1024.4	22.2	19.7	23.9	0	0	0	9	0	0	11	2	2
11/26	18	23.5°	154.3°	09	18	01	1	1023.4	23.3	20.0	24.4	2	2	2	3	0	0	09	2	3
11/26*	22	22.9°	155.3°	07	19			1022.7	25.0	21.1	24.4	4								
11/27*	02	22.3°	156.2°	10	13			1020.0	26.7	22.2	25.0	6								
11/27*	06	21.5°	157.3	09	13			1020.0	23.3	20.0	25.6	4								

* Data from ship's deck log.

Table 2. Synoptic weather observations, SS CALIFORNIAN Voyage 105. Inbound from Honolulu to San Francisco

Date, 1965	Hour (G.c.t.)	Latitude N.	Longitude W.	Wind		Weather		Pressure (mb.)	Temperature (° C.)			Clouds						Waves		
				Direction	Speed	Present	Past		Dry bulb	Wet bulb	Sea water	Total amount	Amount low	Type low	Height of low	Type middle	Type high	Direction	Period	Height
11/28	12	21.9°	156.6°	11	15	02	0	1016.3	22.8	20.0	24.4	0	0	0	9	0	0	11	2	2
11/28	18	22.9°	155.3°	07	15	02	0	1019.3	22.2	20.0	25.0	1	1	1	3	0	0	07	2	2
11/29	00	24.4°	153.0°	07	12	02	0	1018.3	23.3	19.4	23.9	3	3	1	3	0	0	07	2	2
11/29	06	24.7°	152.5°	06	12	01	1	1020.7	21.7	20.0	24.4	1	1	1	3	0	0	06	2	1
11/29	12	25.6°	151.0°	06	10	02	0	1020.3	20.6	17.8	24.4	0	0	0	9	0	0	06	2	1
11/29	18	26.5°	149.4°	06	05	02	0	1021.3	20.0	16.7	23.3	3	3	2	4	0	0	06	2	1
11/30	00	27.4°	147.9°	02	08	02	0	1020.0	20.0	18.3	22.8	3	3	2	4	0	0	02	2	1
11/30	06	28.2°	146.3°	00	00	02	0	1020.0	19.4	17.8	22.8	1	1	2	4	0	0	02	2	1
11/30	12	29.0°	144.8°	11	09	02	0	1020.0	20.3	18.8	22.2	3	3	2	4	0	0	11	2	1
11/30	18	29.8°	143.4°	23	09	02	2	1020.3	20.0	18.9	22.2	6	6	4	4	0	0	23	2	1
12/1	00	30.7°	141.5°	25	10	16	2	1018.6	20.2	18.3	20.0	8	8	4	4	0	0	25	2	1
12/1	06	31.5°	139.7°	25	10	02	1	1020.0	18.3	17.2	19.4	1	1	4	4	0	0	25	2	1
12/1	12	32.3°	138.2°	25	10	02	1	1020.3	19.3	17.5	20.0	1	1	4	4	0	0	25	2	1
12/1	18	33.1°	136.3°	18	10	02	1	1021.7	18.3	17.8	18.9	1	1	4	4	0	0	18	2	1
12/2	00	33.9°	134.5°	17	15	02	1	1020.7	18.7	16.0	18.9	8	8	4	4	0	0	17	2	1
12/2	06	34.5°	132.6°	16	15	02	2	1021.3	17.2	15.0	17.2	5	5	4	4	0	0	16	2	1
12/2	12	35.2°	135.7°	16	20	02	2	1020.0	16.3	13.5	17.2	9	9	6	4	1	1	16	2	2
12/2	18	35.9°	128.9°	17	20	02	2	1023.7	15.6	13.3	16.7	8	8	4	4	0	0	16	2	2
12/3	00	36.5°	126.9°	18	15	02	2	1022.0	17.2	13.8	16.1	9	9	4	4	1	1	18	2	2

Table 3. Direction of wind or waves (in 10's of degrees, from which wind is blowing or from which waves come)

Symbol dd—True direction, in 10's of degrees, FROM which wind is blowing (00–36)

Symbol d_wd_w—Direction, in 10's of degrees, FROM which waves come

Code figures	Direction	Code figures	Direction
00	Calm.	19	185° to 194°.
01	5° to 14°.	20	195° to 204° SSW.
02	15° to 24° NNE.	21	205° to 214°.
03	25° to 34°.	22	215° to 224°.
04	35° to 44°.	23	225° to 234° SW.
05	45° to 54° NE.	24	235° to 244°
06	55° to 64°.	25	245° to 254° WSW.
07	65° to 74° ENE.	26	255° to 264°.
08	75° to 84°.	27	265° to 274° W.
09	85° to 94° E.	28	275° to 284°.
10	95° to 104°.	29	285° to 294° WNW.
11	105° to 114° ESE.	30	295° to 304°.
12	115° to 124°.	31	305° to 314°.
13	125° to 134°.	32	315° to 324° NW.
14	135° to 144° SE.	33	325° to 334°.
15	145° to 154°.	34	335° to 344° NNW.
16	155° to 164° SSE.	35	345° to 354°.
17	165° to 174°.	36	355° to 4° N.
18	175° to 184° S.		
Used only with d_wd_w			
49	Waves confused, direction indeterminate.	99	Waves confused, direction indeterminate, but higher than 14 feet (4½ meters).

NOTE.—In case a vessel is equipped with an anemometer and the true wind speed exceeds 99 knots, 50 will be added to "dd" and only the wind speed in excess of 100 knots will be coded. For example, if direction = 163° and speed = 121 knots, the wind will be coded as "6621" (dd = 16 + 50; ff = 121 − 100).

Table 4. Wind speed

Symbol ff—Wind speed in knots

Code figures	Beaufort No.	Description	Equivalent speed in knots
00	Zero	Calm	0
02	One	Light airs	1–3
05	Two	Light breeze	4–6
09	Three	Gentle breeze	7–10
13	Four	Moderate breeze	11–16
18	Five	Fresh breeze	17–21
24	Six	Strong breeze	22–27
30	Seven	Near gale	28–33
37	Eight	Gale	34–40
44	Nine	Strong gale	41–47
52	Ten	Storm	48–55
60	Eleven	Violent storm	56–63
68	Twelve	Hurricane	64 and above

NOTE.—In case a vessel is equipped with an anemometer and the true wind speed exceeds 99 knots, 50 will be added to "dd" and only the wind speed in excess of 100 knots will be coded. For example, if the direction = 163° and speed = 121 knots, the wind will be coded as "6621" (dd = 16 + 50; ff = 121 − 100).

Table 5. Present weather

Symbol ww—Present weather

ww=00–49 NO PRECIPITATION AT THE STATION AT THE TIME OF OBSERVATION

00–19: No precipitation, fog, ice fog, duststorm, sandstorm, drifting or blowing snow at the station (or ship) at the time of observation, except for 09 and 17, or during the preceding hour.

See note 2. (00–03):

00	Cloud development not observed	Characteristic change of the state of sky during the past hour.
01	Clouds generally dissolving or becoming less developed	
02	State of sky on the whole unchanged	
03	Clouds generally forming or developing	

Haze, dust, sand or smoke. (04–09):

04 Visibility reduced by smoke, e.g., from veldt or forest fires, industrial smoke, or volcanic ashes.
05 Haze.
06 Widespread dust in suspension in the air, not raised by wind at or near the station (or ship) at the time of observation.
07 Dust or sand raised by wind at or near the station (or ship) at the time of observation, but no well developed dust whirl(s) or sand whirl(s) and no duststorm or sandstorm seen.
08 Well developed dust whirl(s) or sand whirl(s) seen at or near the station (or ship) within last hour, but no duststorm or sandstorm.
09 Duststorm or sandstorm within sight of station (or ship) or at station (or ship) at time of observation or during the last hour.
10 Light fog, visibility 1,000 meters (1,100 yards) or more.
11 Patches of ... } Shallow fog or ice fog at the station (or ship) not deeper than about 2 meters (6½ feet) on land or 10 meters (33 feet) at sea (visibility less than 1,000 meters (1,100 yards)).
12 More or less continuous } (as 11)
13 Lightning visible, no thunder heard.
14 Precipitation within sight, but not reaching ground or surface of the sea.
15 Precipitation within sight, reaching ground or surface of the sea, but distant [i.e., estimated to be more than 5 kilometers (3 miles) from station (or ship)].
16 Precipitation within sight, reaching ground or surface of the sea, near to but not at the station (or ship).
17 Thunderstorm, but no precipitation at the time of observation.
18 Squall(s) } within sight during the past hour.
19 Funnel cloud(s)* (tornado or waterspout) } within sight during the past hour.

20–29: Precipitation, fog or ICE fog or thunderstorm at the station (or ship) during the preceding hour but NOT at the time of observation.

20 Drizzle (not freezing) or snow grains } not falling as showers.
21 Rain (not freezing) } not falling as showers.
22 Snow } not falling as showers.
23 Rain and snow or ice pellets. (See fig. 79.) } not falling as showers.
24 Freezing drizzle or freezing rain } not falling as showers.
25 Shower(s) of rain.
26 Shower(s) of snow, or of rain and snow.
27 Shower(s) of hail, or of hail and rain.
28 Fog or ice fog (visibility less than 1,000 meters (1,100 yards)).
29 Thunderstorm (with or without precipitation).

30–39: Duststorm, sandstorm or drifting OR BLOWING snow.

30 Slight or moderate duststorm or sandstorm } has decreased during the preceding hour.
31 Slight or moderate duststorm or sandstorm } no appreciable change during the preceding hour.
32 Slight or moderate duststorm or sandstorm } has begun or increased during the preceding hour.
33 Severe duststorm or sandstorm } has decreased during the preceding hour.
34 Severe duststorm or sandstorm } no appreciable change during preceding hour.
35 Severe duststorm or sandstorm } has begun or increased during the preceding hour.
36 Slight or moderate drifting snow } Drifting snow 10 meters (33 ft.) or below at sea.
37 Heavy drifting snow } Drifting snow 10 meters (33 ft.) or below at sea.
38 Slight or moderate blowing snow } Blowing snow above 10 meters (33 ft.) at sea.
39 Heavy blowing snow } Blowing snow above 10 meters (33 ft.) at sea.

40–49: Fog or ice fog at the time of observation (visibility less than 1,000 meters (1,100 yards)).

40 Fog or ice fog at a distance at the time of observation, but not at the station (or ship) during the last hour, the fog extending to a level above that of the observer.
41 Fog or ice fog in patches.
42 Fog or ice fog, sky discernible } has become thinner during the preceding hour.
43 Fog or ice fog, sky not discernible } has become thinner during the preceding hour.
44 Fog or ice fog, sky discernible } no appreciable change during the preceding hour.
45 Fog or ice fog, sky not discernible } no appreciable change during the preceding hour.
46 Fog or ice fog, sky discernible } has begun or has become thicker during the preceding hour.
47 Fog or ice fog, sky not discernible } has begun or has become thicker during the preceding hour.
48 Fog, depositing rime, sky discernible.
49 Fog, depositing rime, sky not discernible.

Table 5. (Cont.)

50–59 PRECIPITATION AT THE STATION (OR SHIP) AT THE TIME OF OBSERVATION

50–59: DRIZZLE AT TIME OF OBSERVATION.
- 50 Drizzle, not freezing, intermittent } slight at time of observation.
- 51 Drizzle, not freezing, continuous } slight at time of observation.
- 52 Drizzle, not freezing, intermittent } moderate at time of observation.
- 53 Drizzle, not freezing, continuous } moderate at time of observation.
- 54 Drizzle, not freezing, intermittent } heavy (dense) at time of observation.
- 55 Drizzle, not freezing, continuous } heavy (dense) at time of observation.
- 56 Drizzle, freezing, slight.
- 57 Drizzle, freezing, moderate or heavy (dense).
- 58 Drizzle and rain, slight.
- 59 Drizzle and rain, moderate or heavy.

60–69: RAIN AT TIME OF OBSERVATION.
- 60 Rain, not freezing, intermittent } slight at time of observation.
- 61 Rain, not freezing, continuous } slight at time of observation.
- 62 Rain, not freezing, intermittent } moderate at time of observation.
- 63 Rain, not freezing, continuous } moderate at time of observation.
- 64 Rain, not freezing, intermittent } heavy at time of observation.
- 65 Rain, not freezing, continuous } heavy at time of observation.
- 66 Rain, freezing, slight.
- 67 Rain, freezing, moderate or heavy.
- 68 Rain or drizzle and snow, slight.
- 69 Rain or drizzle and snow, moderate or heavy.

70–79: SOLID PRECIPITATION NOT IN SHOWERS AT TIME OF OBSERVATION.
- 70 Intermittent fall of snowflakes } slight at time of observation.
- 71 Continuous fall of snowflakes } slight at time of observation.
- 72 Intermittent fall of snowflakes } moderate at time of observation.
- 73 Continuous fall of snowflakes } moderate at time of observation.
- 74 Intermittent fall of snowflakes } heavy at time of observation.
- 75 Continuous fall of snowflakes } heavy at time of observation.
- 76 Ice prisms (with or without fog).
- 77 Snow grains (with or without fog).
- 78 Isolated starlike snow crystals (with or without fog).
- 79 Ice pellets (i.e., frozen raindrops or largely melted and refrozen snowflakes).

80–99: SHOWERY PRECIPITATION, OR PRECIPITATION WITH CURRENT OR RECENT THUNDERSTORM.
- 80 Rain shower(s), slight.
- 81 Rain shower(s), moderate or heavy.
- 82 Rain shower(s), violent.
- 83 Shower(s) of rain and snow mixed, slight.
- 84 Shower(s) of rain and snow mixed, moderate or heavy.
- 85 Snow shower(s), slight.
- 86 Snow shower(s), moderate or heavy.
- 87 Shower(s) of snow pellets or ice pellets* with or without rain or rain and snow mixed } slight.
- 88 Shower(s) of snow pellets or ice pellets* with or without rain or rain and snow mixed } moderate or heavy.
- 89 Shower(s) of hail with or without rain or rain and snow mixed, not associated with thunder } slight.
- 90 Shower(s) of hail, with or without rain or rain and snow mixed, not associated with thunder } moderate or heavy.
- 91 Slight rain at time of observation } thunderstorm during the preceding hour but not at time of observation
- 92 Moderate or heavy rain at time of observation } thunderstorm during the preceding hour but not at time of observation
- 93 Slight snow or rain and snow mixed or hail* at time of observation } thunderstorm during the preceding hour but not at time of observation
- 94 Moderate or heavy snow, or rain and snow mixed or hail* at time of observation } thunderstorm during the preceding hour but not at time of observation
- **95** Thunderstorm, slight or moderate, without hail* but with rain and/or snow at time of observation } thunderstorm at time of observation.
- **96** Thunderstorm, slight or moderate, with hail* at time of observation } thunderstorm at time of observation.
- **97** Thunderstorm, heavy, without hail* but with rain and/or snow at time of observation } thunderstorm at time of observation.
- ****98** Thunderstorm combined with duststorm or sandstorm—at time of observation } thunderstorm at time of observation.
- 99 Thunderstorm, heavy, with hail* at time of observation } thunderstorm at time of observation.

NOTES

1. In general, when coding ww the highest applicable figure is selected.

2. The amount of cloudiness at the time of observation is reported by symbol "N" in the group "Nddff." Code figures 00 to 03, inclusive, are used only when there is no other applicable code figure in the "ww" table to report. Code figure 00 is used when the observer has not had an opportunity to observe cloud development during the hour preceding the time of observation; 01 for clouds generally dissolving or becoming less developed; 02 for state of sky on the whole unchanged and 03 for clouds generally forming or developing. In coding 01, 02 and 03 there is no limitation on the magnitude of the change of cloud amount. ww=00, 01 and 02 can each be used when the sky is clear at the time of observation. In this case the following interpretations of the specifications will apply:

00 is used when the preceding conditions are not known.
01 is used when the clouds have dissolved during the past hour.
02 is used when the sky condition has been continuously clear during the past hour.

3. Whenever the description "intermittent" is used, precipitation has not continued without a break during the preceding hour.

*Hail, ice pellets, i.e., pellets of snow encased in a thin layer of ice; snow pellets.
**In reporting code figure 98, the observer is allowed considerable latitude in the presumption that precipitation is or is not occurring if it is not actually visible.

Table 6. Past weather

Symbol W—Past weather

Code figures	Description
0	Cloud covering ½ or less of the sky throughout period.
1	Cloud covering more than ½ of sky during part of period, and less than ½ during part of period.
2	Cloud covering more than ½ of sky through out period.
3	Sandstorm or duststorm or blowing snow.
4	Fog or ice fog or thick haze.
5	Drizzle.
6	Rain.
7	Snow or rain and snow mixed or ice pellets.
8	Shower(s).
9	Thunderstorm(s) with or without precipitation.

NOTES

1. In 0000, 0600, 1200 and 1800 G. C. T. reports "Past Weather" covers the preceding 6-hour period while in 0300, 0900, 1500, and 2100 G. C. T. reports, "W" covers the preceding 3-hour period.
2. The code figure for "W" is selected in order that "W" and "ww" together give as complete a description as possible of the weather in the time interval concerned. For example, if the type of weather undergoes a complete change during the time interval concerned, the code figure selected for "W" will describe the weather prevailing before the type of weather indicated by "ww" began. If however more than one code figure may be given to W with regard to past weather, the higher code figure is reported.

Table 7. Cloud amount: total cloud, low cloud

Symbol N—Fraction of the celestial dome covered by clouds

Symbol N_h—Fraction of celestial dome covered by type of cloud reported for C_L (or C_M if no C_L cloud present)

Symbol N_s—Fraction of the celestial dome covered by the cloud layer reported by Symbol C

Code figures	Cloud amount (eighths of sky covered)	*Approximate cloud amount (tenths of sky covered)*
0	None	*None*
1	1	1
2	2	2–3
3	3	4
4	4	5
5	5	6
6	6	7–8
7	7	9
8	8	10
9	Sky obscured by fog, rain, snow, smoke or other phenomena or obstruction except clouds.	

NOTES

1. "Fragments of clouds" are coded as 1.
2. "Overcast but with openings" is coded as 7.
3. The full International specification for code figure 9, is "Sky obscured or cloud amount cannot be estimated owing to darkness."

Table 8. Type of low clouds

Symbol C_L—Clouds of types Stratocumulus, Stratus, Cumulus, and Cumulonimbus

Code figures	Technical language specifications	Plain language specifications
0	No C_L clouds	No Cumulus, Cumulonimbus, Stratocumulus or Stratus.
1	Cumulus humilis, or Cumulus fractus other than of bad weather, or both.	Cumulus with little vertical extent and seemingly flattened, or ragged Cumulus other than of bad weather, or both.
2	Cumulus mediocris or congestus, with or without Cumulus of species fractus or humilis, or Stratocumulus; all having their bases at the same level.	Cumulus of moderate or strong vertical extent generally with protuberances in the form of domes or towers, either accompanied or not by other Cumulus or by Stratocumulus; all having their bases at the same level.
3	Cumulonimbus calvus, with or without Cumulus, Stratocumulus or Stratus.	Cumulonimbus the summits of which, at least partially, lack sharp outlines, but are neither clearly fibrous (cirriform), nor in the form of an anvil; Cumulus, Stratocumulus or Stratus may be present.
4	Stratocumulus cumulogenitus	Stratocumulus formed by the spreading out of Cumulus; Cumulus may also be present.
5	Stratocumulus other than Stratocumulus cumulogenitus.	Stratocumulus not resulting from the spreading out of Cumulus.
6	Stratus nebulosus or Stratus fractus other than of bad weather, or both.	Stratus in a more or less continuous sheet or layer, or in ragged shreds or both, but no Stratus fractus of bad weather.
7	Stratus fractus or Cumulus fractus of bad weather or both (pannus) usually below Altostratus or Nimbostratus.	Stratus fractus of bad weather or Cumulus fractus of bad weather or both (pannus) usually below Altostratus or Nimbostratus.
8	Cumulus and Stratocumulus, other than Stratocumulus cumulogenitus, with bases at different levels.	Cumulus and Stratocumulus, other than those formed from the spreading out of Cumulus; the base of Cumulus is at a different level than that of the Stratocumulus.
9	Cumulonimbus capillatus (often with an anvil), with or without Cumulonimbus calvus, Cumulus, Stratocumulus, Stratus or pannus.	Cumulonimbus, the upper part of which is clearly fibrous (cirriform) often in the form of an anvil; either accompanied, or not by Cumulonimbus without anvil or fibrous upper part, by Cumulus, Stratocumulus, Stratus, or pannus.
X	Clouds C_L not visible owing to darkness, fog, blowing dust or sand, or other similar phenomena.	No Cumulus, Cumulonimbus, Stratocumulus or Stratus visible owing to darkness, fog, blowing dust or sand, or other similar phenomena.

NOTE: "Bad Weather" denotes the conditions which generally exist during precipitation and a short time before and after.

Table 9. Height of low clouds

Symbol h—Height above sea of base of the cloud

Code figures	Feet	Meters
0	0 to 150	0 to 50.
1	150 to 300	50 to 100.
2	300 to 600	100 to 200.
3	600 to 1,000	200 to 300.
4	1,000 to 2,000	300 to 600.
5	2,000 to 3,500	600 to 1,000.
6	3,500 to 5,000	1,000 to 1,500.
7	5,000 to 6,500	1,500 to 2,000.
8	6,500 to 8,000	2,000 to 2,500.
9	8,000 or higher or no clouds.	2,500 or higher or no clouds.

Notes

1. Symbol "h" reports the height of the base of the lowest cloud layer of C_L or C_M clouds. When only fragments of clouds are present, "h" indicates the height of the fragments.
2. If the height of the cloud base is exactly equal to a height given in the table, the higher code figure is used. For example, a height of 600 feet is coded as 3.
3. When the sky is obscured by rain, snow, fog, smoke, or other phenomena so that cloud cannot be observed, "h" is coded as 0 and "N_h" as 9.
4. If the height of the cloud base cannot be reported owing to darkness or any reason not covered by Note 3. an X is reported for "h".

Table 10. Type of middle clouds

Symbol C_M—Clouds of types Altocumulus, Altostratus, and Nimbostratus

Code figures	Technical language specifications	Plain language specifications
0	No C_M clouds	No Altocumulus, Altostratus or Nimbostratus.
1	Altostratus translucidus	Altostratus, the greater part of which is semitransparent; through this part the sun or moon may be weakly visible as through ground glass.
2	Altostratus opacus or Nimbostratus.	Altostratus, the greater part of which is sufficiently dense to hide the sun (or moon), or Nimbostratus.
3	Altocumulus translucidus at a single level.	Altocumulus, the greater part of which is semitransparent; the various elements of the cloud change only slowly and are all at a single level.
4	Patches of Altocumulus translucidus (often lenticular), continuously changing and occurring at one or more levels.	Patches (often in the form of almonds or fishes) of Altocumulus, the greater part of which is semitransparent; the clouds occur at one or more levels and the elements are continually changing in appearance.
5	Altocumulus translucidus in bands, or one or more layers of Altocumulus translucidus or opacus progressively invading the sky; these Altocumulus clouds generally thicken as a whole.	Semitransparent Altocumulus in bands or Altocumulus in one or more fairly continuous layers (semitransparent or opaque) progressively invading the sky; these Altocumulus clouds generally thicken as a whole.
6	Altocumulus cumulogenitus (or cumulonimbogenitus).	Altocumulus resulting from the spreading out of Cumulus (or Cumulonimbus).
7	Altocumulus translucidus or opacus in 2 or more layers, or Altocumulus opacus in a single layer, not progressively invading the sky, or Altocumulus with Altostratus or Nimbostratus.	Altocumulus in two or more layers usually opaque in places and not progressively invading the sky; or opaque layer of Altocumulus not progressively invading the sky; or Altocumulus together with Altostratus or Nimbostratus.
8	Altocumulus castellanus or floccus.	Altocumulus with sproutings in the form of small towers or battlements, or Altocumulus having the appearance of cumuliform tufts.
9	Altocumulus of a chaotic sky, generally at several levels.	Altocumulus of a chaotic sky generally at several levels.
X	Clouds C_M not visible owing to darkness, fog, blowing dust or sand, or other similar phenomena, or because of a continuous layer of lower clouds.	No Altocumulus, Altostratus or Nimbostratus visible owing to darkness, fog, blowing dust or sand, or other similar phenomena, or more often because of the presence of a continuous layer of lower clouds.

Table 11. Type of high clouds

Symbol C_H—Clouds of types Cirrus, Cirrostratus, and Cirrocumulus

Code figures	Technical language specifications	Plain language specifications
0	No C_H clouds	No Cirrus, Cirrostratus or Cirrocumulus.
1	Cirrus fibratus, sometimes uncinus, not progressively invading the sky.	Cirrus in the form of filaments, strands or hooks, not progressively invading the sky.
2	Cirrus spissatus, in patches or entangled sheaves, which usually do not increase and sometimes seem to be the remains of the upper part of a Cumulonimbus; or Cirrus castellanus or floccus.	Dense Cirrus in patches or entangled sheaves which usually do not increase and sometimes seem to be the remains of the upper parts of Cumulonimbus; or Cirrus with sproutings in the form of small turrets or battlements or Cirrus having the appearance of cumuliform tufts.
3	Cirrus spissatus cumulonimbogenitus.	Dense Cirrus often in the form of an anvil, being the remains of the upper parts of Cumulonimbus.
4	Cirrus uncinus, or fibratus, or both, progressively invading the sky; they generally thicken as a whole.	Cirrus in the form of hooks or filaments or both, progressively invading the sky; they generally become denser as a whole.
5	Cirrus, often in bands, and Cirrostratus, or Cirrostratus alone, progressively invading the sky; they generally thicken as a whole, but the continuous veil does not reach 45° above the horizon.	Cirrus, often in bands converging towards 1 point or 2 opposite points of the horizon and Cirrostratus, or Cirrostratus alone; in either case they are progressively invading the sky, and generally growing denser as a whole, but the continuous veil does not reach 45° above the horizon.
6	Cirrus, often in bands, and Cirrostratus, or Cirrostratus alone, progressively invading the sky; they generally thicken as a whole, but the continuous veil extends more than 45° above the horizon, without the sky being totally covered.	Cirrus, often in bands converging towards 1 point or 2 opposite points of the horizon, and Cirrostratus, or Cirrostratus alone; in either case they are progressively invading the sky, and generally growing denser as a whole; the continuous veil extends more than 45° above the horizon, without the sky being completely covered.
7	Cirrostratus covering the whole sky.	Veil of Cirrostratus covering the celestial dome.
8	Cirrostratus not progressively invading the sky, and not entirely covering it.	Cirrostratus not progressively invading the sky, and not completely covering the celestial dome.
9	Cirrocumulus alone, or Cirrocumulus predominant among the cirriform clouds.	Cirrocumulus alone, or Cirrocumulus accompanied by Cirrus or Cirrostratus or both, but Cirrocumulus is predominant.
X	Clouds C_H not visible owing to darkness, fog, blowing dust or sand or other similar phenomena, or because of a continuous layer of lower clouds.	No Cirrus, Cirrostratus or Cirrocumulus visible owing to darkness, fog, blowing dust or sand, or other similar phenomena, or more often because of the presence of a continuous layer of lower clouds.

Table 12. Period of waves

Symbol P_w—Period of waves

Code figures	Period
2	5 seconds or less.
3	6 to 7 seconds.
4	8 to 9 seconds.
5	10 to 11 seconds.
6	12 to 13 seconds.
7	14 to 15 seconds.
8	16 to 17 seconds.
9	18 to 19 seconds.
0	20 to 21 seconds.
1	Over 21 seconds.
x	Calm or period unable to be determined.

