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Environmental Studies of the South Texas Outer Continental Shelf 1975

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I. INTRODUCTION

Physical oceanography is an integral part of any offshore environmental assessment. It is needed for a baseline description, for use in the prediction of dispersion of contaminants and for support of other oceanographic disciplines.

The first year study contained in this report consists of an analysis of existing historical data. The data have been used to attempt to derive as comprehensive a picture as possible of what is known about the physical oceanographic characteristics of the South Texas continental shelf.

The primary area of study is the most southern part of the Texas-Louisiana continental shelf approximately between latitudes 26°-28° N and longitudes 96°-98° W. However, because of the sparseness of the data in this area, the important influence of runoff from the distant Mississippi system, and the general complexity of conditions in the region, characteristics of the entire Texas continental shelf and slope have been considered.

A prime characteristic of conditions in continental shelf regions is their variability. For this reason, a climatology is difficult to establish, and conditions observed during any one period may be quite unrepresentative of mean conditions over a long period of time. Cautious extrapolation is possible, however, and extensive use has been made in this report of a combination of synoptic studies, and studies of average conditions and departures therefrom.

In several cases, each topic has been considered by two or more investigators, each reaching his own conclusions. Often, as in the case of overall surface circulation, a complete picture is not apparent. In such cases it is best to let each data set speak for itself. If the available data set does not lend itself to a complete, unambiguous interpretation, this is in itself a clear indication of the need for further study.

The main body of the report consists of two sections--descriptive studies and modelling studies. In the descriptive section (Section II), a chapter is devoted to each topic, and each chapter may contain several articles. The format is designed so that each article will contribute in turn to the sum of observational knowledge. The chapter on currents comes last, and draws both implicitly on all of the preceding chapters.

The modelling studies (Section III), consist of interpretive reports utilizing the data and analyses of the descriptive section. Water mass characteristics, local and non-local circulation influences and oil spill trajectories are considered.

Inadequacy of data has been a problem throughout the study. There are insufficient temperature and salinity data to develop a reliable three-dimensional climatology. There are no extensive direct current meter measurements in the open-shelf lease area; the only sets of open-shelf current meter data are from locations off Galveston. This is particularly unfortunate in this region because of the existence of complex and intermittent convergence regimes. Consequently, extensive additional field data and analysis is needed in the region. Requirements for further studies are considered in Section IV.

The study has utilized the capabilities of many investigators from the National Ocean Survey (NOS), the National Marine Fisheries Service (NMFS), and Texas A&M. Sections II D2 and II E1b were prepared by Catherine Warsh of the National Ocean Survey, Sections II B2 and II E1a by Robert Temple and John Martin of the NMFS Gulf Coastal Fisheries Center, Section III B1 by Reed Armstrong of the NMFS Atlantic Environmental Group, and Sections II B1, III A and III C by Robert Whitaker and Andrew Vastaro of Texas A&M.

II. OBSERVATIONAL STUDIES

A. Area Climatology

The atmosphere and the coastal waters of South Texas are closely coupled together, as they are in all the world oceanic areas. Thus an understanding of atmospheric conditions is essential for an understanding of oceanic conditions. Moreover, summaries of weather observations in coastal and offshore regions provide the most complete record of conditions in the lease area. Meteorological observations are several orders of magnitude more numerous than oceanic observations.

Observations are most abundant for land stations; a general climatology for the coastal area is considered in sec. 1. Special considerations for the Gulf are discussed in sec. 2. Sec. 3 considers severe storms, particularly hurricanes, which affect the region. For further discussions of these topics see Carr (1967a, 1967b) and Orton (1964, 1969).

1. Coastal Climatology

a. General Climate

The climate of South Texas is subtropical with short mild winters, and hot summers; however, there are significant variations from north to south. In the Galveston area, the climate is predominantly marine, with high humidities, and sufficient rainfall in all seasons. The climate becomes progressively drier from north to south. Compared to an average of 134.85 cm of rain per year at Port Arthur and 106.20 cm at Galveston, Corpus Christi receives only 71.98 cm, and Brownsville 67.95 cm. Somewhat further to the south, annual precipitation increases again, being 114.81 cm at Tampico, Mexico and occurring mostly in the summer and fall. The lease area is therefore, in a semiarid region, between an area of higher all season precipitation to the north and a tropical wet and dry climate to the south. Table 1 gives climatic data for land stations and for Marsden subsquare 076, off Corpus Christi. The wind patterns, particularly are of critical importance for the coastal circulation. These will be further discussed in sections II D and III B.

The climate of South Texas is characteristic of subtropic regions, in that there is no sharply established delineation of the four seasons of temperate zones. Summer and winter predominate, with shortened spring and fall transitional periods often possessing the characteristics of either winter or summer. Characteristic seasonal patterns are:

Summer: Climatically, summer begins with the month of May and lasts through September. While the highest temperatures are normally reached in July and August, both May and September are hot months, and there is little variation in the weather regime from day to day or week to week. Weather in the area is under almost complete control of the tropical maritime air mass extending westward across the Gulf of Mexico from the Bermuda high pressure cell.

Winter: The winter season consists of the traditional period, December through February, although little in the way of actually cold weather is experienced before the 15th of December. This season is not usually marked by any prolonged periods of cold air masses penetrating into these latitudes. The winter season is one of many changes. The weather fluctuates between warm and cold, clear or cloudy, wet and dry, as a wide variety of synoptic systems of various intensities move in and out of the area. Normally, winter temperatures are sufficiently mild as to cause little or no interference with outdoor operations.

Spring and Fall: The fall months of October and November, and the spring months of March and April are transitional, offering some variety in the weather pattern, as modified polar air masses move in and out of the area. Day time temperatures are mild, but usually not hot, and nights are cool.

b. Pressure and Winds

The general circulation of air near the surface in the South Texas area follows the sweep of the western extension of the Bermuda High pressure cell throughout the year. The Bermuda High pressure system becomes dominant during the spring months, as the influence of northern anticyclones disappears. Mean pressure falls as the equatorial trough migrates northward and the low pressure system over Mexico deepens. The minimum mean pressure of about 1014 mb occurs in summer.

Beginning in September, the equatorial trough migrates southward, the Mexican low pressure system fills, and the Bermuda High decreases in strength. Along with this trend, continental high pressure systems to the north intensify as winter approaches. With the weakening of the barriers to the south, these high pressure systems penetrate the lower latitudes and produce the maximum monthly mean pressure of about 1020 mb in winter. The high pressure systems and their associated extratropical cyclones are responsible for the wide pressure ranges in winter.

The surface winds of the South Texas coastal region are dominated by the general circulation of the Bermuda High throughout the year. In March and April, alternating strong north winds and increasingly persistent strong southeast winds produce the highest annual average wind speeds. The warmer months are dominated by persistent southeasterly winds. South-southeast winds reach a maximum frequency in June and July. These winds produce a near monotonous summer period interrupted only occasionally by a rainshower or tropical storm. The lowest mean wind speeds occur during the late summer and early fall with a monthly average of about 16 km/hr.

