UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

VERTICAL SECTIONS OF TEMPERATURE AND SALINITY IN THE TRADE WIND ZONE OF THE CENTRAL NORTH PACIFIC, FEBRUARY 1964 TO JUNE 1965

Circular 323
October 1969

UNITED STATES DEPARTMENT OF THE INTERIOR
Walter J. Hickel, *Secretary*
Russell E. Train, *Under Secretary*
Leslie L. Glasgow, *Assistant Secretary*
for Fish and Wildlife, Parks, and Marine Resources
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ABSTRACT

Temperature and salinity data obtained between lat. 10° and 26° N., along the four meridians long. 148°, 151°, 154°, and 157° W., are presented in vertical sections for 16 monthly cruises of the Trade Wind Zone Oceanography Pilot Study. The sections can be used in planning applied oceanography experiments, exploratory cruises in marine biology and fisheries, or in fishery extension work. The text will aid those who are not familiar with the central North Pacific or who are not specialists in oceanography.

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INTRODUCTION

This circular contains sections of the vertical temperature and salinity distributions between lat. 10° and 26° N., along the four meridians long. 148°, 151°, 154°, and 157° W. for each month from February 1964 to June 1965, except August 1964.

The sections are based on data collected by the R/V Townsend Cromwell as part of the TWZO (Trade Wind Zone Oceanography) Pilot Study. A fixed grid of oceanographic stations (fig. 1) was occupied on a series of 16 cruises. The TWZO Pilot Study was described by Seckel (1968) and the observations were published by Charnell, Au, and Seckel (1967a, 1967b, 1967c, 1967d, 1967e, 1967f).

Although these sections were obtained to study the mechanism of change in the distribution of temperature and salinity, they can, at the same time, serve the needs of applied oceanography. A main purpose of the vertical sections presented here is to serve these needs. For example, the sections can be used in planning experiments or exploratory cruises in marine biology and fisheries, and may also become of use in "fishery extension" work, where the results of research in fishery oceanography are interpreted to the fishermen.

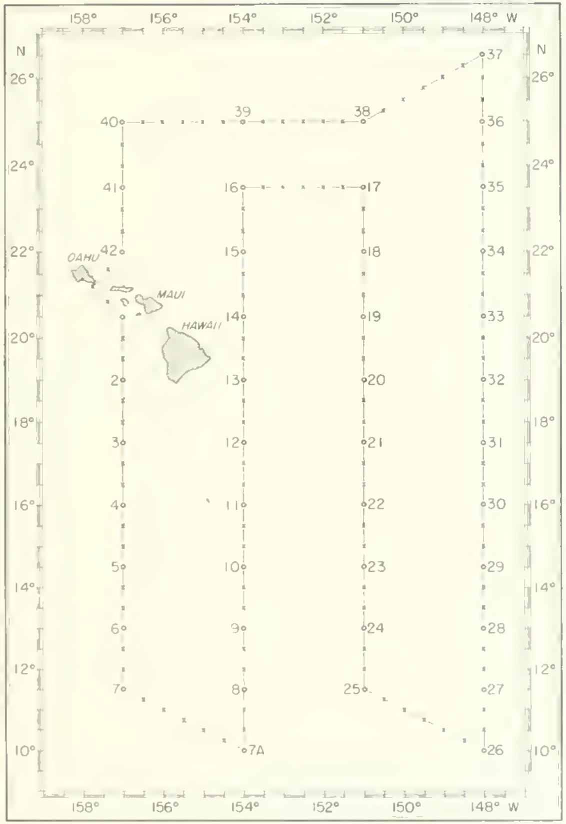

Figure 1.--Cruise track and station pattern of the Trade Wind Zone Oceanography Pilot Study. Open dots represent oceanographic stations, crosses represent bathythermograph stations.

The general distribution of temperature and salinity in the trade wind zone region of the central North Pacific based on historic data is well known. (See, for example, recent publications by Barkley, 1968; Reid, 1965; and Tsuchiya, 1968.) The sections of this circular, however, provide, in addition to more detail, the month-to-month changes in the distribution of temperature, salinity, and water masses that occurred from February 1964 to June 1965. Although predictions for any given month cannot be made, the sections show the month-to-month variability and limits of occurrence that can be expected of the properties presented.

Not all of those who may use this circular are familiar with the central North Pacific or are specialists in oceanography. For this reason some basic features of the vertical temperature and salinity distributions are described below and possible applications are indicated.

Finally, since the oxygen concentration was not determined regularly during the TWZO cruises, I show how the gross distribution of the dissolved oxygen concentration can be inferred from salinity sections.

DESCRIPTION OF SECTIONS

The temperature and salinity sections are presented in sets of four each per cruise and are identified by cruise number, month, and year when the cruise began. The temperature distribution in ° C. from the surface to 240 m. is based on bathythermograph observations made at 30-nautical mile intervals. The salinity distribution in parts per thousand (grams of salt per kilogram of water) from the surface to 600 m. is based on oceanographic stations occupied at 90-nautical mile intervals (see fig. 1). At these stations samples were obtained at 25-m.

depth intervals in the upper 300 m., and at 100-m. intervals from 300 m. to 600 m.

In the North Pacific trade wind zone the salinity distribution can be used to identify water masses (Seckel, 1968). Those of concern in this circular are the North Pacific Central, the North Pacific Equatorial, the North Pacific Intermediate, and the Pacific Equatorial Intermediate Waters. In the salinity sections each water mass is shaded differently. The transition waters between water masses have been left unshaded.

The North Pacific Central Water occurs at the surface in the northern portion of the sections and protrudes southward in a tongue below the surface layer. It has a salinity of more than 34.8‰ and in the charts of this circular is warmer than 16.5° C.

The North Pacific Equatorial Water occurs as a shallow surface layer in the southern portion of the sections. It is generally found in the eastern Pacific centered about lat. 10° N., but may extend into the region shown here, as in summer and fall of 1964, when it has a salinity of less than 34.2‰ and a temperature of more than 15° C.

The North Pacific Intermediate Water, with a salinity of less than 34.4‰ and a temperature of less than 15° C., occurs below the North Pacific Central Water in the northern portion of the sections. It markedly decreases in thickness southward of lat. 18° N.

The Pacific Equatorial Intermediate Water, with salinity of more than 34.6‰ and temperature of less than 16° C., occurs below the North Pacific Equatorial Water in the southern portion of the sections. It is found at intermediate depths in a band across the equatorial Pacific.

THE MERIDIONAL TEMPERATURE DISTRIBUTION

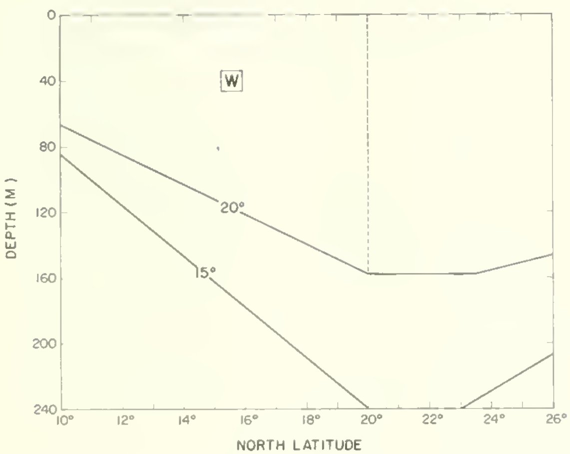

Figure 2.--Schematic presentation of the meridional thermocline structure in the trade wind zone based on the temperature section at long. 148° W., February 1964. W indicates a geostrophic flow setting westward.

In the trade wind zone of the North Pacific, the meridional temperature distribution is basically defined by the characteristic thermocline structure. The thermocline structure is illustrated schematically in figure 2 by the 15° and 20° C. isotherms, which lie within the thermocline. Isotherms slope upward towards lat. 10° N. where the minimum depth occurs in this schematic example at lat. 10° N. Maximum depths of isotherms below 20° C. are north of lat. 20° N. In addition to the upward sloping of the isotherms, the vertical distance between isotherms becomes smaller toward lat. 10° N.

Thus, as one progresses southward from lat. 20° to 10° N., at a depth of 150 m. for example, the temperature decreases. This meridional temperature gradient at 150 m. is not obvious from the surface temperature, which increases toward the lower latitude. Also, the temperature decrease with increasing depth (the vertical temperature gradient) is greater at lat. 10° N. than at 20° N.

This information can be usefully applied when longlining for fish. Assume, for example, a fish which prefers a range of 15° to 18° C. In fishing at lat. 20° N., fishermen must place the hooks at greater depth than when fishing at 10° N. Also at lat. 20° N. the depth range within which hooks must be placed is larger than at 10° N. where 15° and 18° C. water may be found in depths which are less than 20 m. apart.

The thermocline structure, which is evident from the temperature sections, can also be used to estimate qualitatively the east-west component of the ocean current. This use is demonstrated in figure 3, showing schematically the thermocline fluctuations at long. 157° W., in March 1964 and the related current directions. When the thermocline slopes upward toward the south, there is a component of flow to the west, and when it slopes downward toward the south, the component of flow is to the east. The steeper the slope, the faster the current. Thus (in fig. 3), the westward flow between lat. 19° and 20° N. is faster than that between lat. 14° and 18° N., which in turn, is faster than the flow between lat. 10° and 20° N. in figure 2. When the thermocline slope is small, the flow direction is indeterminate. The convention for the direction of flow shown in these figure applies to the Northern Hemisphere.

THE MERIDIONAL SALINITY DISTRIBUTION

The definition of water masses and their distribution in the trade wind zone which was given above is principally based on the salinity distribution. Thus, lateral or vertical changes in the position of salinity isopleths (lines of equal salinity) also may indicate changes in the lateral distribution and thickness of water masses. This relation holds particularly for those isopleths that are associated with water mass boundaries.

Consider, for example, the salinity sections for May and October 1964 at long. 148° W. At the sea surface one finds the boundary of the North Pacific Central Water in May at lat. 22° N. and in October at lat. 18° N. The North Pacific Equatorial Water is not present during May but is found at 17° N. in October. Displacement distances of the subsurface boundary of the North Pacific Central Water (at or just below 100-m. depth) are similar. This boundary is at lat. 12° N. in May and at lat. 17° N. in October.

The thickness of the North Pacific Central Water and North Pacific Intermediate Water masses is greater in the northern portion of the sections than in the southern portion. In the northern portion the North Pacific Central Water extends from

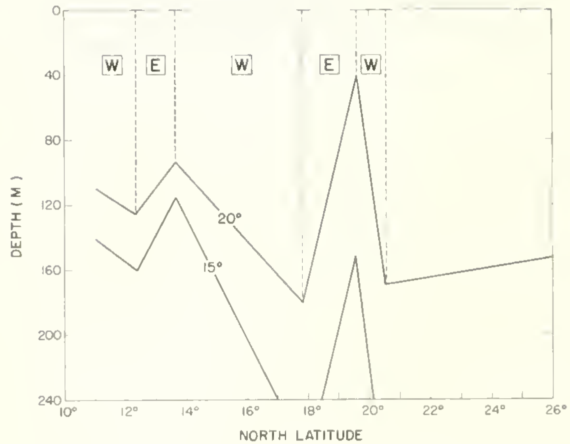

Figure 3.--Schematic presentation of the meridional thermocline structure and east or west direction of the ocean current in the trade wind zone based on the temperature section at long. 157° W., March 1964.

the surface to about 200 m. The North Pacific Intermediate Water occurs below about 250 m. At any fixed location, changes in thickness also occur due to varying depths of water masses or lateral displacement of boundaries. Compare for example the distribution of the North Pacific Central Water for the sections of May and October 1964 at long. 148° W.

The sections showing the distribution of salinity and water masses can again be of aid to longline fishing. Evidence of an association between the availability of skipjack tuna to the Hawaiian fishery and the type of water surrounding the islands, was presented by Seckel and Waldron (1960), Murphy, Waldron, and Seckel (1960), and Seckel (1963). The association indicates that availability of skipjack tuna during spring and summer is poorer than normal when North Pacific Central Water is in the fishing area and better than normal when the lower salinity transition water is in the area. An outstanding example of this association occurred in the spring of 1965 and is illustrated in figure 4, which shows the salinity of the water at Koko Head, Oahu, and the weekly catches of the skipjack tuna fishery. The rapid increase in weekly landings coincided with the drop of the salinity below 34.8‰ at Oahu. The concurrent changes mean that as the North Pacific Central Water moved out of the island region and was replaced by transition water of lower salinity, skipjack tuna became abundant. (Also see location of the boundary at the sea surface of the North Pacific Central Water along long. 157° W. during April, May, and June 1965.) The association between skipjack tuna and the water mass distribution at the sea surface implies that such associations may also exist between longline-caught fishes and the subsurface distribution of water masses. The salinity section can therefore be used to place longline hooks in the desired water mass or orient them relative to desired vertical or horizontal water mass boundaries.

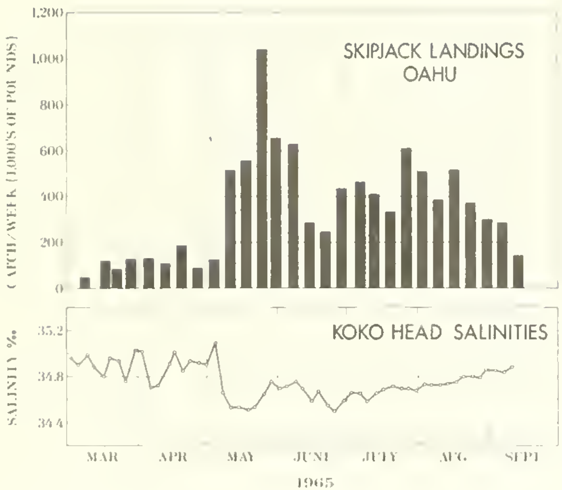

Figure 4.--Weekly skipjack tuna landings at Oahu, March to September 1965 (upper panel), and salinities at Koko Head, Oahu (lower panel).

GROSS FEATURES IN THE MERIDIONAL DISSOLVED OXYGEN DISTRIBUTION

Finally, the salinity sections can be used to make gross estimates of the concentration of dissolved oxygen in the different water masses. To illustrate, figure 5 shows the salinity and dissolved oxygen concentration in a vertical section along long. 148° W. for September 1964.

In the North Pacific Central and the North Pacific Equatorial Waters the oxygen concentration is greater than 4 ml./ℓ. It declines in the transition to the intermediate water masses. The decline in oxygen concentration is most rapid in the transition to the Pacific Equatorial Intermediate Water where it is less than 0.5 ml./ℓ.

In the southern portion of the sections the Pacific Equatorial Intermediate Water with the low oxygen concentration may be found within 100 m. of the surface. Again this condition is of interest in longline fishing since hooks may fish deeper than 100 m. It is unlikely that active species of fish with a high oxygen demand are found in water with an oxygen concentration as low as that in the Pacific Equatorial Intermediate Water.

Interesting features in the vertical distribution of oxygen are relatively thin layers of higher oxygen concentration in the upper portion of the thermocline. Two such layers are apparent in figure 5. A thin layer with an oxygen concentration of more than 5 ml./ℓ. occurs at 30 to 40 m. between lat. 10° and 13° N., and another layer occurs at 50 to 100 m. between lat. 16° and 23° N. These layers are common in the region where the salinity increases with depth in the upper portion of the thermocline. Although the continuity or seasonality of these layers of higher oxygen concentration is not known, they are probably of biological significance.

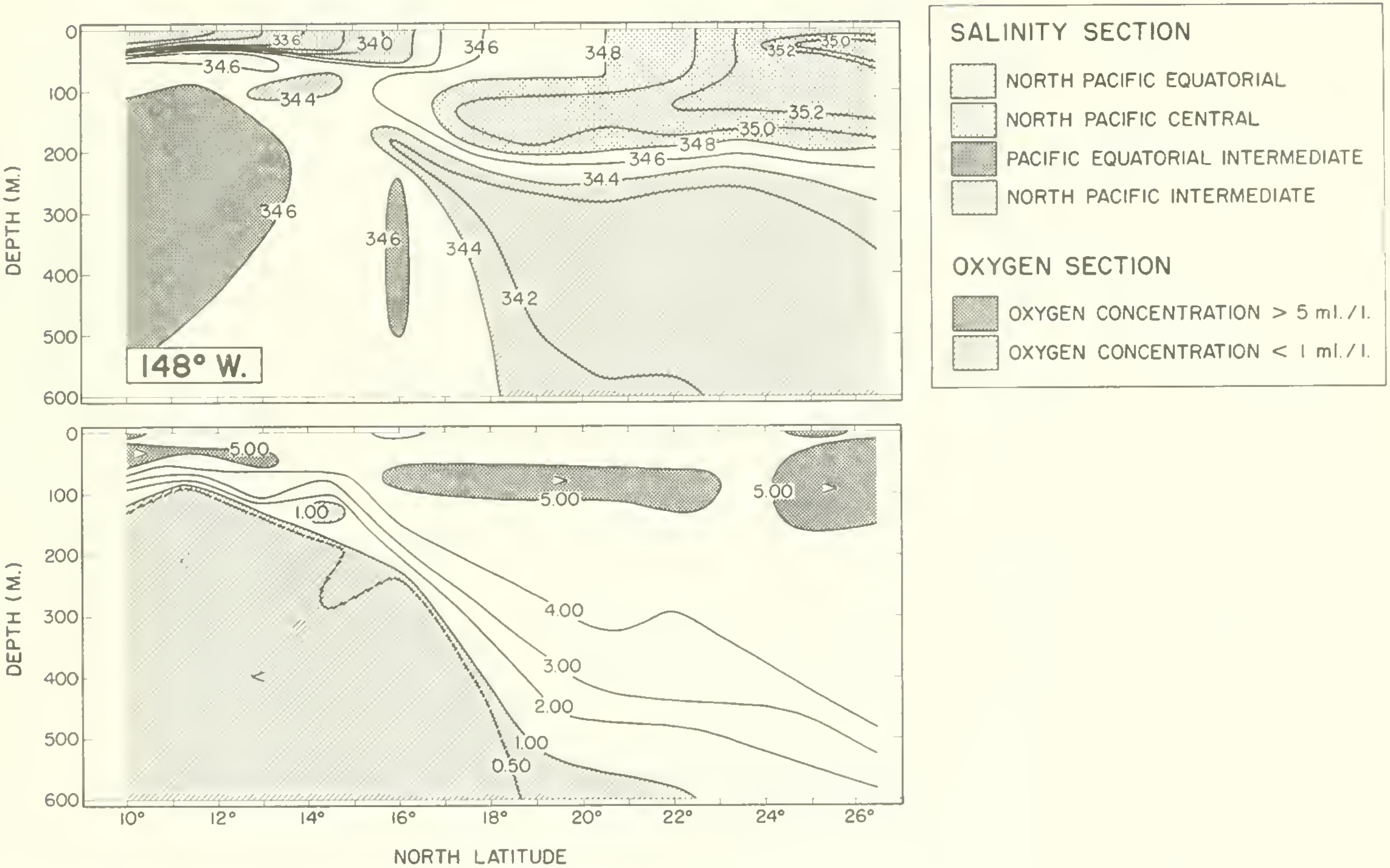

Figure 5.--Upper panel: Meridional salinity (°/₀₀) distribution, lat. 10° to 25° N., long. 148° W., September 1964. Lower panel: Meridional oxygen (ml./ℓ.) distribution, lat. 10° to 25° N., long. 148° W., September 1964.