Table 13. Height of waves

Symbol H_w—Height of waves

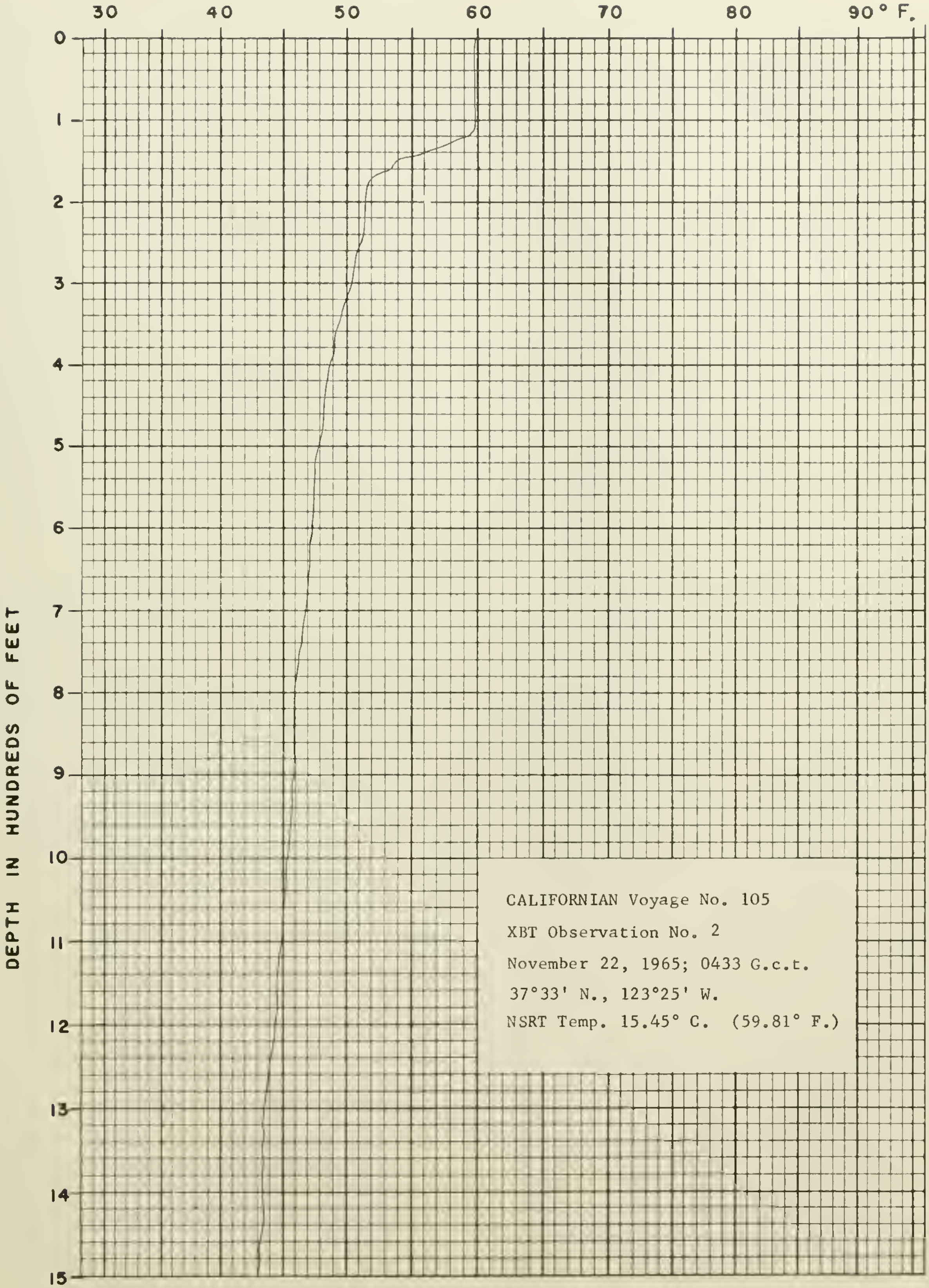
Code figures	Height
0	Less than 1 foot (¼ meter).
1	1½ feet (½ meter).
2	3 feet (1 meter).
3	5 feet (1½ meters).
4	6½ feet (2 meters).
5	8 feet (2½ meters).
6	9½ feet (3 meters).
7	11 feet (3½ meters).
8	13 feet (4 meters).
9	14 feet (4½ meters).
x	Height impossible to determine.
	(When 50 is added to d_wd_w, the height of waves is as follows):
0	16 feet (5 meters).
1	17½ feet (5½ meters).
2	19 feet (6 meters).
3	21 feet (6½ meters).
4	22½ feet (7 meters).
5	24 feet (7½ meters).
6	25½ feet (8 meters).
7	27 feet (8½ meters).
8	29 feet (9 meters).
9	30½ feet (9½ meters).
x	Height impossible to determine.

Notes

1. Each code figure except "zero" covers a range of ½ meter; e. g., code figure 1=¼ meter to ¾ meter, code figure 2=¾ meter to 1¼ meters.

2. If the wave height is exactly between the heights corresponding to 2 code figures, the lower code figure is reported.

3. For wave heights greater than 31 feet (9¾ meters), the code figure for 30½ feet (9½ meters) is reported followed by the word "WAVES" and the actual height of the waves in feet or meters; e. g., "WAVES 37."



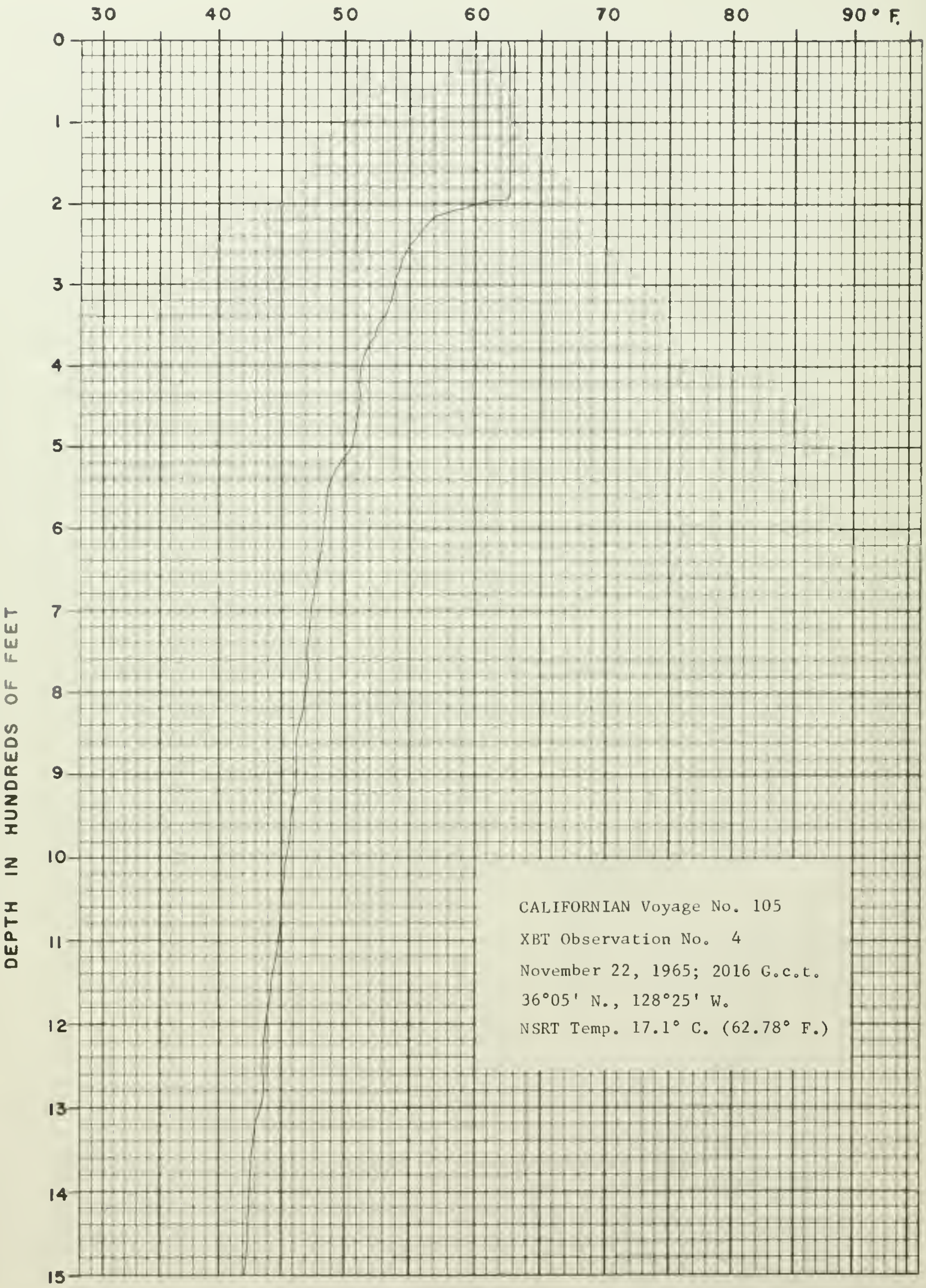
CALIFORNIAN Voyage No. 105

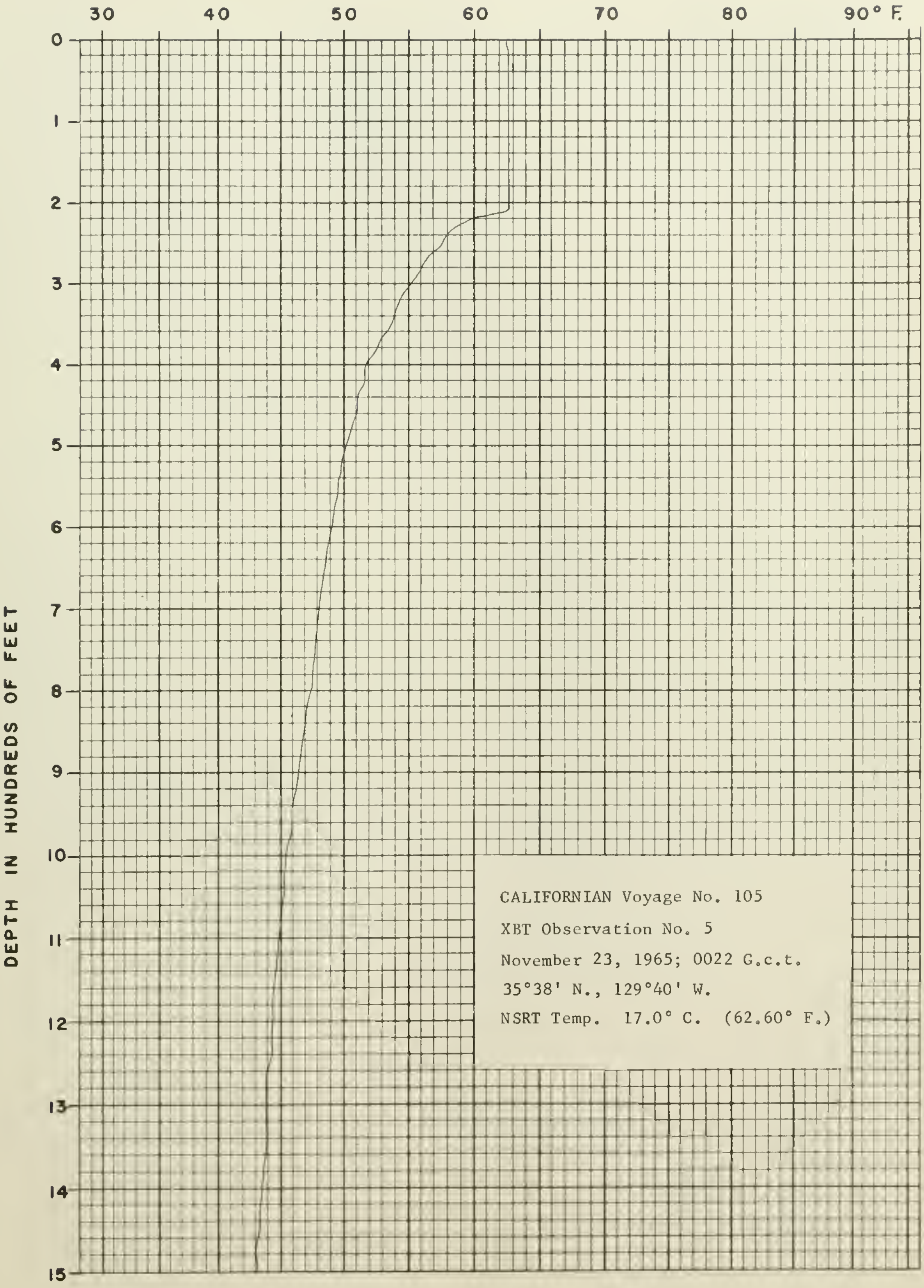
XBT Observation No. 2

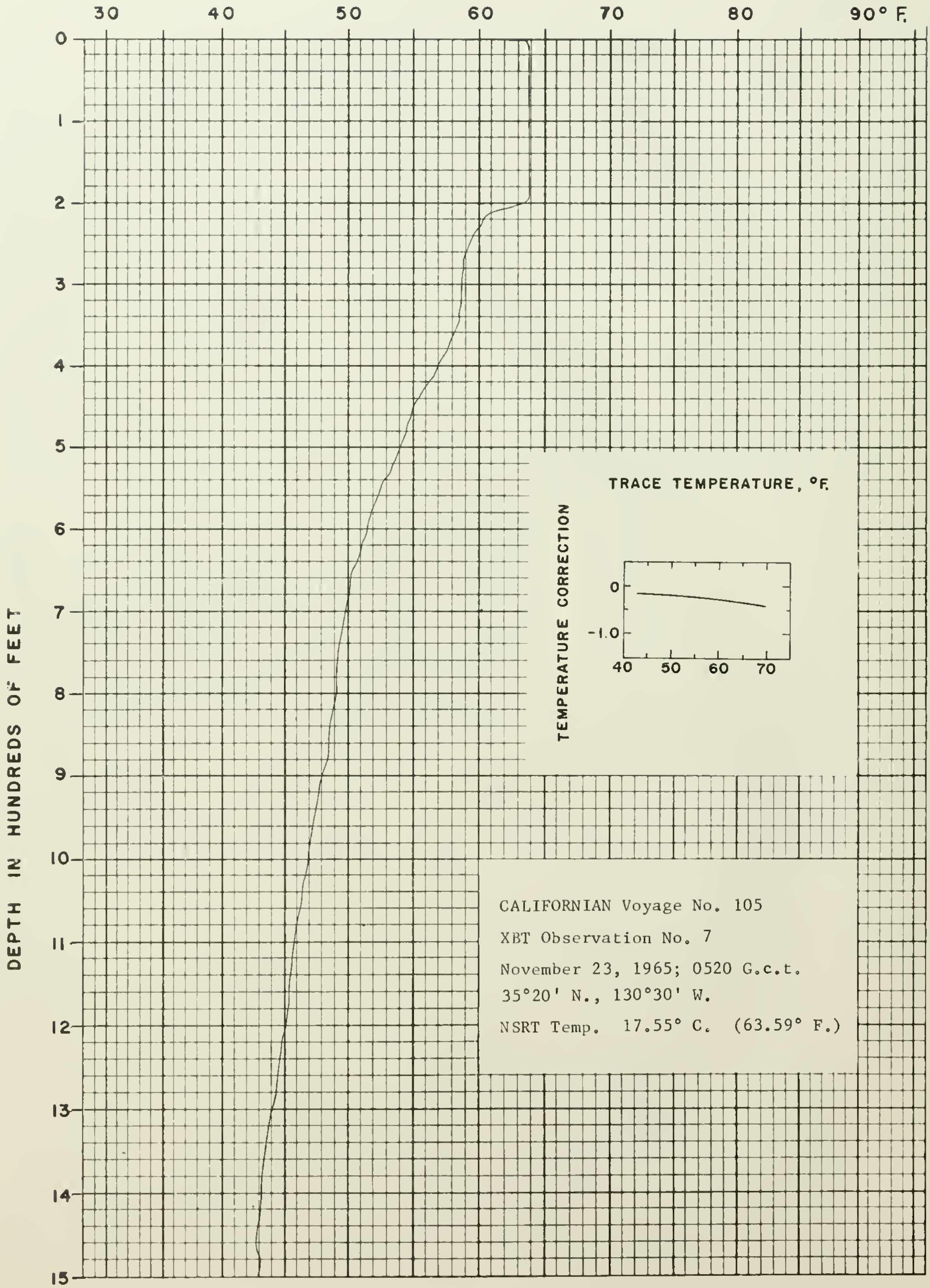
November 22, 1965; 0433 G.c.t.

37°33' N., 123°25' W.

NSRT Temp. 15.45° C. (59.81° F.)


30
40
50
60
70
80
90° F.
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 4
November 22, 1965; 2016 G.c.t.
36°05' N., 128°25' W.
NSRT Temp. 17.1° C. (62.78° F.)


30
40
50
60
70
80
90° F.
DEPTH IN HUNDREDS OF FEET
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
CALIFORNIAN Voyage No. 105
XBT Observation No. 5
November 23, 1965; 0022 G.c.t.
35°38' N., 129°40' W.
NSRT Temp. 17.0° C. (62.60° F.)

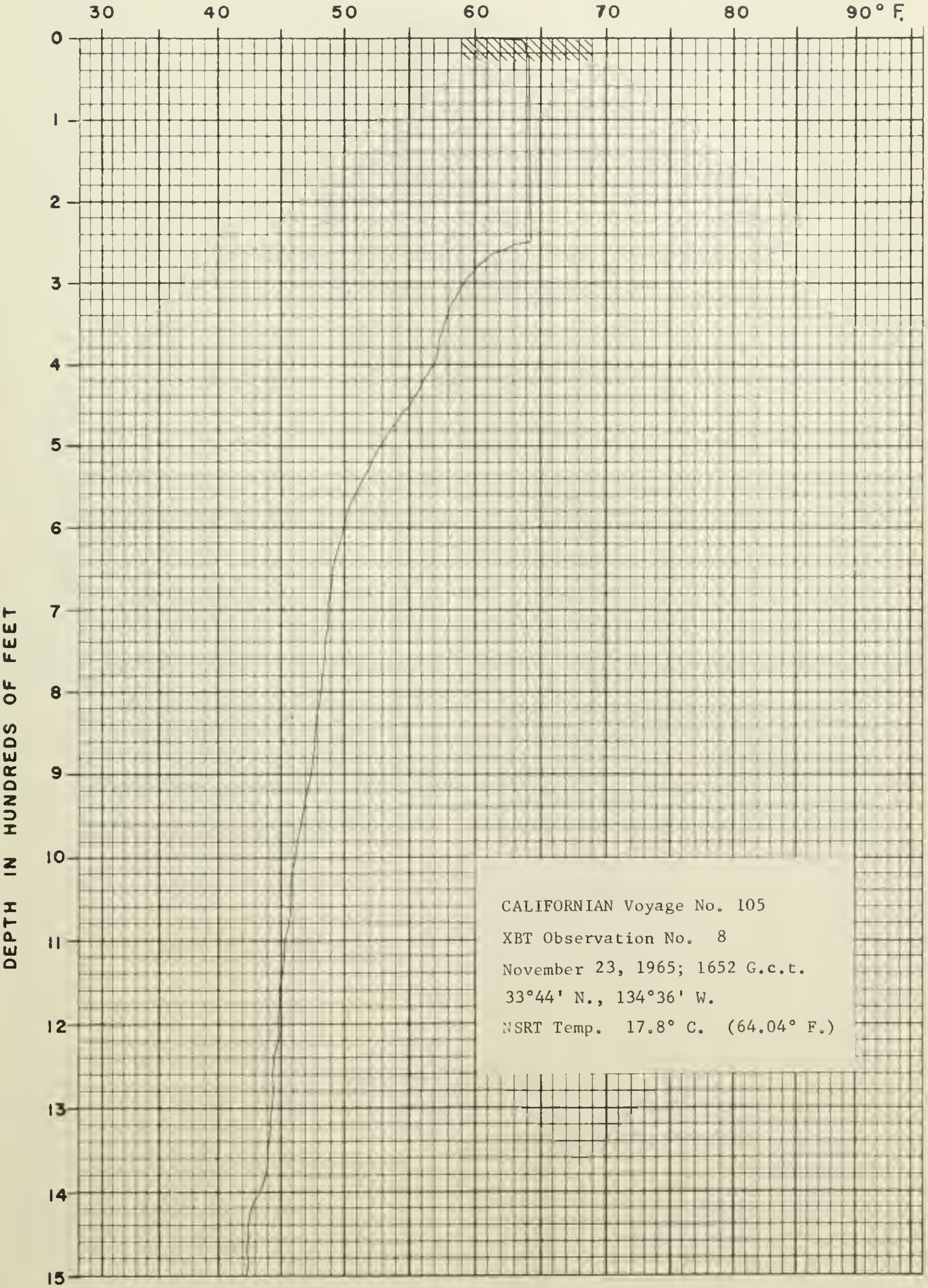


CALIFORNIAN Voyage No. 105

XBT Observation No. 7

November 23, 1965; 0520 G.c.t.
35°20' N., 130°30' W.