As winter approaches, the winds become more variable in both speed and direction. During winter, northerly winds associated with the intensified North American continental high pressure systems produce a maximum in the frequency of wind speeds greater than 50 km/h. Although the frequency of northerly wind direction increases during winter, the South Texas coastal area is far enough south to remain under the dominance of the Bermuda High and its prevailing southeasterly winds.

c. Temperature and Precipitation

Air temperature extremes for the South Texas area are tempered significantly by the combined effects of prevailing southeasterly winds and the large area of Gulf waters. Low temperatures occur when strong northerly winds associated with cold continental fronts penetrate the area. Freezing temperatures normally occur at near-coast weather stations at least once each winter; the largest departure from normal air temperatures, and the largest temperature departures for coastal waters occur at such times. (See sec. II B 3, table 3, for examples). The highest summer temperatures occur when there is a shift of wind direction from the prevailing southeasterlies to south and southwest. These winds, having recently left the semi-arid land mass to the southwest, have had insufficient time to be modified by the relatively cooler Gulf waters. Such air temperature extremes diminish seaward.

The normal climate for the South Texas area is semi-arid, and this is accentuated by periodic droughts, such as occurred in the early 1950's. Peak precipitation months are May and September. Tropical cyclones may add large amounts to the monthly rainfall totals for the period June to October, and may cause normally hypersaline bays to freshen in a period of a few hours.

The winter months have the least amount of rainfall. Winter precipitation comes mainly from frontal activity and low stratus clouds, the latter producing slow, continuous rain. Precipitation may begin at any hour, and may continue intermittently for several days. Such occurrences account for the highest frequency of precipitation being in December and January.

Frozen precipitation is rarely observed. While the coastal regions have on the average a trace of snow during winter, such occurrences decrease seaward. Rarely, hail occurs when large cumulonimbus clouds develop to great heights.

d. Synoptic Aspects

The synoptic aspects of the South Texas climate are determined by the dominating air masses, together with concomitant pressure centers (in summer) and frontal movement (in winter).

Air Masses: The following air masses influence the weather in South Texas:

Tropical Maritime (Tm)--This air mass enters South Texas from the south and southeast, as a result of the circulation around the Bermuda high pressure cell. During the period March through October Tm air predominates at low levels across all of South Texas. From May through September, Tm air dominates the area almost completely. Overrunning of polar air by tropical maritime in the winter season is a common occurrence. This situation almost always results in stratus clouds with accompanying low ceilings and visibilities.

Polar Continental (Pc)--This air mass rarely pushes into South Texas before October or after April, but is frequent during the winter and early spring months. It undergoes rapid modification in the area. When this air mass pushes out over the Gulf of Mexico, the return flow of modified Pc and Tm air almost always produces low stratus clouds over South Texas.

Polar Maritime (Pm)--This air mass is most frequent during the late fall and during the spring. It is rapidly modified, and the return flow of Pm and Tm air from the Gulf also results in extensive stratus formation over South Texas. Overrunning by Tm air is not as frequent as with the Pc air mass. The small migratory highes of either Pm or Pc air that move down into Texas result in the most favorable flying weather: clear skies, no fog, and little or no turbulence.

Arctic (A)--The invasion of South Texas by this air mass is not frequent, and is normally confined to the months of January and February. Although it has been modified considerably by the time it reaches South Texas, the accompanying low temperatures are disastrous to most vegetation, and few dwellings or buildings in the area are properly insulated against the cold. This air mass is usually shallow and produces some of the worst flying weather in the form of low ceilings and freezing rain. Snow has occurred at times but is very infrequent.

Tropical Continental (Tc)--The source region of this air mass includes the area of Arizona, New Mexico, and northern Mexico during the summer months. Occasionally, Tc air replaces Tm in South Texas during the summer months as is evident by the passage of a dew point discontinuity eastward toward the coast. Maximum temperatures of 40°C or higher occur inland when this Tc air dominates the area.

Pressure Centers: In the warm seasons, the weather in South Texas is primarily controlled by the position and intensity of pressure centers. During the late spring, summer and early fall, the predominant southerly and southeasterly circulation around the southweatern extension of the Bermuda High brings moisture upslope to the Coastal Plains of Texas. This circulation almost always results in night and early morning stratus formation. During the winter and early spring, the return onshore flow from migrating high pressure cells may produce stratus which usually covers all of South Texas. Stratus resulting from return flow usually produces very low ceilings that, at times, persist for days. In summer and early fall stratus forms later in the day, breaks earlier, and has higher ceilings. The formation of stratus and advection fog is related to the Gulf water temperatures, and as these temperatures rise in the spring, both appear less regularly and are less persistent than in winter. There is a semi-permanent thermal low pressure center positioned over the mountainous region of northwestern Mexico. During the summer, when the Bermuda High builds westward, the gradient across South Texas increases sufficiently to produce moderate to strong southeasterly winds almost every day. On rare occasions, the thermal low moves eastward to north central Mexico, further intensifying the pressure gradient, so that surface winds in the afternoon may reach 55.5 km/h.

Fronts: There is little frontal activity in South Texas during May or September, and none during the summer. However, polar fronts begin pushing southward occasionally during October, and an average of about one polar front every 5 to 6 days enters South Texas from November through April.

Quasi-Stationary Fronts: The quasi-stationary front is probably the most important synoptic feature of the winter and early spring weather in the South Texas region. South Texas is a favored area for polar fronts to become stationary, as the invading air mass attempts to move against a strong flow of Tm air from the south or southeast. Gusty northerly surface winds must continue for 18 to 24 hours following the passage of a sharp cold front in the area to insure continued southward movement out of Texas. Diminishing winds in less time often indicate wave formation or the front becoming stationary along the warm coastal water. Flying activity is hindered for periods as long as a week because of the low stratus ceilings and low visibilities, while thunderstorms and heavy showers persist intermittently.

Fronts may become stationary at any season in which they enter the area, but this occurs most frequently in the spring. A great variability of intensity, frequency, and persistence of these fronts is experienced from year to year. Surface winds are light to moderate and vary from southeast to northeast with oscillation of the front. Thunderstorm activity is general in a broad band along the front, with showers of varying intensity and duration. Clear skies may persist for several hours after passage of a particular line of thunderstorms before the onslaught of another series of thunderstorms. Very heavy amounts of precipitation are often received with these quasi-stationary fronts.

Cold Fronts: Rapid movement of a cold front through South Texas, together with a northwesterly flow aloft over the frontal surface results in little or no precipitation, and rapid clearing behind the front. This situation is unusual in South Texas, however, as most cold fronts entering the area have a shallow slope, and cloudiness and precipitation persist for some time after passage. The overrunning by the Tm air aloft is sufficient to cause light rain or drizzle, which in turn adds enough moisture to the lower cold air to produce a low type cloud. This cloudiness persists for 24 to 30 hours. As the cold air moves farther to the south, the circulation aloft gradually changes to the north and sweeps out the cloudiness. If the migratory high moves deep into Texas, several days of clear, crisp weather will follow before the cloudiness reappears with the return circulation off the Gulf of Mexico.

Cold frontal passages associated with Pc outbreaks from Canada are the most frequent, although Pm fronts in the spring often produce the most violent weather when squall lines precede them. Winter frontal activity results in low ceilings due to stratus, while spring and fall passages bring more thunderstorm activity.

During the fall and early winter, while coastal waters are still relatively warm, the Gulf of Mexico has a retarding effect on cold fronts. As a result, when the front passes into the Gulf it tends to take the shape of the coastline, and in those cases where the cold air is shallow, it becomes stationary about 100 miles from the coast.

Warm Fronts: Tropical warm frontal weather conditions are generally confined to the winter season, although they may occur in the spring or fall. Winter warm fronts move northward through South Texas at a speed of 15 to 25 km/hr.

2. The Adjacent Gulf Waters

a. Offshore Climatology

The general characteristics of the offshore area can be seen in Table 1. Winter temperatures are higher and mean winds are stronger than in the adjacent coastal area. Summer mean conditions are more similar, but with some important diurnal differences. The daily temperature range is smaller, and the afternoon wind speed maximum is less pronounced offshore than at coastal land stations.