CONCLUSION

In the trade wind zone the seasonal and year-to-year changes in temperature and salinity are of the same order of magnitude. It cannot, therefore, be inferred that a distribution found during any one of the months shown in this circular will be the same as during the same month of other years. The sections are, however, a reference to the characteristic distribution of the temperature, salinity, and water masses in the trade wind zone of the central North Pacific and give an indication of the limits of occurrence and month-to-month variability of these properties. If more detailed information is desired, the reader is referred to the tabulations of the original data (Charnell, Au, and Seckel, 1967a-f).

LITERATURE CITED

Barkley, Richard A.
1968. Oceanographic atlas of the Pacific Ocean. Univ. Hawaii Press, Honolulu. 20 pp., 156 figs.

Charnell, Robert L., David W. K. Au, and Gunter R. Seckel.
1967a. The Trade Wind Zone Oceanography Pilot Study. Part I: Townsend Cromwell cruises 1, 2, and 3, February to April 1964. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 552, v + 75 pp.

1967b. The Trade Wind Zone Oceanography Pilot Study. Part II: Townsend Cromwell cruises 4, 5, and 6, May to July 1964. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 553, v + 78 pp.

1967c. The Trade Wind Zone Oceanography Pilot Study. Part III: Townsend Cromwell cruises 8, 9, and 10, September to November 1964. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 554, v + 78 pp.

1967d. The Trade Wind Zone Oceanography Pilot Study. Part IV: _Townsend Cromwell_ cruises 11, 12, and 13, December 1964 to February 1965. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 555, v + 78 pp.

1967e. The Trade Wind Zone Oceanography Pilot Study. Part V: _Townsend Cromwell_ cruises 14 and 15, March and April 1965. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 556, iv + 54 pp.

1967f. The Trade Wind Zone Oceanography Pilot Study. Part VI: _Townsend Cromwell_ cruises 16, 17, and 21, May and June 1965 and January 1966. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 557, iv + 59 pp.

Murphy, Garth I., Kenneth D. Waldron, and Gunter R. Seckel.

1960. The oceanographic situation in the vicinity of the Hawaiian Islands during 1957 with comparisons with other years. Calif. Coop. Oceanic Fish. Invest. Rep. 7: 56-59.

Reid, Joseph L., Jr.

1965. Intermediate waters of the Pacific Ocean. Johns Hopkins Oceanogr. Stud. 2, 85 pp.

Seckel, Gunter R.

1963. Climatic parameters and the Hawaiian skipjack fishery. _In_ H. Rosa, Jr. (editor), Proc. World Sci. Meet. Biol. Tunas Related Species. FAO Fish. Rep. 6, 3: 1201-1208.

1968. A time-sequence oceanographic investigation in the North Pacific trade wind zone. Trans. Amer. Geophys. Union 49: 377-387.

Seckel, Gunter R., and Kenneth D. Waldron.

1960. Oceanography and the Hawaiian skipjack fishery. Pac. Fish. 58: 11-13.

Tsuchiya, Mizuki.

1968. Upper waters of the intertropical Pacific Ocean. Johns Hopkins Oceanogr. Stud. 4, 50 pp.

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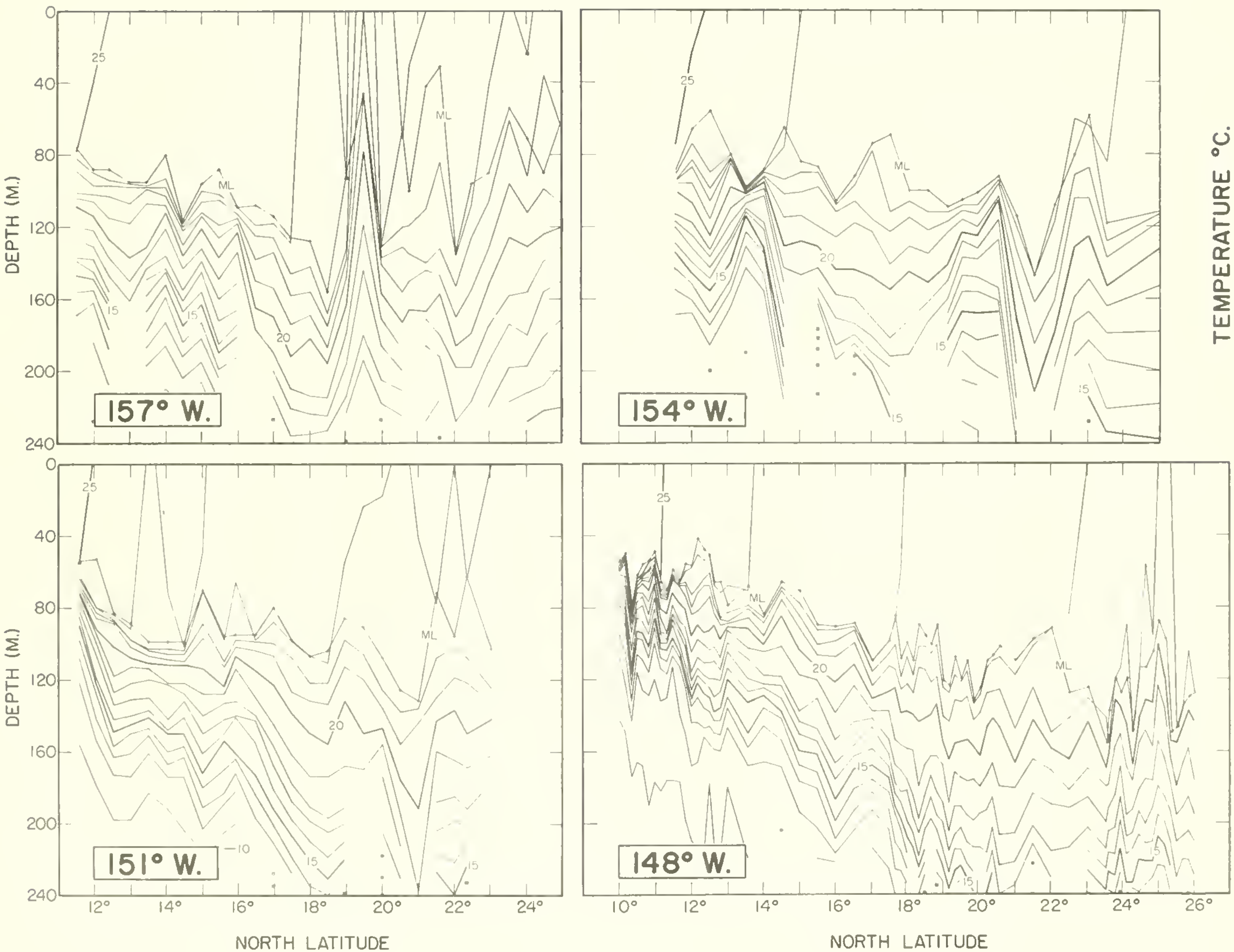
APPENDIX FIGURES

Vertical sections of temperature and salinity in the trade wind zone of the central North Pacific, Townsend Cromwell cruises 1-6, February to July 1964, and cruises 8-17, September 1964 to June 1965.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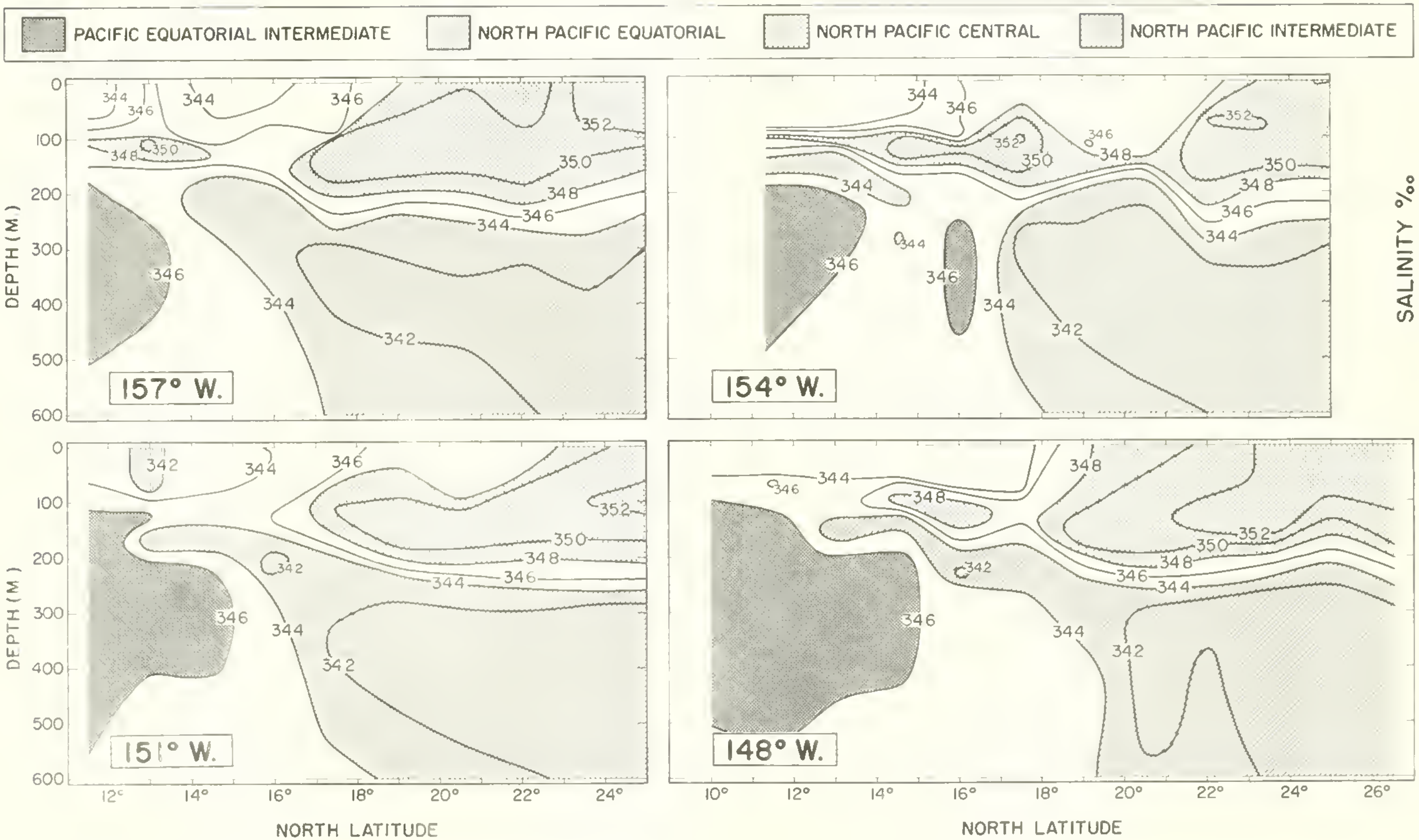

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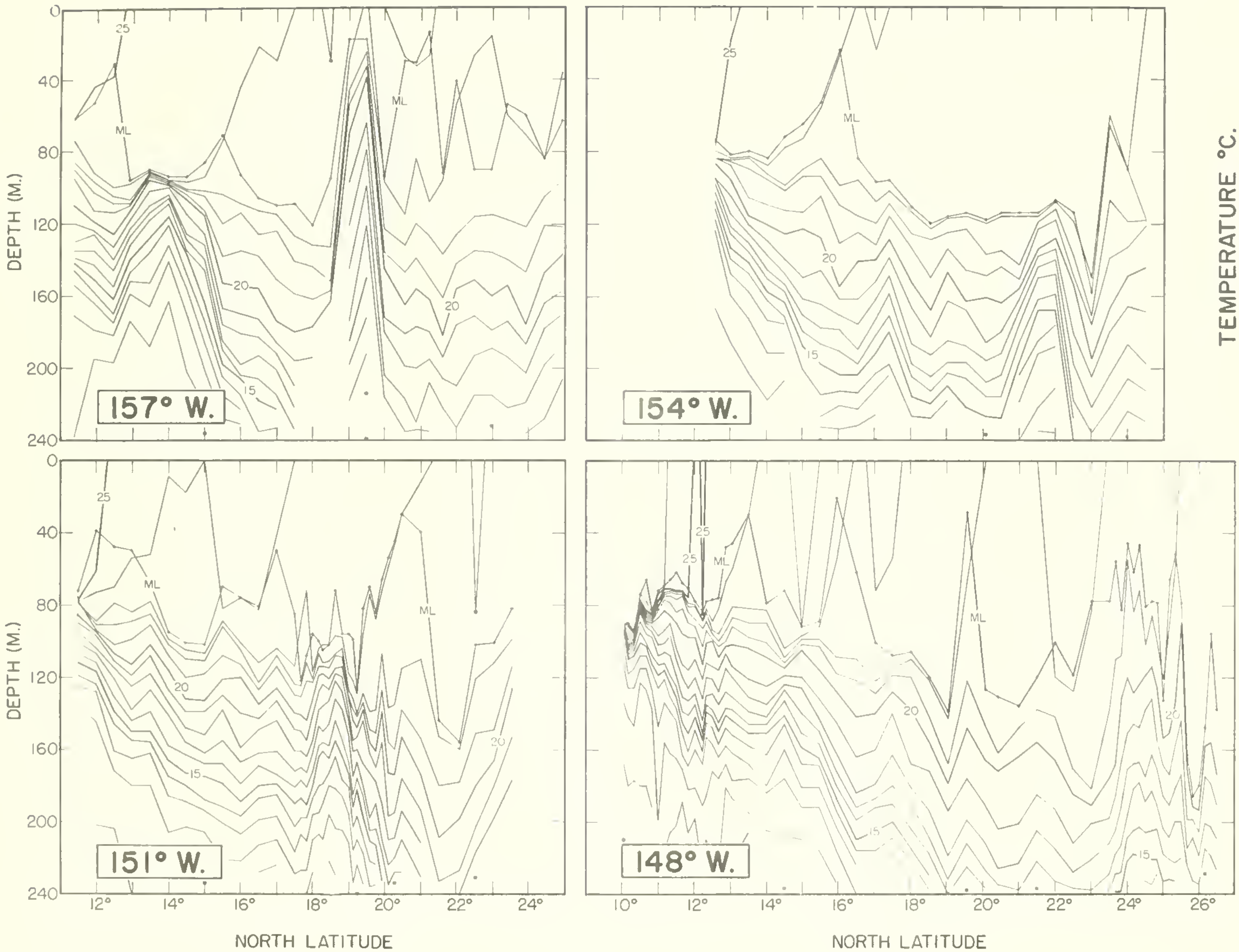