NSRT Temp. 17.55° C. (63.59° F.)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90° F.
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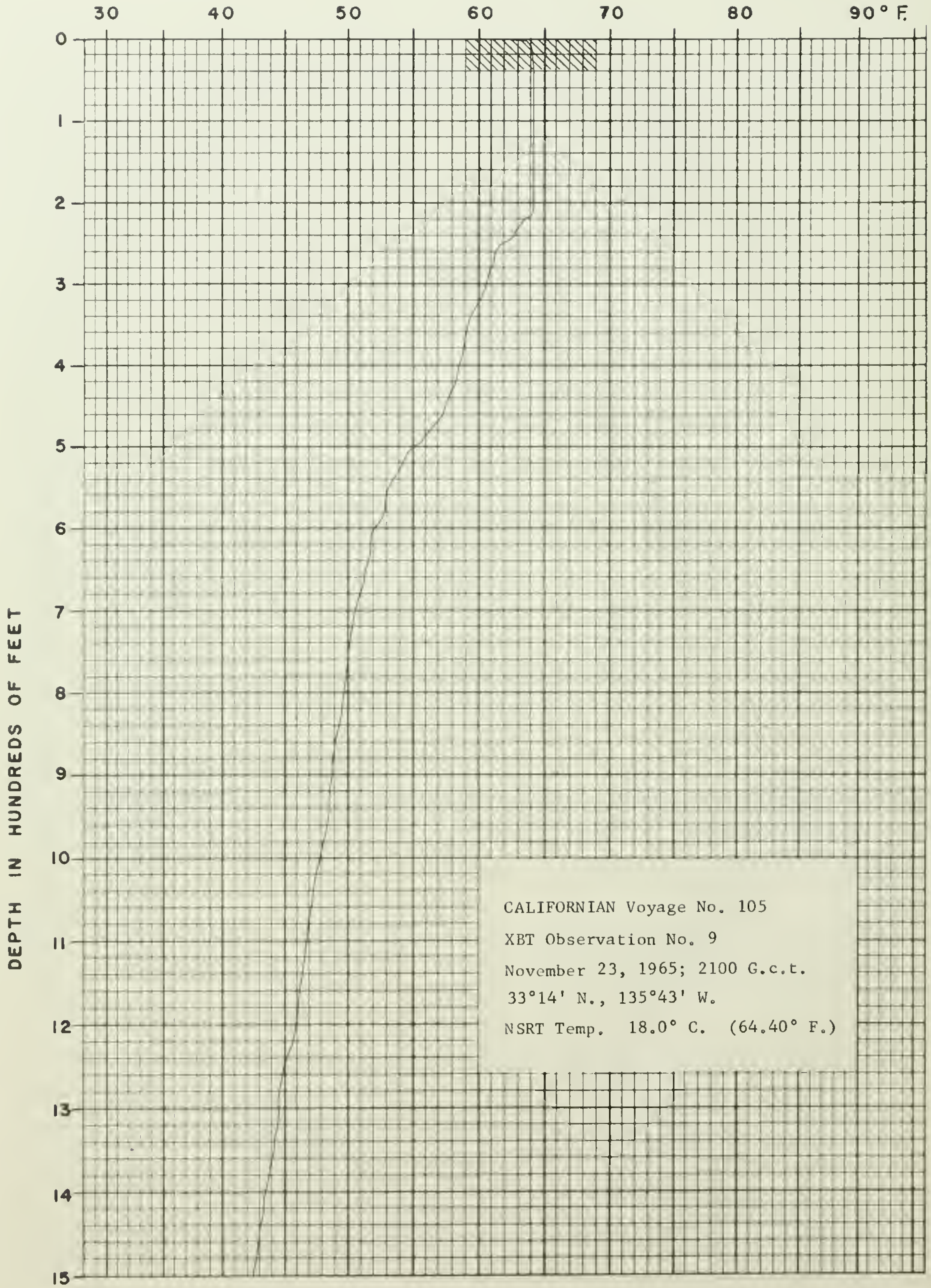
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 8
November 23, 1965; 1652 G.c.t.
33°44' N., 134°36' W.
NSRT Temp. 17.8° C. (64.04° F.)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90° F.
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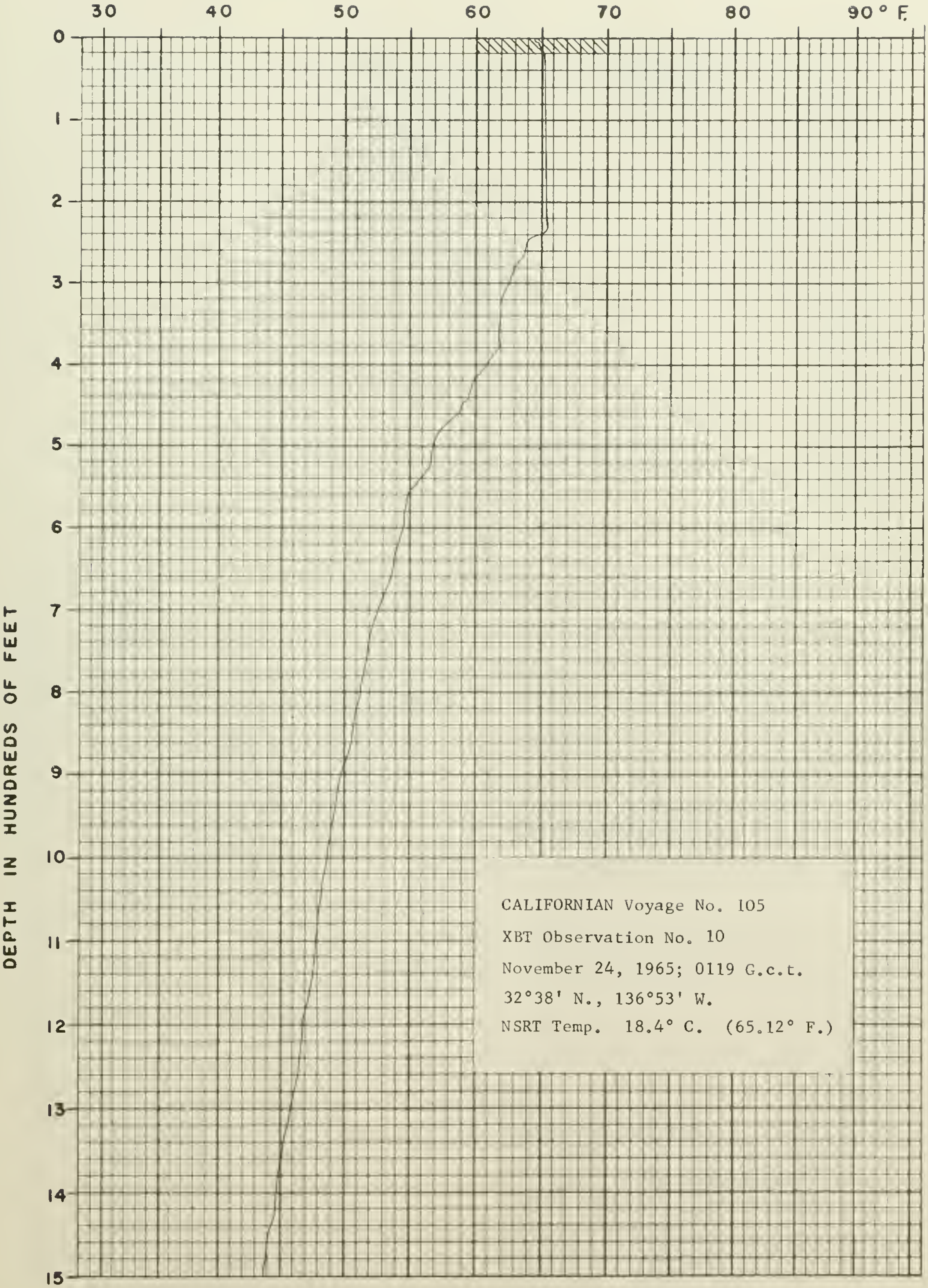
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 9
November 23, 1965; 2100 G.c.t.
33°14' N., 135°43' W.
NSRT Temp. 18.0° C. (64.40° F.)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90° F.
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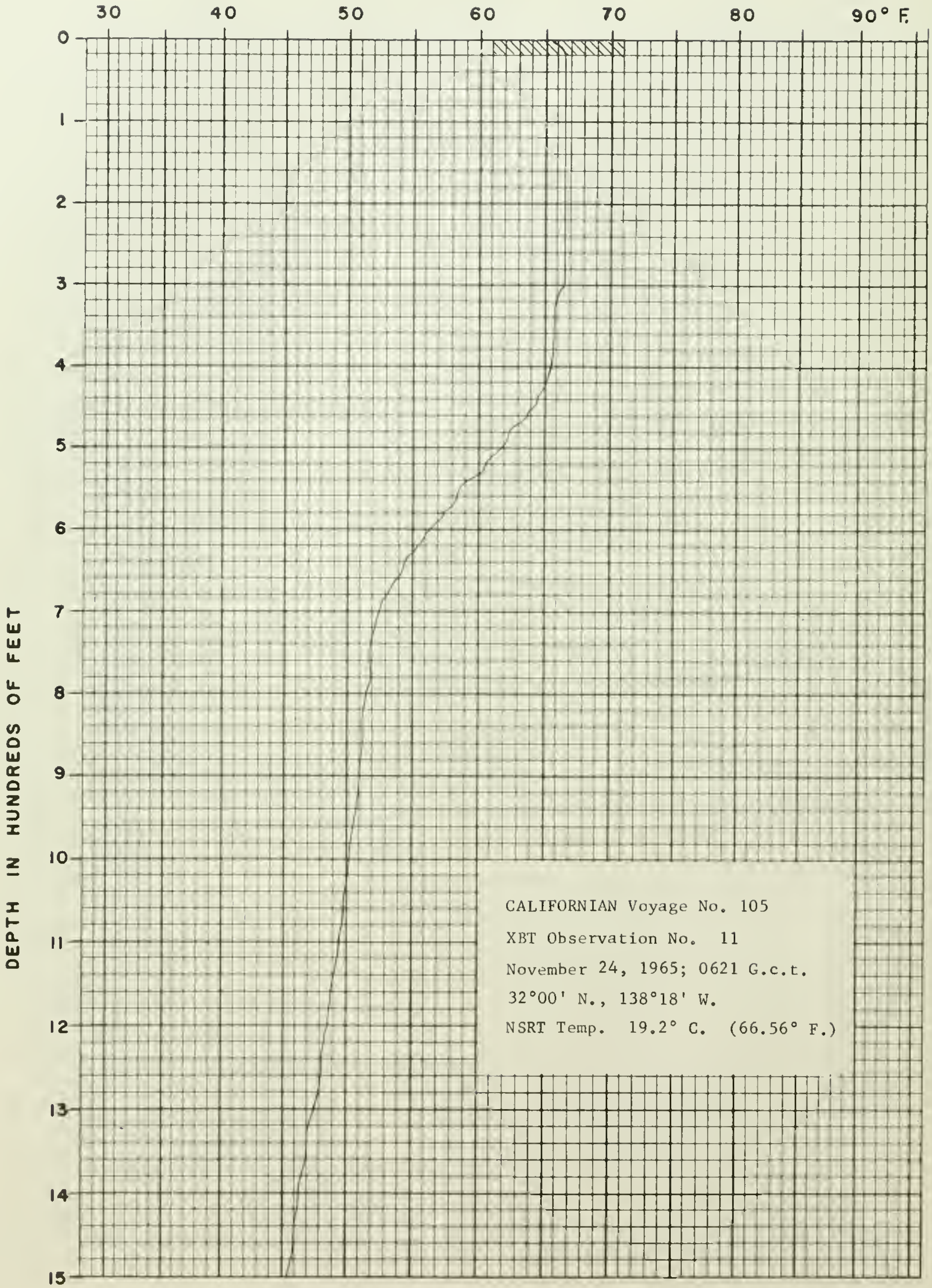
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 10
November 24, 1965; 0119 G.c.t.
32°38' N., 136°53' W.
NSRT Temp. 18.4° C. (65.12° F.)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90° F.
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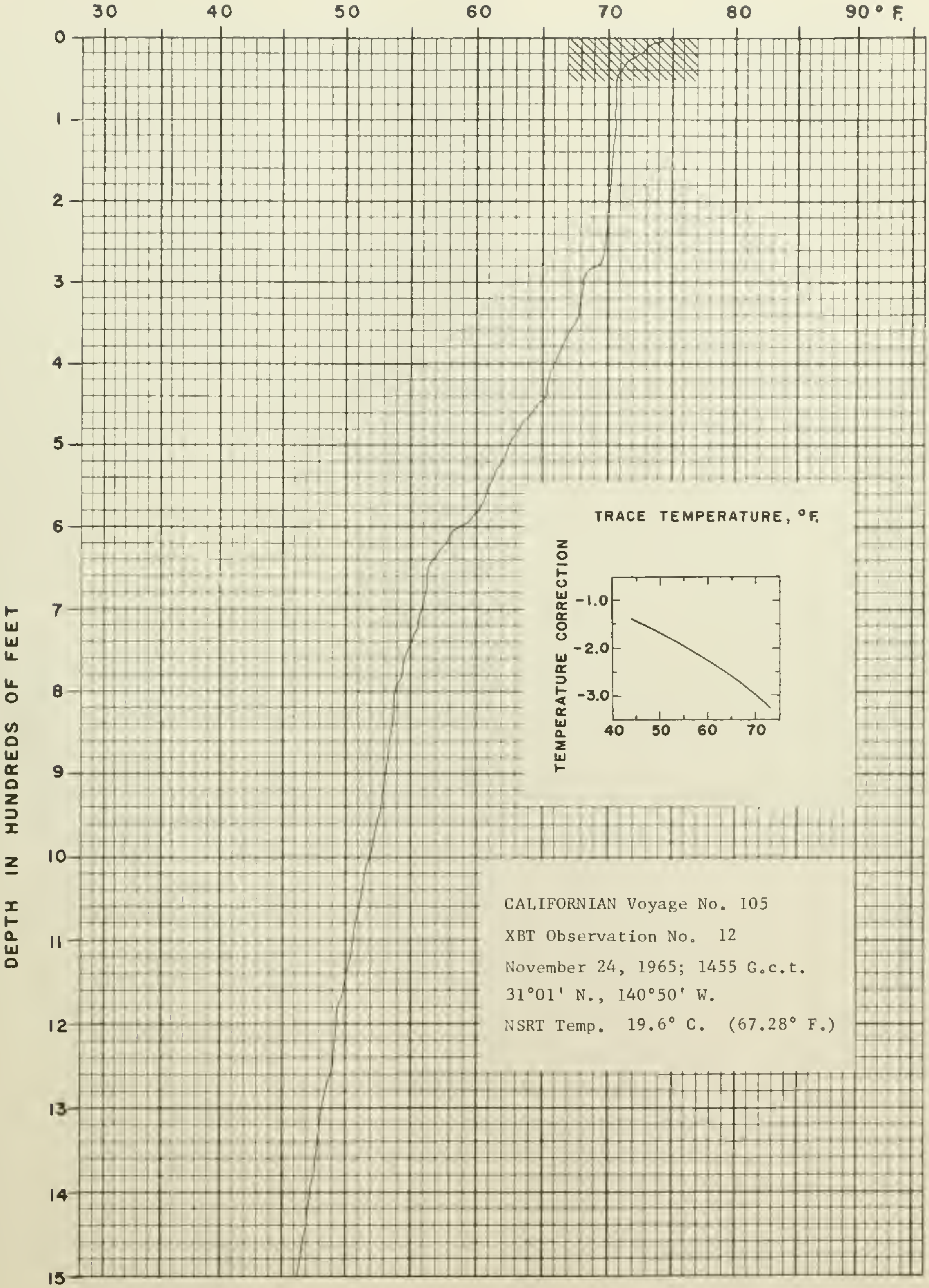
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 11
November 24, 1965; 0621 G.c.t.
32°00' N., 138°18' W.
NSRT Temp. 19.2° C. (66.56° F.)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90° F.
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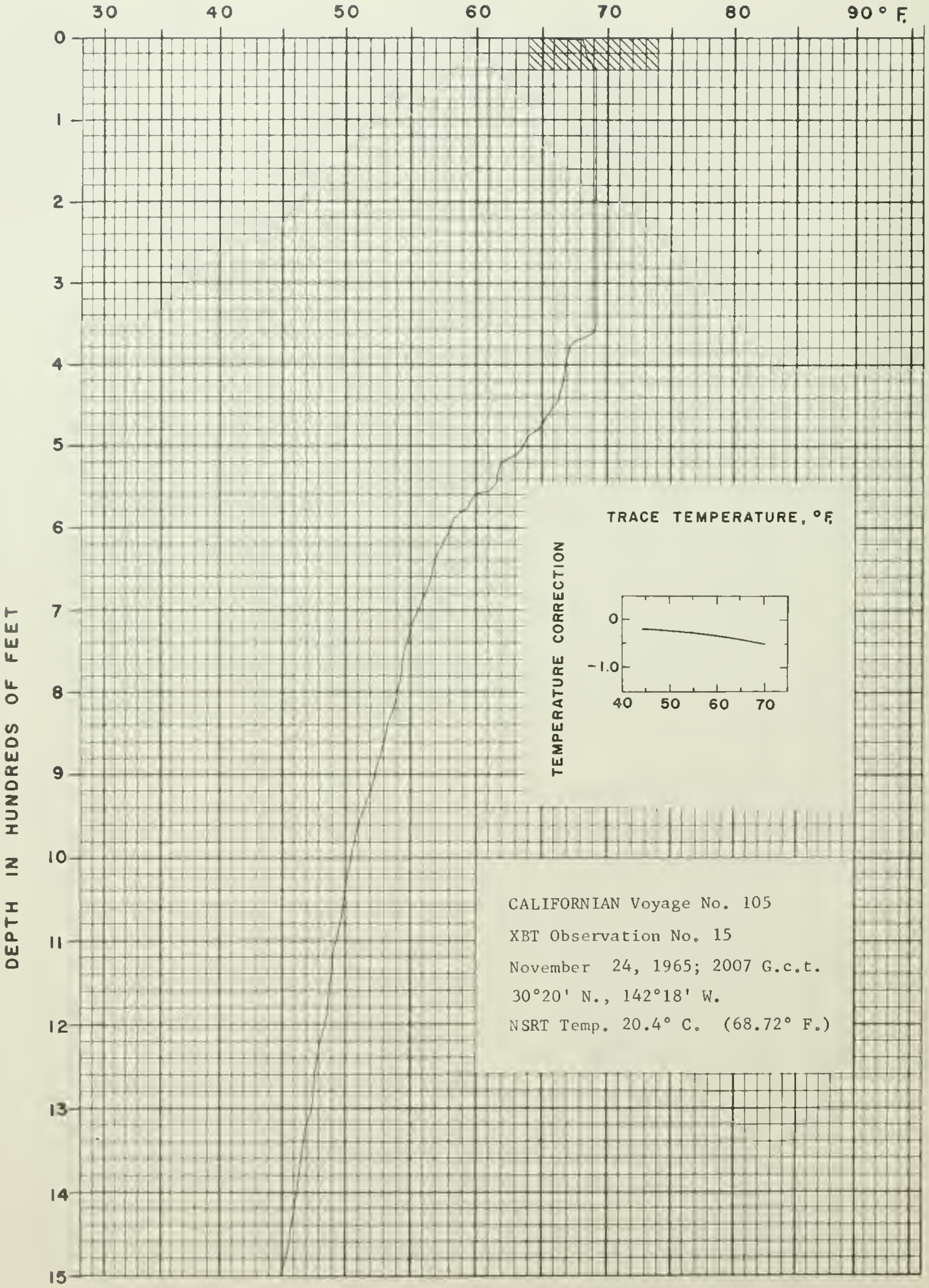
DEPTH IN HUNDREDS OF FEET
TRACE TEMPERATURE, °F.
TEMPERATURE CORRECTION
-1.0
-2.0
-3.0
40
50
60
70
CALIFORNIAN Voyage No. 105
XBT Observation No. 12
November 24, 1965; 1455 G.c.t.
31°01' N., 140°50' W.
NSRT Temp. 19.6° C. (67.28° F.)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90 ° F.
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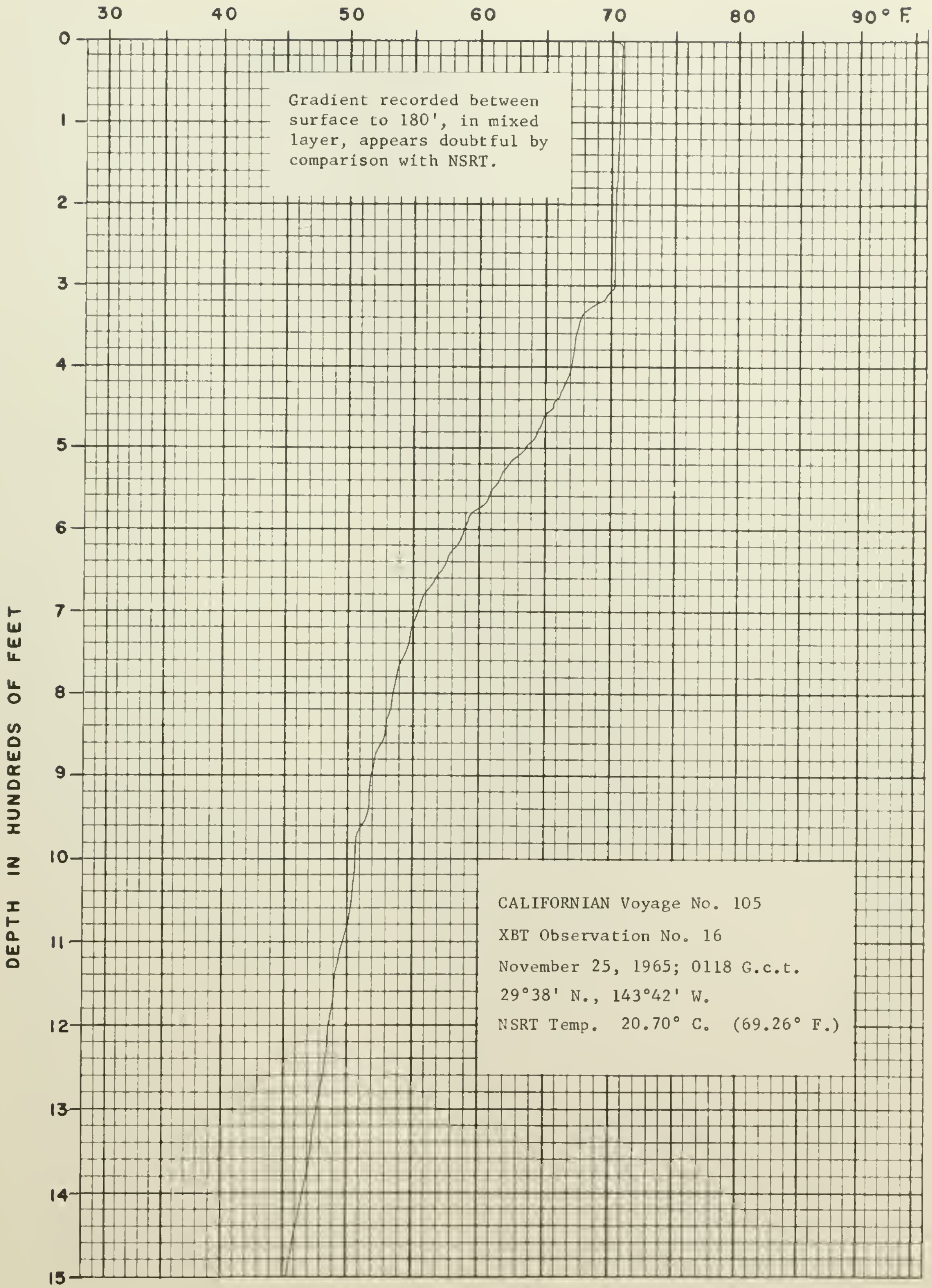
DEPTH IN HUNDREDS OF FEET
TRACE TEMPERATURE, °F.
TEMPERATURE CORRECTION
0
-1.0
40
50
60
70
CALIFORNIAN Voyage No. 105
XBT Observation No. 15
November 24, 1965; 2007 G.c.t.
30°20' N., 142°18' W.
NSRT Temp. 20.4° C. (68.72° F.)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90° F.
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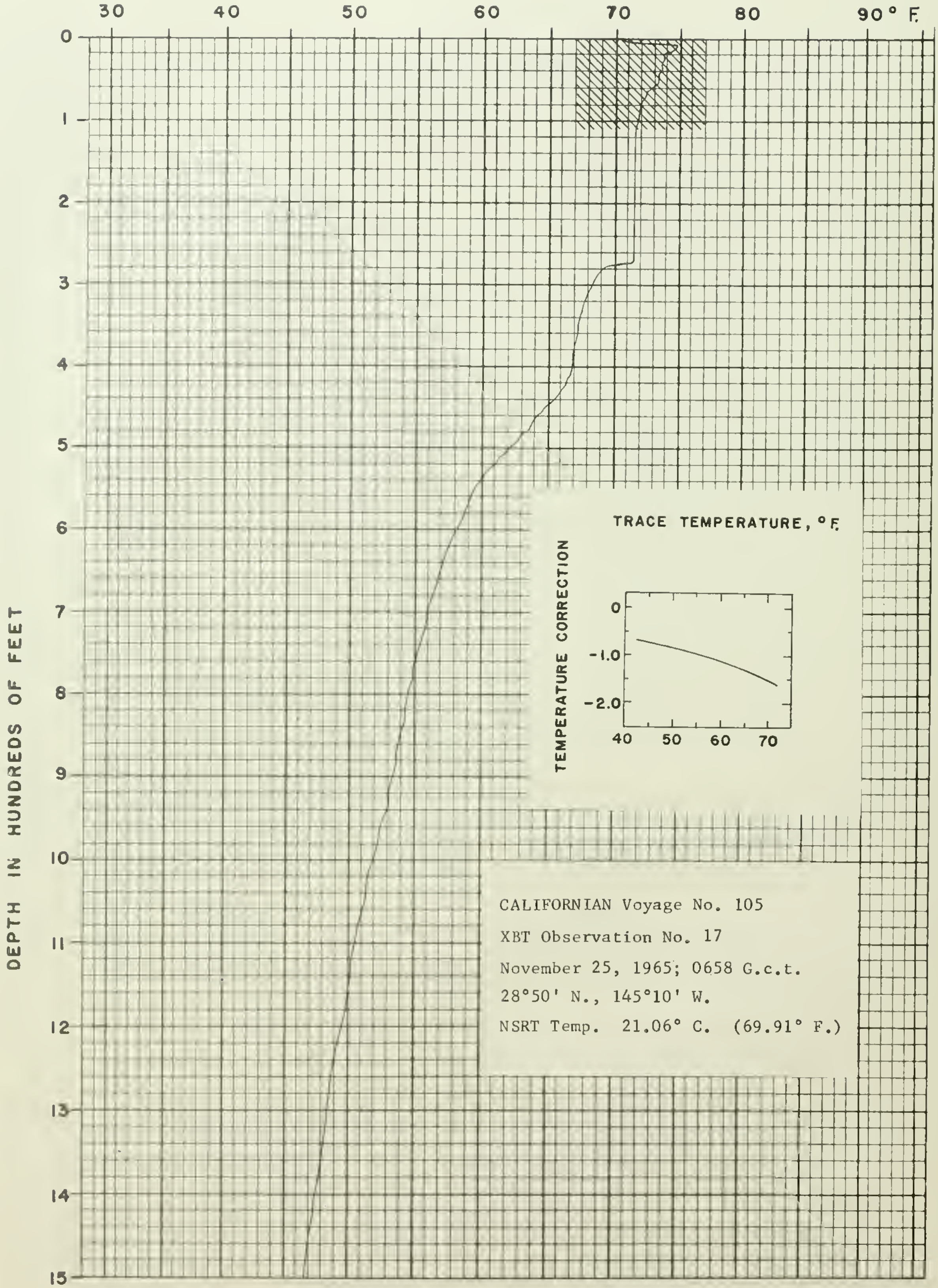
DEPTH IN HUNDREDS OF FEET
Gradient recorded between surface to 180', in mixed layer, appears doubtful by comparison with NSRT.
CALIFORNIAN Voyage No. 105
XBT Observation No. 16
November 25, 1965; 0118 G.c.t.
29°38' N., 143°42' W.
NSRT Temp. 20.70° C. (69.26° F.)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90° F.
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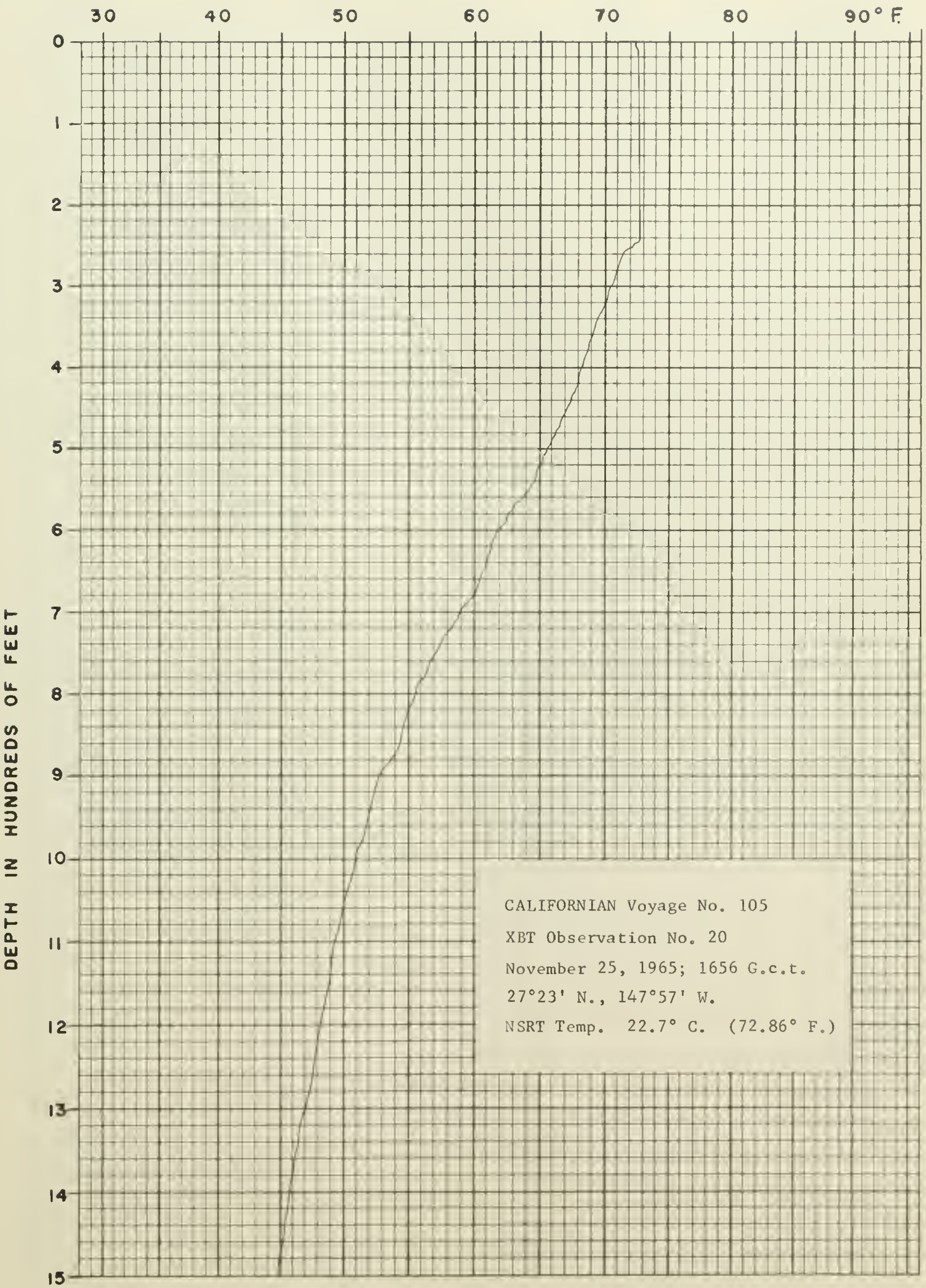
DEPTH IN HUNDREDS OF FEET
TRACE TEMPERATURE, °F.
TEMPERATURE CORRECTION
0
-1.0
-2.0
40
50
60
70
CALIFORNIAN Voyage No. 105
XBT Observation No. 17
November 25, 1965; 0658 G.c.t.
28°50' N., 145°10' W.
NSRT Temp. 21.06° C. (69.91° F.)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90° F.
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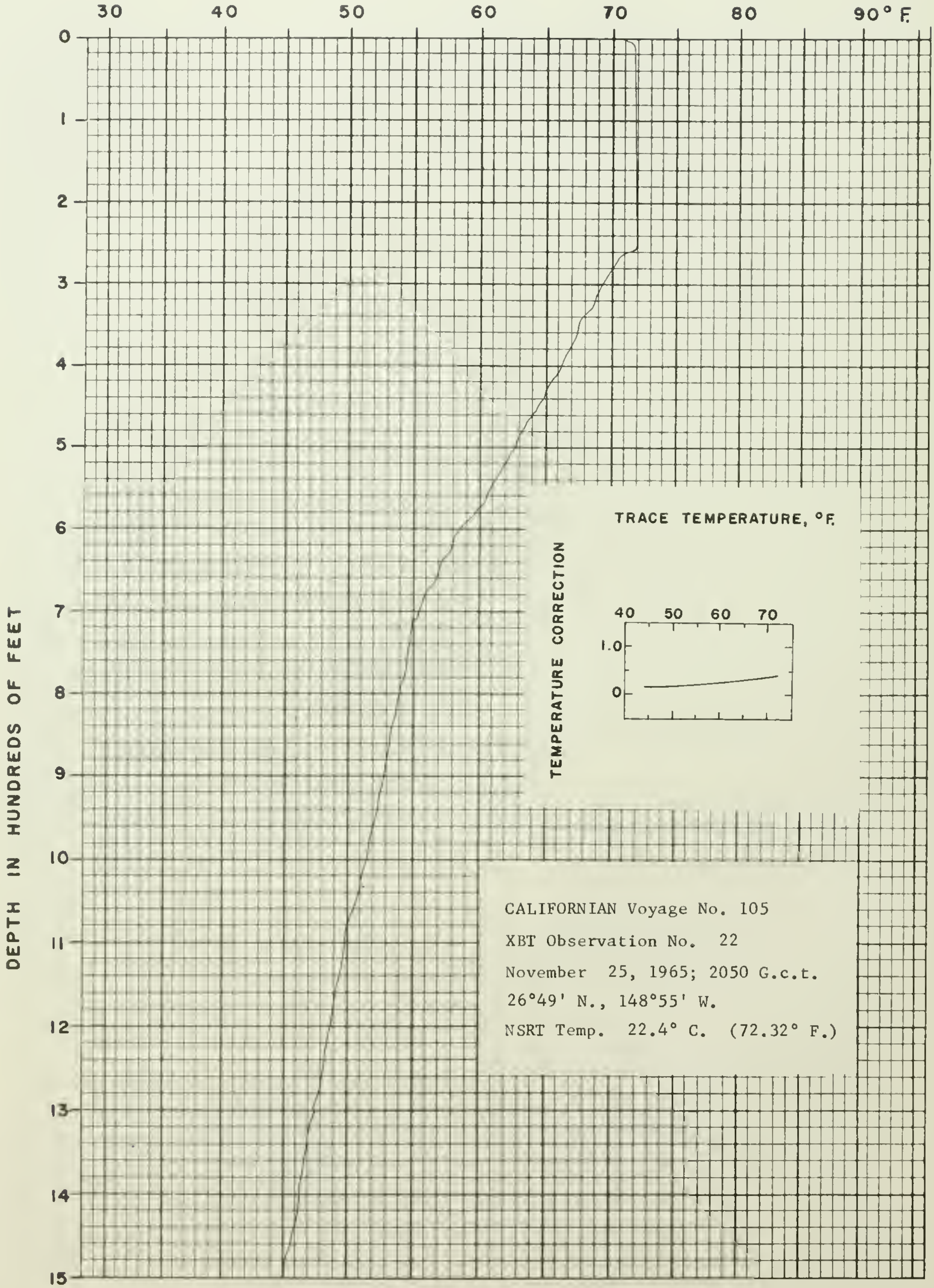
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 20
November 25, 1965; 1656 G.c.t.
27°23' N., 147°57' W.
NSRT Temp. 22.7° C. (72.86° F.)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90° F.
DEPTH IN HUNDREDS OF FEET
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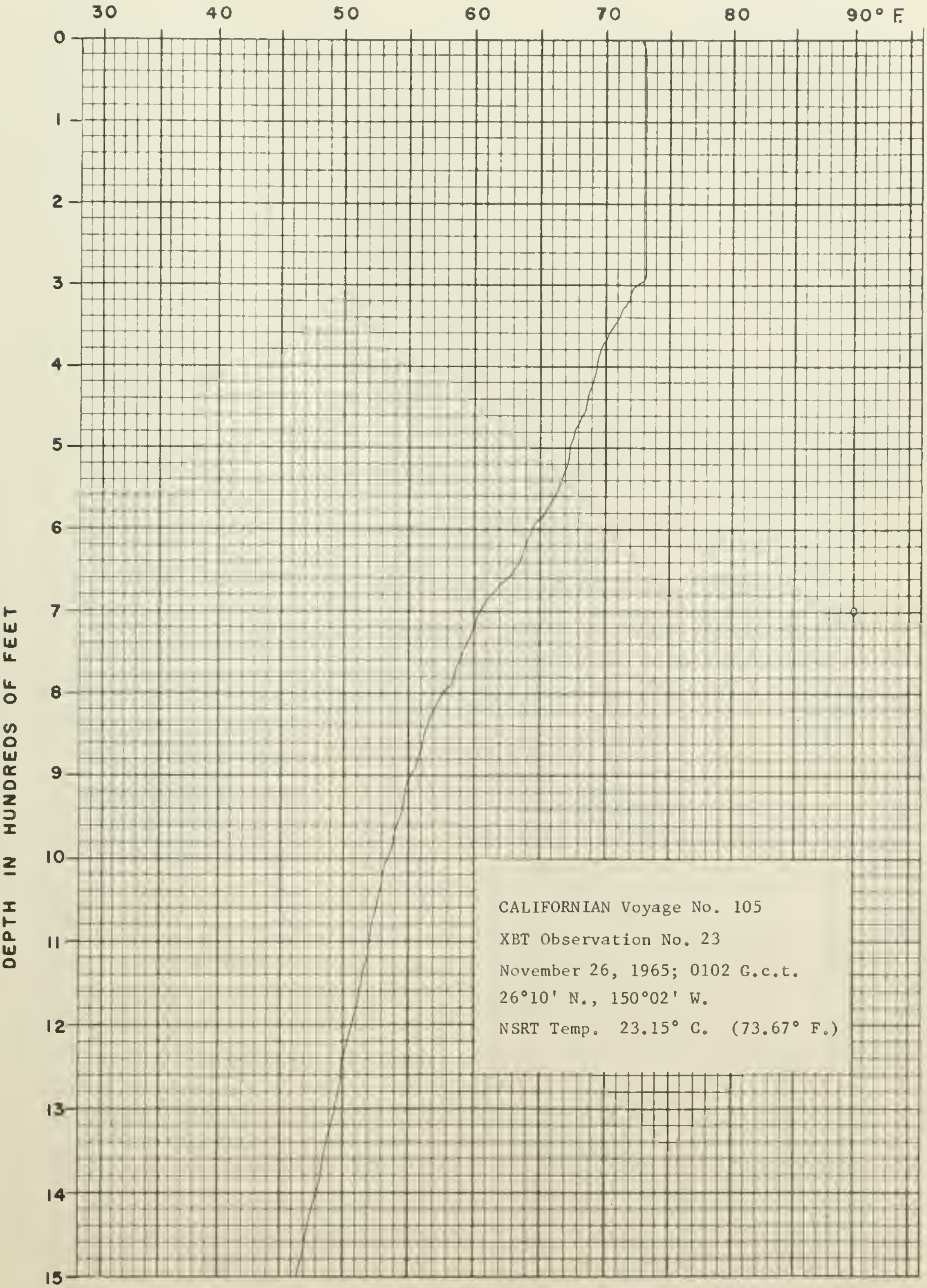
TRACE TEMPERATURE, °F.
TEMPERATURE CORRECTION
40
50
60
70
1.0
0
CALIFORNIAN Voyage No. 105
XBT Observation No. 22