The offshore area, like the coastal region, is not rainy at any season, particularly when compared to offshore areas in the middle and North Atlantic. Rain is most frequent in December and January with a secondary maximum in August and September. Based on rain frequency, the "dry" season in the area is March-June with an average of less than 3% of ship observations reporting rain.

Polar air masses move out over the Gulf of Mexico during the period October through March, disrupting the normal east to southeast flow across this area. As these cold air masses become more frequent during late fall, winter, and early spring, the sea surface temperature is gradually cooled, so that south to north gradients develop in the sea surface isotherms, as well as in the air above the surface. This chilling of the water surface immediately offshore is a very important factor in the formation of advection radiation fogs at coastal and near coastal stations from November through March, as well as in the formation of dense advection fogs (sea fogs) out over the cold water surface during the winter months, December through February, that may persist for several days.

Seasonal conditions are:

Winter: Mean monthly surface air temperatures over the area vary from about 20°C in December to 17.8°-18.3°C in January and February. More than 90% of the actual observations are within about ±6°C of the mean. Isotherms have an east-west orientation across the Gulf, then turn to follow the contour of the Texas coastline; the air near the coast is colder than that in the outer shelf. The mean offshore sea surface temperature is 2°-3°C warmer than the air in December, decreasing to about 1°C in February.

Spring: The mean monthly surface air temperatures over the areas are about 19.4°-20°C in March, 21.7°-22.2°C in April, and 25°-25.6°C in May. The temperature gradient characteristic of the winter season is still present in March. During April, the area becomes mostly dominated by tropical maritime air, so that there is less contract in surface air temperature from north to south. Approximately 90% of the actual surface air temperature observations in the Gulf of Mexico are within ±6°C of the mean (22.2°C) in April, when frontal passages still occur, compared to ±3°C of the mean (25.6°C) in May, when little frontal activity occurs. There is little temperature variation from north to south by May. The mean sea surface temperature is about the same as the air temperature by mid-April.

Summer: There is little geographical variation in mean monthly surface air temperature during the summer season. The mean for June is about 27.8°C, and for both July and August, 28.9°C. Approximately 90% of the actual observation are within ±3°C of the mean.

During the summer season there is little difference between the mean surface air and sea temperature. An exception may occur in possible upwelling conditions near Brownsville, where sea temperatures may occasionally be 3°-6°C colder than mean air temperature (see sec. II B).

Fall: Both sea and air temperature are quite warm during September, so that it might be more proper to include this month in the summer season. Mean surface air temperature is about 28.3°C with little geographical variation. During October, surface air temperature isotherms begin to show a weak south to north gradient. The mean monthly temperature is about 25.6°C near Corpus Christi and 26.7° to 27.8°C south of this area.

The November pattern of mean monthly surface air temperature isotherms is almost identical to April's; the mean sea surface temperature in October-November is about 1.6°C higher than the air temperature with a weak north-south gradient.

b. Synoptic Aspects, Cloud Cover, and Visibility

Synoptic aspects of the climate are most evident in winter due to frontal activity, but thunderstorms and tropical storms are important weather features in the warmer months.

Seasonal characteristics are:

Winter: As cold fronts, especially Pc types, become quasi-stationary after moving out over the Gulf of Mexico in the winter, the area becomes a favored region for cyclogenesis. Waves usually develop in the front near the Texas or Mexican coast in association with an upper air trough moving eastward from southern Arizona. These waves usually travel eastward rapidly, once movement begins, but in the development stage low ceilings and continuous rains persist for 24 hours or longer.

High pressure cells migrate in rapid succession across the southern United States during winter, passing eastward or southeastward into the South Atlantic. Fair weather in the northern Gulf of Mexico is confined largely to the closed centers of those cells that pass directly over the area. This limits the duration of ideal flying weather (scattered clouds and unrestricted visibility) to about 36 to 48 hours at a time during the winter season. Predominant wind directions are from the north, east, and southeast. High winds over 31.5 km/h occur most frequently in the winter months, about 20% of the time. They are most often from the north. Winds greater than 52 km/h occur less than 2% of the time.

Weather reports from ships indicate that the cloud cover over the area is 2/8 or less approximately 25% of the time, and 7/8 or more approximately 50% of the time in January and February. Fog is most frequent in January and February with the visibilities less than 4 km reported about 5% of the time.

Spring: During March, Pc fronts become quasi-stationary farther north, on an average, than in February, so that the principal track of low centers associated with wave formation along these fronts lies just inland along the Gulf coast, and north of the lease area. However, quasi-stationary fronts continue to frequent the northern Gulf region and cause persistent periods of low ceilings and rains lasting 24 hours or longer. Fair weather is still largely associated with closed centers of migratory anticyclones. Strong winds occur fairly frequently in April, most often from the south and southeast. Cold fronts enter the Gulf of Mexico much less frequently in April, and almost never in May so that frontal weather becomes less of a problem than in the winter and early spring months. Considerable cloudiness persists through April, but breaks off sharply in May. Sky cover of 7/8 or more occurs approximately 40% of the time during March and April, decreasing to about 20% in May.

The semi-permanent subtropical anticyclone is well established over the South Atlantic in May. Westerly systems are too weak to penetrate the strong ridge of high pressure extending westward across the Gulf of Mexico, and the season is too early for easterly systems to play an important role in the weather; consequently, May is one of the most favorable months of the year for air operations.

Summer: The easterly circulation is predominant in June so that easterly waves, and occasionally more intense tropical disturbances begin to appear in the Gulf of Mexico during the month. The percentage of favorable weather is high. The frequency of sky cover 7/8 or more is only about 10% in June and July. The greatest frequency of calm and light winds occurs in the summer, especially in August. No restriction to visibility occurs except in heavy rainshowers. There are no significant differences in the number of tropical disturbances, amount of cloud cover, or visibility between June and July. Because of warmer sea surface temperatures, air mass thundershower activity increases during the period from early morning to early evening. The frequency of cloud cover 7/8 or more increases to about 20% in August.

The Bermuda High is very strong during July and August with a normal anticyclonic curvature in the isobar pattern over the Gulf. Easterly waves and tropical storms in the Gulf of Mexico increase significantly in August.

Fall: Although September is considered a fall month in more northerly latitudes, it belongs more properly with summer months as far as Gulf weather is concerned. Easterly waves and tropical storms reach their peak frequencies during this month. The principal storm tracks enter the Gulf of Mexico through the Yucatan Channel, but are oriented in a more northwesterly direction than in July. September is a transitional month only in the sense that the weakening of the Bermuda High results in a more easterly and variable wind direction than in June-August.

October is the true fall transitional month, when easterly systems weaken and westerly systems are not yet strong enough to reach the Gulf with any regularity. Continental air masses that do move over the Gulf of Mexico are usually of the Pm type that produce several days of nearly cloudless skies.

Tropical disturbances may still enter the Gulf during October, but the storms generally recurve more rapidly than in September, and the lease area has not recorded any tropical storm impacts after early October. The frequency of cloud cover 7/8 or more is low, about 15%. There are very few thunderstorms in October compared to September.

The high frequency of nearly cloudless skies, characteristic of October, decreases sharply in November. The frequency of cloud cover 7/8 or more is over 40%. Advection and frontal fogs begin to appear in November with about 2% of reported nearshore visibilities less than 4 km.