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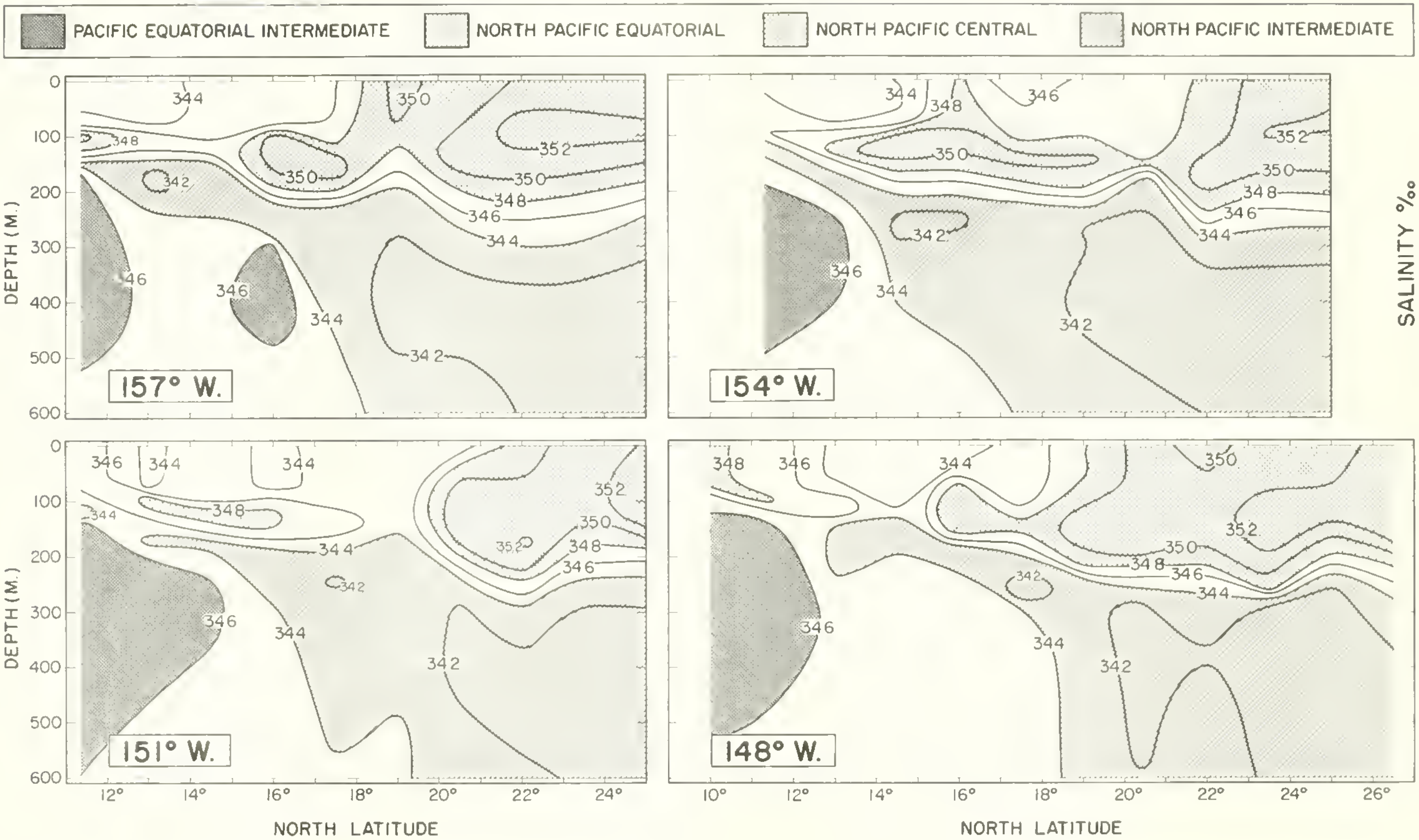

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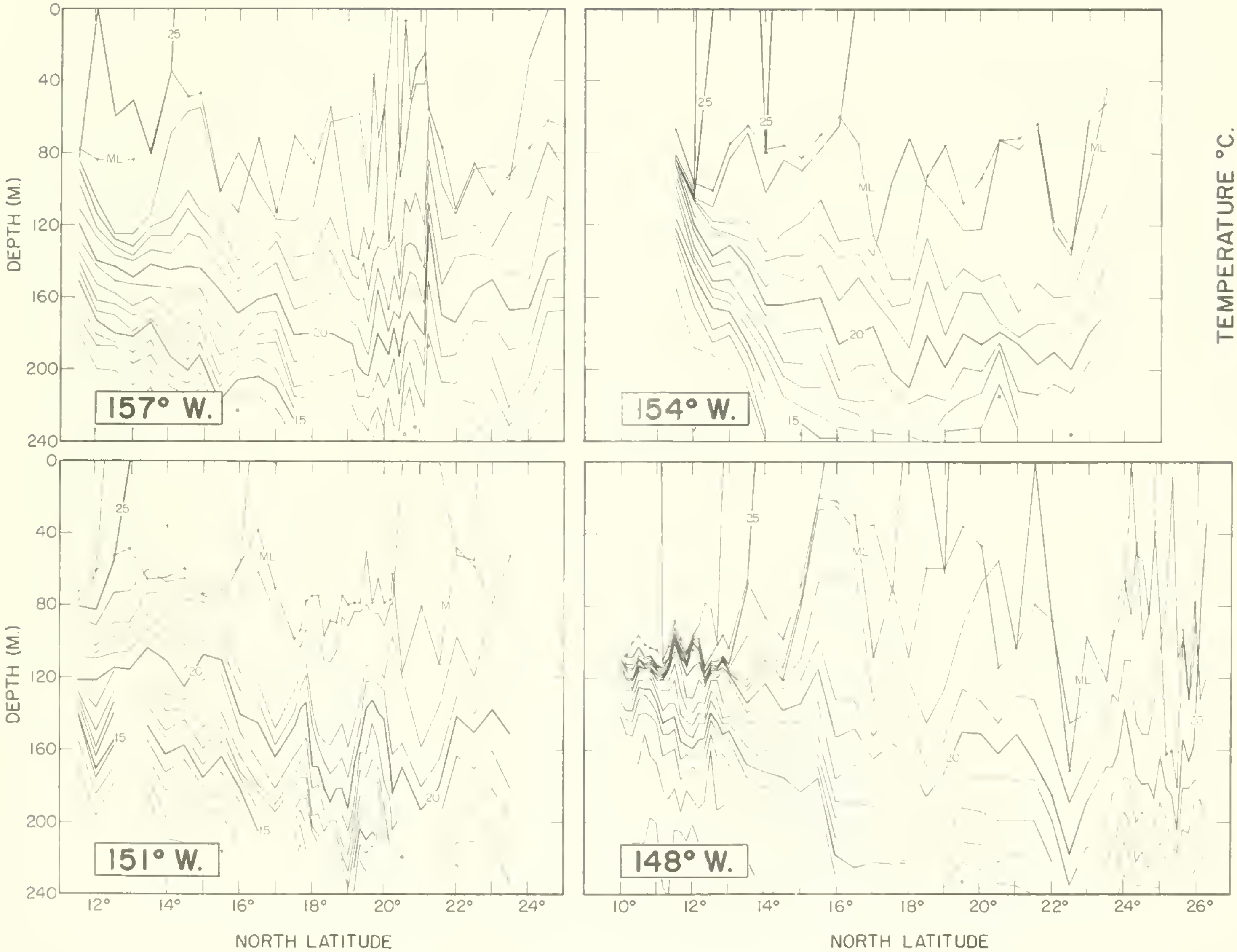

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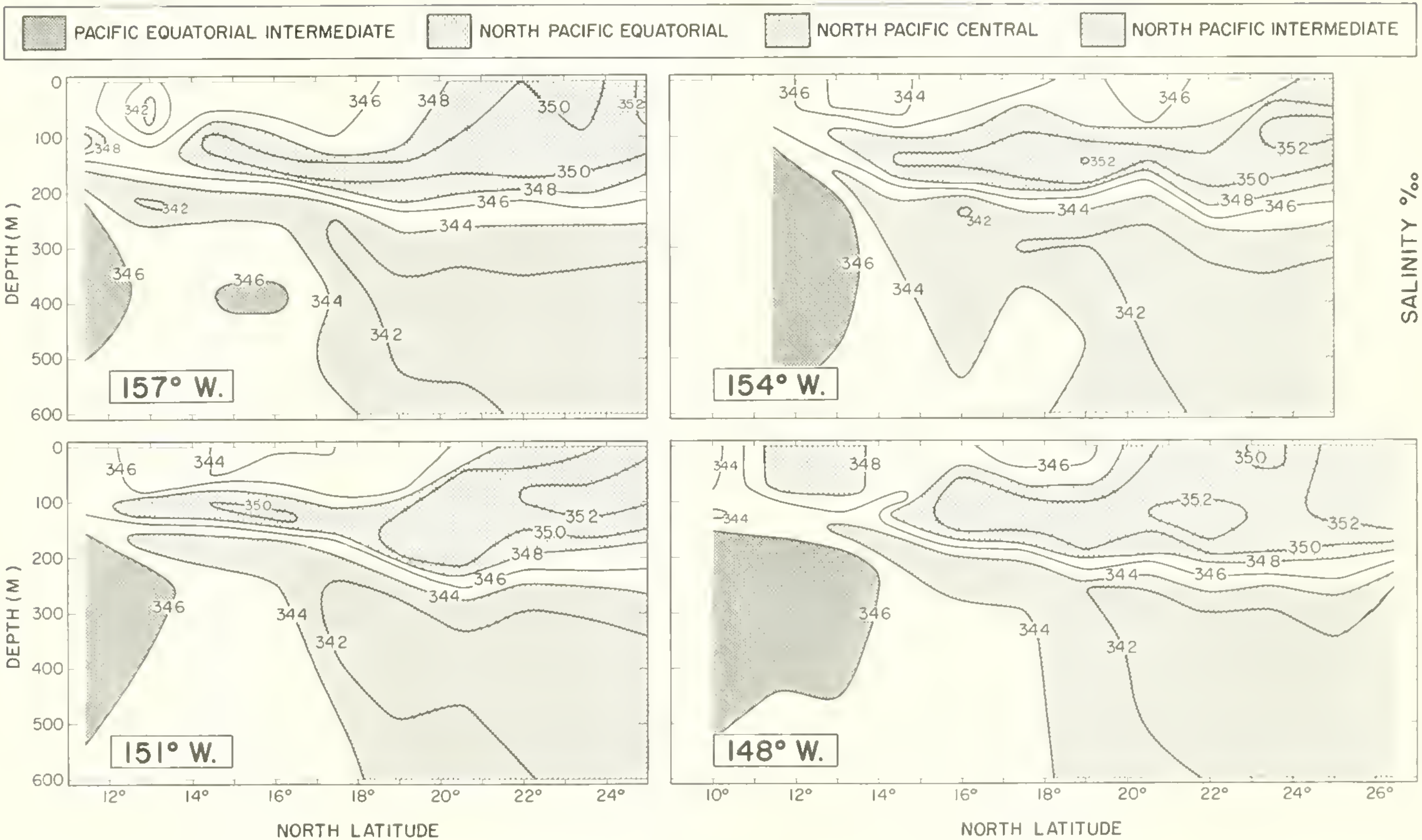

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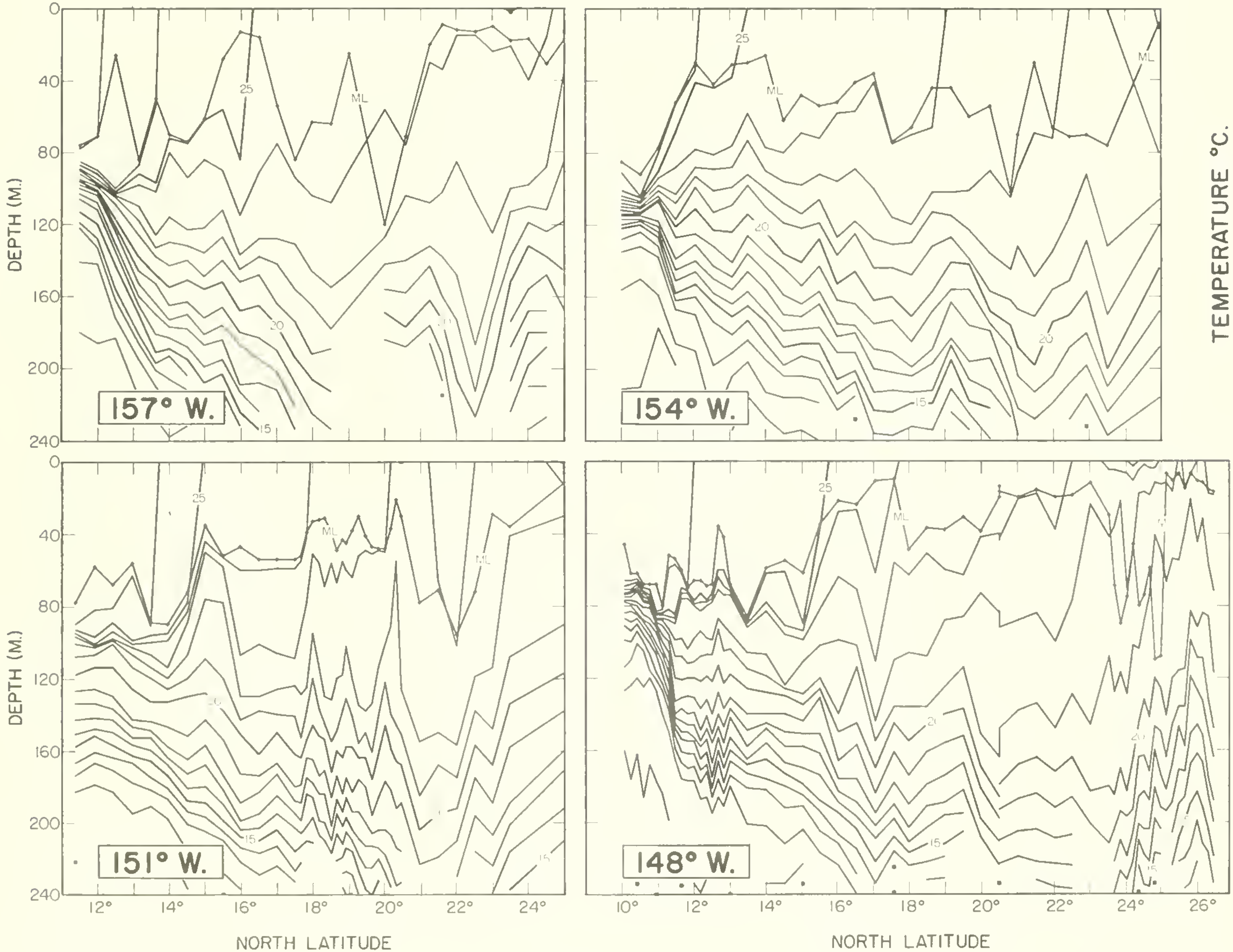
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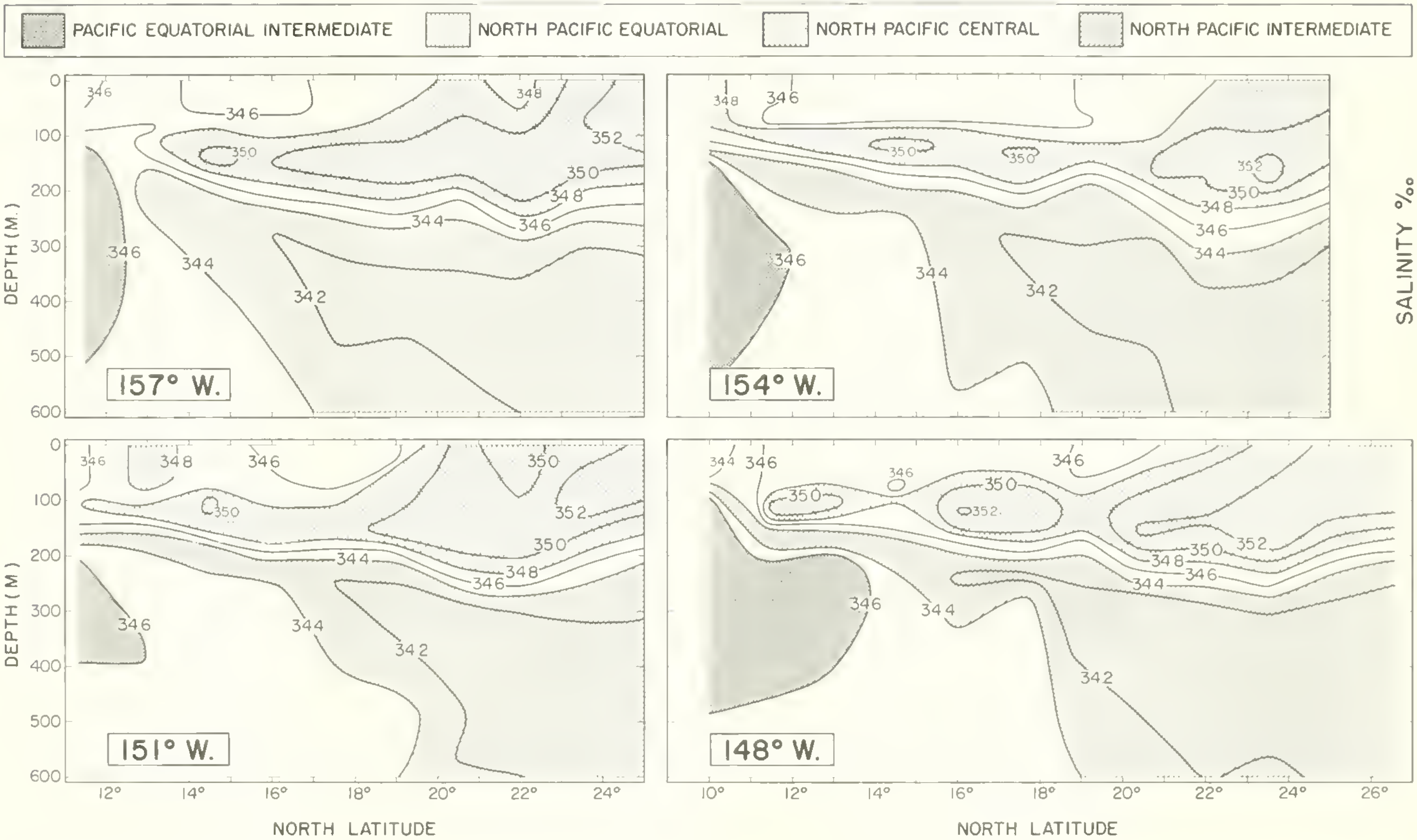