November 25, 1965; 2050 G.c.t.
26°49' N., 148°55' W.
NSRT Temp. 22.4° C. (72.32° F.)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90° F.
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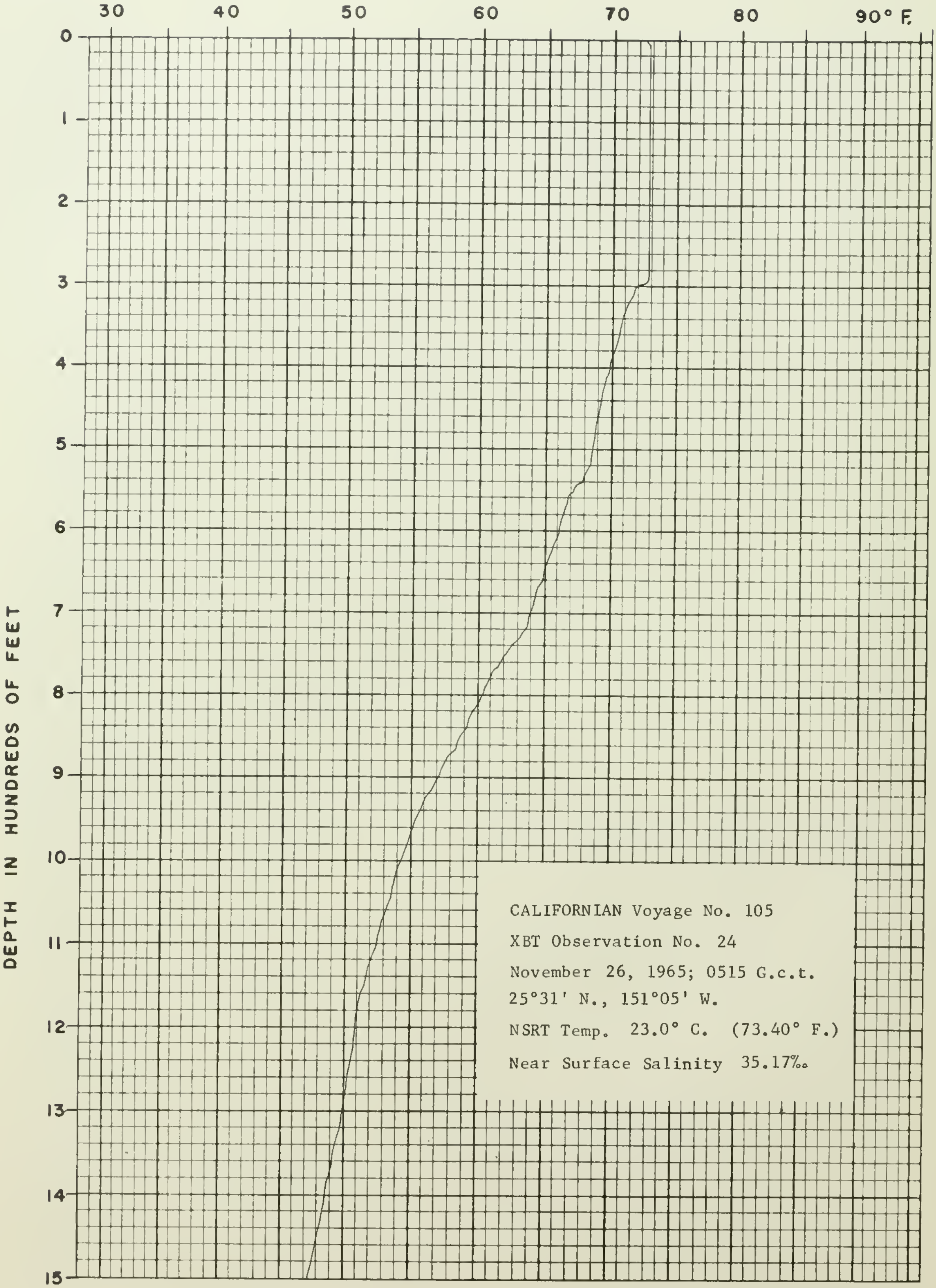
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 23
November 26, 1965; 0102 G.c.t.
26°10' N., 150°02' W.
NSRT Temp. 23.15° C. (73.67° F.)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90° F.
DEPTH IN HUNDREDS OF FEET
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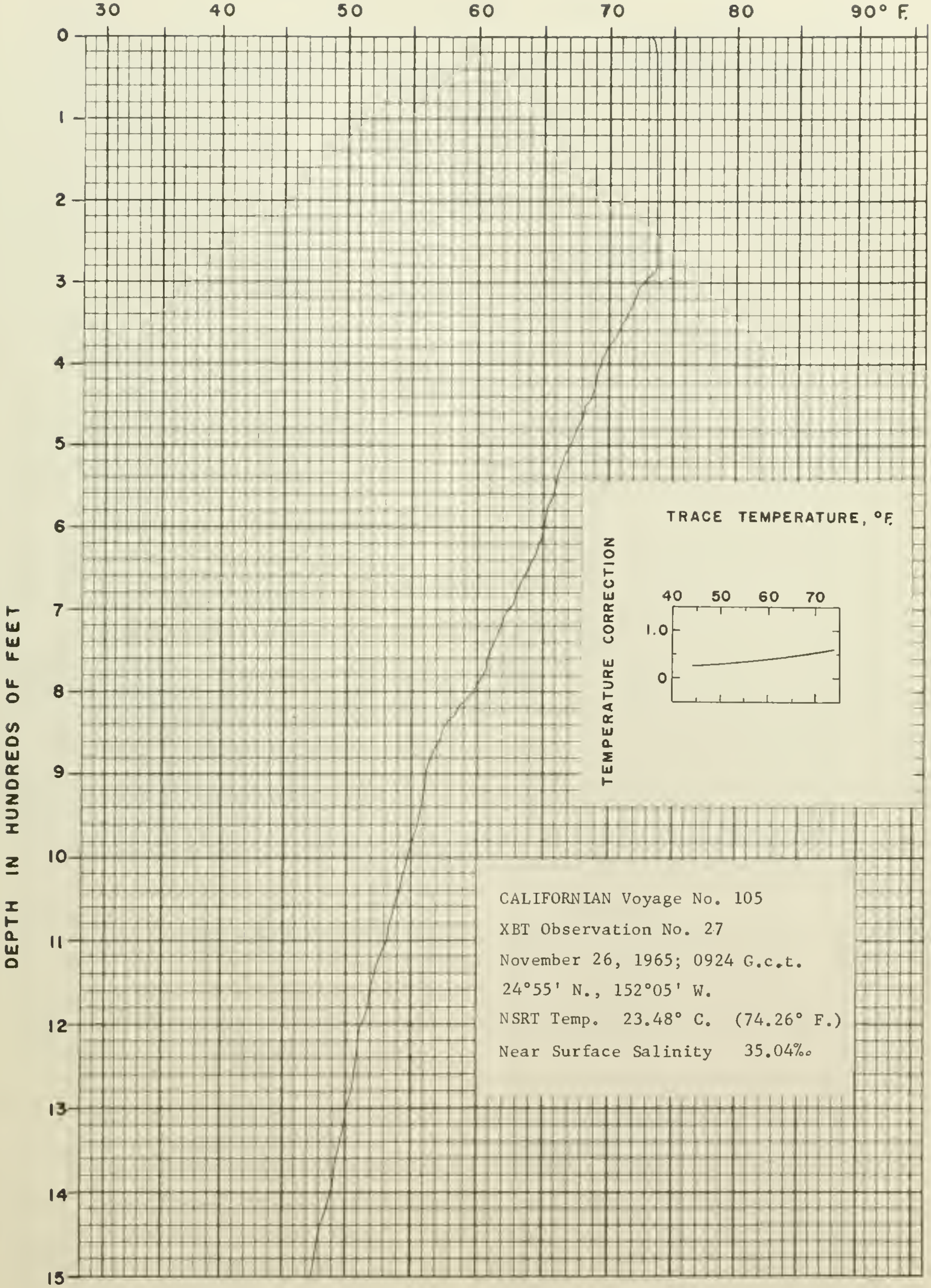
CALIFORNIAN Voyage No. 105
XBT Observation No. 24
November 26, 1965; 0515 G.c.t.
25°31' N., 151°05' W.
NSRT Temp. 23.0° C. (73.40° F.)
Near Surface Salinity 35.17‰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90° F.
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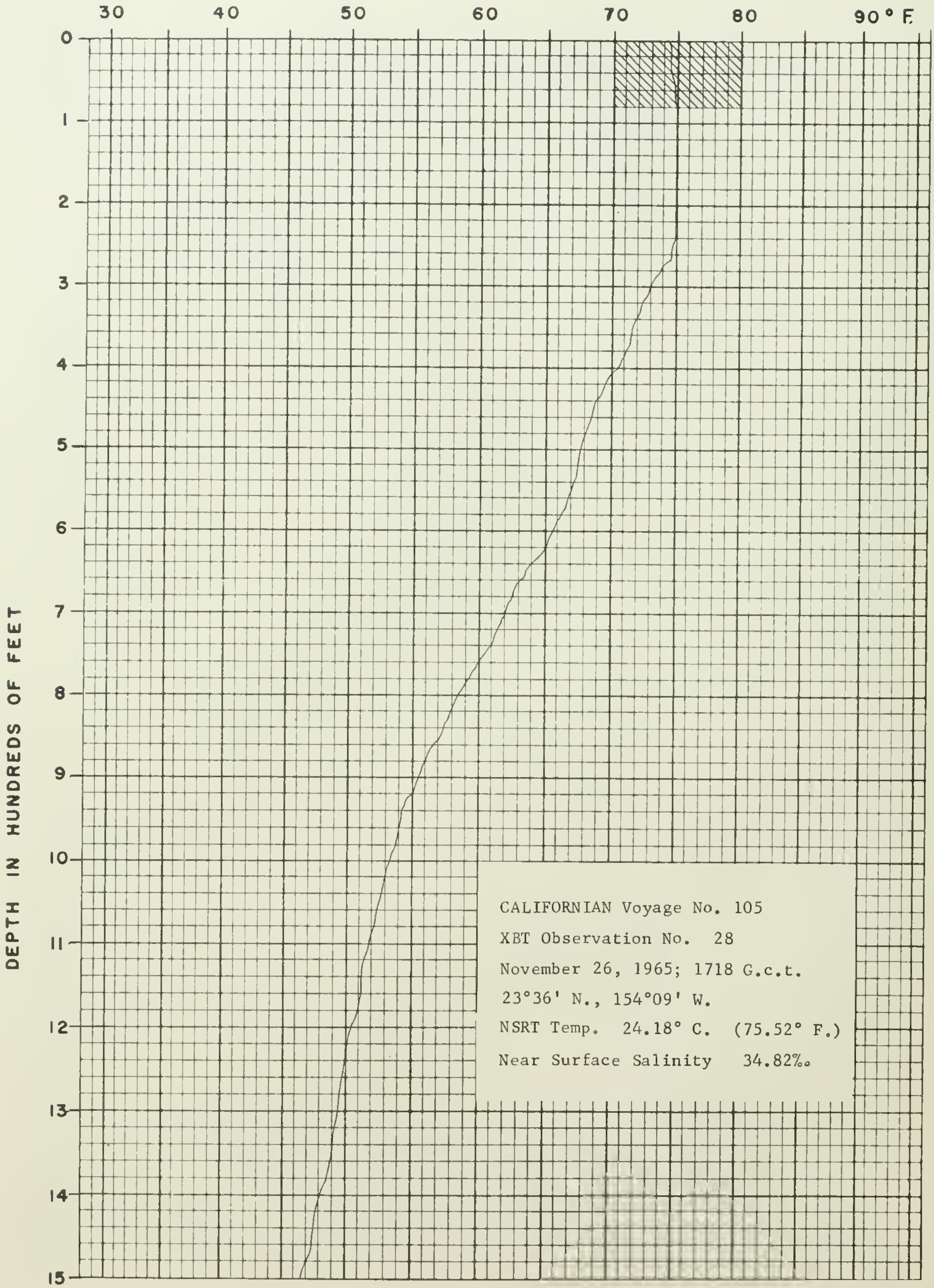
DEPTH IN HUNDREDS OF FEET
TRACE TEMPERATURE, °F.
TEMPERATURE CORRECTION
40 50 60 70
1.0
0
CALIFORNIAN Voyage No. 105
XBT Observation No. 27
November 26, 1965; 0924 G.c.t.
24°55' N., 152°05' W.
NSRT Temp. 23.48° C. (74.26° F.)
Near Surface Salinity 35.04‰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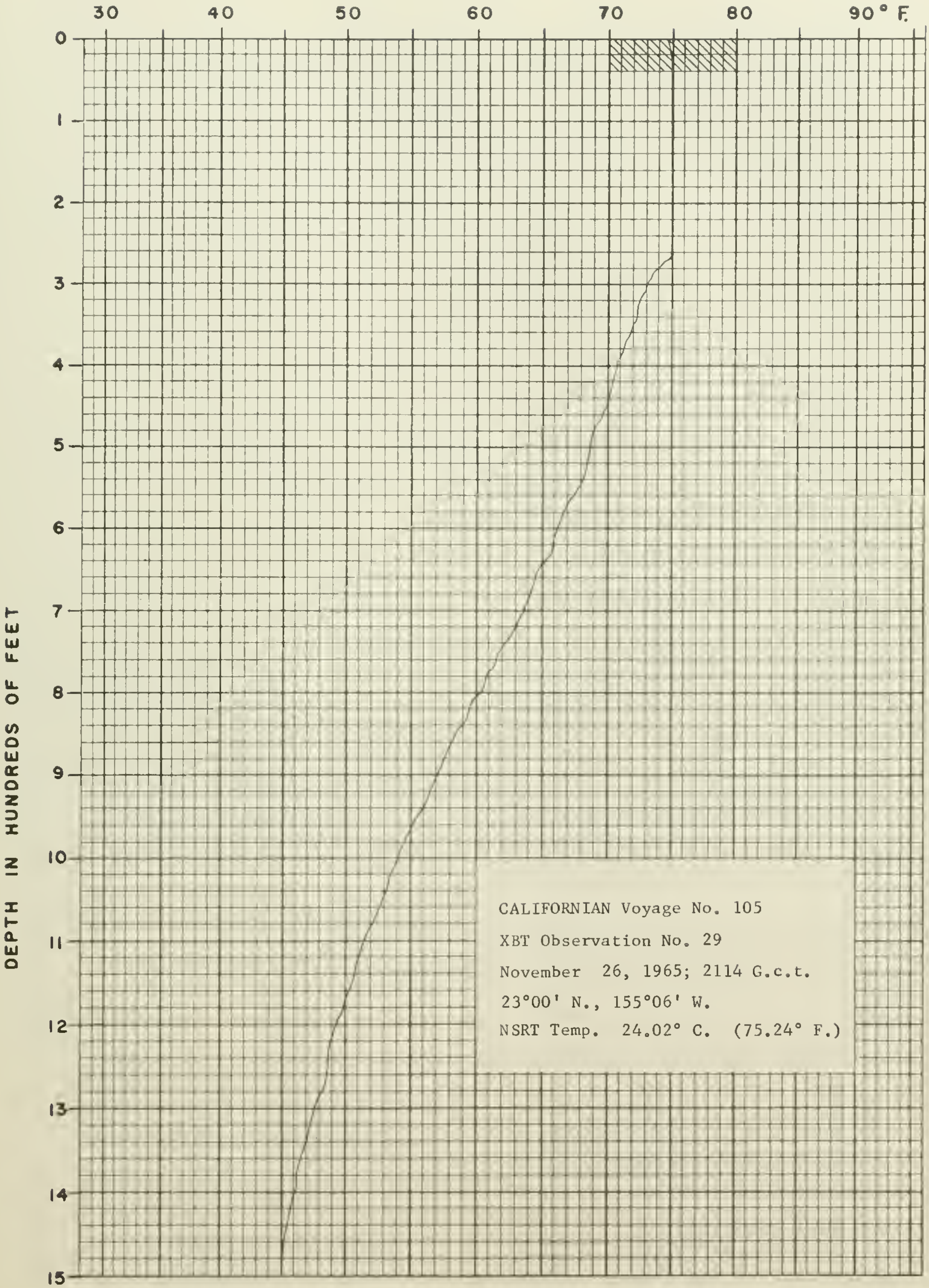
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 28
November 26, 1965; 1718 G.c.t.
23°36' N., 154°09' W.
NSRT Temp. 24.18° C. (75.52° F.)
Near Surface Salinity 34.82‰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90° F.
DEPTH IN HUNDREDS OF FEET
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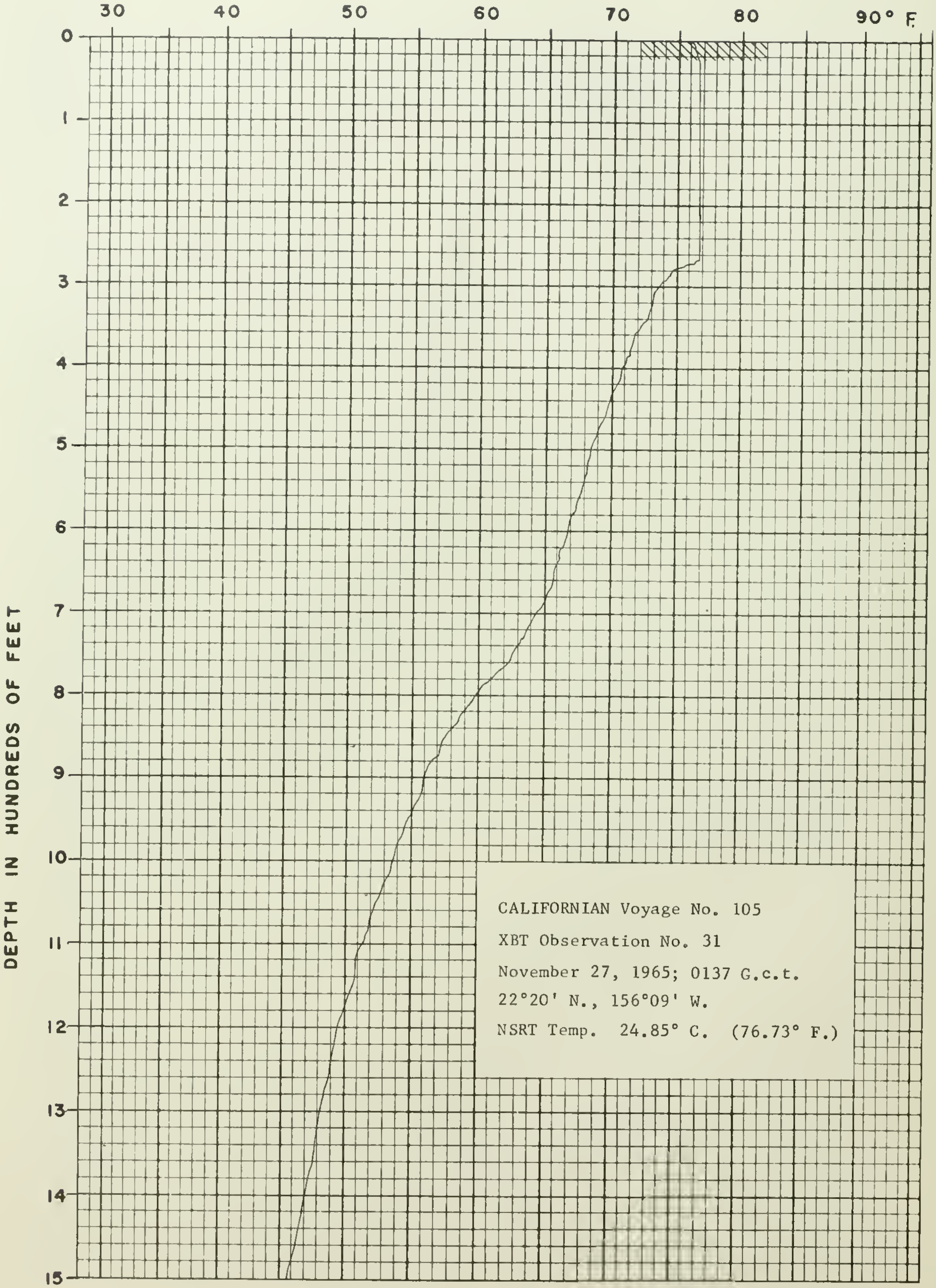
CALIFORNIAN Voyage No. 105
XBT Observation No. 29
November 26, 1965; 2114 G.c.t.
23°00' N., 155°06' W.
NSRT Temp. 24.02° C. (75.24° F.)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90° F
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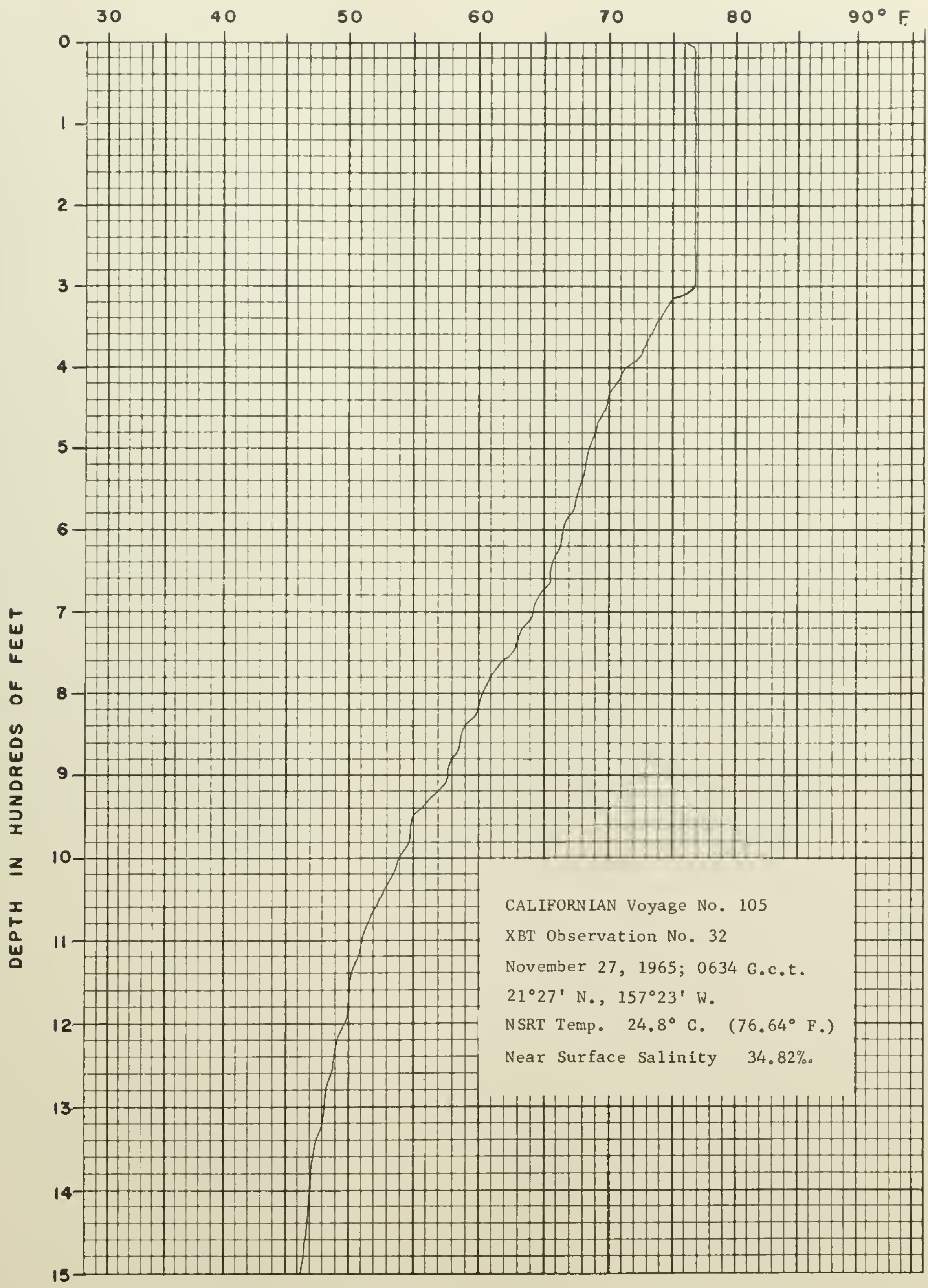
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 31
November 27, 1965; 0137 G.c.t.
22°20' N., 156°09' W.
NSRT Temp. 24.85° C. (76.73° F.)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90° F
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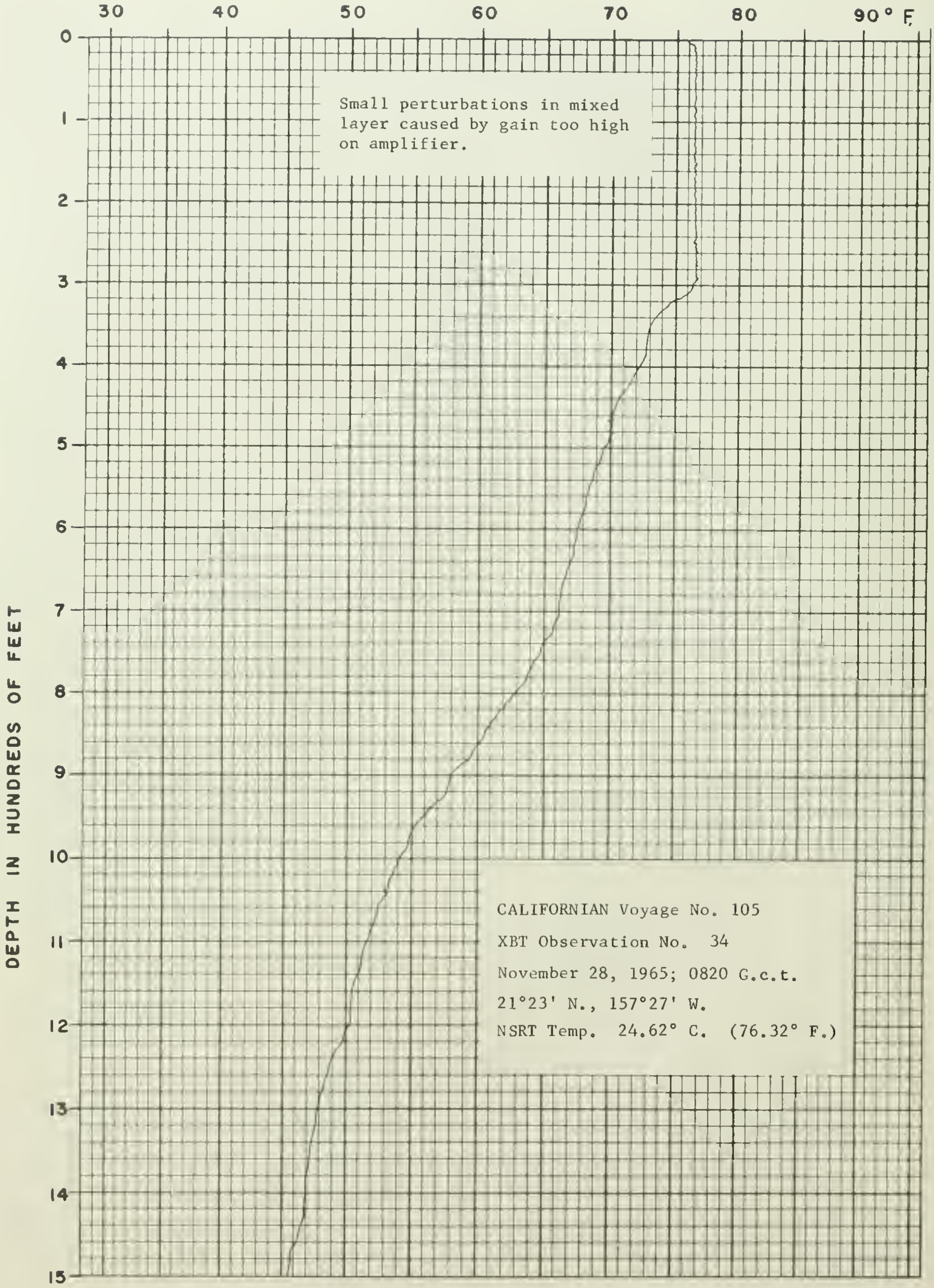
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 32
November 27, 1965; 0634 G.c.t.
21°27' N., 157°23' W.
NSRT Temp. 24.8° C. (76.64° F.)
Near Surface Salinity 34.82‰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90° F
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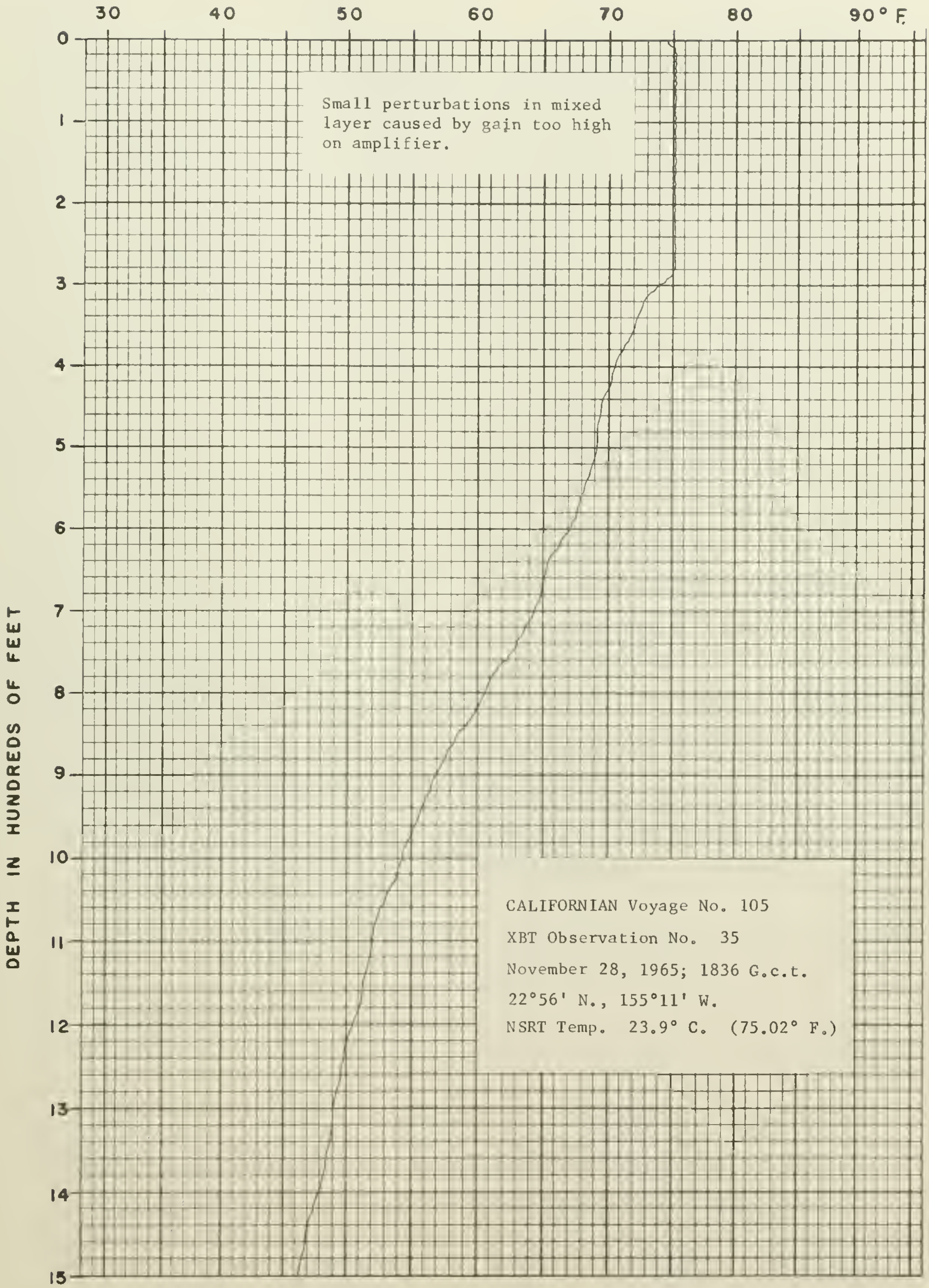
DEPTH IN HUNDREDS OF FEET
Small perturbations in mixed layer caused by gain too high on amplifier.
CALIFORNIAN Voyage No. 105
XBT Observation No. 34
November 28, 1965; 0820 G.c.t.
21°23' N., 157°27' W.
NSRT Temp. 24.62° C. (76.32° F.)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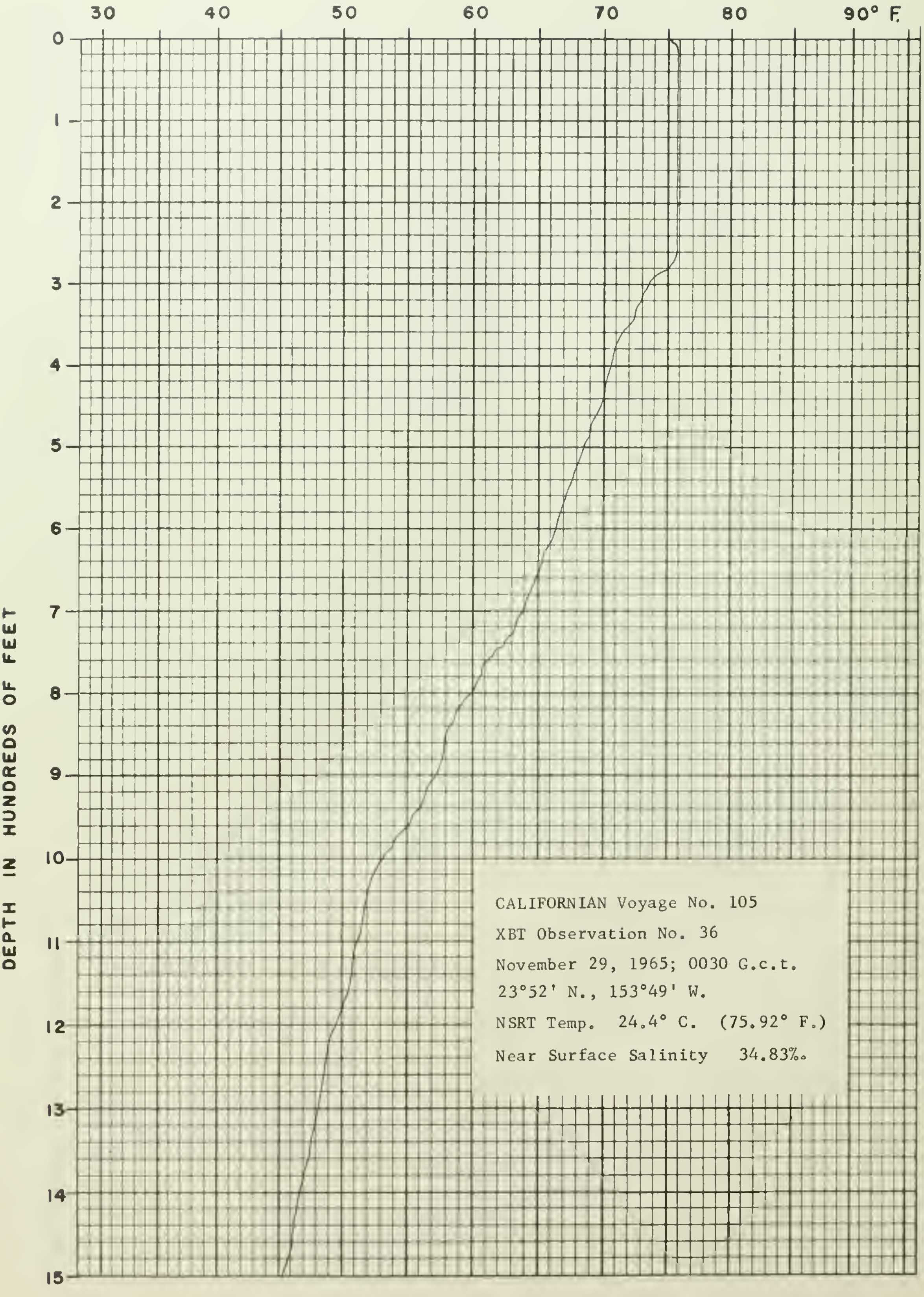
DEPTH IN HUNDREDS OF FEET
Small perturbations in mixed layer caused by gain too high on amplifier.
CALIFORNIAN Voyage No. 105
XBT Observation No. 35
November 28, 1965; 1836 G.c.t.
22°56' N., 155°11' W.
NSRT Temp. 23.9° C. (75.02° F.)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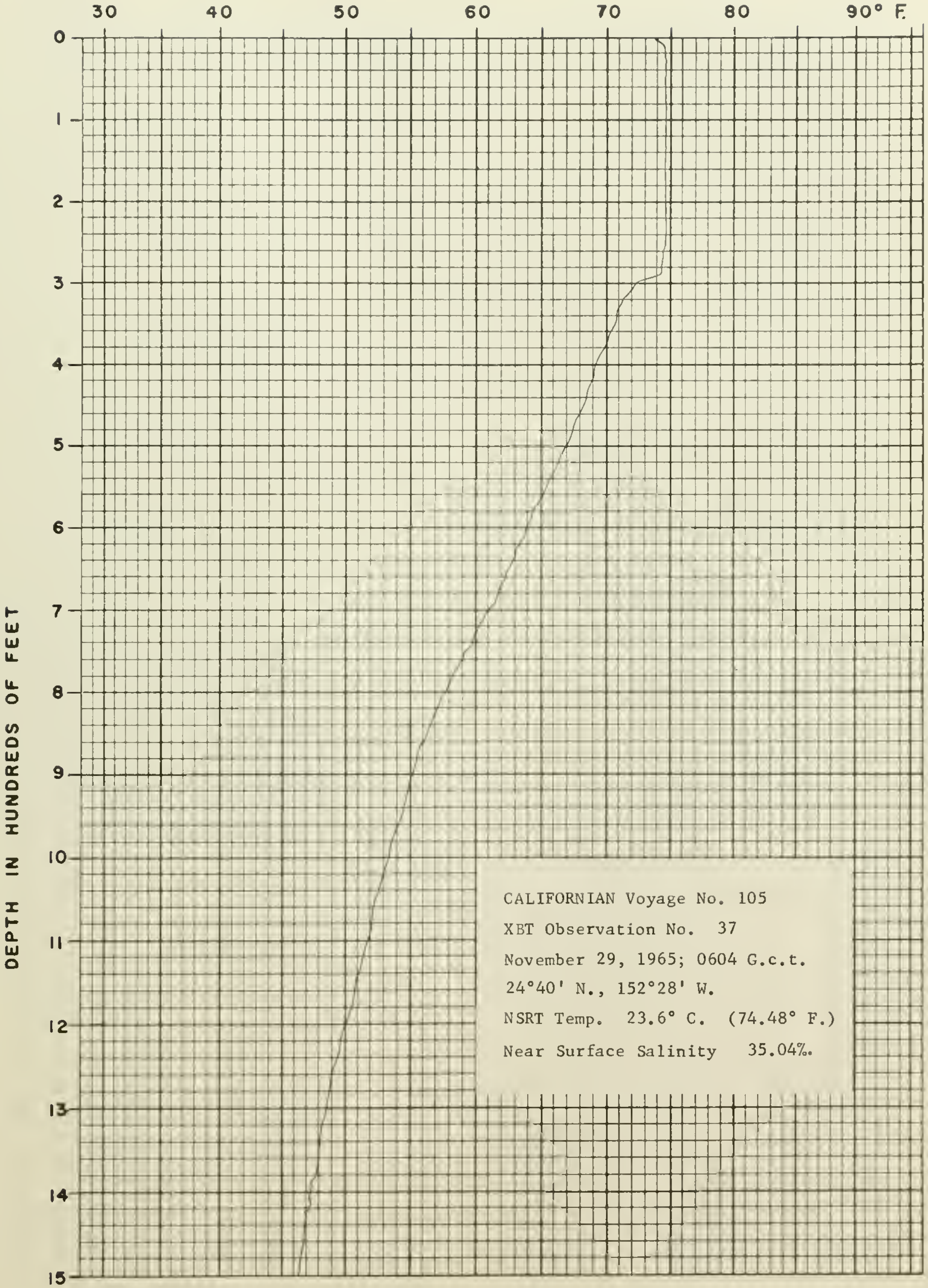
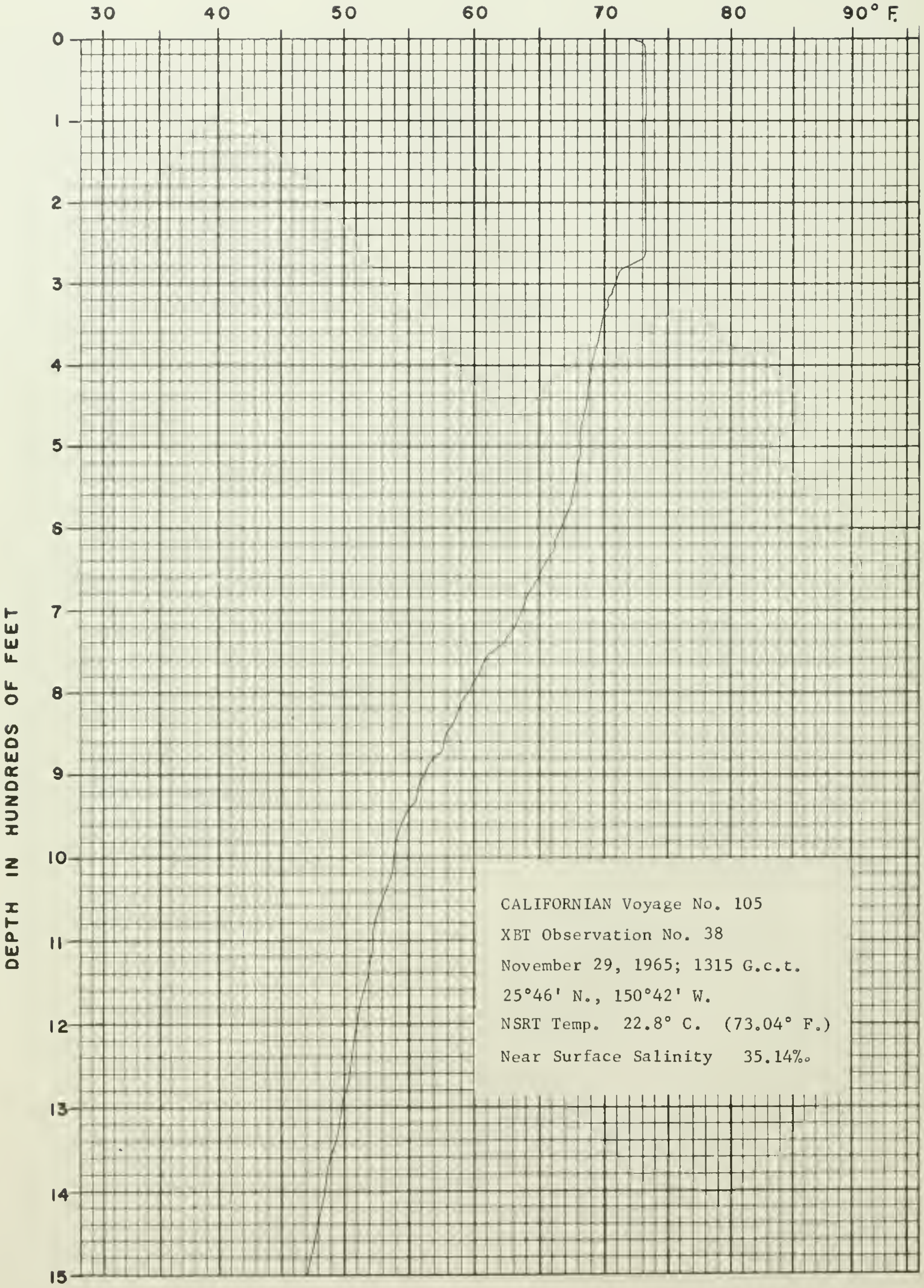
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 36
November 29, 1965; 0030 G.c.t.
23°52' N., 153°49' W.
NSRT Temp. 24.4° C. (75.92° F.)
Near Surface Salinity 34.83‰