3. Severe Weather

a. Tropical Cyclones

The largest and most destructive storms which affect the Texas coastal and offshore areas are tropical cyclones. The intensity of tropical cyclones may range from weak to barely-noticeable but possibly developing areas of bad weather, to large and intense storms with maximum winds approaching 320 km/h.

Virtually all tropical cyclones which have affected the Texas coast have originated in the Gulf of Mexico, the Caribbean Sea, or the southern part of the North Atlantic Ocean. The season extends from June to October; storms are most frequent in August and September, and rarely affect the Texas coast after the first days of October.

The average frequency of tropical cyclones for the entire Texas coast is a little less than one per year; they were most frequent in 1886 and 1933, with four in each of these years. A total of 37 hurricanes affected Texas during the period 1900-1974, about one every 2 years. All occurred from June to October. Of these, nine were severe in the lease area, all occurring in August and September (although a major hurricane nearly destroyed Brownsville on October 12-13, 1880). The storms are often small in diameter; the August 1970 hurricane which brought 200 km/h winds and 258 km/h gusts to Corpus Christi brought no high winds or appreciable rain to Brownsville.

In coastal areas, although hurricane winds cause a great amount of damage and sometimes loss of life, surveys of past hurricanes indicated that storm tides cause the greatest destruction and largest number of deaths. In offshore areas, high waves are most destructive. The most extreme storm tides occur near and to the right (looking forward along the line of progress of the storm center) of the area where the hurricane center moves inland.

The reverse is true of the coastal area to the left of the storm center. In this case, bay waters are depressed and forced out by strong winds blowing away from the coast and lower tides results. The extent of extreme tides along the coast depends upon the size and intensity of each individual hurricane. Tide heights in bays (especially near the heads of geographical or physical configuration where water can be trapped) are usually much higher than tides along the immediate coast in the same area. Storm tides of 5-6 m have been recorded, in Matagorda and Corpus Christi Bays; tides on the sparsely inhabited exposed coast are somewhat lower, but 3-3.5 m-heights have been recorded, and Padre Island has been inundated several times.

Far offshore, in depths of 100 m or more, fully developed hurricane waves occur. These waves can reach significant heights of 12-15 m and extreme heights of 20-25 m. As the waves move into shallow water they are modified due to shoaling, retraction, and bottom friction. These effects will generally cause an attenuation of 50% or more as waves move over the outer shelf; however, actual attenuation factors are different for different geographical locations.

In the inner shelf, with mean depths of 10-15 m, breaking waves, with heights of 0.78 of the water depth become important. The storm surge can be quite significant, as much as 2-3 m, which in turn increases the heights of breaking waves.

Statistical probabilities for the occurrence of extreme winds and waves can be generated. From past hurricane occurrences with wave conditions provided by wave hindcast techniques. Estimates of extreme wind and wave reoccurrence intervals are given in Table 2. Such statistics must be used with caution, however, as hurricane occurrences tend to cluster in time. Table 3 shows the major hurricane occurrences in the lease area for the period 1875-1974. Several characteristics of the storms are worthy of note.

(1) Although hurricanes occur along the Texas Coast from June to October, all of these storms except one occurred in August and September.

(2) Long periods can occur without a given coastal area being struck; from 1880 to 1933 no major hurricane struck Brownsville.

(3) The major storms tend to cluster in time; 1875-86 three storms, 1882-1915 none, 1916-19 two, 1920-32 none, 1933-45 three, 1946-60 none, 1961-71 four.

Other characteristics of individual storms are noted in the Table. In Table 4, some general statistical characteristics of tropical cyclones in the lease area are given by 80 km coastline segments.

b. Northers

Some 30 to 40 polar air masses penetrate from the North American continent to the Gulf of Mexico each winter. During the year some 15 or 20 of these generally bring forcible northerly winds to the Gulf, and are called northers. The norther is associated with a strong anticyclone, and cold air masses descending from the north and should not be confused with the northerly winds in the western quadrants of tropical cyclones which approach from the east. Occasionally, local usage has corrupted the term norther to apply to any wind shift to northerly accompanied by a temperature drop. However, there should be a wind of at least 37 km/h when speaking of northers, and from 46 up to 92.5 km/h or more may occur in severe northers over the Gulf. From one to six northers are likely to be severe over the Gulf during individual years. Northers ordinarily occur from November to March, and are most severe from December to February. As these winds travel southward from the Gulf into the Caribbean Sea, their strength is diminished.

c. Tornadoes

Tornadoes can be spawned in association with hurricanes over the South Texas coast (three were reported during Carla in 1961) but are rare otherwise. Waterspouts are fairly common over the Gulf of Mexico and the bay waters during the summer months in association with shower and thundershower activity. Normally, they are rather small funnels that dissipate rapidly after crossing the coast line and cause little or no damage. However, large waterspouts can be dangerous to small boats and to poorly constructed buildings.

d. Severe Thunderstorms

As a general rule, severe thunderstorms are not frequent in South Texas, as they are in North Texas or Oklahoma. Damaging hailstorms rarely occur south of about 31°N latitude, and wind damage is usually spotty and of no major significance.

B. Temperature, Salinity, and Density

1. Climatological Temperature, Salinity, and Density

TEMPERATURE AND SALINITY DATA

The first phase of the study was devoted to obtaining the available existing temperature and salinity observations. Most of the data accumulated came from the Department of Oceanography, Texas A&M University (TAMU) and was provided by the National Oceanographic Data Center. These data were supplemented and updated with temperature and salinity recordings from TAMU departmental data files, the University of Texas Marine Sciences Institute, the U.S. Geological Survey (Corpus Christi), and the National Marine Fisheries Service (Galveston). Additional data, collected by the Mexican Navy, Instituto Nacional de Pesca, and others were also incorporated.

The data were initially sorted by month. Table 5 gives the resulting monthly distribution of the surface observations. Although this is a large number of surface observations for the limited area considered, the geographical distribution of the data is poor. A bi-monthly sort of the data was made in an attempt to bolster the number of observations in the area south of Aransas Pass. However, the spatial coherence, particularly in the observed surface salinity, was weakened by extreme local variations. The unfavorable distribution of the data suggested that monthly fields of temperature and salinity would be more typical of actual conditions.

Monthly surface charts of temperature, salinity, and density computed from the observations were constructed by machine plotting the values at the recorded latitude and longitude. The resulting fields were scanned for trends, and isopleths were drawn to reflect the observed tendencies. This procedure was subjective, particularly in the treatment of the monthly surface salinity fields. However, the monthly surface temperature maps do agree with the monthly average sea surface temperatures given by Fuglister (1947) and Robinson (1973). Furthermore, the monthly maps of surface salinity depict the gross variations documented by the few synoptic surveys of the study area (see Section IIB).

The spatial distribution of the data, combined with the rapid decrease in the number of observations with depth, makes it impossible to construct typical vertical sections of temperature and salinity. Vertical sections from individual cruises are available and these are presented.

SEA SURFACE TEMPERATURE

The monthly maps of sea surface temperature are given in Figures 1 through 12. With the exception of June, July, and August, the isotherms are parallel to the coast. The sea surface temperature gradient is a maximum during January over the study area. Through the following four-month period it progressively relaxes under the influence of increasing seasonal heating. From June through September, inclusive, the sea surface is in a near isothermal condition. During October, November, and December seasonal cooling produces an increasing temperature gradient.

For most of the year, cooler water is found nearshore and the temperature in the shallow water increases as one moves south along the coast. The exceptional period is again June, July, and August, when the surface temperature increases from south to north over the entire shelf.