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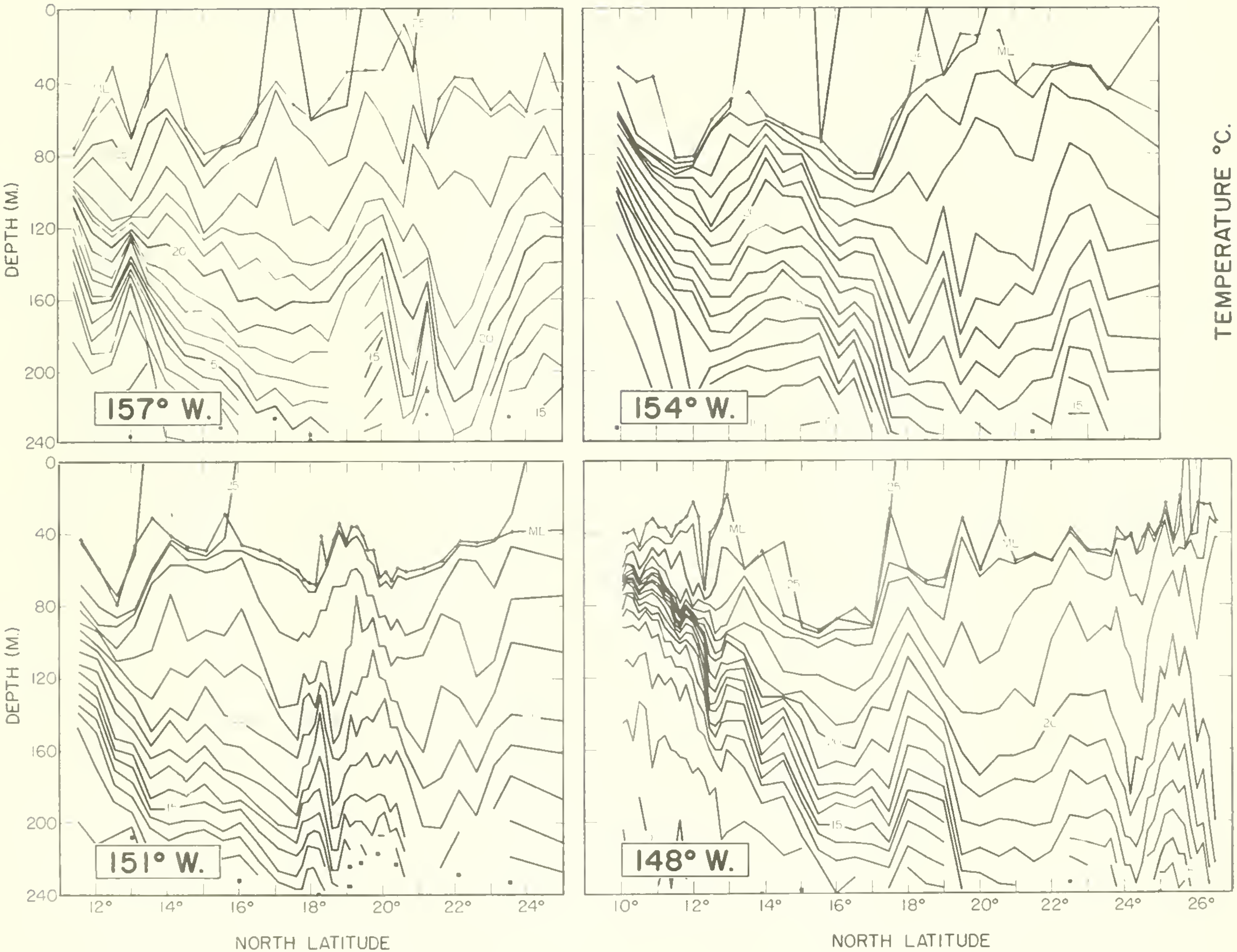

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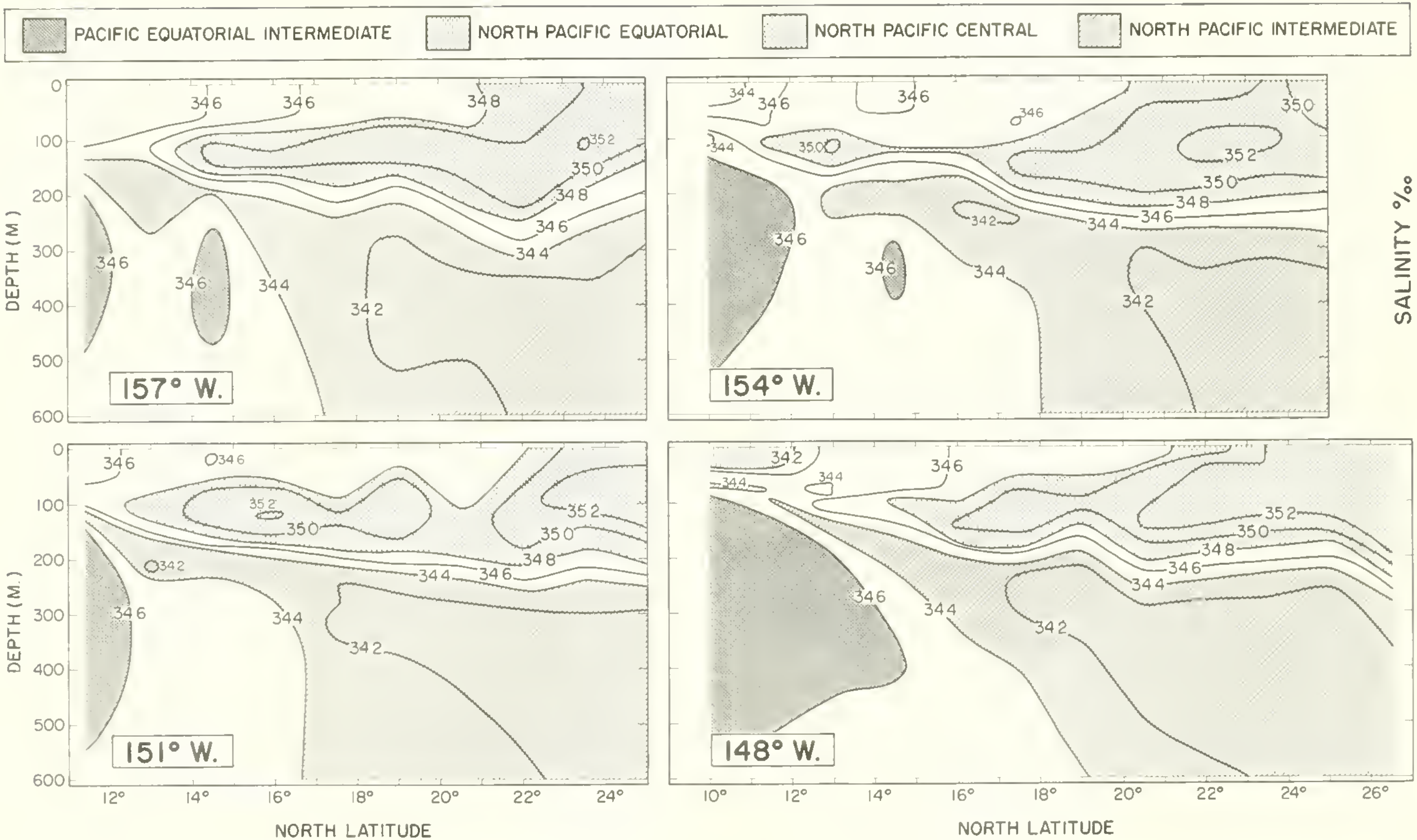

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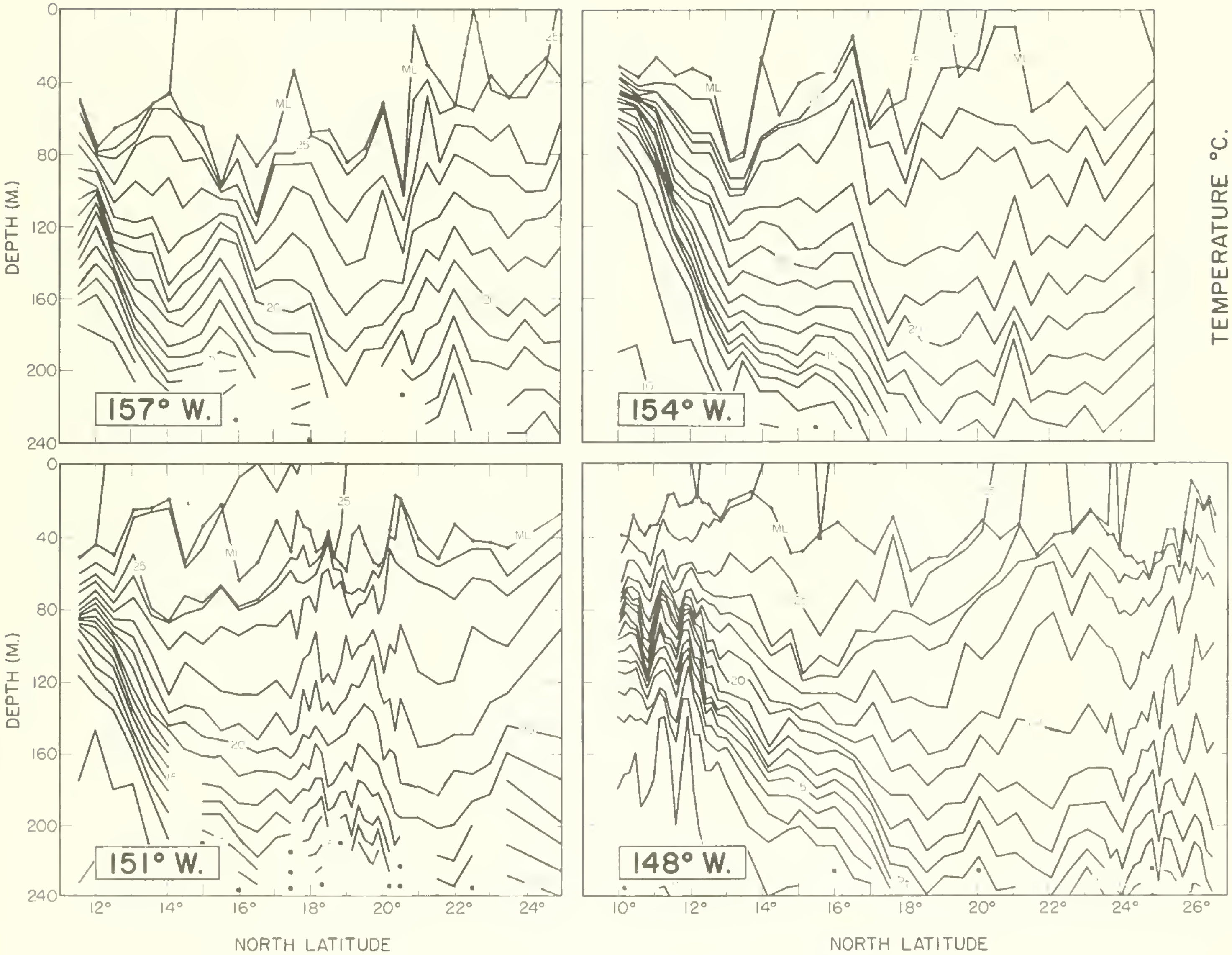

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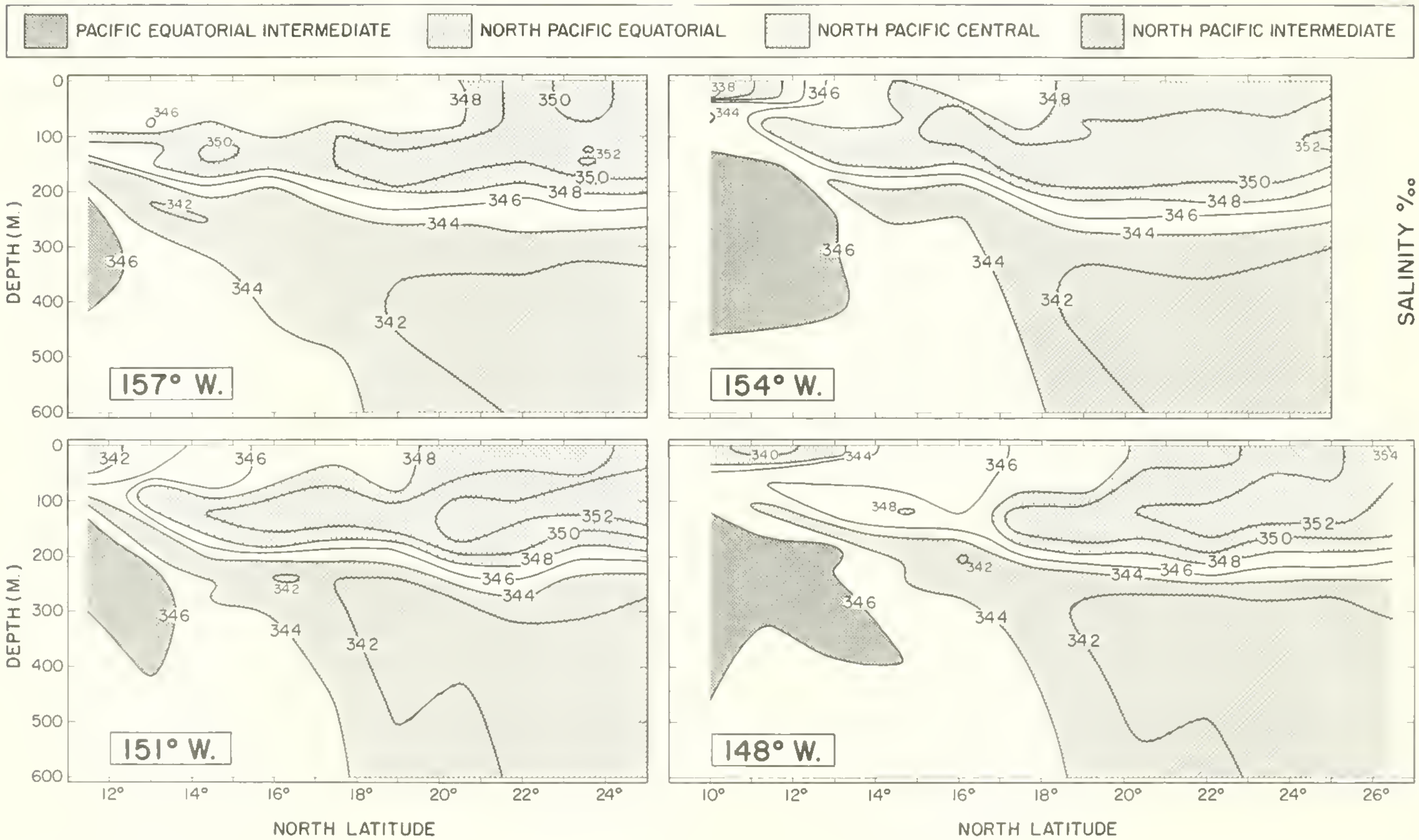

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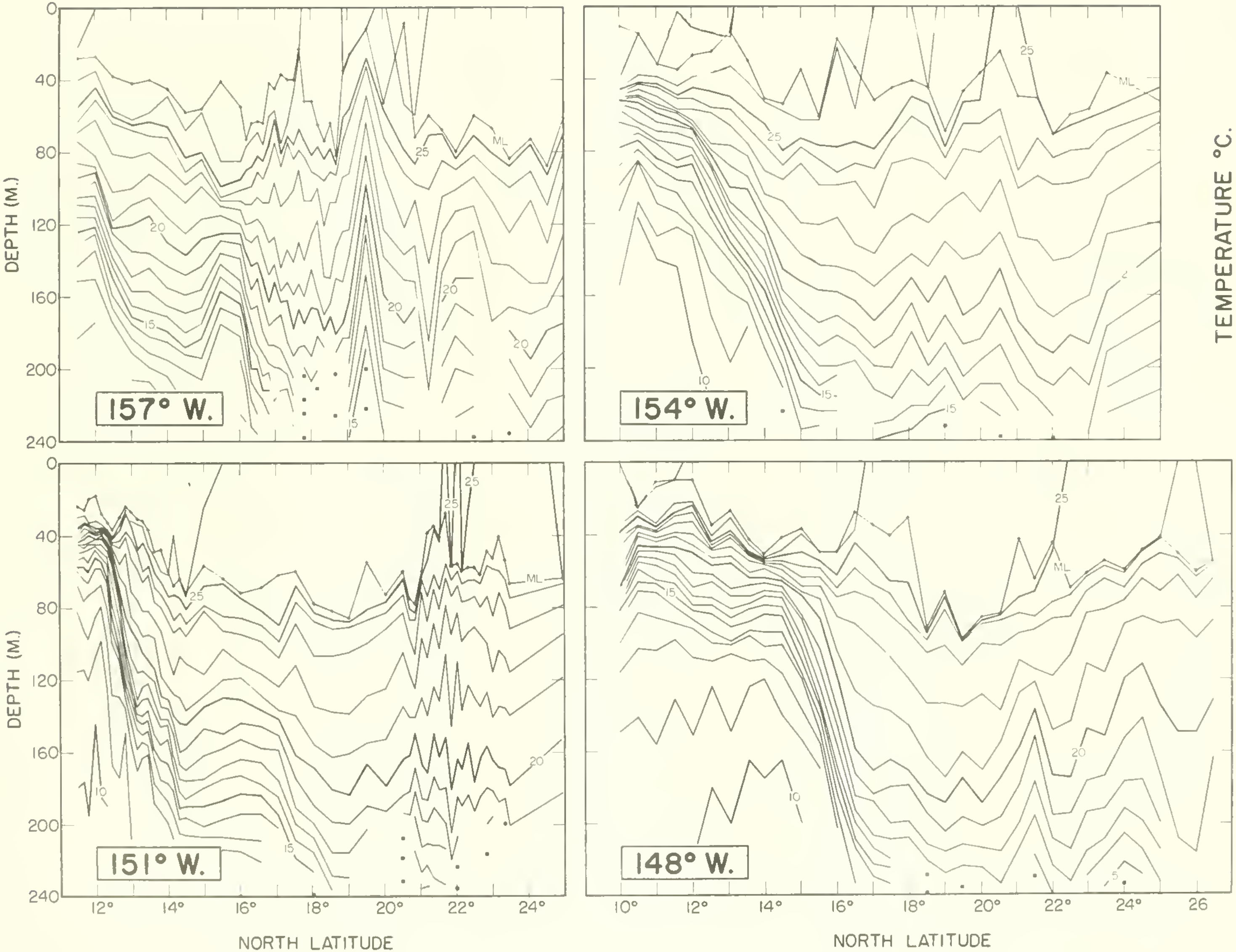
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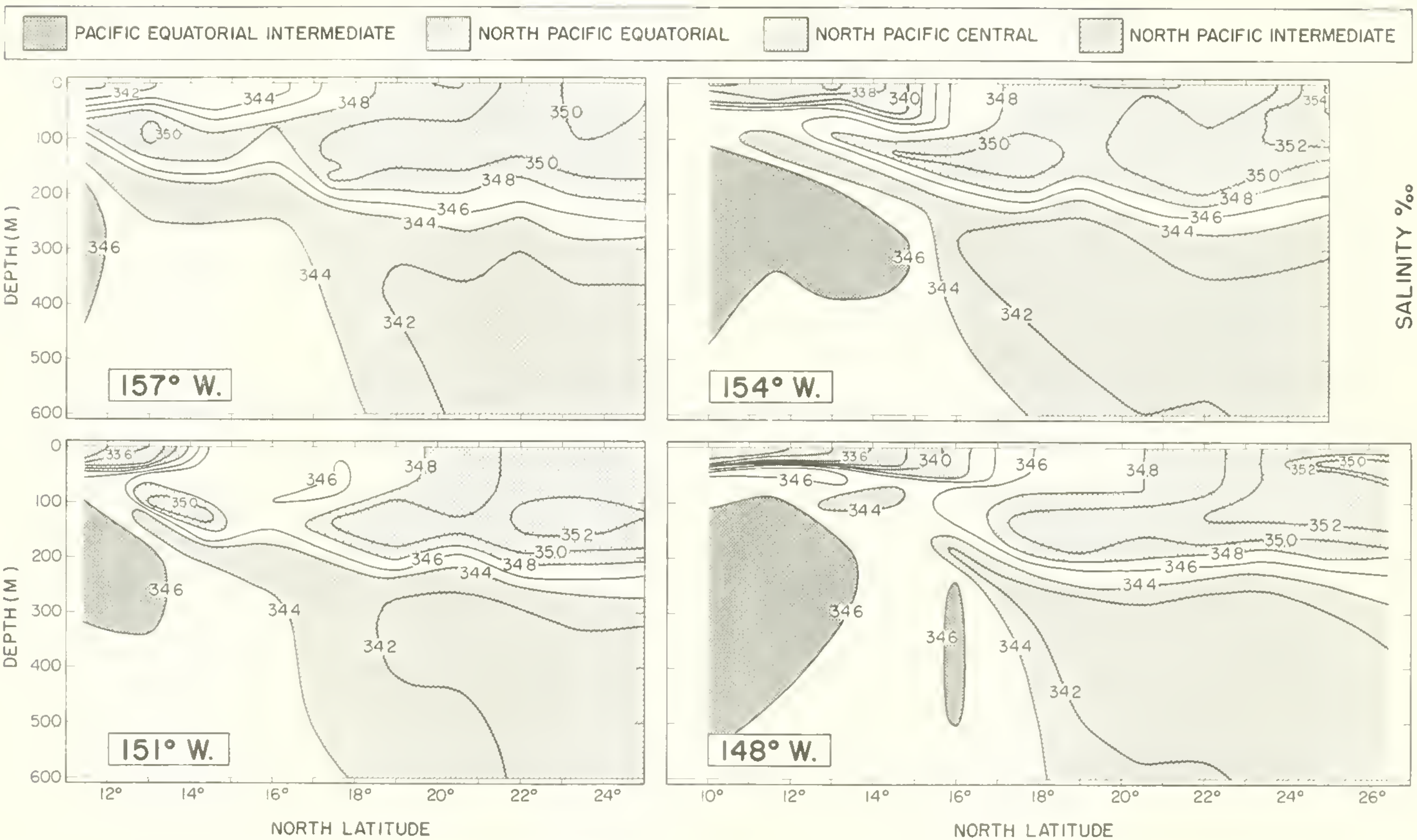