CALIFORNIAN Voyage No. 105
XBT Observation No. 37
November 29, 1965; 0604 G.c.t.
24°40' N., 152°28' W.
NSRT Temp. 23.6° C. (74.48° F.)
Near Surface Salinity 35.04‰.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90° F.
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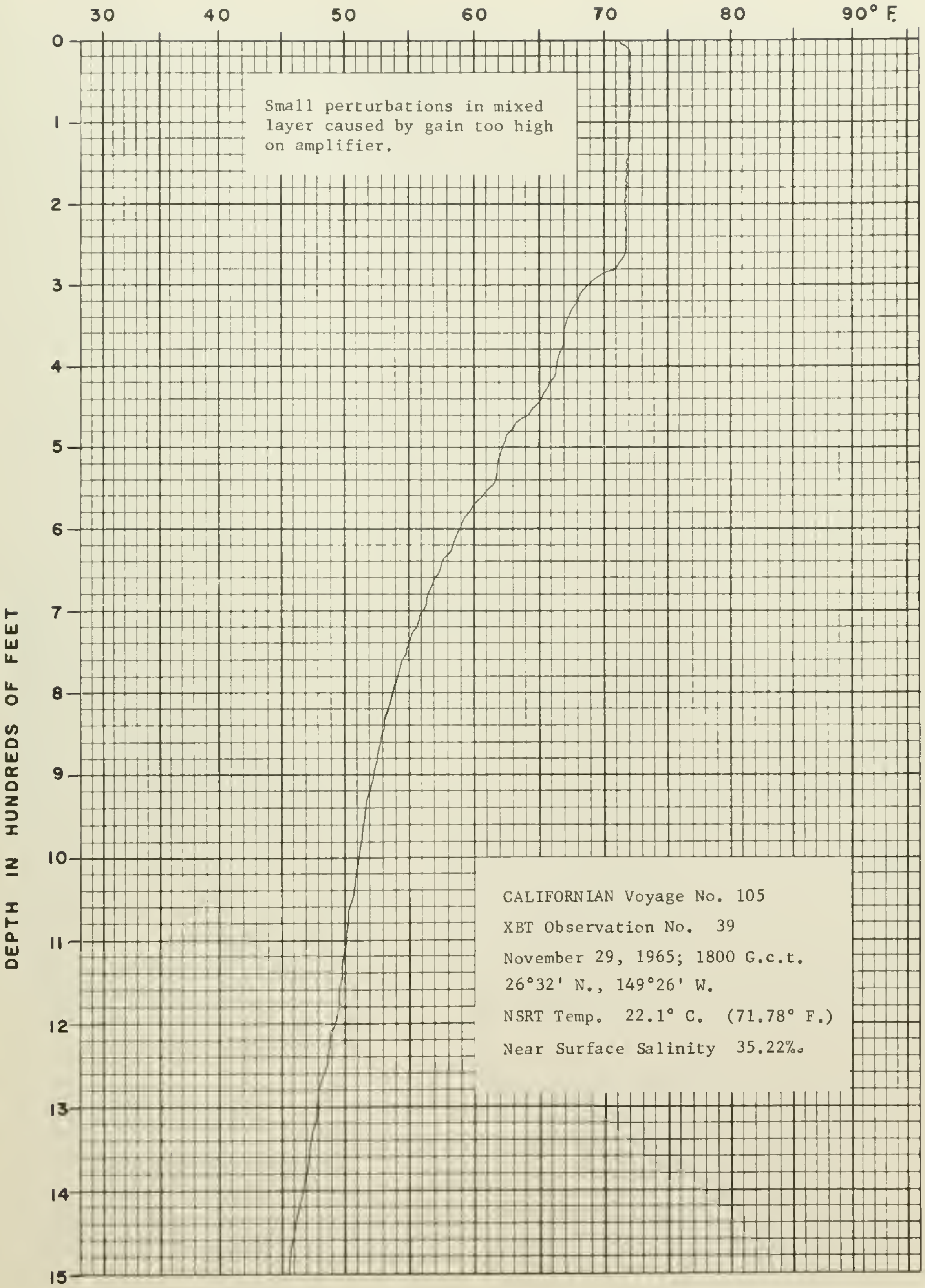
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 38
November 29, 1965; 1315 G.c.t.
25°46' N., 150°42' W.
NSRT Temp. 22.8° C. (73.04° F.)
Near Surface Salinity 35.14‰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90° F.
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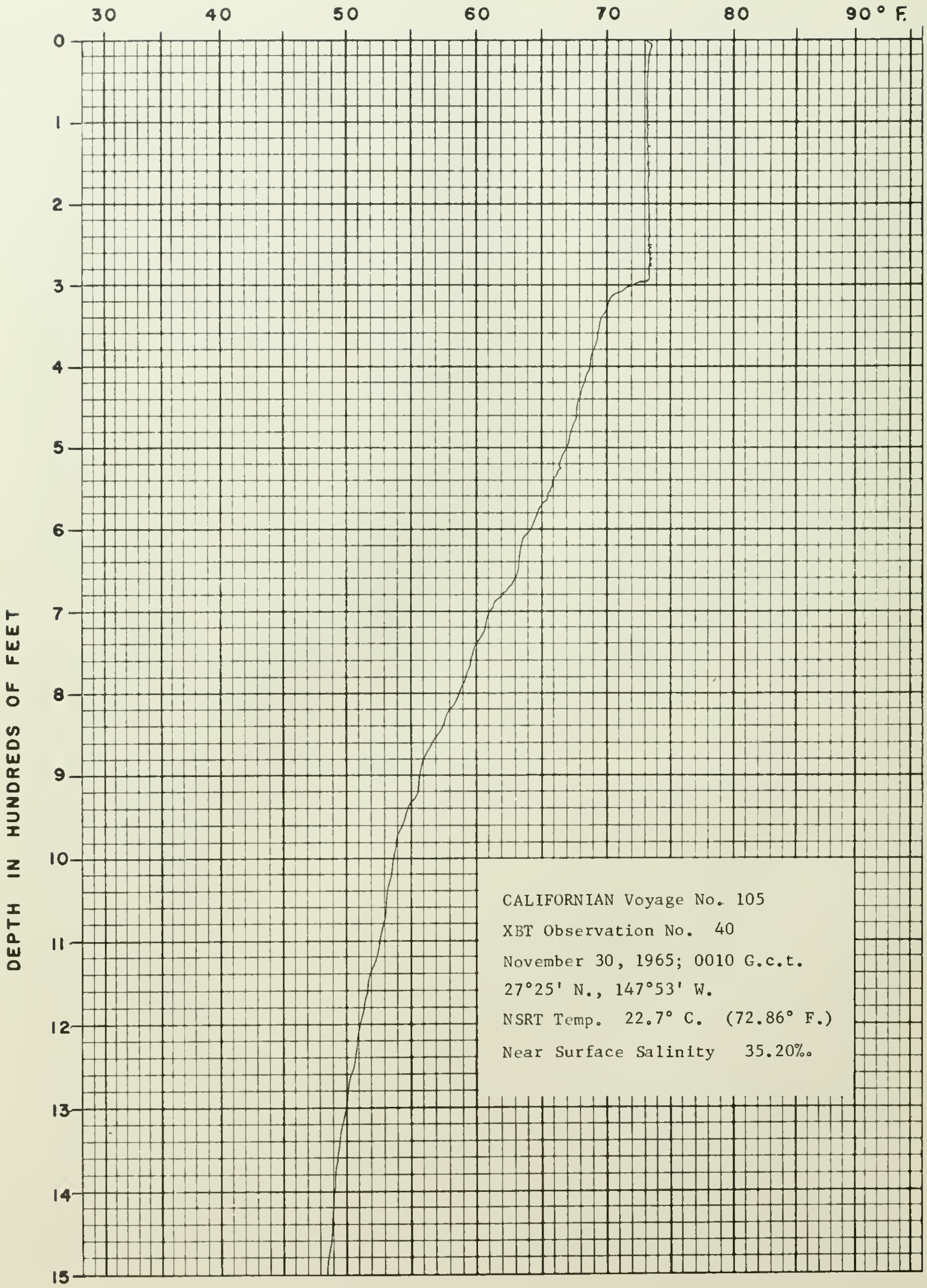
DEPTH IN HUNDREDS OF FEET
Small perturbations in mixed layer caused by gain too high on amplifier.
CALIFORNIAN Voyage No. 105
XBT Observation No. 39
November 29, 1965; 1800 G.c.t.
26°32' N., 149°26' W.
NSRT Temp. 22.1° C. (71.78° F.)
Near Surface Salinity 35.22‰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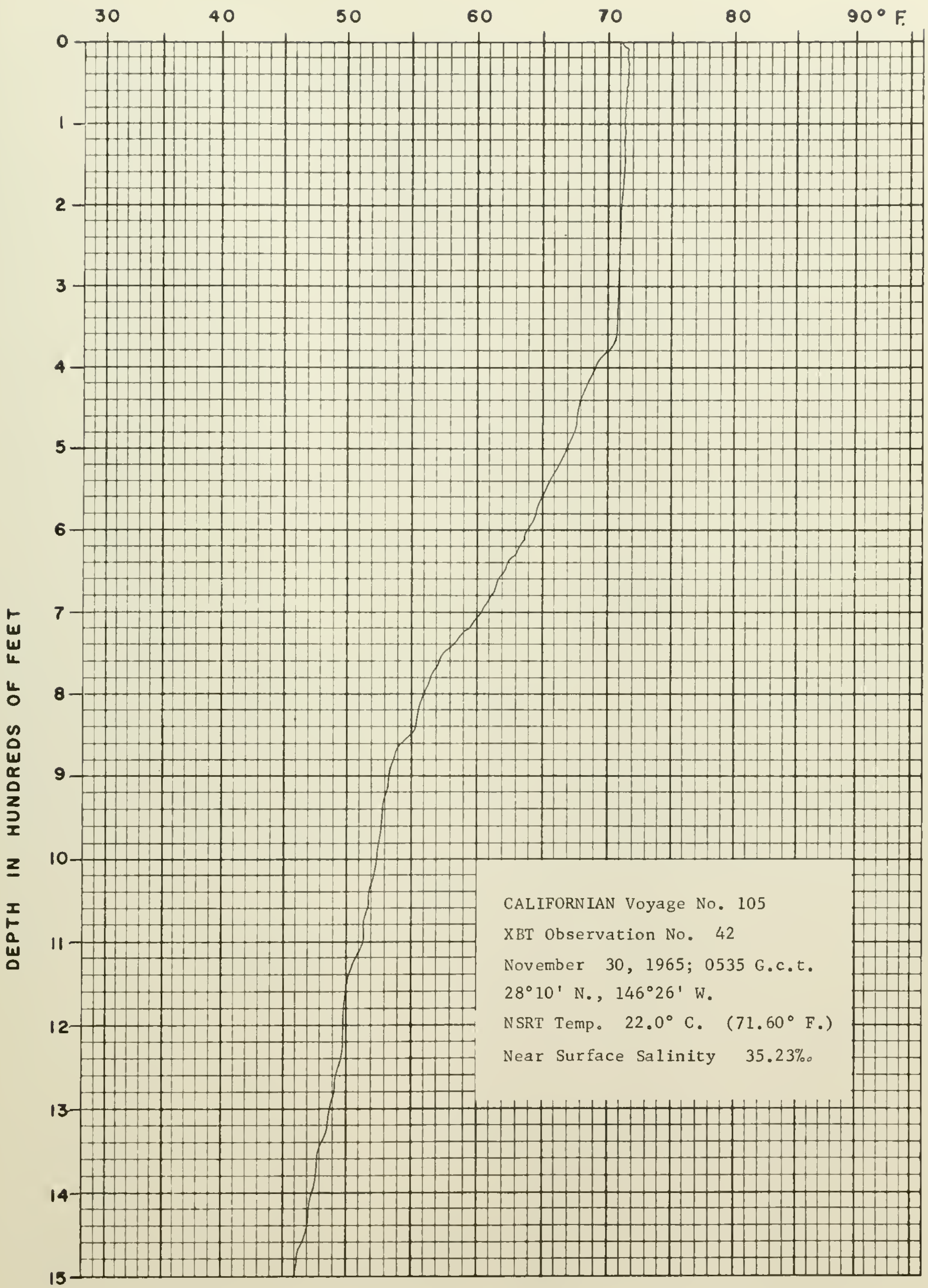
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 40
November 30, 1965; 0010 G.c.t.
27°25' N., 147°53' W.
NSRT Temp. 22.7° C. (72.86° F.)
Near Surface Salinity 35.20‰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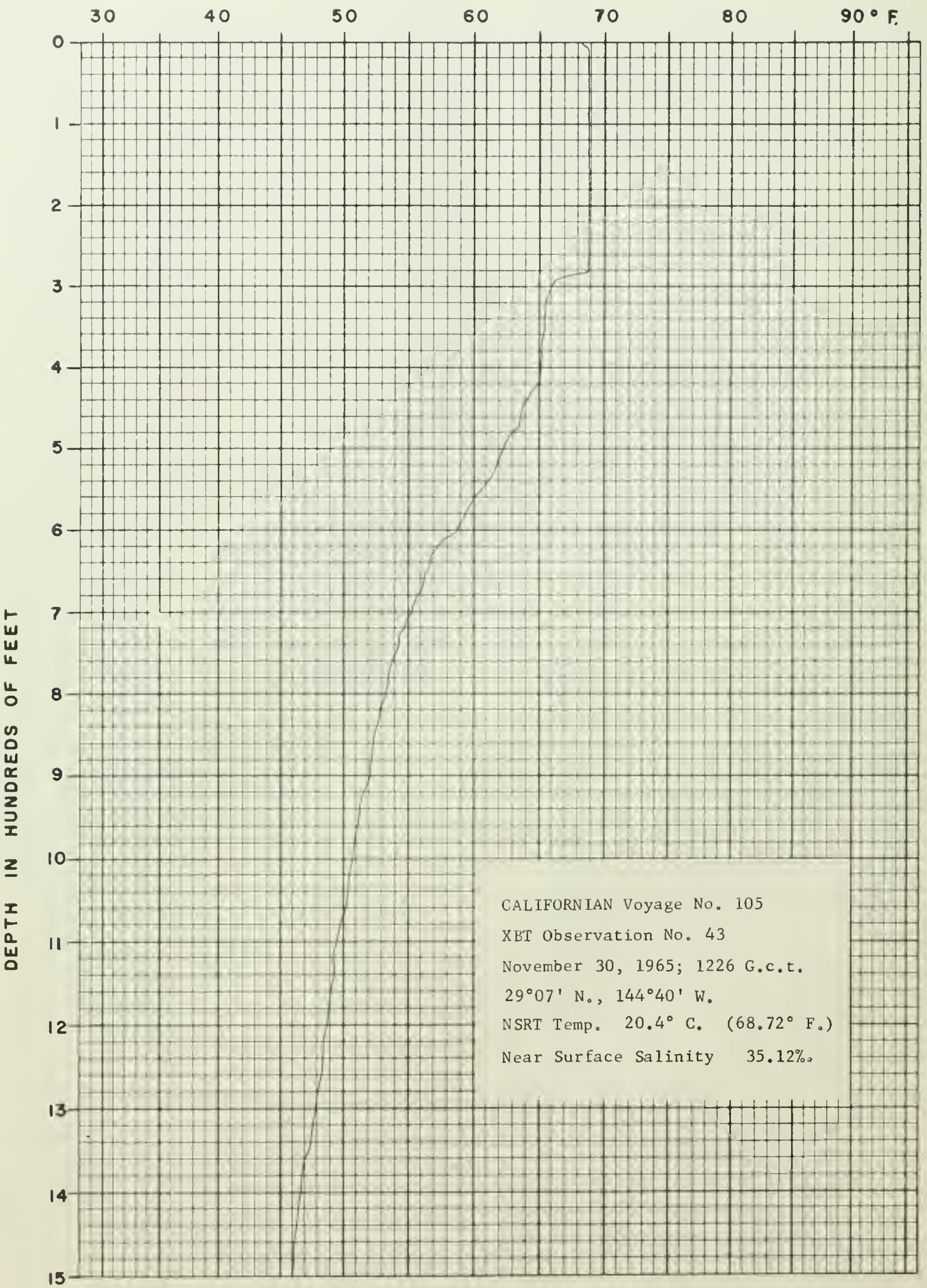
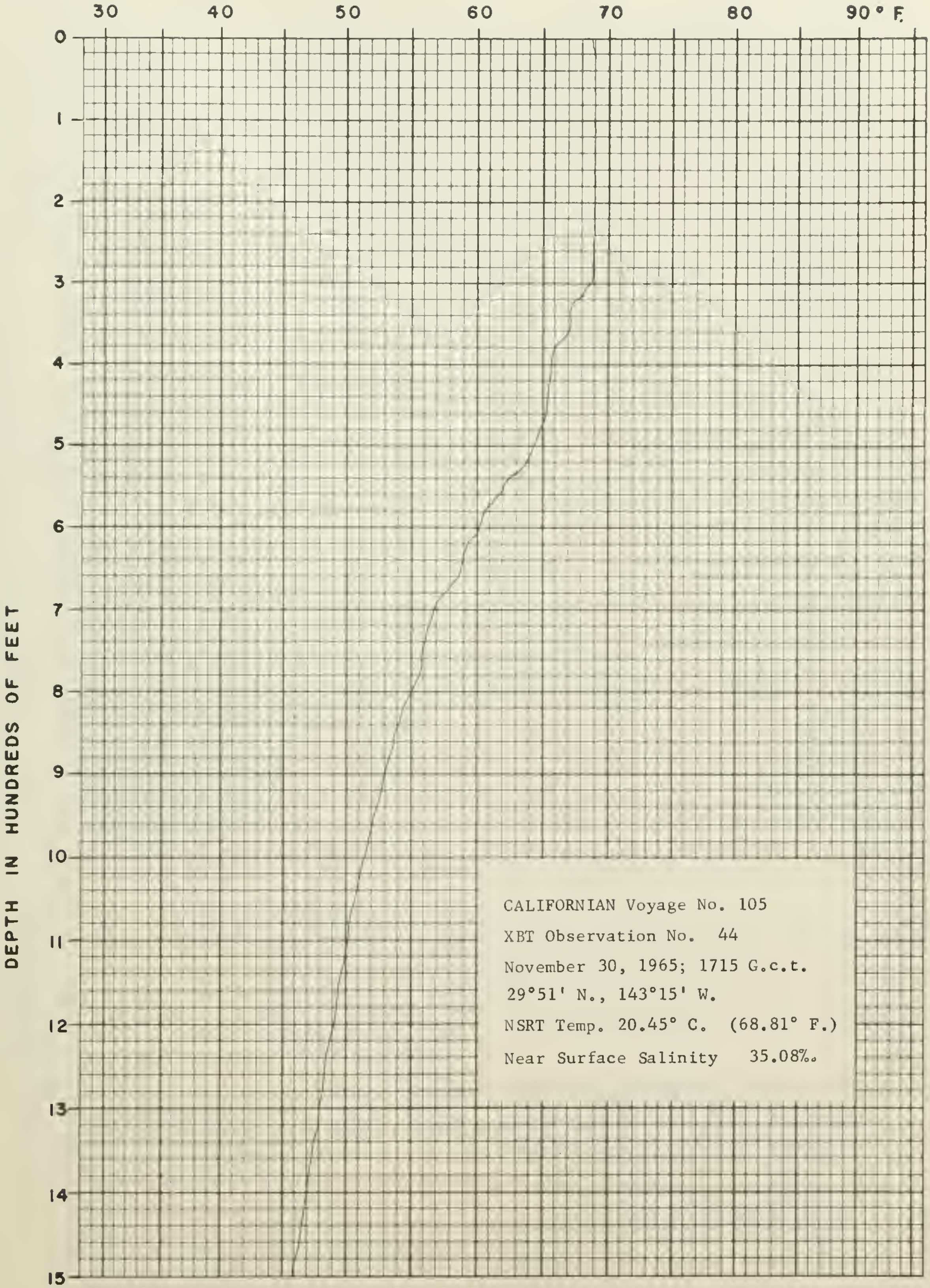
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 42
November 30, 1965; 0535 G.c.t.
28°10' N., 146°26' W.
NSRT Temp. 22.0° C. (71.60° F.)
Near Surface Salinity 35.23‰