During January the temperature east of Galveston is 12°C. The temperature increases south of this region to 22°C in the open Gulf, or a change of 10°C over 262 km. In the same period the temperature just north of the Rio Grande is 20°C. In February the surface temperature east of Galveston has increased to 14°C, but the temperature 243 km to the south has decreased to 21°C. Likewise, the temperature just north of the Rio Grande has decreased to 18°C in the nearshore zone. Another 2°C increase in temperature occurs by March east of Galveston, as well as in the shallow waters in the vicinity of 26°30'N. The open Gulf temperatures increase slightly over the same time period. In April the coolest water, between 20° and 21°C, is still found above 29°N, while just north of the Rio Grande, the temperature has increased to 22°C. The waters 250 km south of Galveston have temperatures between 22° and 23°C.

The sea surface temperatures are radically altered over the next four months, May through August. During May, temperatures between 24° and 25°C are found from east of Galveston southwest to the region north of the Rio Grande. The lowest temperatures, less than 24°C, are found around 28°15'N. By June, temperatures greater than 28°C are found above 28°N, while to the south temperatures less than 28°C prevail. The reversal of the positions of warmer and cooler water is completed by July, and is maintained through August. The surface temperature east of Galveston is greater than 29°C during July and greater than 30°C in August. Along the coast south of 28°N, temperatures less than 28°C and 29°C are found in July and August, respectively.

The pattern of isotherms is rapidly realigned with the coastline from August to September, although the temperature gradients remain small. The surface temperature over the shelf varies from slightly less than 28°C east of Galveston to more than 28°C in the area just north of the Rio Grande. Offshore, in the open Gulf, the surface temperature is 29°C and higher.

The effects of seasonal cooling are evident over the October, November, and December period. The surface waters east of Galveston exhibit a decrease of approximately 6°C from October to November alone. The surface temperature in this region is depressed an additional 4°C from November to December. The temperature changes during the same time period in the area of 26°N are not as drastic. From October to November in this region, the temperature changes from 27°C to 23°C, approximately. During December the temperature is reduced to approximately 20°C. The temperature changes in the surface waters of the open Gulf amount to about -2°C per month, or a total change from greater than 27°C to greater than 23°C, during the period October through December.

THE MONTHLY DISTRIBUTION OF SURFACE SALINITY

The monthly pattern of isohalines (Figures 13 through 24), like surface isotherms, parallel the coast during most of the year. Beginning in May, the isohalines, under influence of less saline water introduced from the east, assume an increasingly normal alignment to the coast. In September, the isohalines are again parallel to the coast, and they maintain this pattern through the remainder of the year. Throughout the year, the freshest water is found nearshore east of Galveston.

From January through April, the 36.4°/oo isohaline is found offshore over the shelf break. Nearshore, about 29°N, the salinity changes from the low thirties in January to the twenties in April. The data are not sufficient to portray changes in the salinity during this period in the region south of approximately 27°N. In the period of January through March, the largest surface salinity gradients are found nearshore in the area east of Galveston.

The influence of increasing river offing, first seen in April, becomes more evident during May, June, July, and August. The surface salinity increases along the coast as well as in the offshore direction in this time period. Moreover, the surface salinity about 27°30'N increases from May through August. This may appear contrary to the effect produced by the addition of fresher water from the east. Note, however, that in May the salinities south and southwest of Galveston over the middle of the shelf are depressed compared with those found during April and June.

The pattern of isohalines given for July and August are tenuous since the data are sparse for these months, but the general tendency toward increasing salinity over the study area is realistic.

The source of the fresh water effecting the salinity appears to be the Mississippi and Atchafalaya Rivers. Figure 25 shows the twenty-year (1950-1970) mean monthly discharge rates of the Mississippi and Atchafalaya Rivers and the sum of the monthly means of all the rivers west of the Atchafalaya to the Rio Grande, inclusive. It is immediately clear why the effects of local offings are masked in the surface salinities given here. Note that the mean flow rate is a maximum during April, while the surface salinities over the shelf south of Galveston are lowest during May.

The discharge rates for the Atchafalaya were computed for Kortz Springs, about 415 km from the Gulf, and the Mississippi rates are for Red River Landing, about 490 km from the Head of Passes. Taking the distance from the mouth of the Atchafalaya to 94°W as 258 km gives an average speed of about 26 cm/s if the travel time is taken as thirty days. This speed is in agreement with the regional westward drift of less than 50 cm/s given by the current charts for April and May (U.S.N.O.O., 1972). The distance from the Head of Passes to 94°W is 465 km. Over thirty days, this gives an average speed of 37 cm/s, which again is reasonable. Thus, it appears that both the Mississippi and Atchafalaya Rivers have commanding rules in producing the atypical pattern of isohalines present from May through August.

Monthly surface salinity patterns, from September through December, inclusive, are quite similar. Salinities of 30.0°/oo to 31.0°/oo are found east of Galveston. Proceeding offshore from Galveston the salinity increased to 36.4°/oo over the shelf break, except for December when the maximum salinity is 36.5°/oo.

During September in the area north of the Rio Grande, the surface salinity increases slightly from 36.0 $^{o}/oo$ nearshore to 36.2 $^{o}/oo$ midway to the shelf break. In October and November the salinity increase from nearshore to the shelf break is approximately 34.0 to 36.0 $^{o}/oo$. During December the salinity gradient in the region north of the Rio Grande is large, with the salinity increasing from 34.0 $^{o}/oo$ to 36.5 $^{o}/oo$ over a distance of 60 km.

THE MONTHLY SURFACE DENSITY

Figures 26 through 37 show the monthly distribution of surface density given as sigma-t values (σ_t) where $\sigma_t=(1-\rho)\ 10^3$; ρ is defined as the specific gravity of sea water. Clearly, the monthly distribution of density is necessarily similar to the surface temperatures and salinities. Moreover, they exhibit the same general strengthening of gradients from September through March followed by a rapid erosion of the gradients from April through August. The November surface density is anomalous in this respect. During this month the density gradients relax, but the density increases over the entire area.

Throughout the year, the less dense surface water is found east or east and southeast of Galveston. The sigma-t values range from 15 during May to 24 in December. The occurrence of the minimum density in May reflects, as the May temperature and salinity fields, the influence of the fresher water originating in the east. From April through June, inclusive, and in the period September through November, the more dense surface water is found offshore. The smaller range of temperature and salinity experienced in this more oceanic environment is indicative of the density variation, with a sigma-t range between 23 and 25.

The sequence of surface isopycnals found during the December through March period is interesting because of the persistence of very dense surface waters. In December a tongue of water with sigma-t values equal to or greater than 25.5 extends from 93°W along the outer reaches of the shelf. During January the 25.5 isopycnal outlines a slightly smaller area compared with the previous month, but a tongue of water with sigma-t values of 26 and greater is found within the 25.5 isopleth.

Surface sigma-t values of 26 and greater are found over a large portion of the shelf during February. Offshore, in the open Gulf the surface water density is less than or equal to 25. By March, the denser waters of greater than or equal to 26 exists as an elongated cell centered at 28°N, 95°50'W.

VERTICAL SECTIONS

The paucity of data is such that vertical sections cannot be constructed on a monthly, or bimonthly basis. Furthermore, there have been few systematic surveys on the Texas shelf following more or less the same traverses month to month, or year to year. The exception is the series of observations by the National Marine Fisheries Service, Galveston. However, vertical sections from individual cruises are available. Samples of existing sections are presented here.