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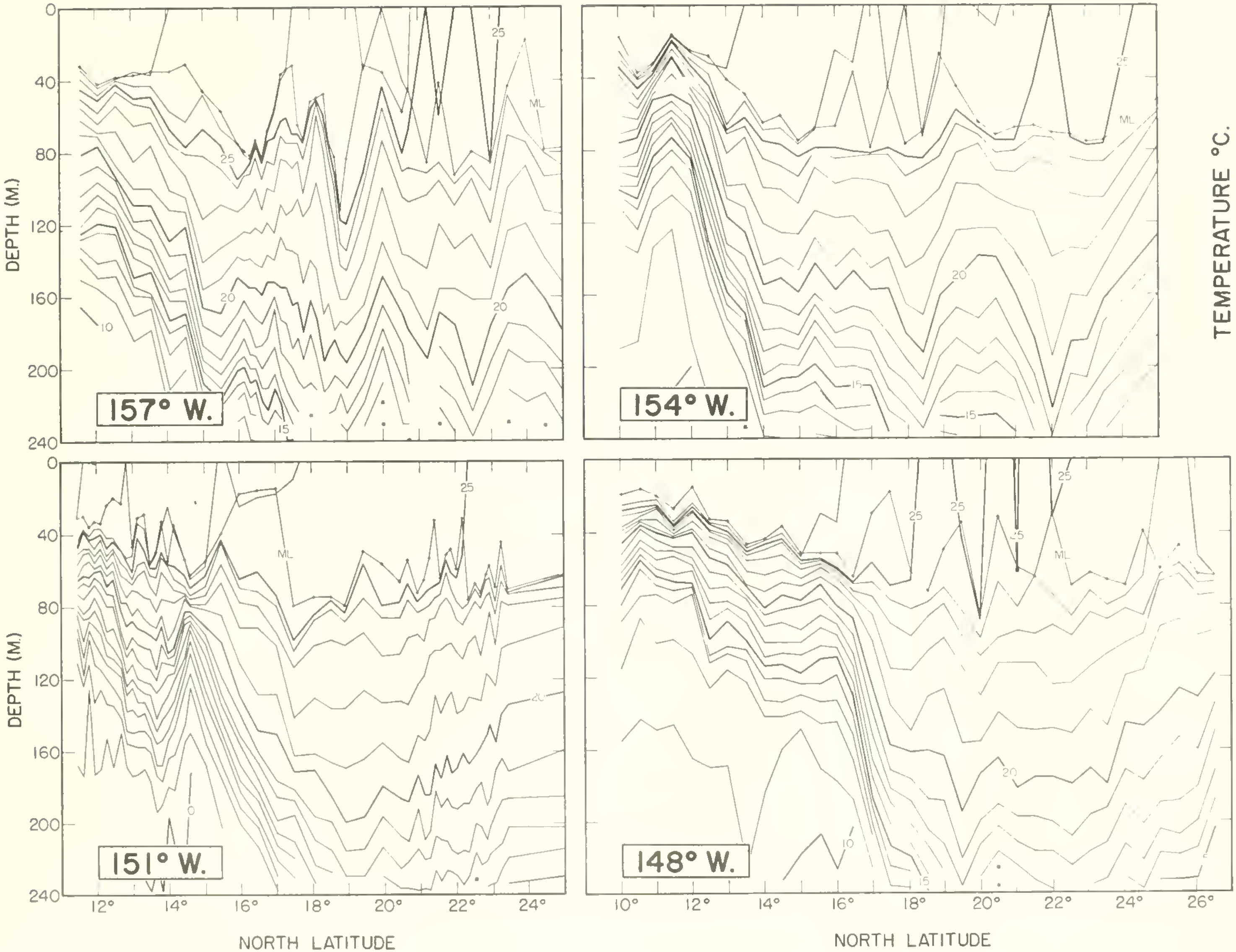

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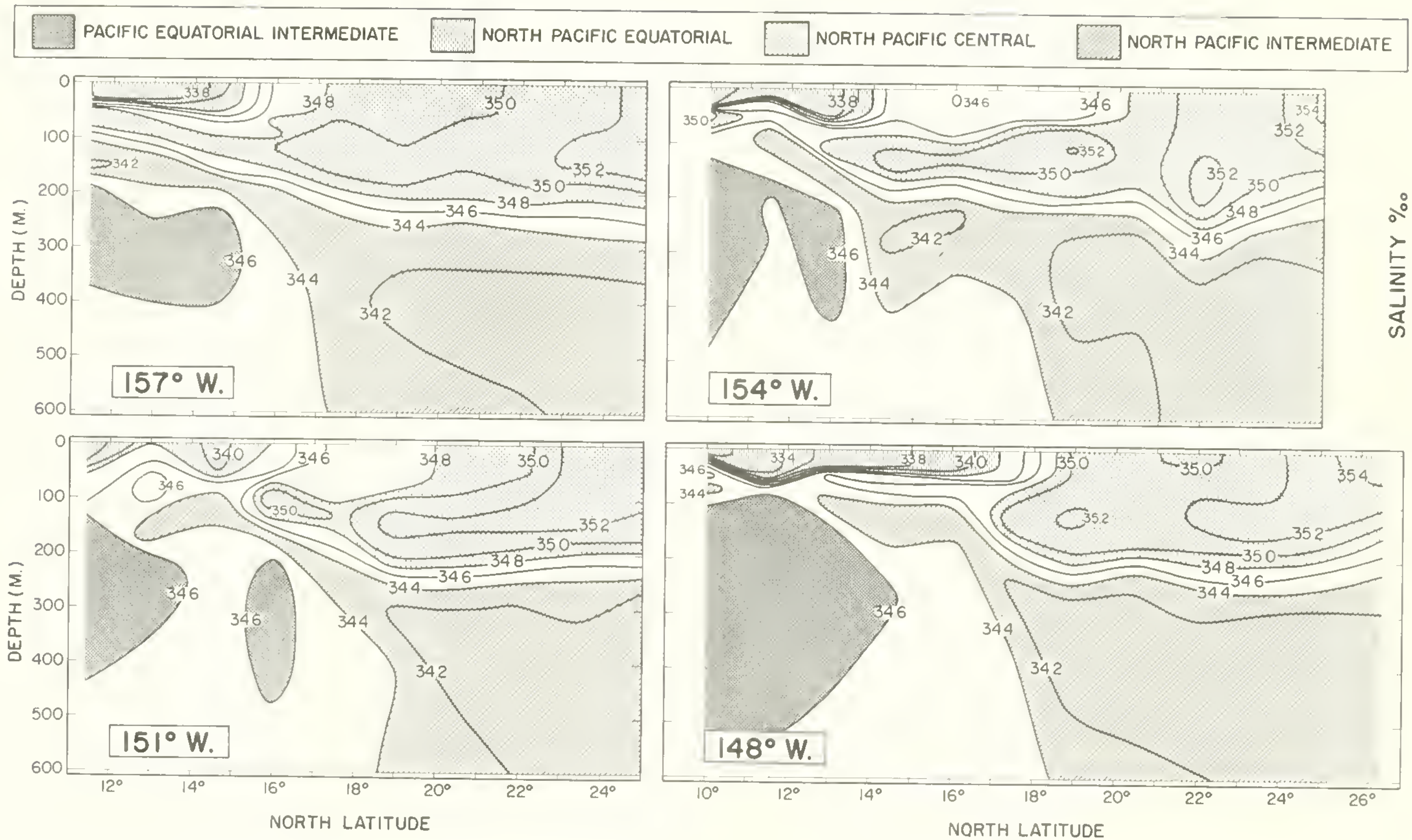

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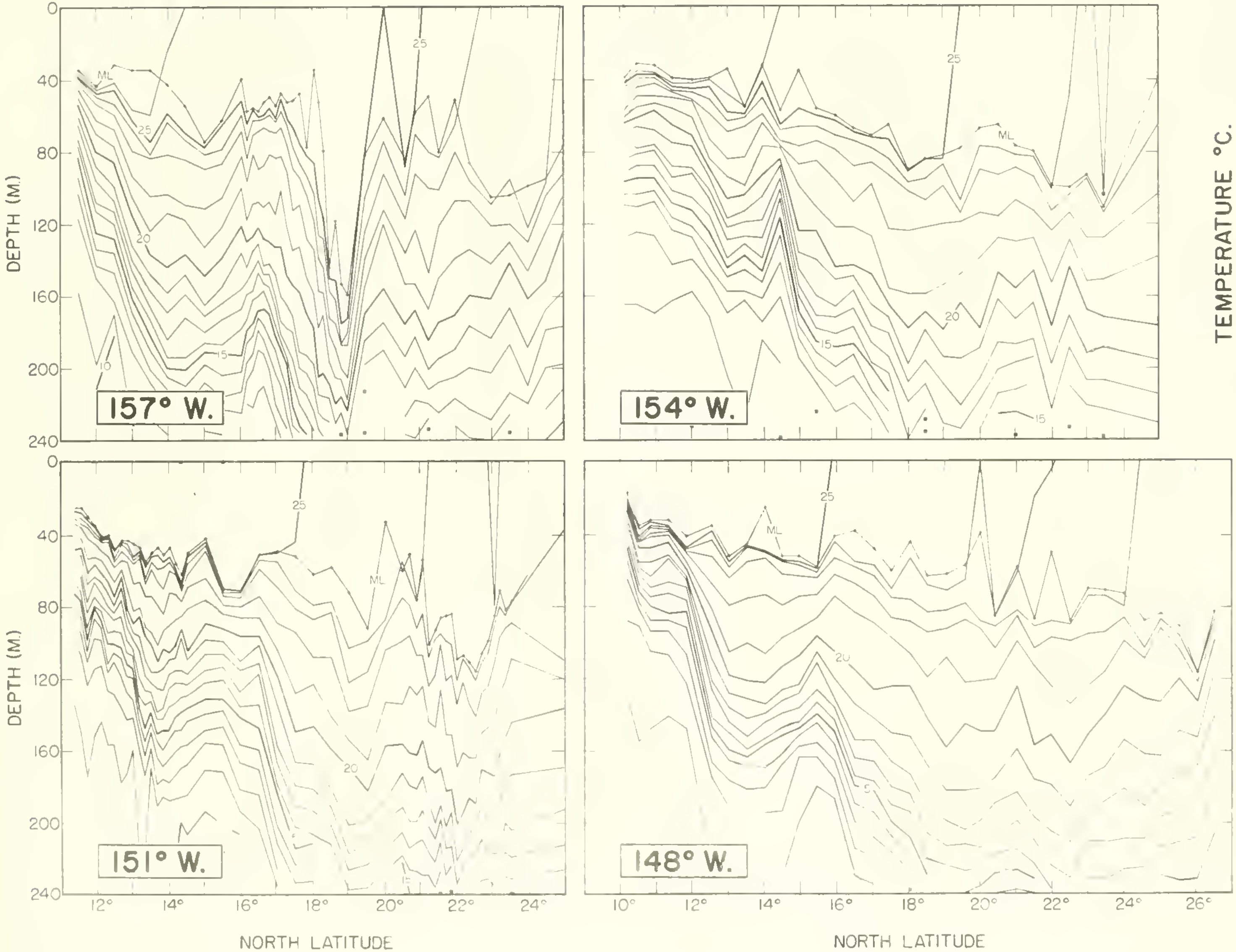

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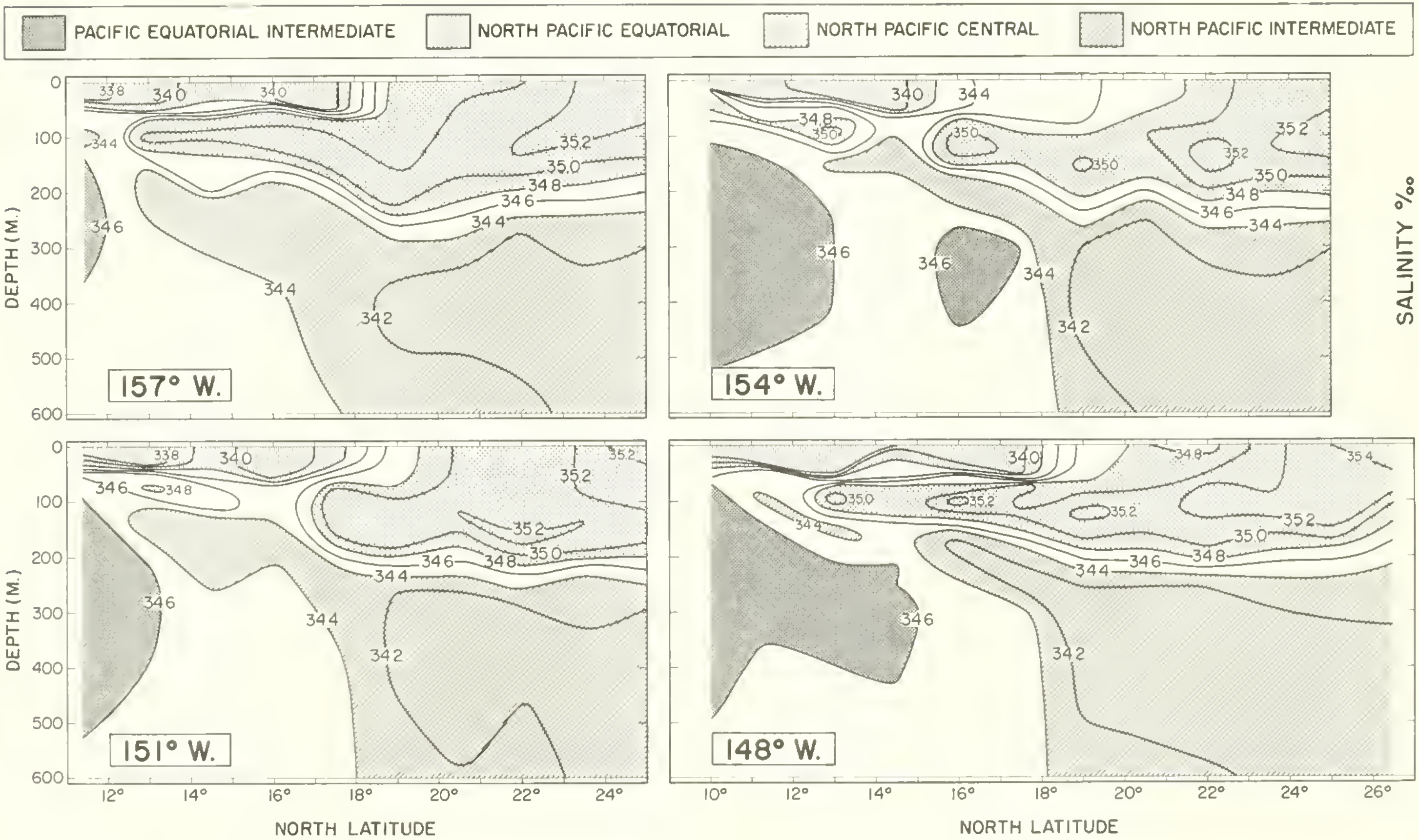