30 40 50 60 70 80 90° F.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 43
November 30, 1965; 1226 G.c.t.
29°07' N., 144°40' W.
NSRT Temp. 20.4° C. (68.72° F.)
Near Surface Salinity 35.12‰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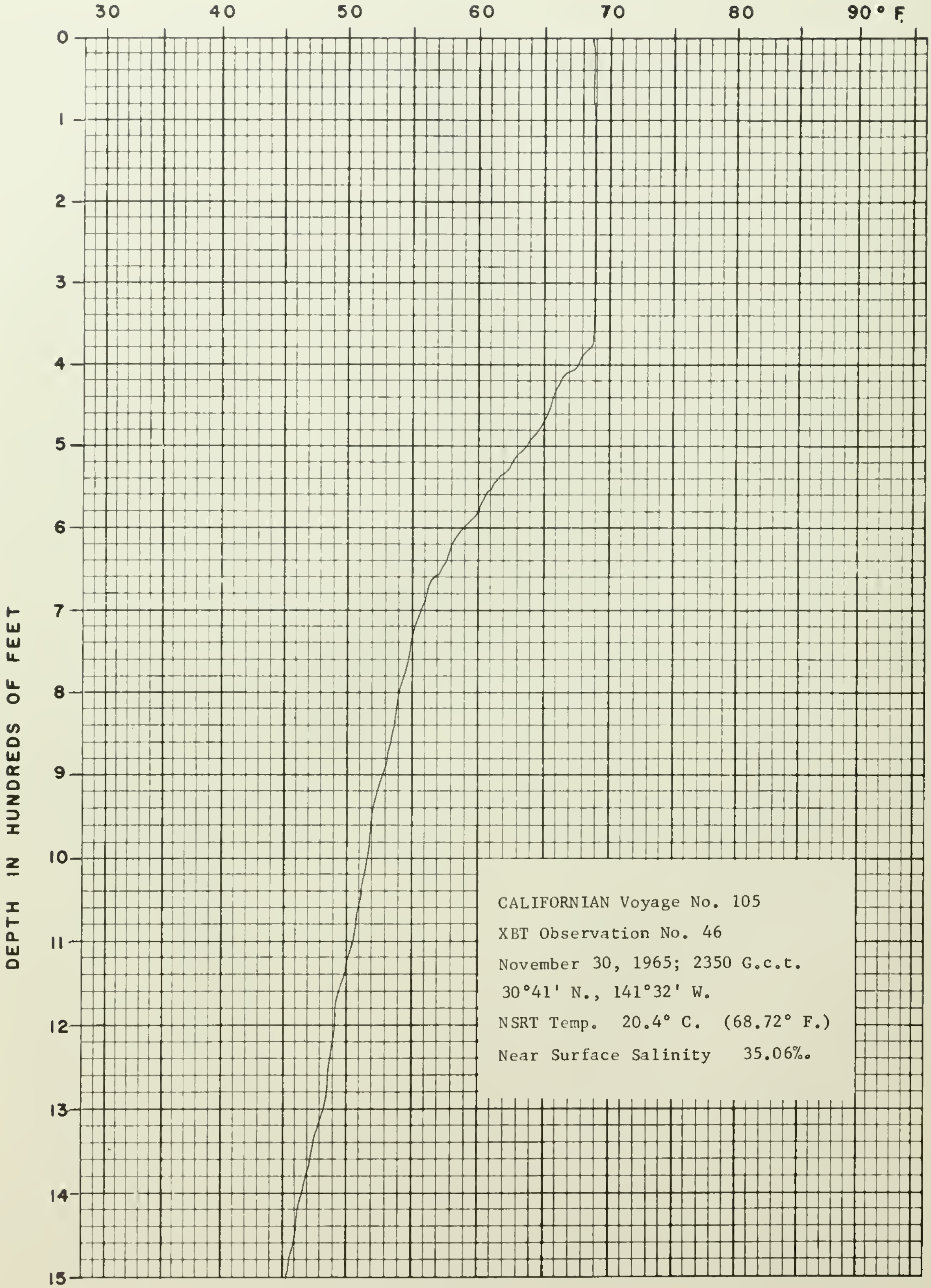
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 44
November 30, 1965; 1715 G.c.t.
29°51' N., 143°15' W.
NSRT Temp. 20.45° C. (68.81° F.)
Near Surface Salinity 35.08‰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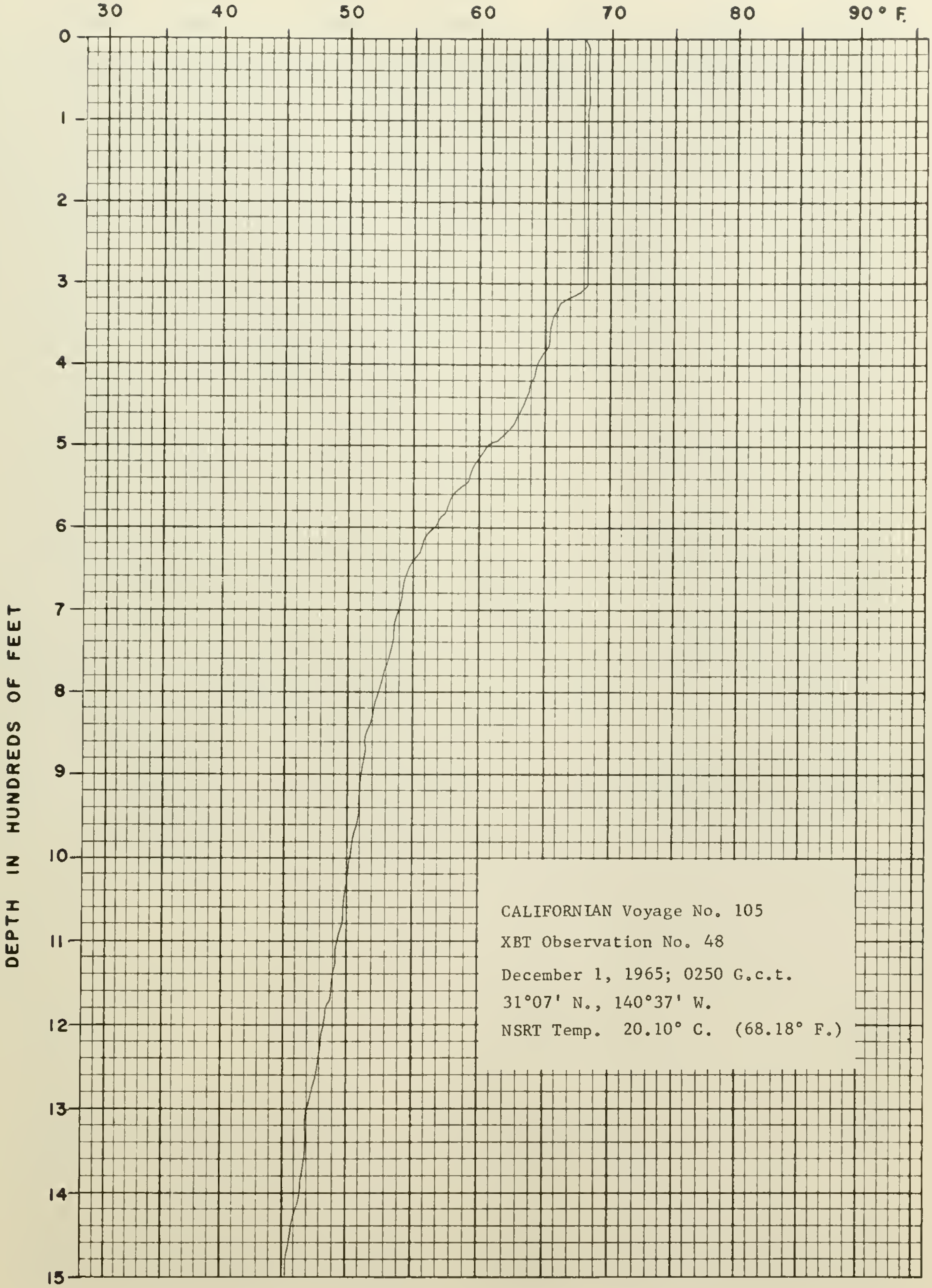
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 46
November 30, 1965; 2350 G.c.t.
30°41' N., 141°32' W.
NSRT Temp. 20.4° C. (68.72° F.)
Near Surface Salinity 35.06‰.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90° F.
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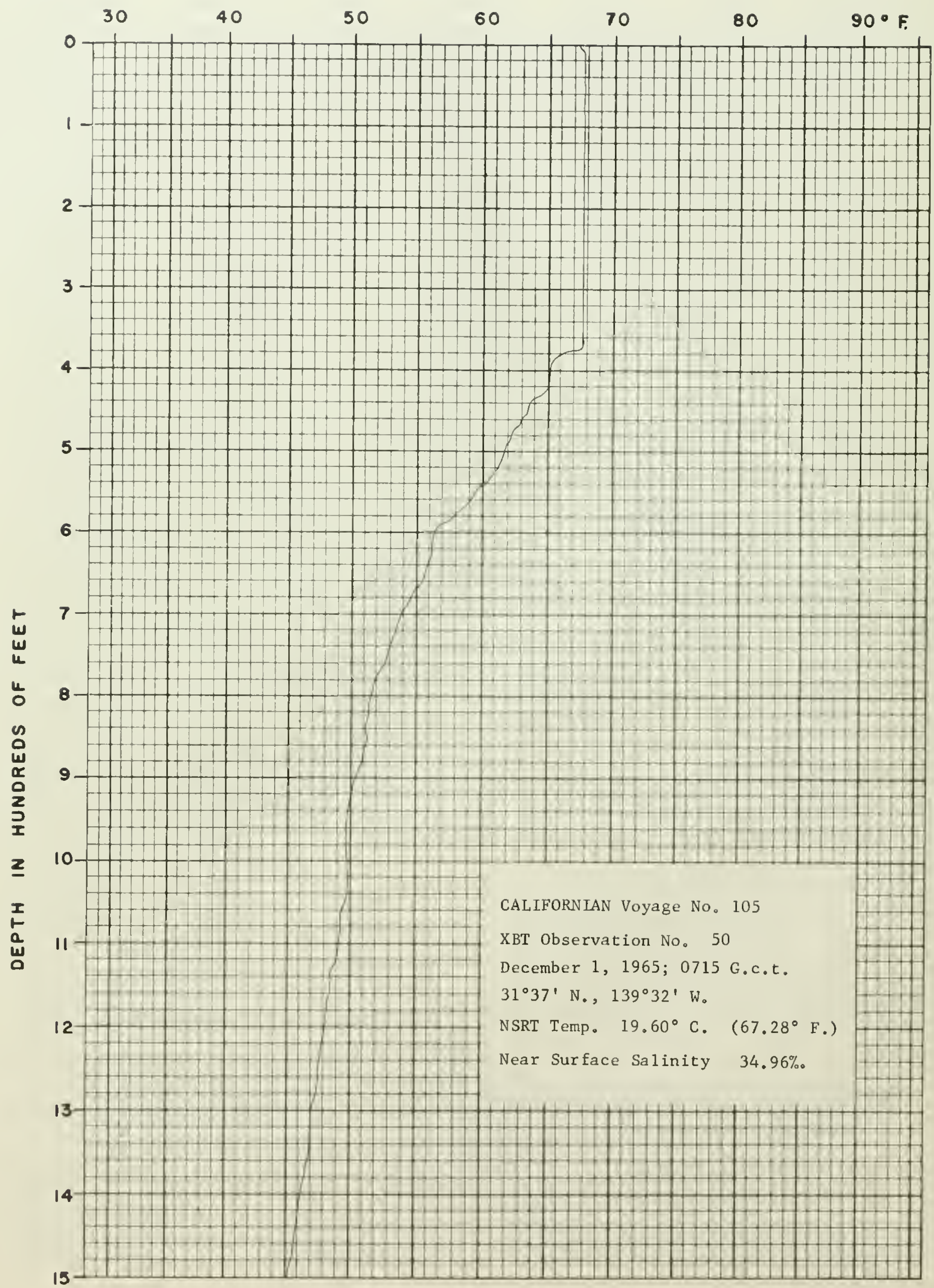
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 48
December 1, 1965; 0250 G.c.t.
31°07' N., 140°37' W.
NSRT Temp. 20.10° C. (68.18° F.)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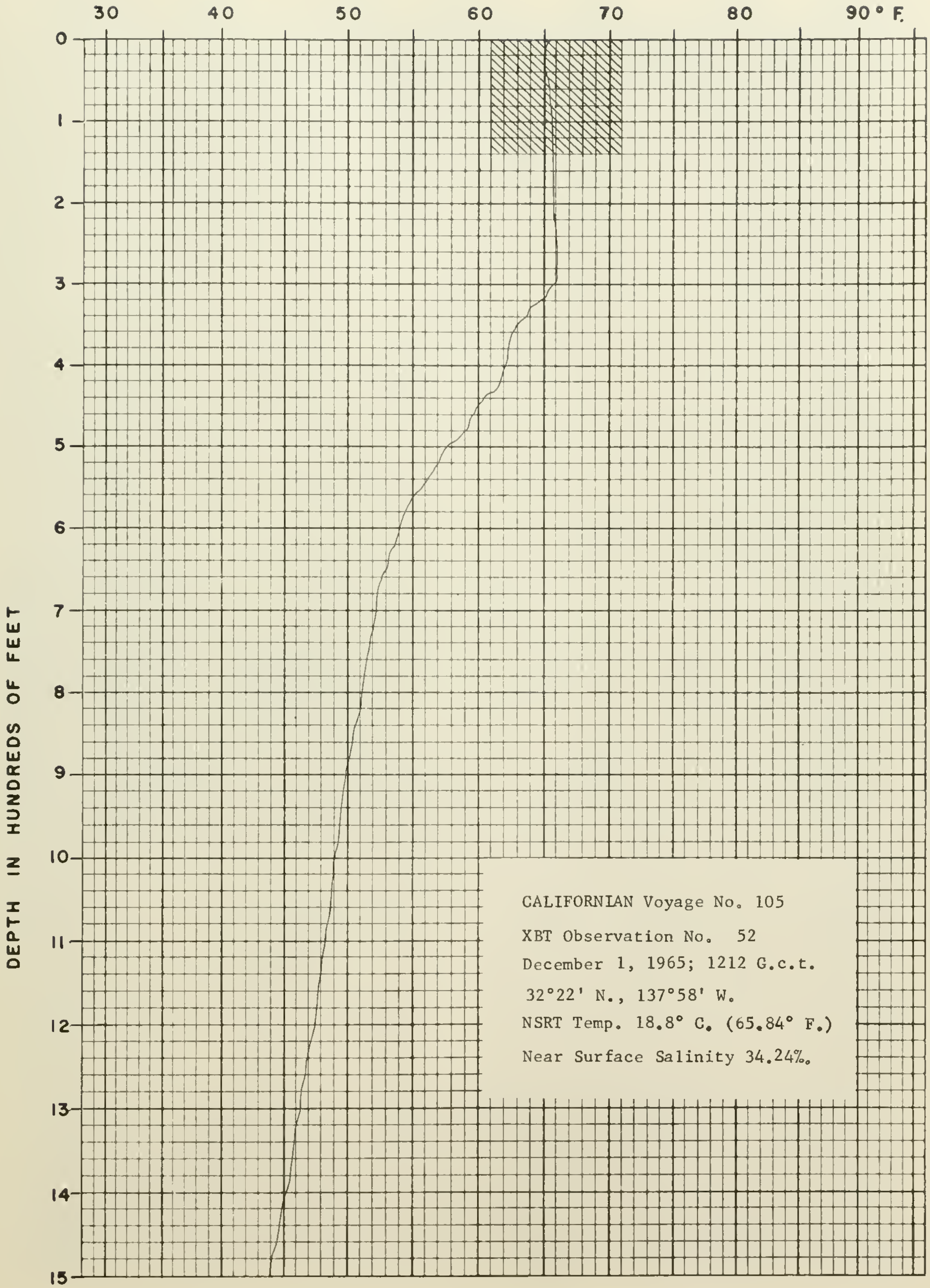
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 50
December 1, 1965; 0715 G.c.t.
31°37' N., 139°32' W.
NSRT Temp. 19.60° C. (67.28° F.)
Near Surface Salinity 34.96‰.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90° F.
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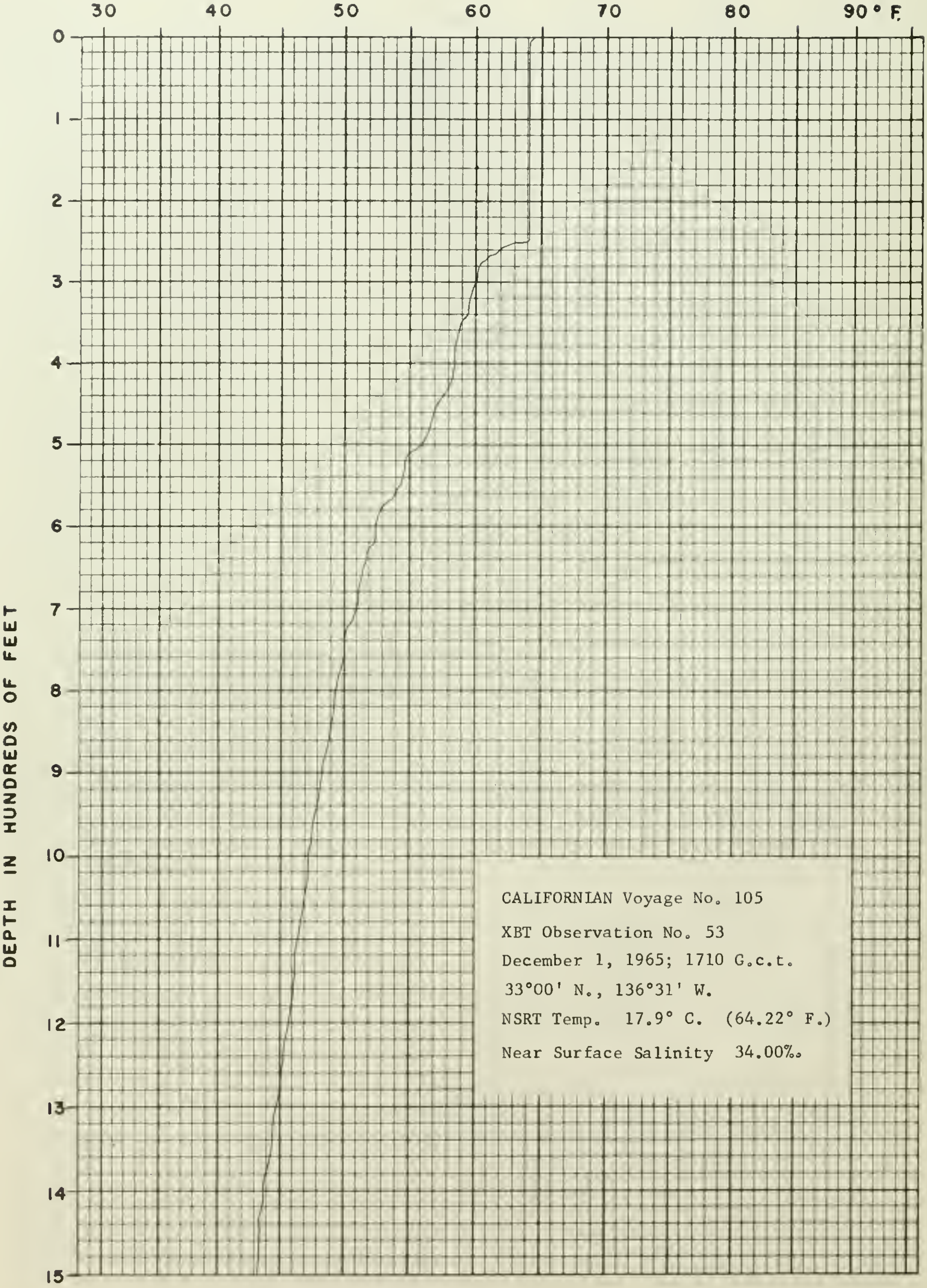
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 52
December 1, 1965; 1212 G.c.t.
32°22' N., 137°58' W.
NSRT Temp. 18.8° C. (65.84° F.)
Near Surface Salinity 34.24‰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90 ° F
DEPTH IN HUNDREDS OF FEET
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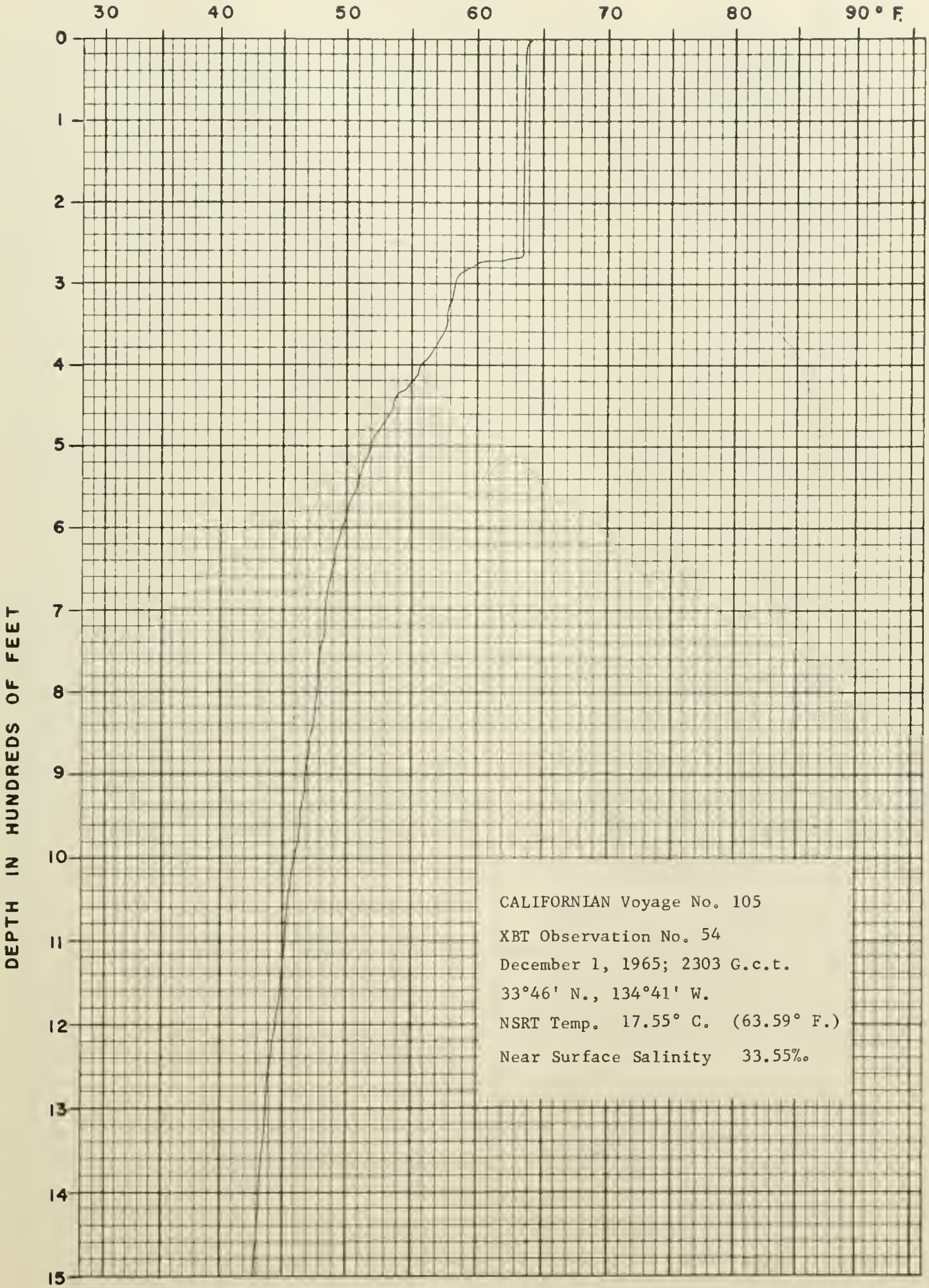
CALIFORNIAN Voyage No. 105
XBT Observation No. 53
December 1, 1965; 1710 G.c.t.
33°00' N., 136°31' W.
NSRT Temp. 17.9° C. (64.22° F.)
Near Surface Salinity 34.00‰.