Figures 38 through 40 identify the cruises and show the locations of the transects. The sections identified as Texas A&M University (TAMU) cruises 54J2, 61H19, 64A7, 66A12, and 67A4 originated at Galveston. Cruise 54J2 extended south-southwest from Galveston while cruises 61H19, 66A12, and 67A4 made southeast traverses across the shelf (Etter and Cochrane, 1975).

Vertical homogeneity characterizes the shelf waters during the period October through March (Figures 41 through 48 and 54 through 56). Temperature inversions and weak vertical temperature and salinity gradients are observed nearshore, but these relax rapidly with distance from shore. The top of the thermocline is deeper, in waters greater than 100 m deep, during November through February as compared to conditions in March. Notice that during January the top of the thermocline in the deeper regions delineates a sensibly homohaline surface layer.

The January and February density sections (Figure 41 through 47) deserve attention in that both show the presence of very dense (σ_t>26.5) water over the shelf. These waters are the same types found beneath the subtropical underwater core in the open Gulf at depths of around 200 m. The density structure found during cruise 66A2 and the NMFS February cruise indicates that locally formed dense shelf waters replenish the subsurface waters of the open Gulf, as suggested by Nowlin and Parker (1974).

Figures 48 through 50 indicate that a thinning of the mixed thermal layer has occurred during the March to May interval. The initiation of thermal stratification is also in evidence, even in the shallowest waters over the shelf. The salinity regime shown in Figure 50 illustrates the pronounced effect of the increasing addition of fresher water from the east. Notice that in the southern and northern sections, the fresher water is nearshore and nearly homohaline in the vertical. In section 2, however, the fresher water is found in a narrow, thin region offshore.

Thermal stratification intensified during June (Figure 56) and July (Figure 51) while the water temperature in general, increases. During August (Figure 52) the temperature structure reveals isothermal conditions exist to depths of 20 to 25 m, beneath which is a pronounced thermocline. Moreover, in conjunction with the corresponding salinity sections, the waters to depths of 20 to 25 m are homogeneous in the southern section, and nearly so in section 2. The northern section shows a thin, narrow region of relatively fresh water in the intermediate offshore zone. This core of relatively fresh water probably represents the last vestiges of the freshening effect commenced the previous spring.

ANNUAL CYCLES OF SURFACE TEMPERATURE

In order to examine the seasonal fluctuations of surface temperature and how these variations change with distance from shore, the sorted data were divided into four zones depending on station position. Annual cycles of surface salinity were not constructed because of the small monthly sample sizes. Zone 1 extends from the shallowest depths to the 20 m isobath, and zone 2 is defined by the 20 m and 50 m lines. Zone 3 incorporates the region between the 50 and 200 m isobaths while zone 4 is defined by the 200 and 2000 m depth lines.

Figure 57 gives the annual cycle of monthly average surface temperatures for the four zones. The vertical bars indicate the monthly ranges.

A minimum average temperature of 12.79°C occurs in January in the nearshore zone, while minimums of 16.7°C, 19.3°C, and 20.3°C are experienced during February in zones 2, 3, and 4, respectively. The maximum temperature is found during August in all four zones. The maximum mean temperatures for zones 1, 2, 3, and 4 are 29.4°C, 29.1°C, 29.1°C, and 29.4°C, respectively.

The annual range of the monthly means rapidly decrease from 16.6°C in zone 1 to 12.2°C in zone 2. Zone 3 experiences an even smaller range of 9.8°C. As one would expect, the smallest range (9.1°C) is found in zone 4, which reflects the moderate fluctuations normally experienced in an oceanic environment. The monthly ranges also tend to decrease with distance from shore. Inadequate sampling is probably responsible for the few anomalous cases seen in Figure 57.

SEASONAL VARIATION OF THE MIXED LAYER DEPTH

The annual trend of isotherm depths for the zonal band between 27°30' and 27°50'N and from 92° to 96°W is given in Figure 58 (Nowlin and Parker, 1974). The data used to prepare this figure were solely from Texas A&M University, Department of Oceanography, BT files. Notice there were no observations for April, July, September, and November.

Figures 59 through 70 are monthly maps of the mixed layer depths (MLD), defined here as the depth at which the temperature has decreased by 1.1°C from the observed surface temperature. The annual course of isotherms and the maps of MLD exhibit a seasonal trend in which the MLD is deep in the winter and shallow in the summer. Generally, the November through February period (Figures 69, 70, 59, and 60) is characterized by comparatively strong winds and seasonal cooling (Orton, 1964). The MLD deepens during this period under the combined effects of instability produced by seasonal cooling and more vigorous vertical mixing by surface waves. Moreover, since the evaporation rate far exceeds the precipitation rate during this period, the mixing process is enhanced (Etter, 1975; Moller, 1955).

From April to June (Figures 62 through 64) the MLD decreases under the influence of subsiding winds and increasing seasonal heating. By June, surface heating and light winds have produced a thin mixed layer above a strong thermocline (Figure 58).

The mixed layer slowly deepens in the period July through October (Figures 65 through 68). The thermocline remains strong through October, but growing winds, seasonal cooling, and an increasing dominance of evaporation over precipitation, causes the MLD to deepen.

2. Historical Temperature and Salinity Data

INTRODUCTION

Between 1962 and 1965 the Galveston Laboratory of the National Marine Fisheries Service, formerly the Bureau of Commercial Fisheries, conducted an intensive survey of the waters over the continental shelf of the northwestern Gulf of Mexico. Although this survey was designed primarily to provide biological information on shrimp (Kutkuhn, 1963; Temple and Fischer, 1965 and 1967; Brusher, Renfro, and Neal, 1972; and Temple, 1973) and finfish (Moore, Brusher, and Trent, 1970), the collection of hydrographic data was incorporated into the study to provide information essential for a more complete understanding of the environment over the continental shelf. This effort included the systematic monitoring of temperatures and salinities as well as the periodic release of drift bottles to determine surface currents at all biological sampling sites.

Much of the aforementioned work was completed in the south Texas OCS lease site and generated a considerable amount of data, the analysis of which will provide valuable baseline information on environmental conditions prior to mineral exploration. Consequently, and as specified in Interagency Agreement 08550-IA5-19 between the Department of Interior and the Department of Commerce, the objective of this report is to:

1. Compile and analyze the historical temperature and salinity data.
2. Compile and analyze the historical drift bottle data to document the direction and rate of flow of surface ocean waters.

The drift bottle data are considered in Section II E1.

TEMPERATURES AND SALINITIES

Between January 1963 and December 1965, 35 cruises were conducted in continental shelf waters of the northwestern Gulf of Mexico with a chartered shrimp trawler. Sampling was conducted monthly at stations positioned on ten sections, four of which were either in or adjacent to the south Texas BLM study area (Figure 71). The inshore stations were in 7.3 m of water and the outermost station was in 109.8 m of water. Operations were continuous with observations made upon arrival on station regardless of time of day. Occasionally, however, some stations could not be occupied because of adverse weather conditions or mechanical breakdowns.

Temperatures--Temperatures were measured with mechanical bathythermographs that were allowed to sound bottom on all casts. Surface bucket temperatures were taken for correction purposes with stem thermometers graduated to 0.1°C. In the laboratory, temperature and depth corrections were calculated for each slide before photography, and bathythermogram profiles were aligned by the average correction process as outlined by La Fond (1951). For tabulation purposes, temperatures at a station were recorded at 0 (surface), 3, 11, 24, 43, 70, 107 and B (bottom) m, depending on total water depth.