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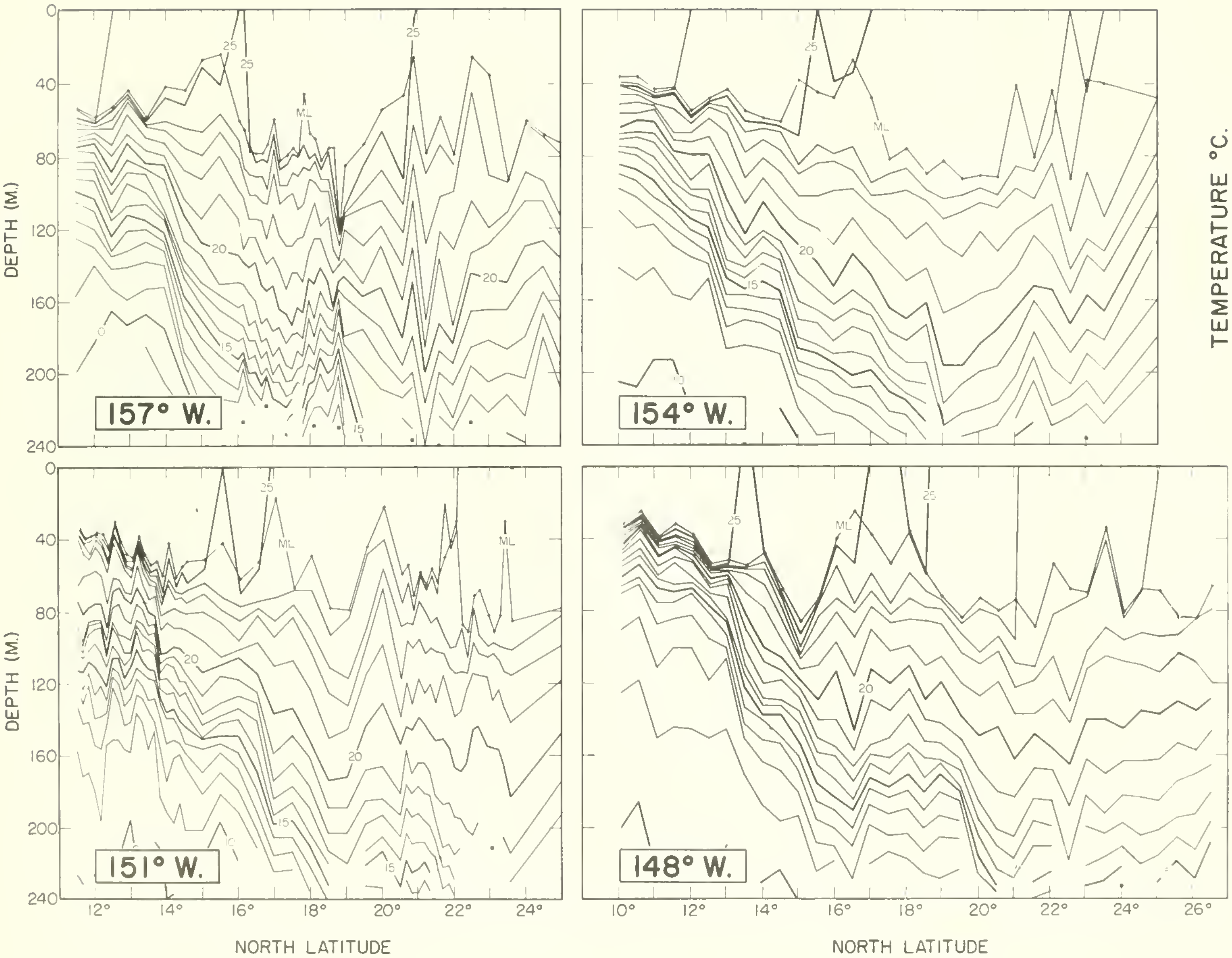

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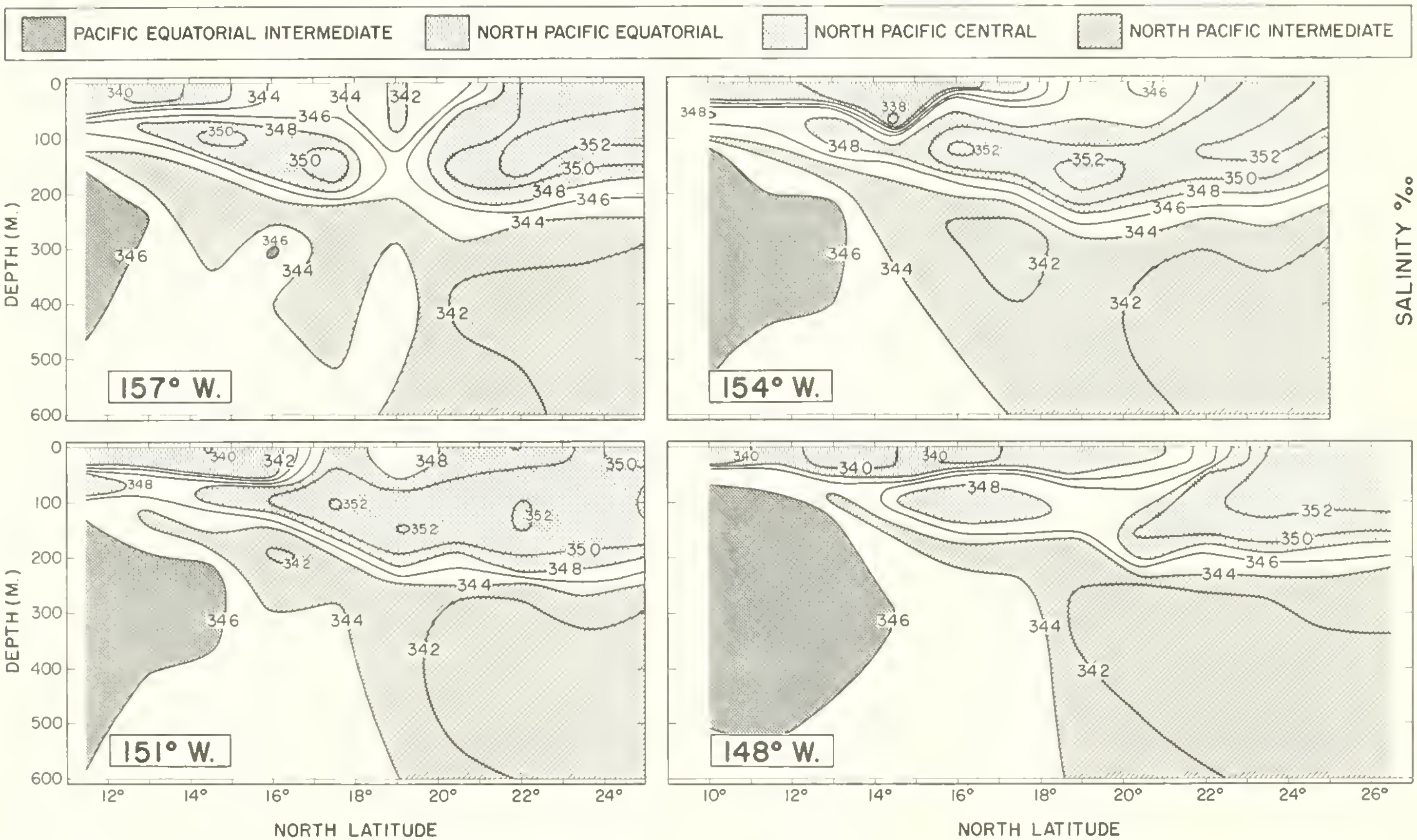

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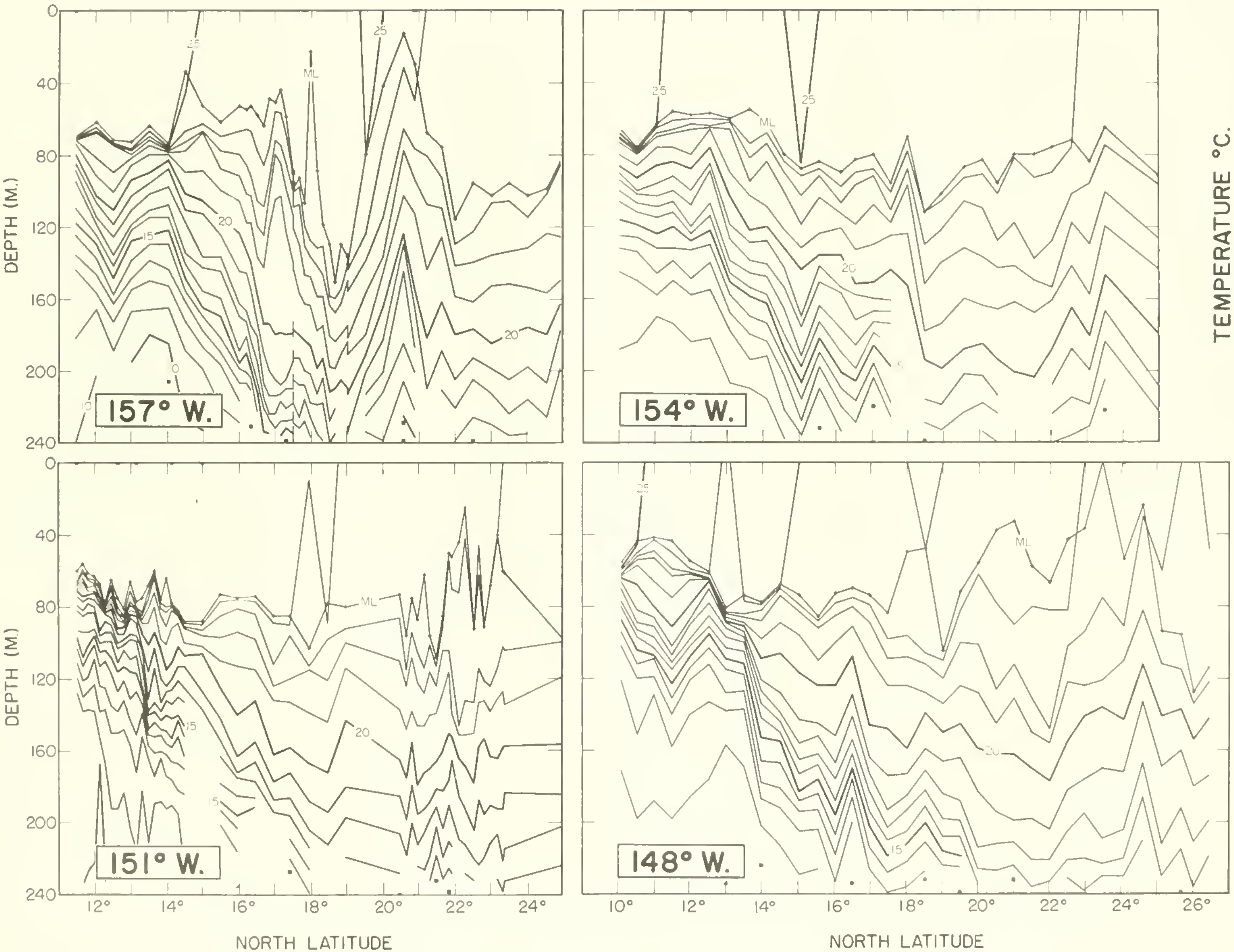
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148° W.
DEPTH (M.)
NORTH LATITUDE
TEMPERATURE °C.
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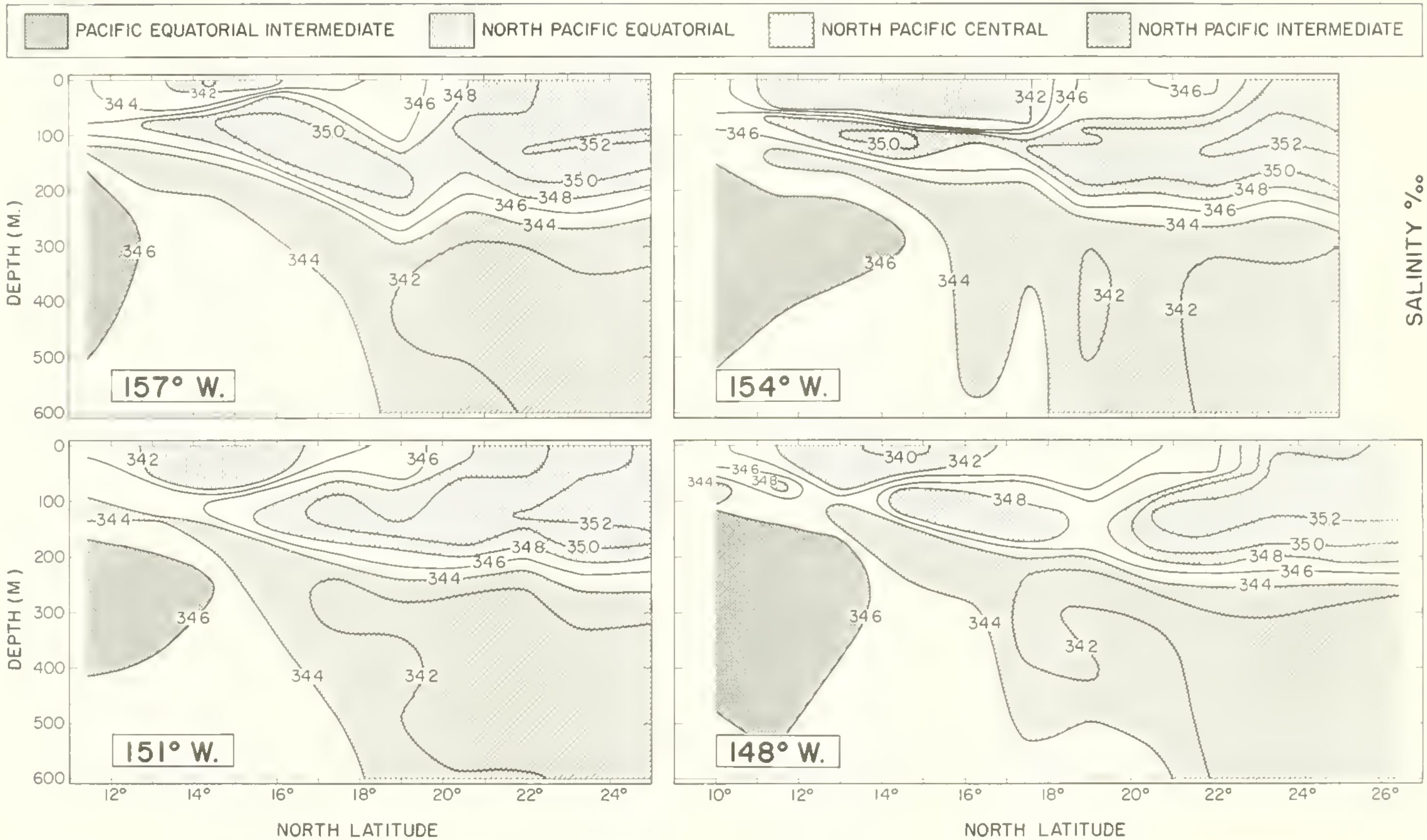
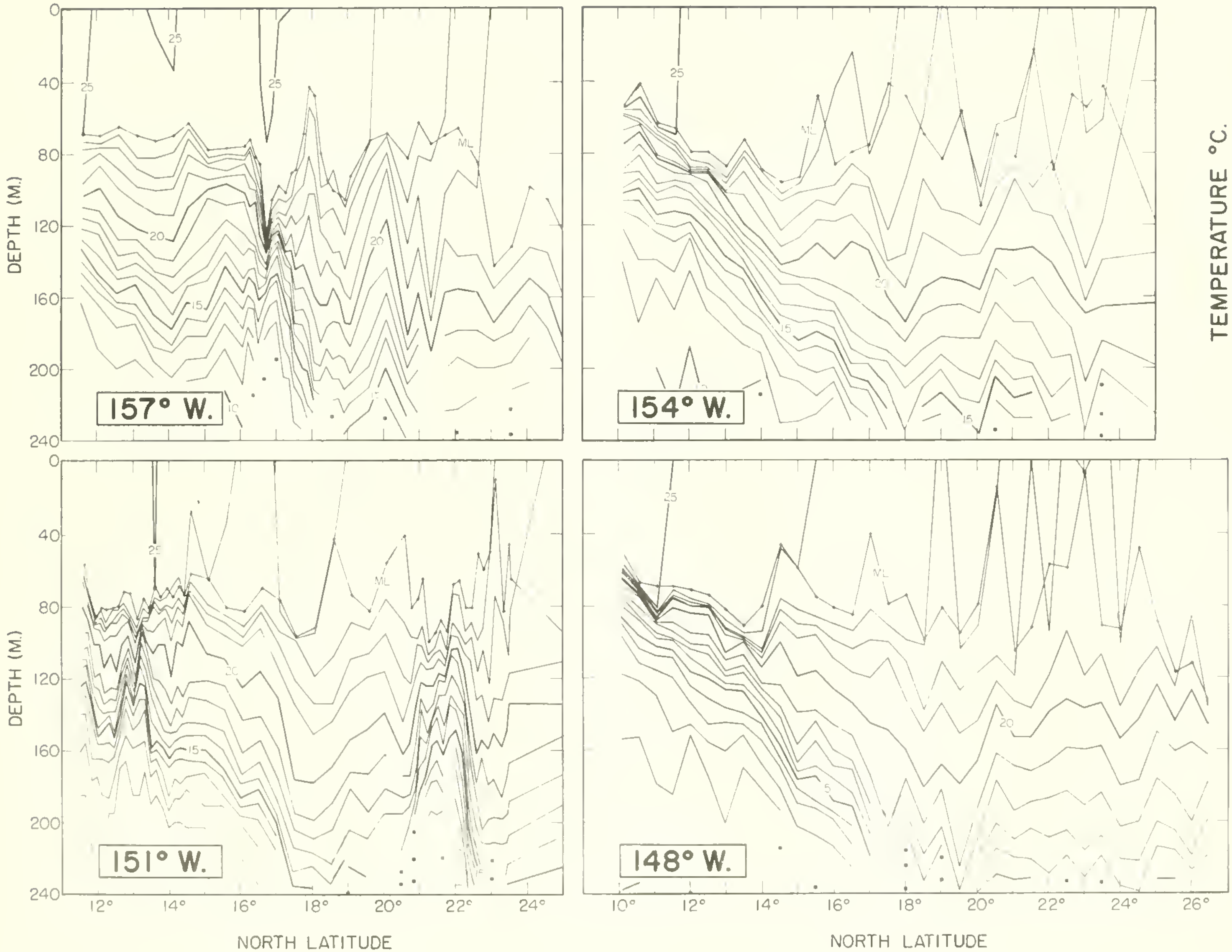