CALIFORNIAN Voyage No. 105

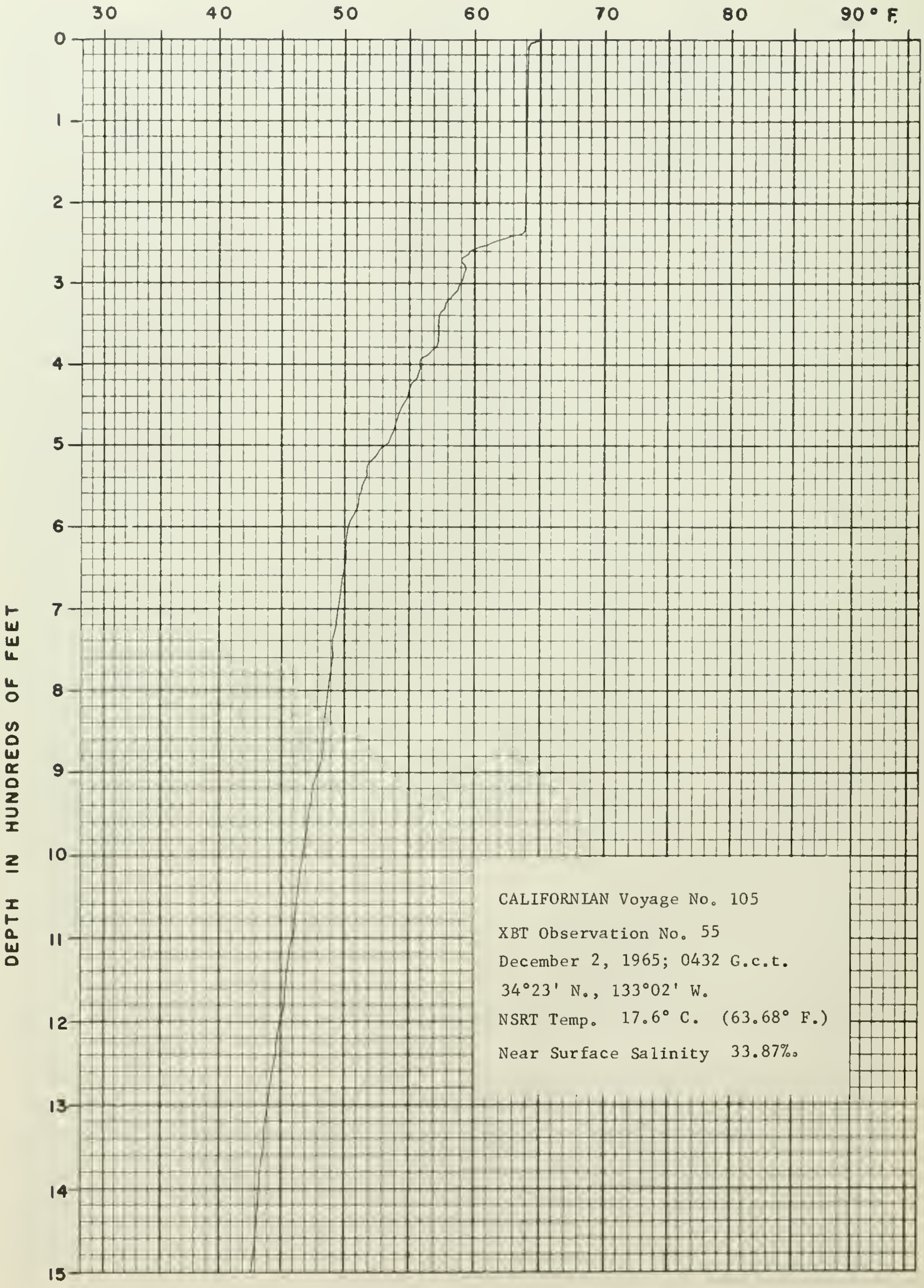
XBT Observation No. 54

December 1, 1965; 2303 G.c.t.

33°46' N., 134°41' W.

NSRT Temp. 17.55° C. (63.59° F.)

Near Surface Salinity 33.55‰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90° F.
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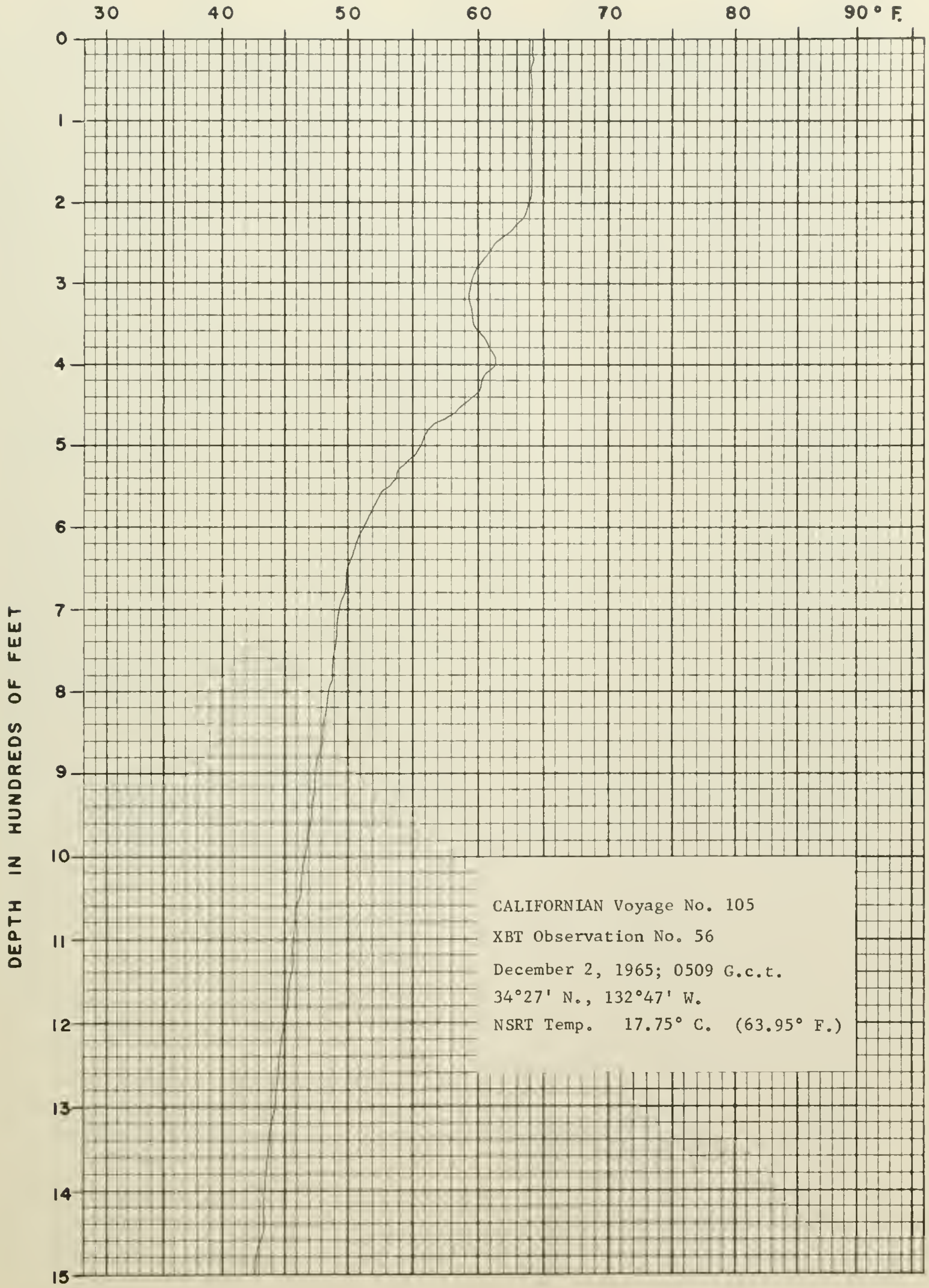
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 55
December 2, 1965; 0432 G.c.t.
34°23' N., 133°02' W.
NSRT Temp. 17.6° C. (63.68° F.)
Near Surface Salinity 33.87‰



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90° F.
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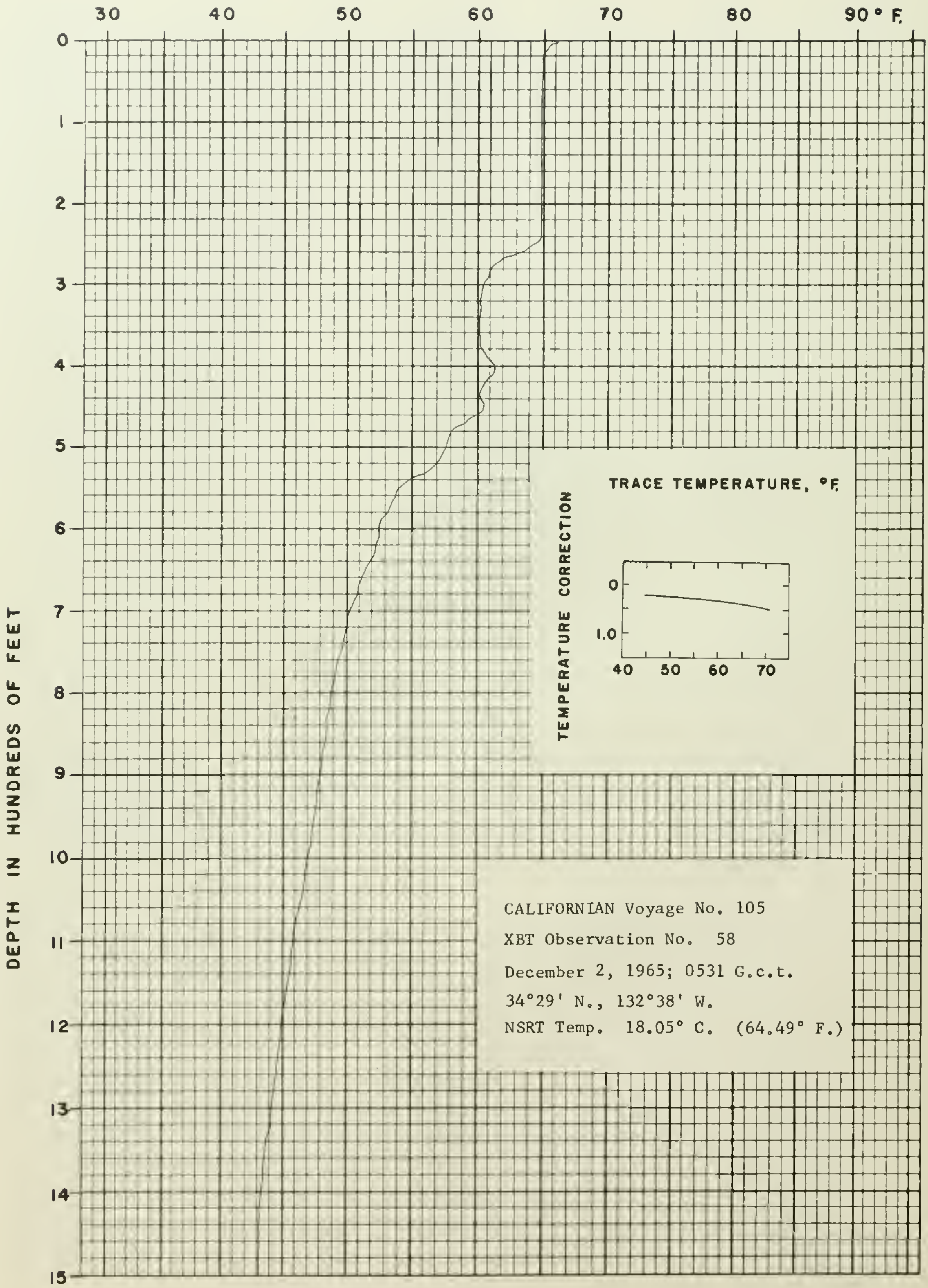
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 56
December 2, 1965; 0509 G.c.t.
34°27' N., 132°47' W.
NSRT Temp. 17.75° C. (63.95° F.)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90° F.
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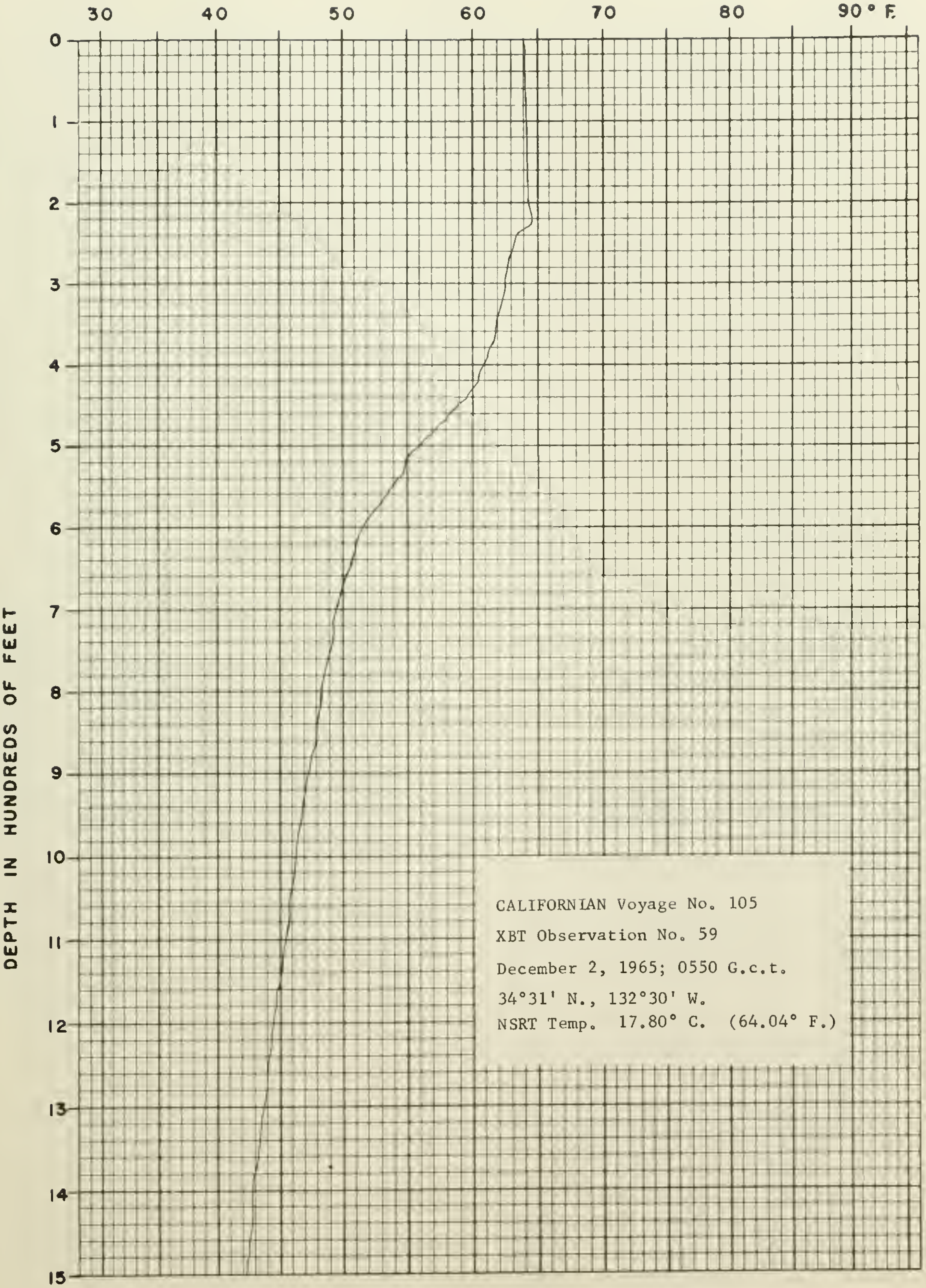
DEPTH IN HUNDREDS OF FEET
TRACE TEMPERATURE, °F.
TEMPERATURE CORRECTION
0
1.0
40
50
60
70
CALIFORNIAN Voyage No. 105
XBT Observation No. 58
December 2, 1965; 0531 G.c.t.
34°29' N., 132°38' W.
NSRT Temp. 18.05° C. (64.49° F.)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90° F.
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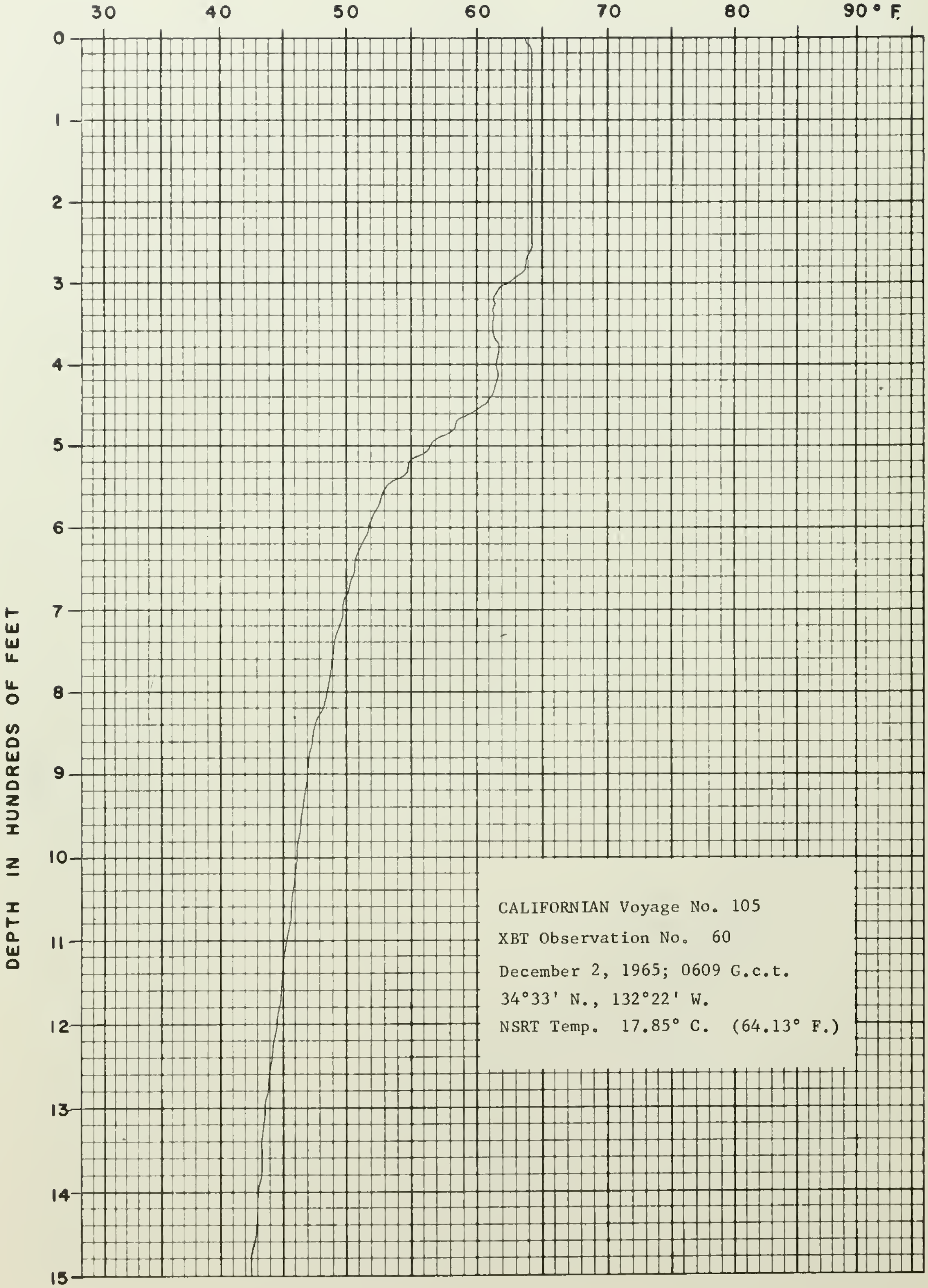
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 59
December 2, 1965; 0550 G.c.t.
34°31' N., 132°30' W.
NSRT Temp. 17.80° C. (64.04° F.)