Salinities--Samples of surface water for salinity determinations were obtained from the bucket samples used for bathythermograph reference temperatures. Samples of subsurface waters were taken at depths of 3, 11, 24, 43, 70, and 107 m with Nansen bottles. The deepest sample at any station was 3 m above the bottom. Depths were determined from the wire angles and precalculated length-of-wire tables. Regardless of the method of collection, all samples were drawn into 200-mm culture tubes with Polyseal caps. Chlorinity was determined in the laboratory by the Knudsen method as soon as possible after each cruise.

Compilation--All temperature and salinity data collected from the study area in 1963-1965 are listed by section and station in Tables 1-4 of the appendix. These data have been forwarded to the Atlantic Environmental Group and National Ocean Survey for incorporation into their data banks and their subsequent analyses to determine physical oceanographic features of the south Texas OCS study area, and to document environmental conditions prior to mineral exploration.

3. Temperature and Salinity at Shore Stations

Temperature and density have been recorded routinely at National Ocean Survey tide stations for many decades. The observation is taken once daily, not always at the same time of day, and several days per month are often missing. Despite this, one may expect that over a long period of time, these records will provide a good representation of mean shoreline conditions; moreover, synoptic meteorological and hydrological phenomena (cold fronts, river discharge, etc.) are reflected in the day-to-day records. As continuous synoptic observations are not available for offshore regions, these records provide a unique time source for coastal conditions. Summaries of these observations are available from the National Ocean Survey (U.S. Department of Commerce, 1973).

Compared to open-sea stations, shore stations exhibit large seasonal and daily variations. Table 6 gives monthly mean temperatures for stations at Galveston (29°17'N, 94°47'W), Port Aransas (27°49'N, 97°03'W), Brazos Santiago (26°04'N, 97°09'W), and Ciudad Madero, Mexico (22°15'N, 97°48'W) as well as records from adjacent Continental Shelf Marsden subsquares (084 Galveston, 076 Port Aransas, and 056 for Port Isabel; an open-ocean subsquare, 022, is used for Ciudad Madero). The greater seasonal change at the shore stations is clear.

The salinity cycle at coastal stations is dependent, as would be expected, on seasonal precipitation and runoff patterns. Table 7 gives mean coastal salinities at Galveston, Port Aransas, Brazos Santiago, and Ciudad Madero. Except in the summer, there is sufficient local precipitation and runoff in all seasons to make salinities lower at Port Aransas and Brazos Santiago than offshore. However, there is a distinct spring minimum in the salinity at Galveston and Port Aransas which is not found at Brazos Santiago. The main sources for low salinity water in the region are the Mississippi and Atchafalaya with the largest outflow occurring in April. Thus we can infer that substantial penetration of spring low salinity water from the north normally extends into, but not to the southern border, of the lease area. The extent of penetration of low salinity water can be expected to vary considerably from year to year, depending on the amount of runoff, which is subject to wide fluctuation (see tide station records). The average extent of southward penetration of the offshore low salinity water on the OCS cannot be confirmed due to the lack of systematic observation of spring salinity in the southern part of the lease area and northern Mexico.

The pattern of low salinity penetration is of considerable importance for circulation dynamics. The spring tendency of currents to set north in the lease area under prevailing southeast winds can be offset by runoff induced, southerly baroclinic flow.

The record at Ciudad Madero, showing about 400 km south of the lease area, is distinctly different from the Texas stations. The salinity is low in all seasons due to direct river influence and shows a summer-fall salinity minimum associated with the onset of the rainy season as well as easterly, rather than southeasterly, spring-summer winds. Thus, characteristic water movement in the spring may well be quite different in different parts of the lease area, and in adjacent areas, with important implications for oil spill and pollutant trajectory modelling.

The records are useful also as indications of the variability to be encountered in near-shore waters. As expected this is much greater than in offshore areas, due to the direct land influence. Table 8 shows the characteristics of temperature and salinity over a 5-year period at Galveston, Port Aransas, and Brazos Santiago for the months of January (winter), May (spring; lowest salinity), and August (summer; highest temperature and salinity), together with temperatures and precipitation at Galveston, Corpus Christi and Brownsville.

Consistent with the results of Sec. II, B1, 2, salinity generally increases from north to south. The strongest gradients and greatest within-month variability occur in May, associated with the intrusion of fresh water from high spring runoff. The May 1975 records show the lowest salinities noted for the 6 years; it appears as if, unlike the average situation, substantial fresh water penetrated as far south as Brownsville. Summer salinities appear to be qualitatively correlated with local precipitation.

In general, variations in winter monthly mean sea water temperatures follow variations in mean air temperatures. Total variation is less, as would be expected, and the north to south gradient is clear. By May there is no consistent south to north gradient in water temperature, although the mean air temperature increases by about 2°C from Galveston to Brownsville. The most notable aspect of summer temperatures is the anomalously low values of Brazos Santiago, due most probably, to intermittent upwelling (see below).

Synoptic records can provide indications of significant dynamic processes. On examining monthly mean records, a summer decrease in mean temperature from June to July is found at Brazos Santiago but not at other stations. Examination of daily sea temperature and wind records shows a correlation with wind.

Temperature records for June-July 1973 with vector mean daily winds at Brownsville are shown in Figure 72. It is hypothesized that the periodic anomalously low temperatures may indicate the presence of coastal upwelling. It appears that in addition to the characteristic seasonal shift to predominantly south-southeast winds, several days of persistent winds almost parallel to the coast are necessary to establish the upwelling; this is a time scale consistent with baroclinic adjustment of the coastal mass field in other upwelling areas (Smith, 1974). If upwelling is present, the associated horizontal and vertical shelf motions have important implications for movement and dispersion of pollutants. The upwelling, if it exists, is present rather tenuously, it is not observed at Port Aransas, where the winds are less parallel to shore, although not radically so, and it can be broken down by a variety of interruptions in the strength or direction of the south-southeast winds which establish it.

Winter sea water temperature can change drastically in short periods of time, and can be quite different from year to year. The daily march of temperature at Galveston and Brazos Santiago for January 1972 and January 1973 is given in Figure 73. The lowest observed temperature (4.4°C on January 11, 1973) actually occurred at Brazos Santiago. This coincided with a major cold air outbreak, with associated shelf and slope energy and water exchange (see Nowlin and Parker, 1974). Note that the temperature at both stations in January 1972 is higher for almost every day of the month than in January 1973. This may imply significant year-to-year differences in the winter circulation.

C. Tides, Tidal Currents and Sea Level

Tide stations provide a continuous record of vertical water movement at stations in U.S. Coastal regions. Two of these stations are at partially exposed coastal locations bordering the lease area; those at Aransas Pass (27°50'N, 97°03'W) which has numerous breaks in the record and Brazos Santiago (26°04'N, 97°09'W). The exposed coastal station at Galveston Pleasure Pier (29°17'N, 94°47'W) has a long term nearly unbroken record, and in conjunction with the record at Brazos Santiago can be used to study longshore changes along the coast.

Long-term tide records reveal not only the astronomic component of the tide, but also meteorological, climatological, and geological disturbances, with time scales ranging from decades down to a few minutes. Tide station records have been used by many investigators to study such phenomena as perturbations in the Gulf Stream (Niiler and Richardson, 1973) and to test the validity of geodetic leveling (Sturges, 1974).

Tide records are reduced and analyzed harmonically to provide tide predictions for hundreds of coastal, estuarine, and riverine locations. The predictions are published annually by the National Ocean Survey (U.S. Department of Commerce, 1974a), and include seasonal, but not short-term, non-astronomic variations.