TOWNSEND CROMWELL CRUISE 12, JANUARY 1965



157° W.
154° W.
151° W.
148° W.
TEMPERATURE °C.
DEPTH (M.)
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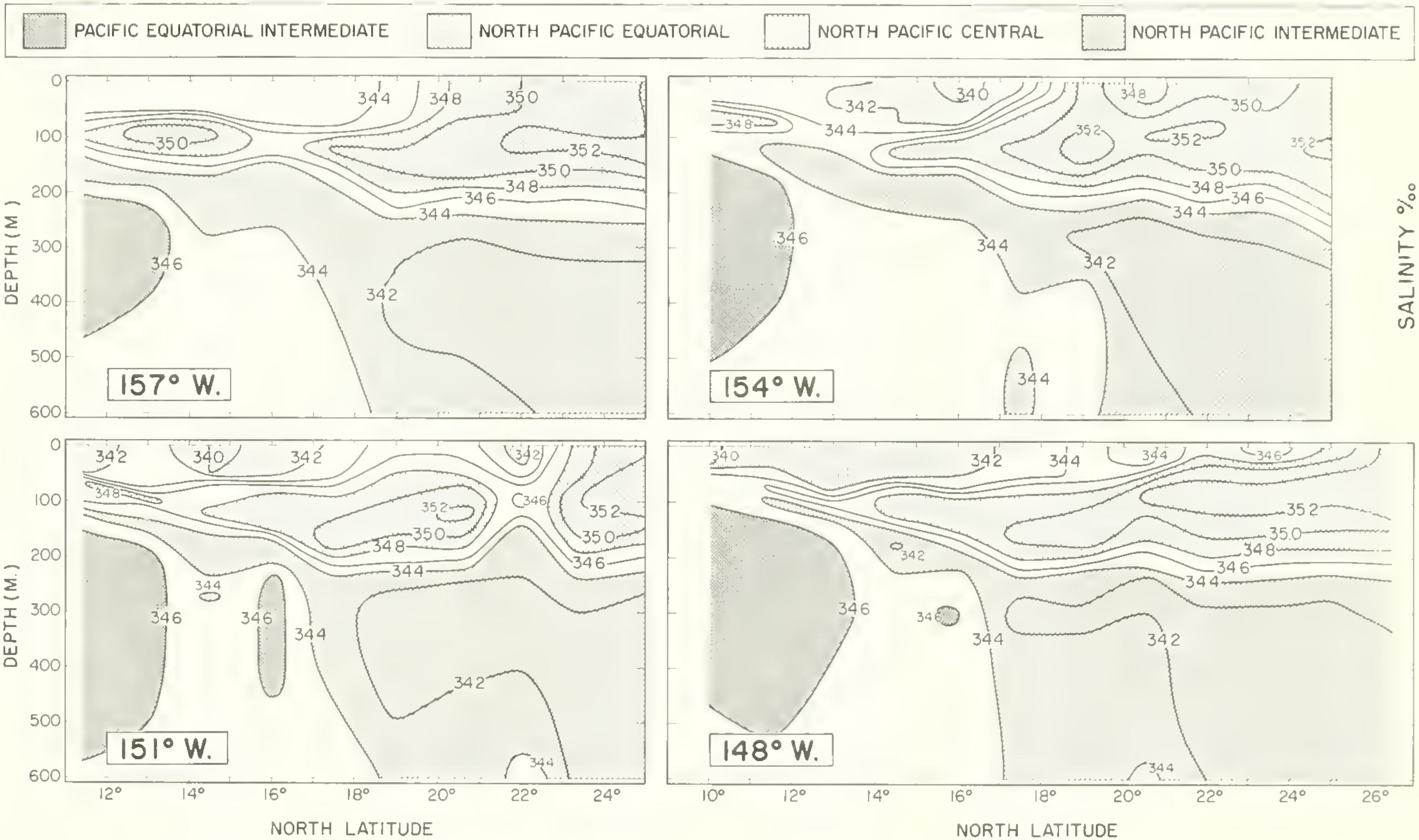

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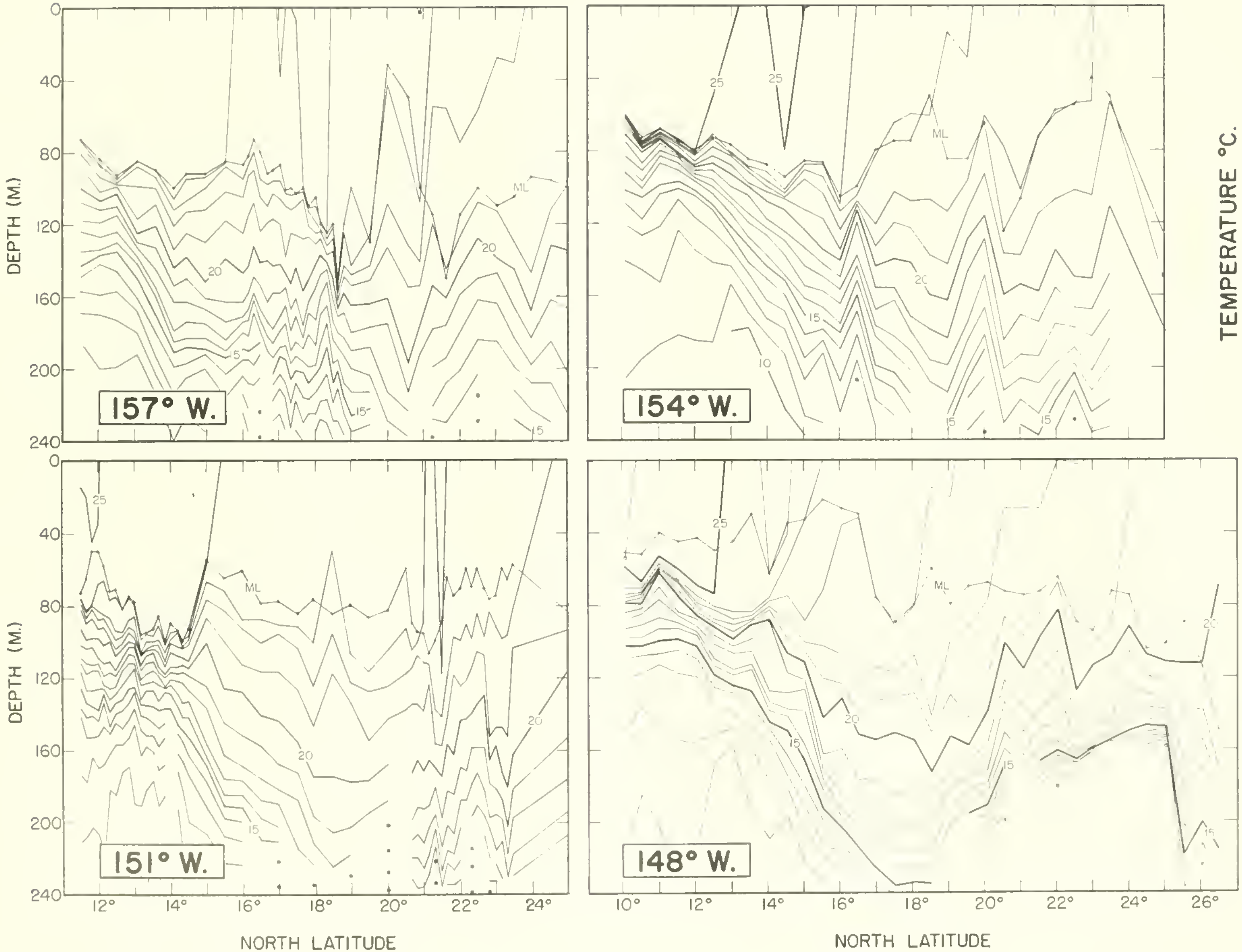
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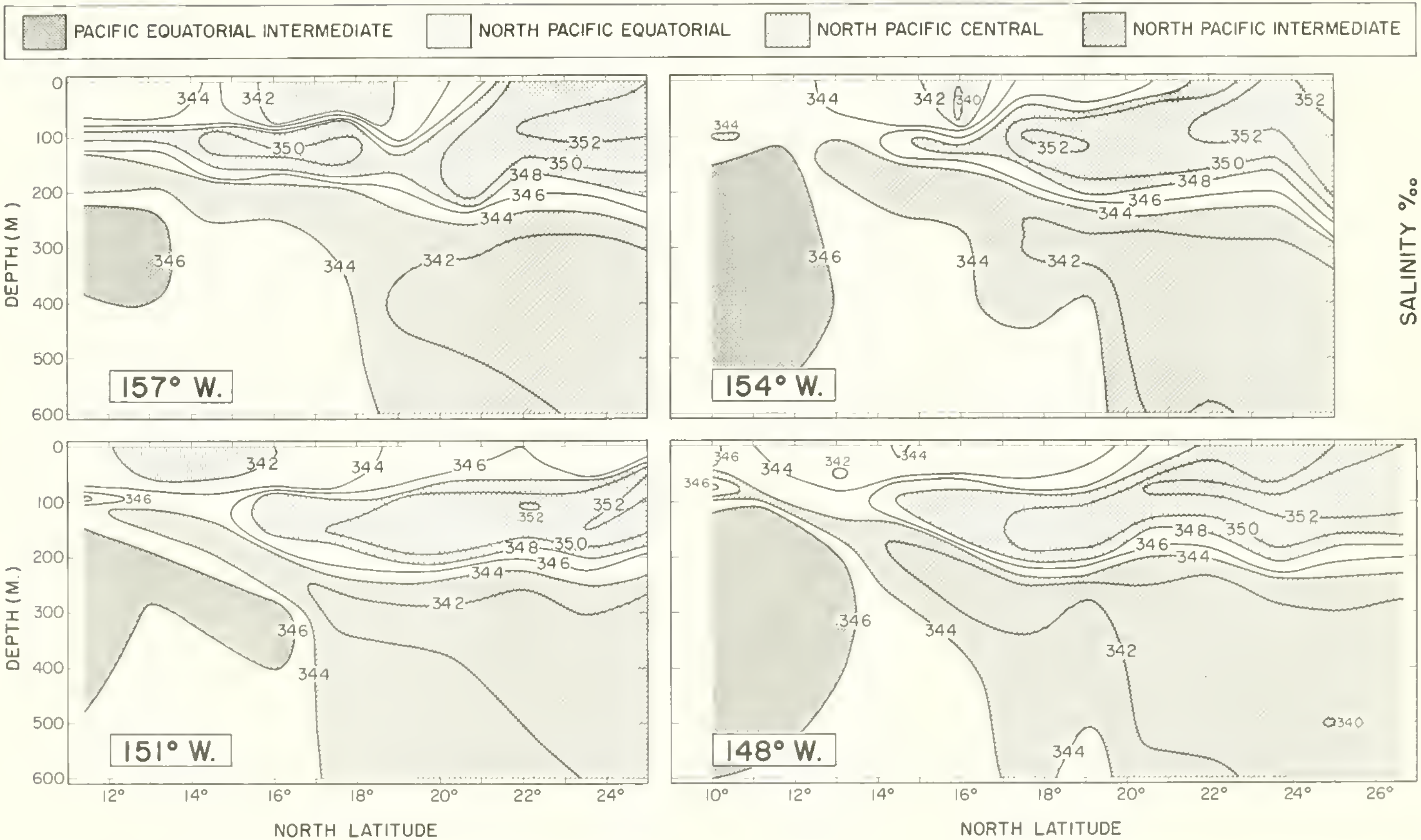

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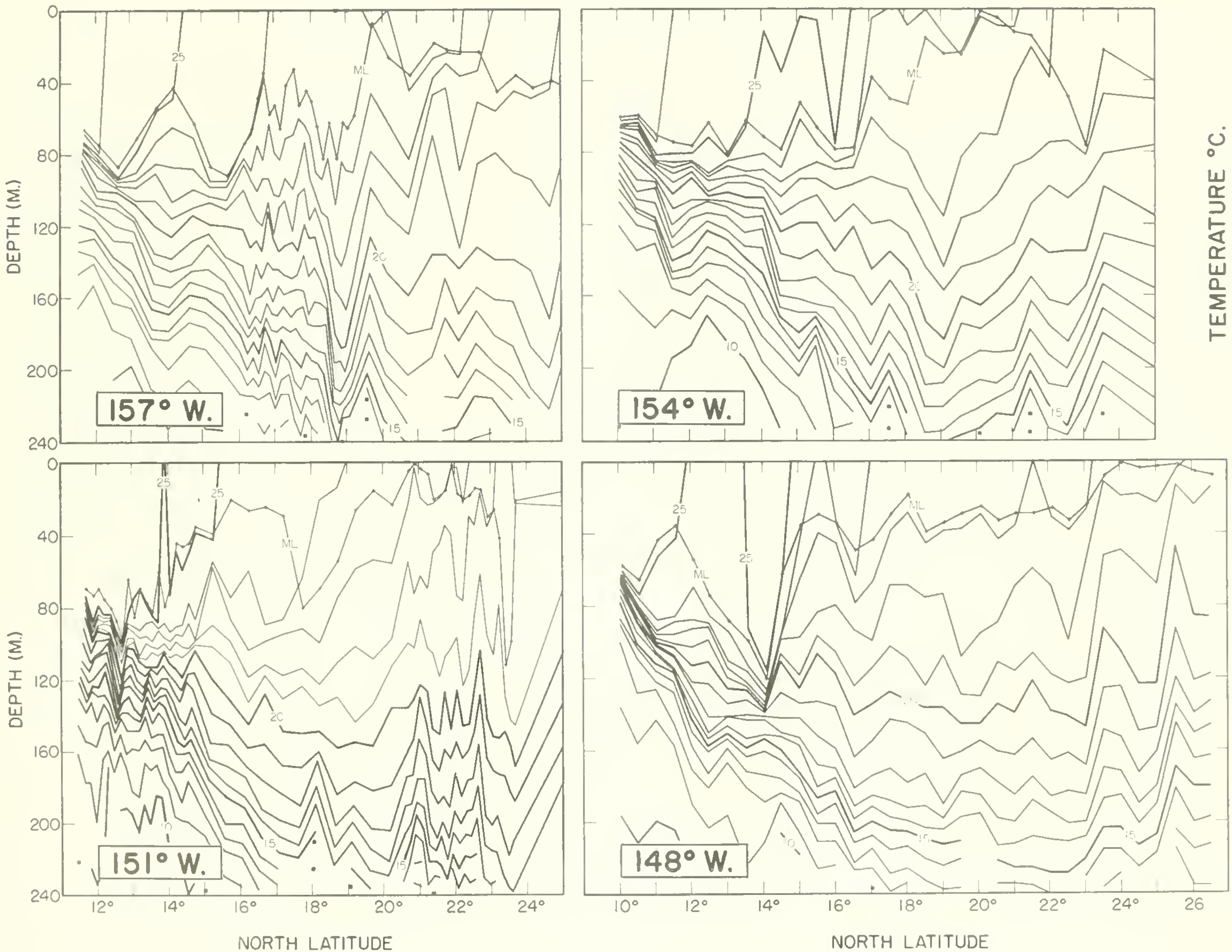