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90° F
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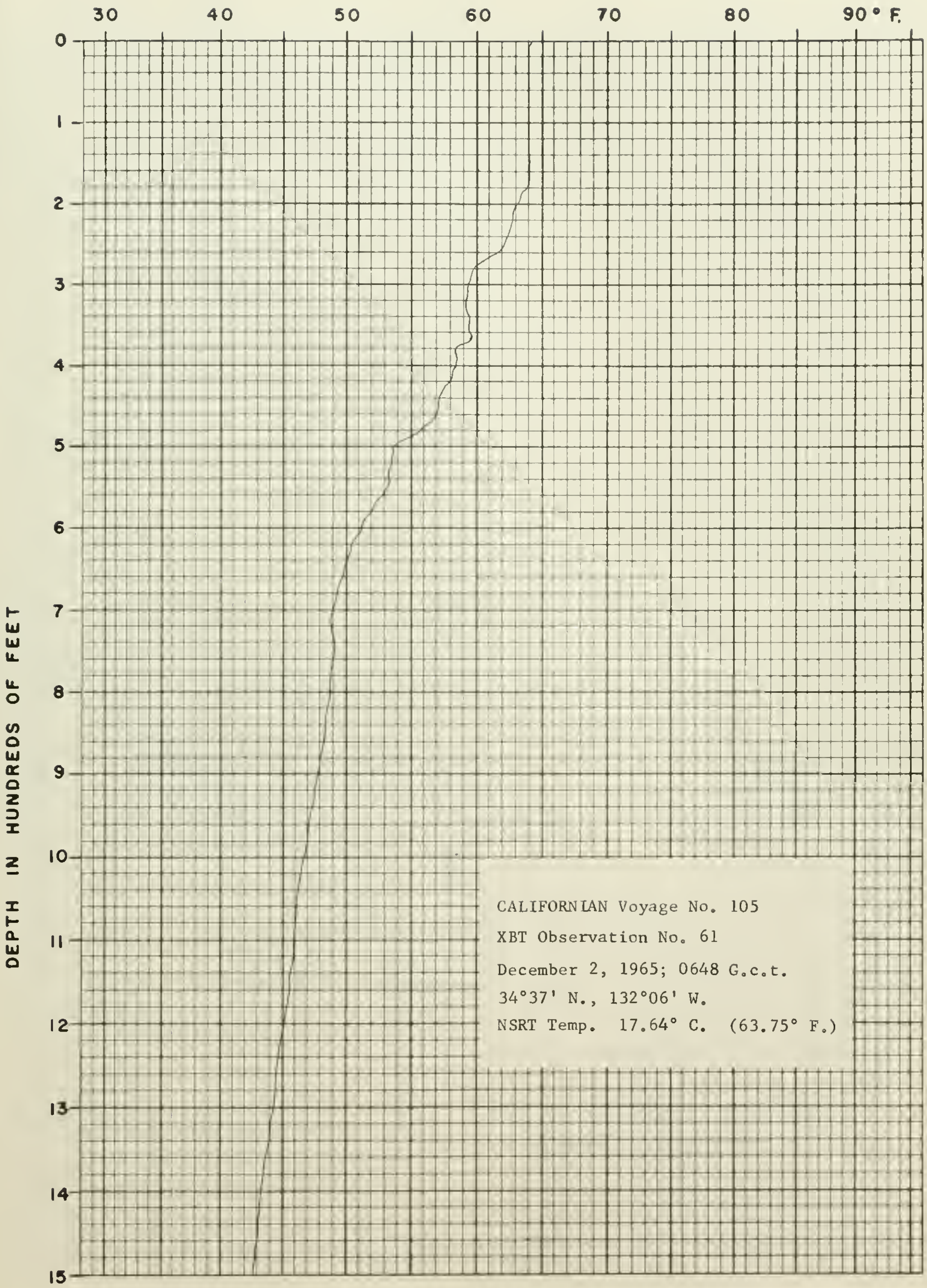
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 60
December 2, 1965; 0609 G.c.t.
34°33' N., 132°22' W.
NSRT Temp. 17.85° C. (64.13° F.)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90° F.
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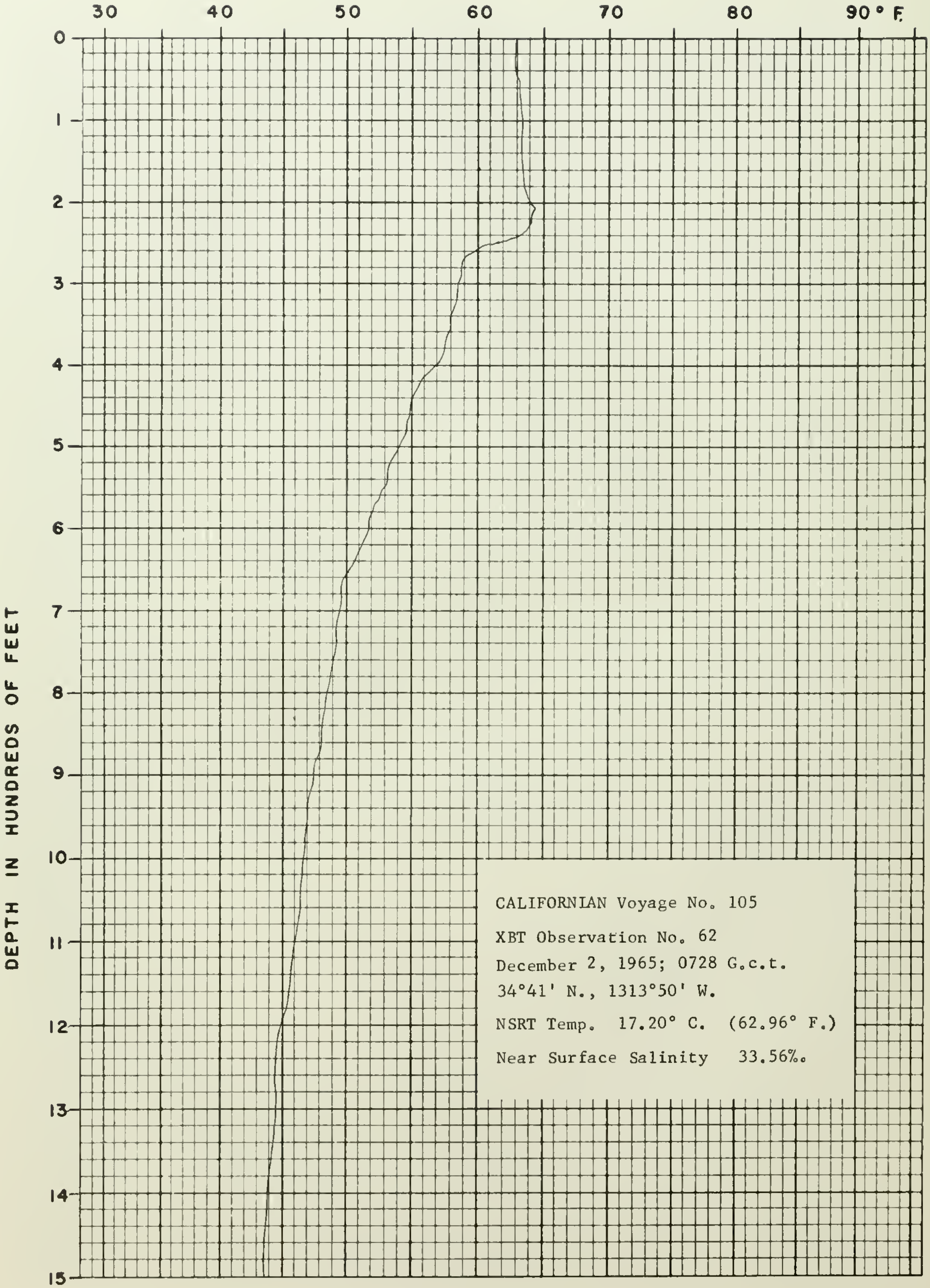
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 61
December 2, 1965; 0648 G.c.t.
34°37' N., 132°06' W.
NSRT Temp. 17.64° C. (63.75° F.)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90° F.
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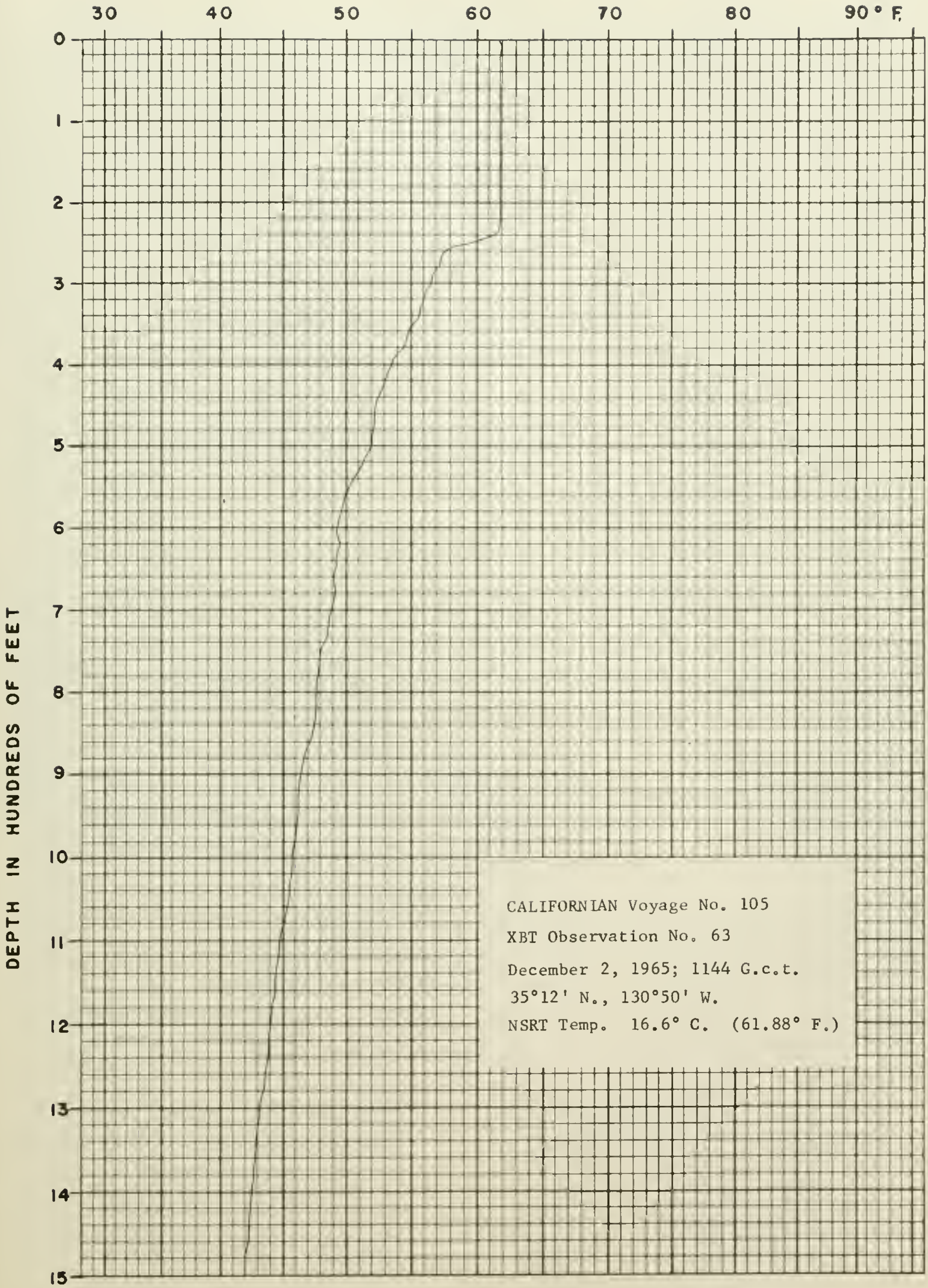
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 62
December 2, 1965; 0728 G.c.t.
34°41' N., 1313°50' W.
NSRT Temp. 17.20° C. (62.96° F.)
Near Surface Salinity 33.56‰.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90° F.
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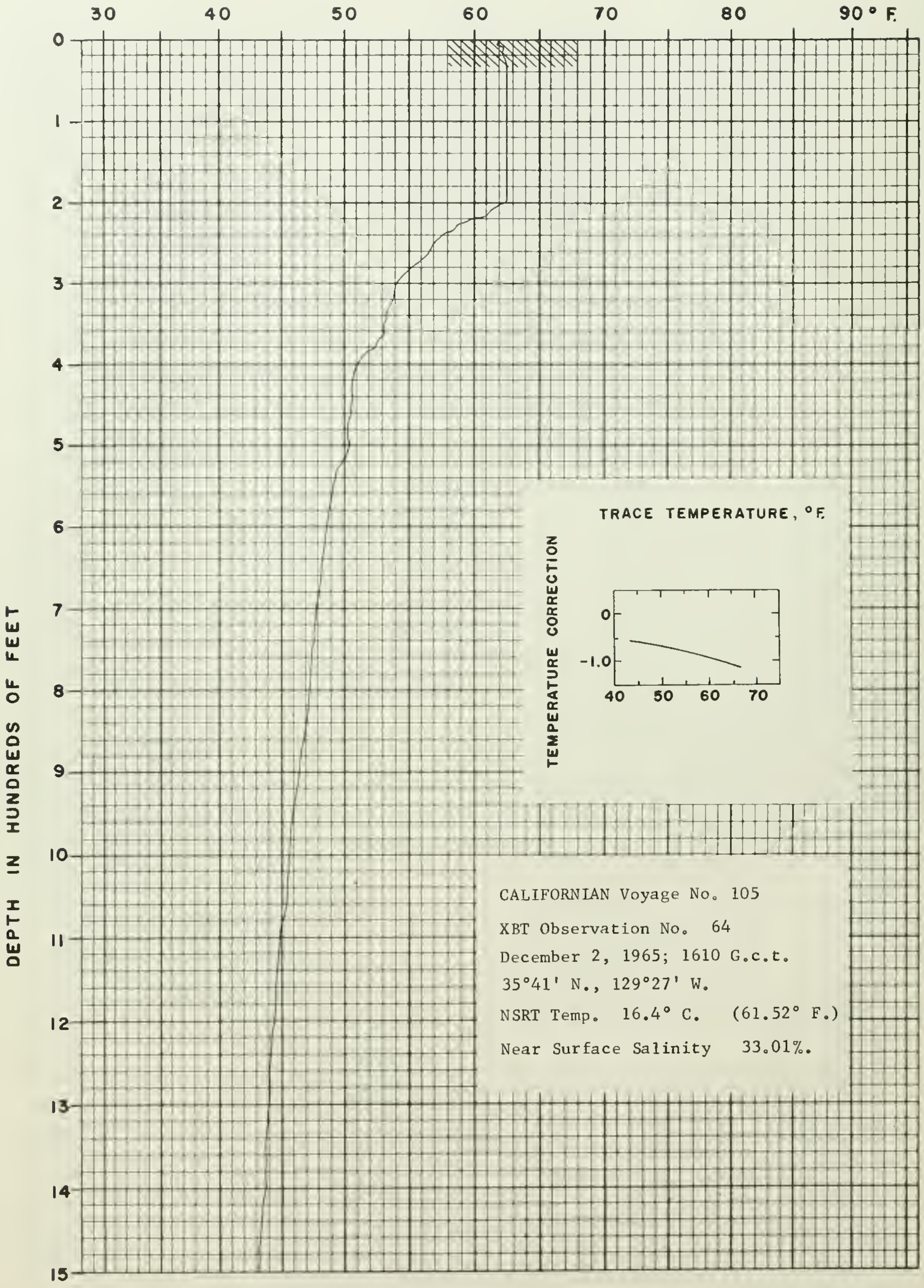
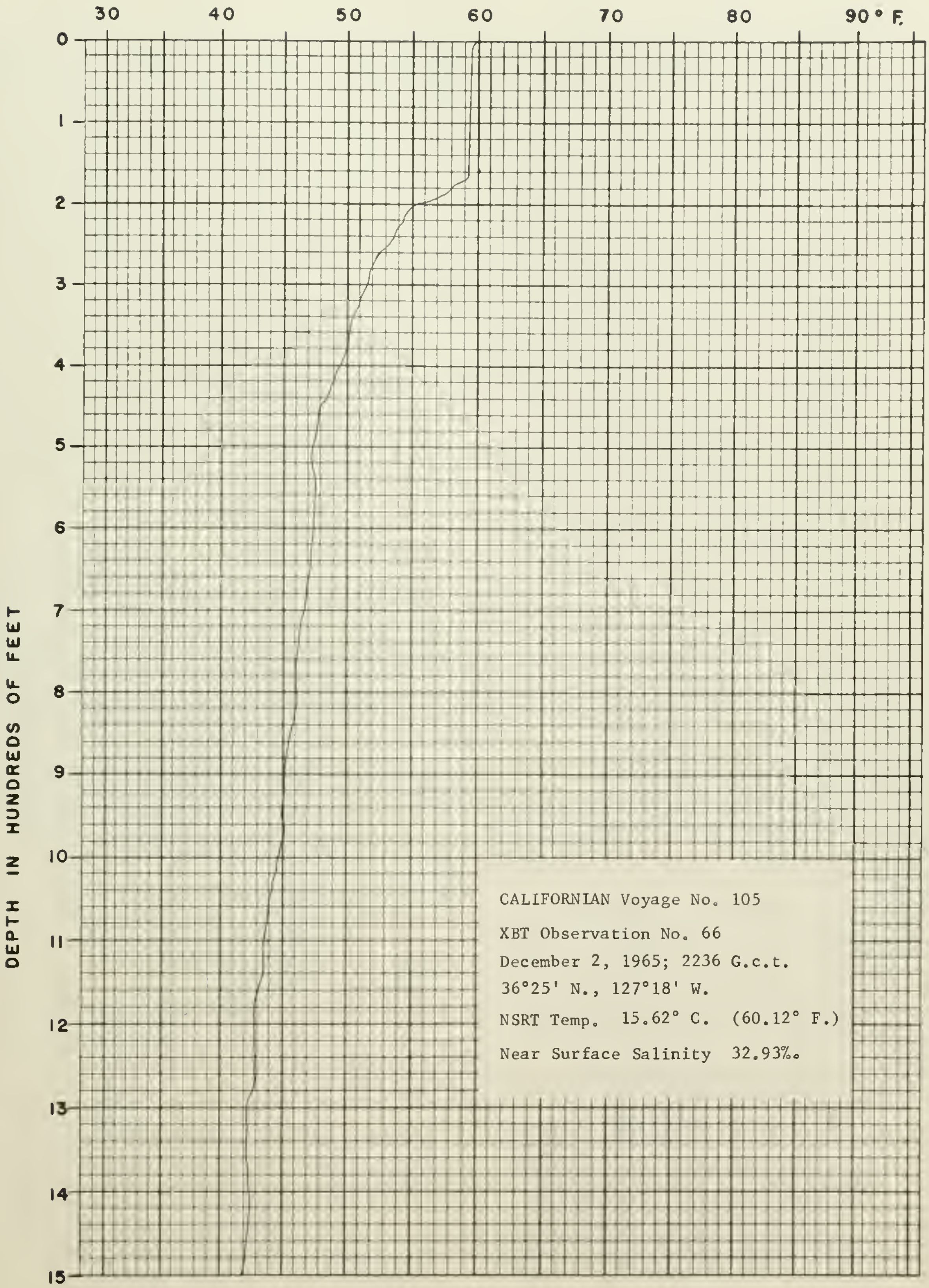
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 63
December 2, 1965; 1144 G.c.t.
35°12' N., 130°50' W.
NSRT Temp. 16.6° C. (61.88° F.)


30 40 50 60 70 80 90° F.
DEPTH IN HUNDREDS OF FEET
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
TRACE TEMPERATURE, °F.
TEMPERATURE CORRECTION
0
-1.0
40 50 60 70
CALIFORNIAN Voyage No. 105
XBT Observation No. 64
December 2, 1965; 1610 G.c.t.
35°41' N., 129°27' W.
NSRT Temp. 16.4° C. (61.52° F.)
Near Surface Salinity 33.01‰.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90° F.
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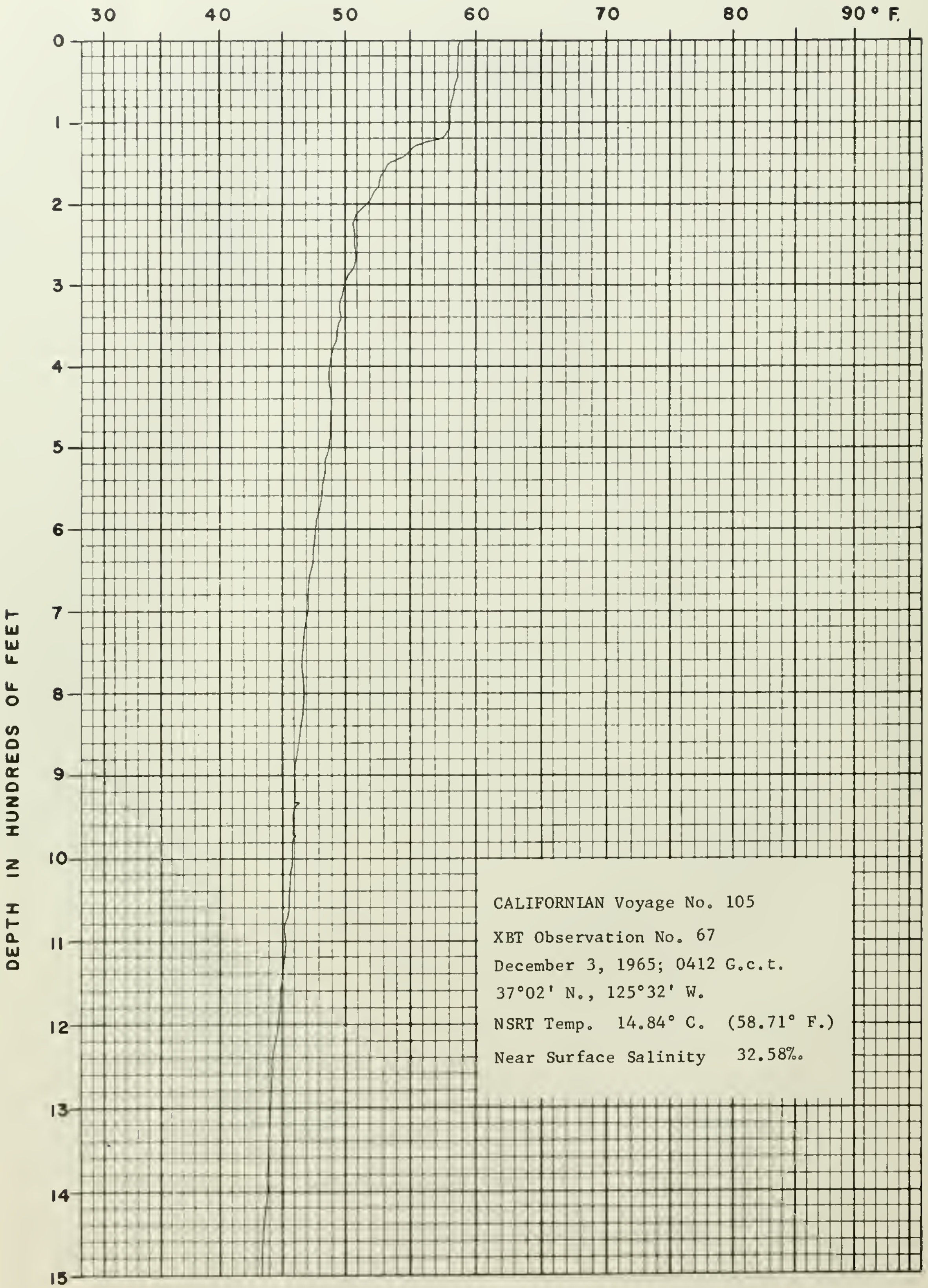
DEPTH IN HUNDREDS OF FEET
CALIFORNIAN Voyage No. 105
XBT Observation No. 66
December 2, 1965; 2236 G.c.t.
36°25' N., 127°18' W.
NSRT Temp. 15.62° C. (60.12° F.)
Near Surface Salinity 32.93‰



CALIFORNIAN Voyage No. 105

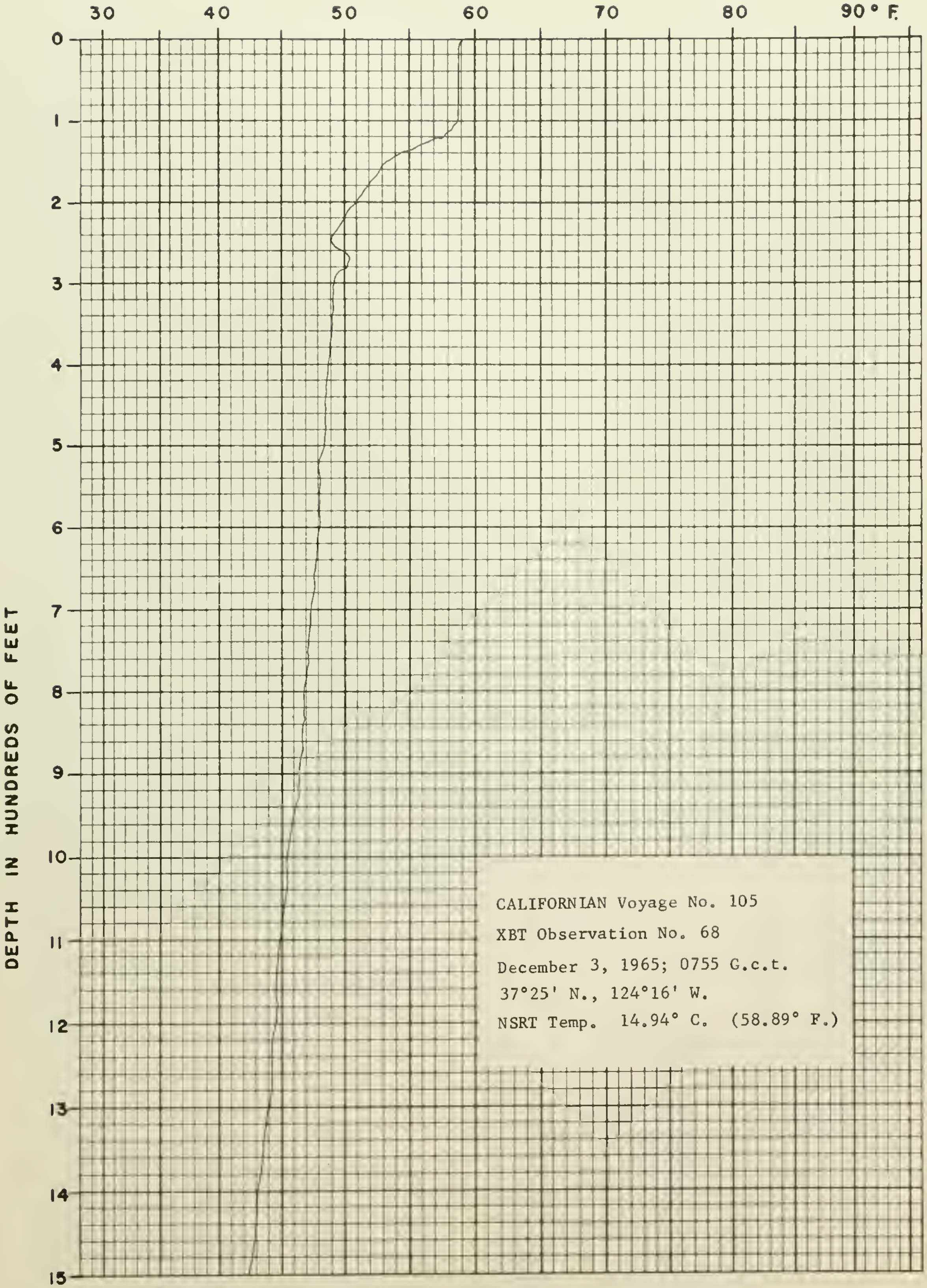
XBT Observation No. 67

December 3, 1965; 0412 G.c.t.

37°02' N., 125°32' W.

NSRT Temp. 14.84° C. (58.71° F.)

Near Surface Salinity 32.58‰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90° F.
DEPTH IN HUNDREDS OF FEET
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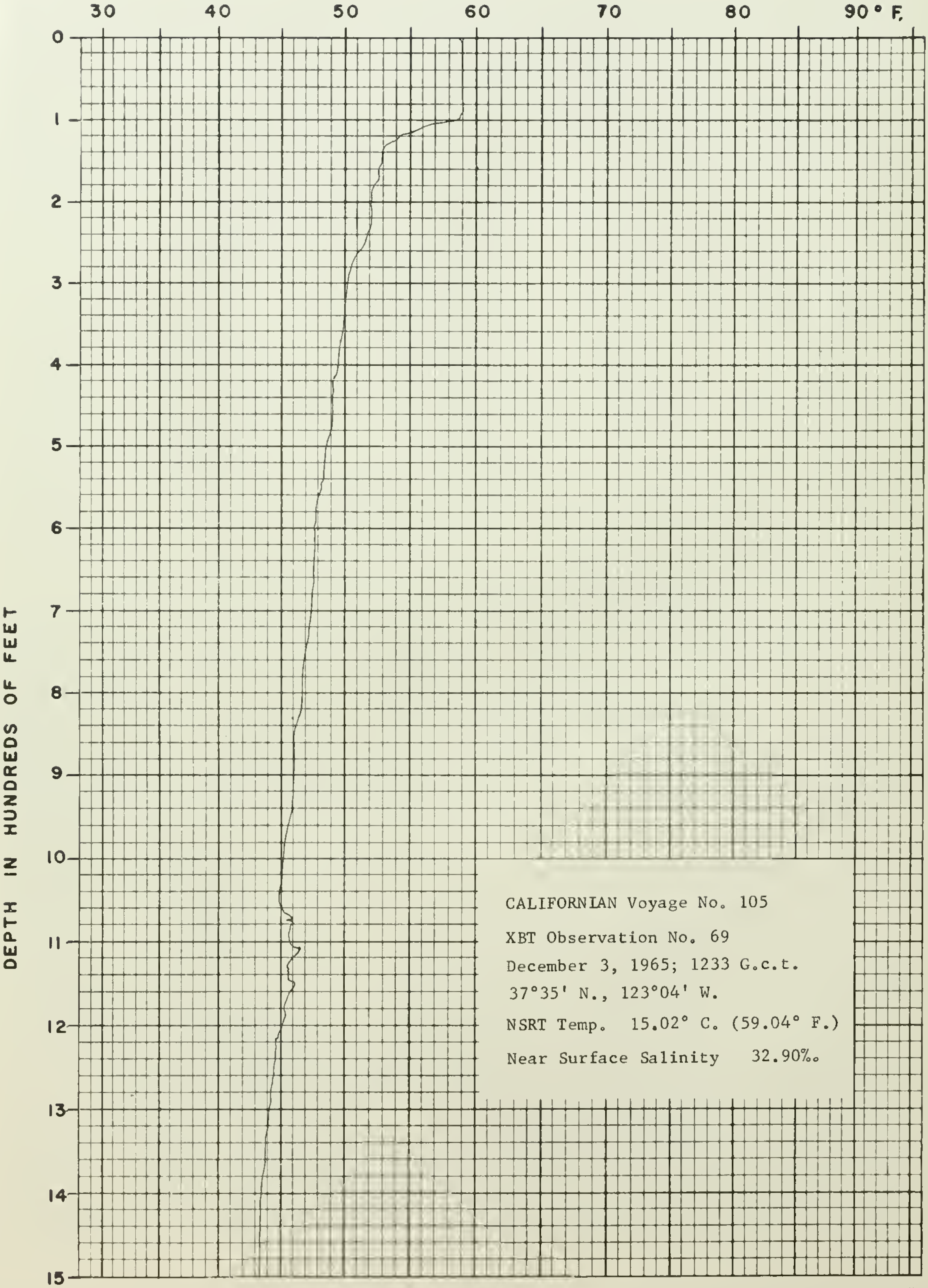
CALIFORNIAN Voyage No. 105
XBT Observation No. 68
December 3, 1965; 0755 G.c.t.
37°25' N., 124°16' W.
NSRT Temp. 14.94° C. (58.89° F.)



CALIFORNIAN Voyage No. 105
XBT Observation No. 69
December 3, 1965; 1233 G.c.t.
37°35' N., 123°04' W.
NSRT Temp. 15.02° C. (59.04° F.)
Near Surface Salinity 32.90‰.

MS #1621

GPO 922-338

Created in 1849, the Department of the Interior--a department of conservation--is concerned with the management, conservation, and development of the Nation's water, fish, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States--now and in the future.