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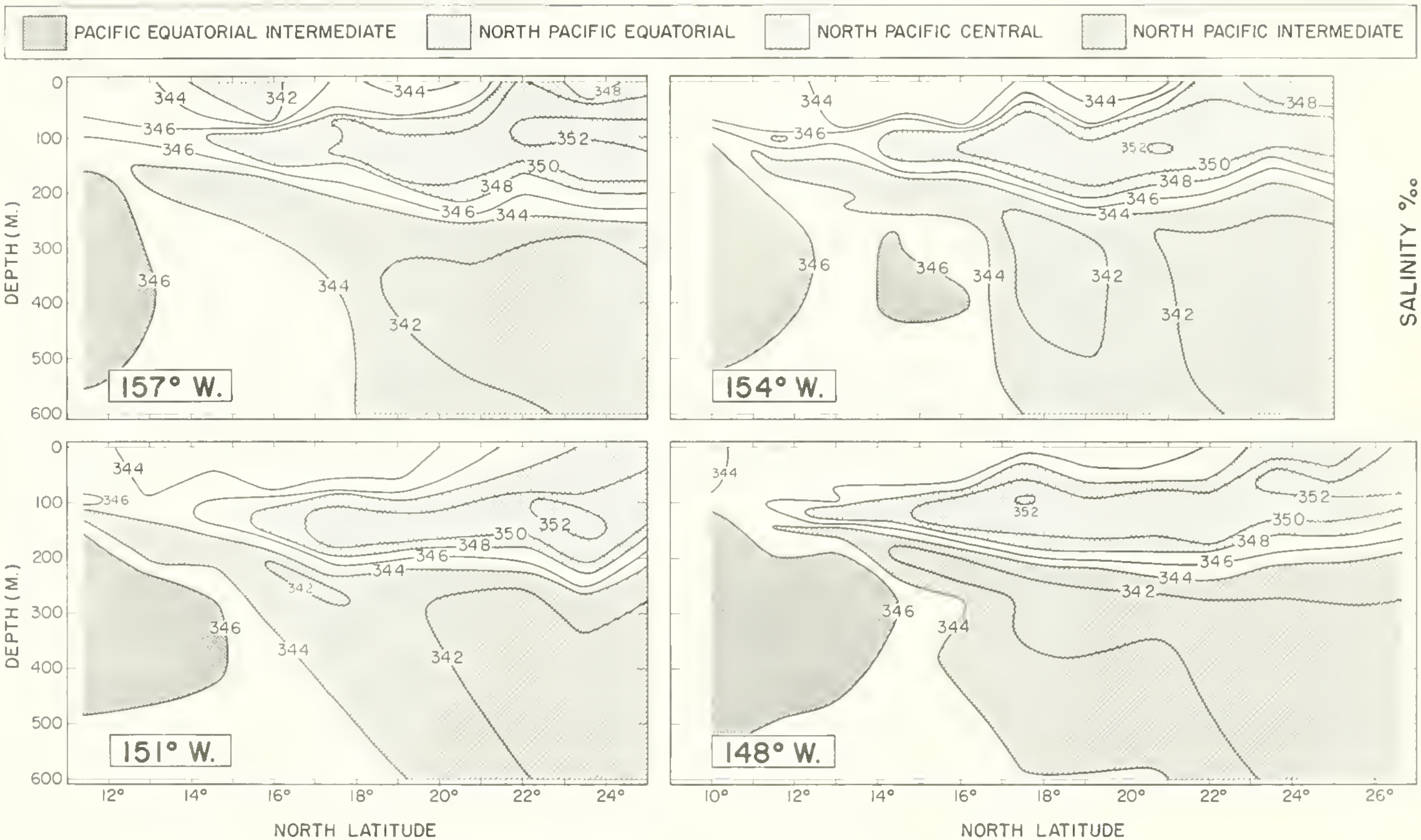

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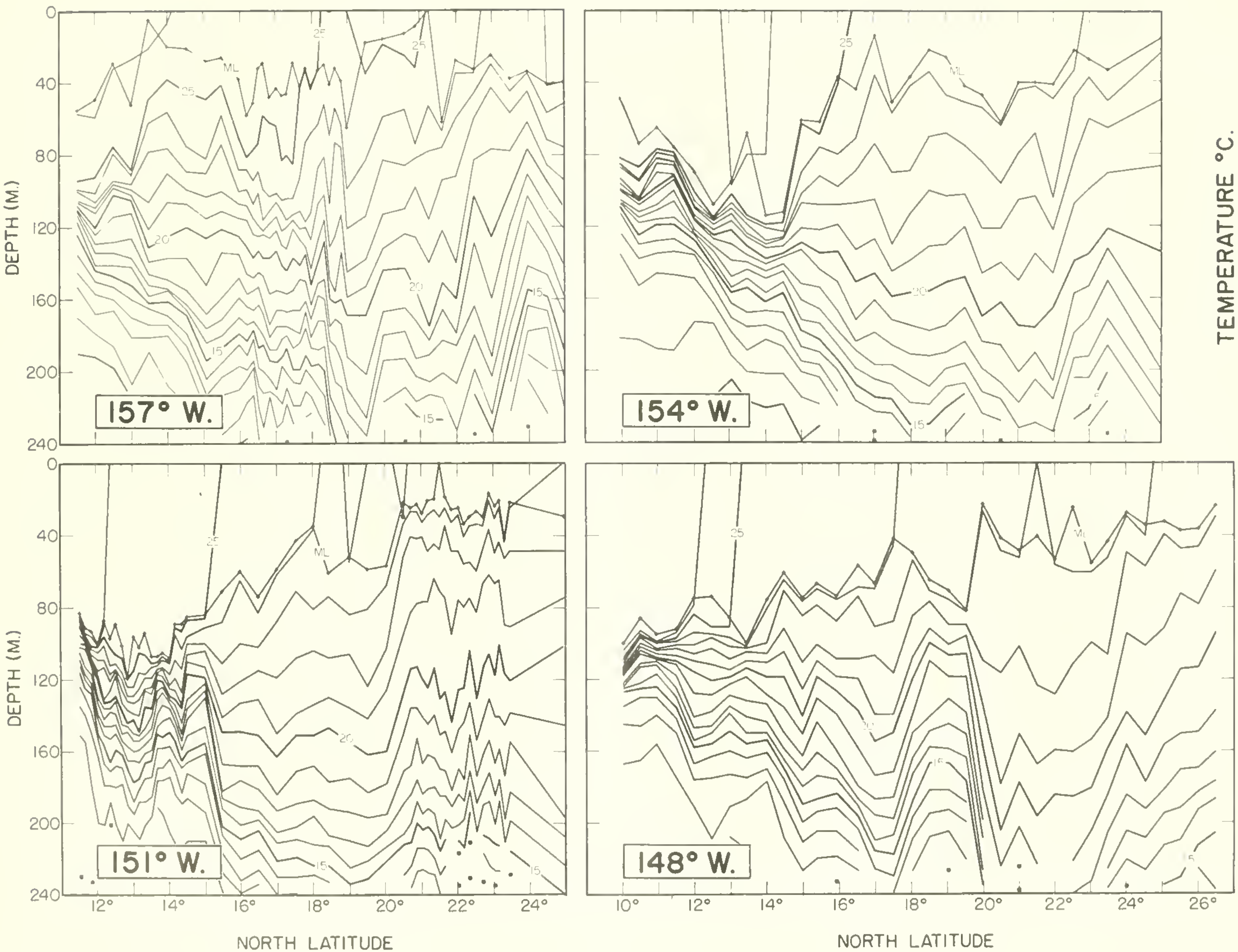
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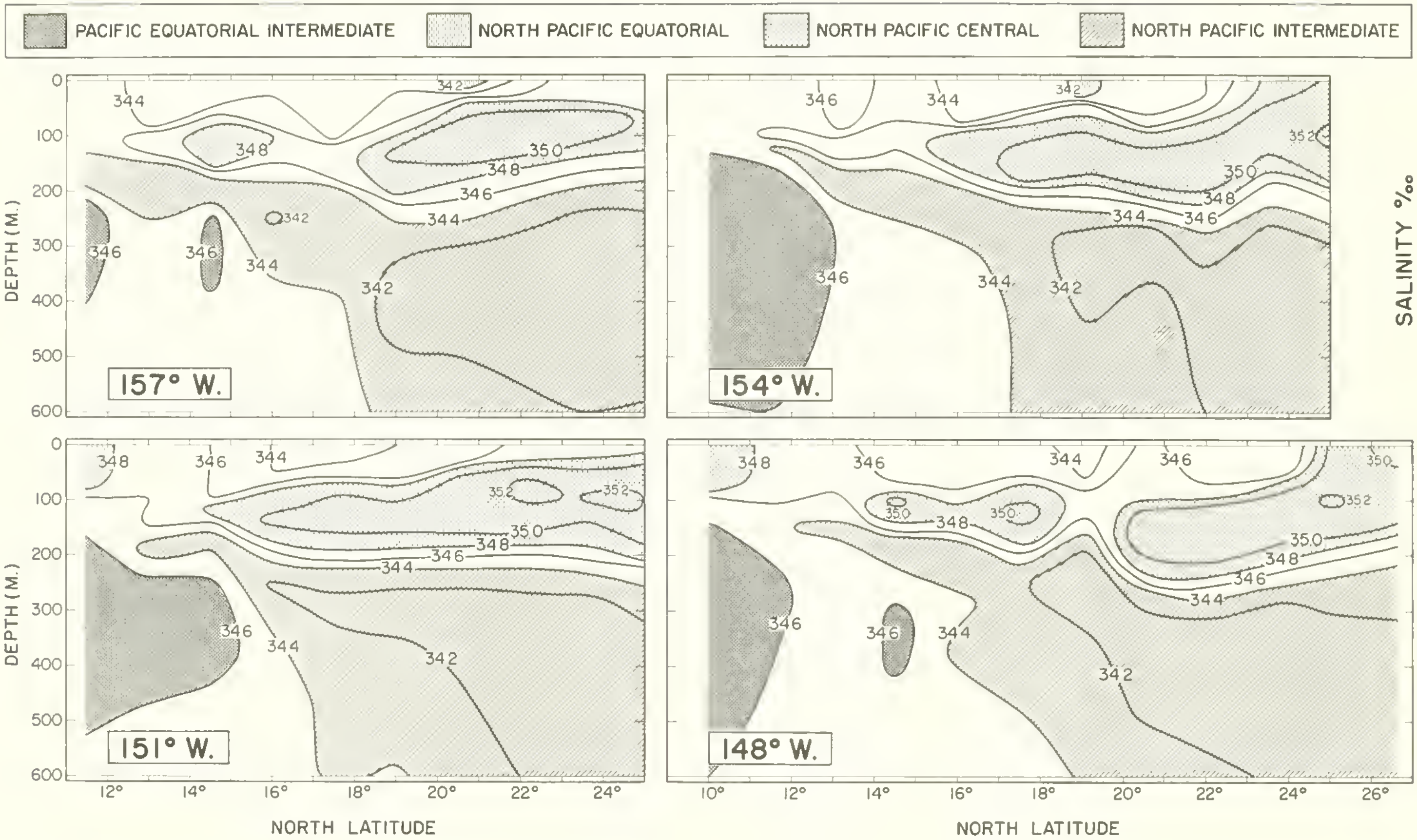
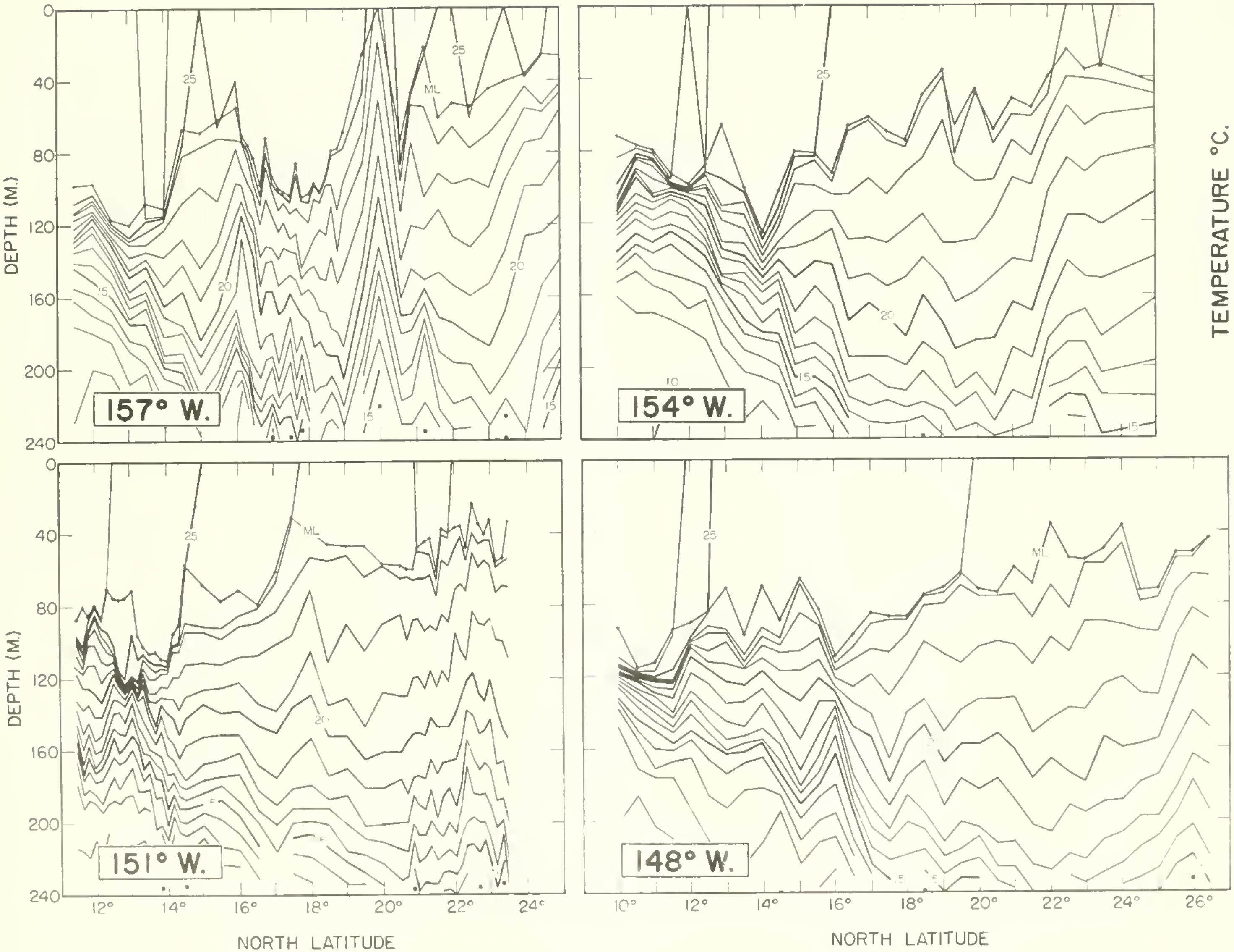


TOWNSEND CROMWELL CRUISE 16, MAY 1965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148° W.
DEPTH (M.)
NORTH LATITUDE
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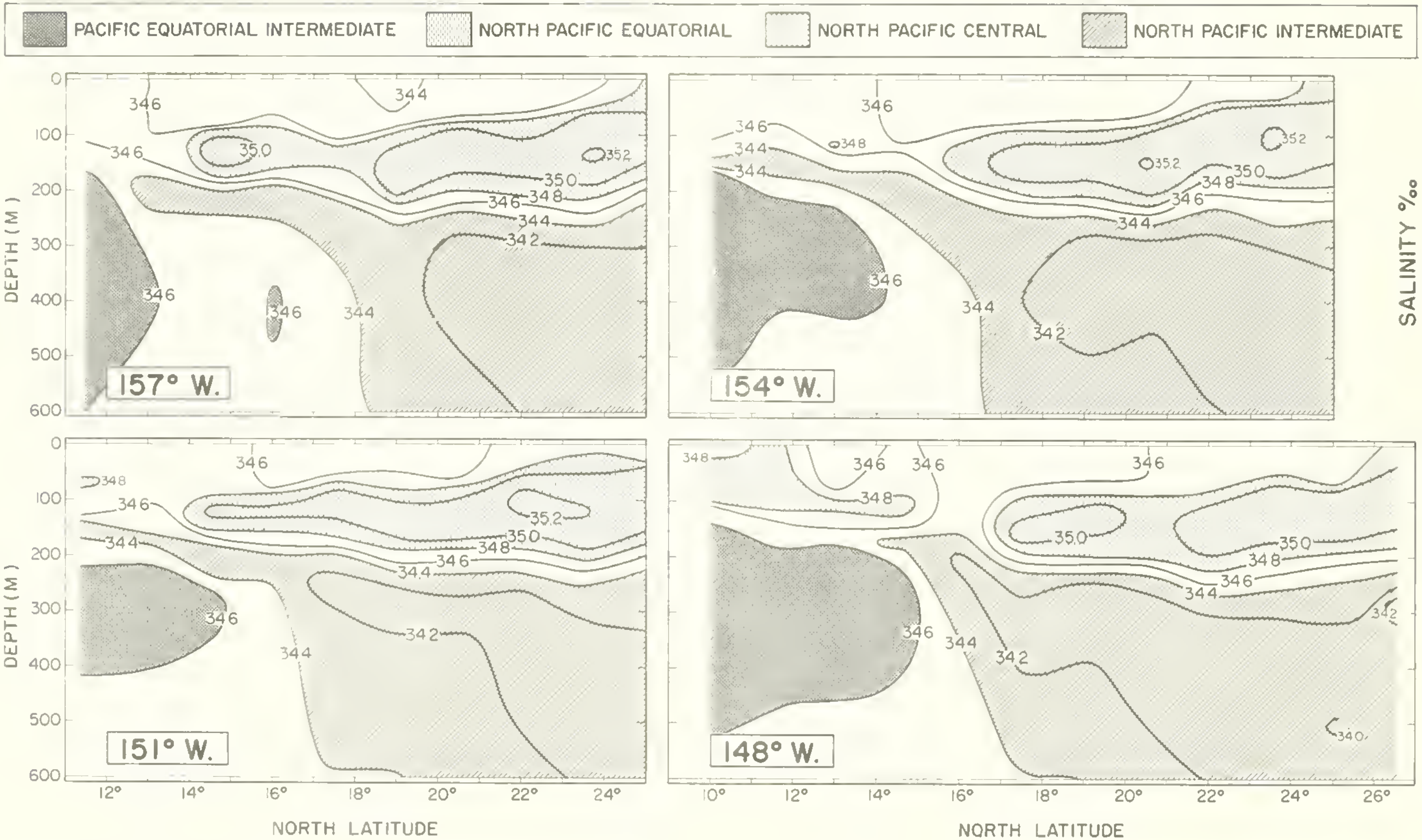

TOWNSEND CROMWELL CRUISE 17, JUNE 1965

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The Department works to assure the wisest choice in managing all our resources so each will make its full contribution to a better United States -- now and in the future.

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DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
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