Astronomical tides in the lease area are small as they are generally in the Gulf of Mexico. They are diurnal near times of maximum declination of the moon, and mixed semi-diurnal near times of zero declination with a diurnal range of 40-50cm along the coast. Typical tidal curves are shown in Figure 74 (after Marmer, 1954). There is only a small phase difference between Aransas Pass (27°50'N, 97°03'W) and Brazos Santiago (26°04'N, 97°09'W).

The controlling dynamics of the tides in this part of the Gulf are not clear. Zetler and Hansen (1972) postulate that the observed principally diurnal tide in the Western Gulf is due to cooscillation with the neighboring Atlantic. Platzman (1972), however, based on numerical calculations, feels that the hypothesis of resonant oscillation with diurnal forcing, advanced by Marmer and others, may be valid.

Predictions of tidal currents for inshore and estuarine regions, and passes are provided in an annual NOS publication (U.S. Department of Commerce, 1974b); these are based on 29 day current observations in these regions. Tidal current observations along the coast are sparse. Tidal currents in the vicinity of Aransas Pass have diurnal speeds of 45cm/s at flood, and 60cm/s at ebb, but velocities decrease to 15cm/s or less on the open shelf.

Seasonal and synoptic effects cause important variations in sea level. In the lease area, the annual non-astronomic variation is larger than the astronomic. Long-term records of monthly highest and lowest tides at Galveston (Figure 75) show an annual range of 1.5-2.5m, although heights of 4-6m have been recorded during severe hurricanes. Storm surges associated with tropical storms account for the very high levels, while most of the abnormally low levels are associated with set-down and drainage out of Galveston Bay during Northers. The set-down effect is similar, but less pronounced in the lease area.

An annual sea level cycle is also apparent in Figure 75. An observed annual cycle in sea level may be due to a variety of causes. These are analyzed in some detail by Lisitzin and Pattulo (1963). A recent study by Brunson and Elliot (1974) pays particular attention to the steric contribution on the West Coast and to associated baroclinic currents.

The inverse barometer effect is the most elementary factor which tends to alter sea level, both synoptically and seasonally. A rise/fall of 1mb in the sea level pressure will cause a 1cm fall/rise in sea level. In some areas, this effect alone can account for a 10cm or more increase in sea level from winter to summer.

Steric effects are usually of considerable importance in coastal areas. Lighter water will tend to stand higher, and denser water lower. The seasonal departure from mean sea level is given by Pattulo et. al. (1955) and Brunson and Elliot as: $Z_\alpha = \bar{\rho} \int_0^{Z_\gamma} \Delta\alpha \, dZ$

where

ζ_α = steric departure from mean sea level

$\overline{\rho}$ = average water column density

$\Delta\alpha$ = departure of specific volume from yearly mean

ζ_γ = depth of shelf bottom

The application of this formula becomes progressively more questionable as the water becomes very shallow. To obtain the steric departure at the coast, one must extrapolate from a near-shore, moderately deep station, and assume reasonable spatical smoothness in the sea level. As the alternative would produce a type of nearshore singular behavior which is not observed, this is a reasonable procedure.

Wind effects can be large, but are not completely quantifiable. In Asia, the shift from the winter northeast Monsoon to the summer southeast Monsoon probably accounts for most of the 1m rise in mean sea level from winter to summer in the shallow Bay of Bengal.

Along the West Coast of the United States, a seasonal shift from winter longshore southerly winds to summer longshore northerly winds appears to account, by Ekman dynamics, for at least part of the 20cm winter to summer lowering of sea level at coastal tide stations in Washington and Oregon. Thus, onshore winds and longshore winds with the coast on the right tend to raise sea level while offshore winds and longshore winds with the coast on the left tend to lower it. In bounded basins, however, non-local effects are critical (Pedlosky, 1974), and this may be important in the Gulf of Mexico. If non-local factors produce a longshore gradient in sea level, this will alter the effect of the longshore wind (sec. IIIB). Much remains to be done concerning the problem of seasonal wind effects on sea level.

In Figure 76, mean monthly sea level and sea level differences are shown for Galveston and Brazos Santiago. The pure inverse barometer effect, a 1cm rise/fall in sea level for each 1cm fall/rise in mean atmospheric pressure is also indicated; it is not well correlated with the observed sea level variations. The record shows the effect of subsidence in the Galveston area, as the 1958 mean sea level is taken as zero.

The characteristic spring sea level rise, summer lowering, later summer-early autumn rise and late autumn fall can be correlated with changes in the wind and density pattern.

The spring rise is attributable to high river runoff, the summer lowering to increased density and south-southeast winds, and the late summer rise to a shift in winds into the east quadrant. The sea level patterns, and perhaps also the mean current pattern, are subject to considerable year-to-year variation as shown in Figures 77 and 78 where records for 1970 and 1971 are given. Among other features, the high September-October 1971 level and the distinctly different winter patterns in 1970 and 1971 are notable.

Short-term variations are also significant and may be associated with large synoptic shifts in the coastal current regime (Beardsley and Butman, 1973; Cutchin and Smith, 1973). The application of a 39-hour low pass filter to a tide record effectively removes the astronomical component, while retaining short-term large-scale atmospheric effects which typically have a time scale of several days. Two such filtered records are shown in Figures 79 and 80 for the coastal stations of Galveston and Brazos Santiago; significant wind events are also indicated for Port Arthur and Brownsville. The first record is for the late winter season, February 5 - March 20, 1970. The notable set-downs at Galveston are associated with the passage of Northers; set-down at Brazos Santiago is noticeable, but quantitatively less in most cases; in the February 25-26 instance, winds were much less intense at Brownsville than at Port Arthur, with little associated set-down. An inverse barometer effect was also noticeable in most cases. The highest sea level (March 6-7) was associated with over a week of winds almost consistently from the south-southeast quadrant. It is probably that current reversals were associated with these winds and sea level shifts (see Section IIE).

The second record is for the period August 15 - September 30. In this season, the low sea level in the early period is associated with persistent winds from the southeast quadrant. A shift to winds predominantly from the east quadrant (August 25 - September 1) results in a strong sea level rise. Sea level falls again with a return (September 2-9) to summer type southeasterly winds, then undergoes the characteristic seasonal rise with the seasonal shift to higher speed, more variable winds more in the east quadrant. There is a characteristic shift in mean currents along the Texas coast in September associated with the characteristic change in wind and sea level. The relationship of the short-term patterns in surface drift and wind is considered further in Section IIE.

D. Winds and Waves

1. Vector Mean Winds

It has been shown by many investigators (e.g., Munk, 1950) that the large-scale patterns of ocean circulation are related to the distribution of wind stress over the ocean. More recently (Collins and Pattulo, 1970; Huyer et. al., 1975), fluctuations in time-variable longshore currents have been found to be barotropic and to be strongly coherent with variations in the longshore wind. The seasonal mean circulation is more complex, being produced in most areas by a combination of steric (Brunson and Elliot, 1973) and wind influences. At any rate, a determination of the characteristics of the offshore wind is clearly critical to a determination of coastal circulation.

The distribution of wind stress might appear to be the most useful parameter for application to coastal circulation problems (Franceschini, 1953). However, it should not be forgotten that what is measured is wind velocity and that the transformation to wind stress and the mechanism of the transfer of stress to the water are by no means unambiguous clear-cut procedures (Krauss, 1968; Stewart, 1974). For this reason, vector mean wind is displayed as the fundamental parameter.

The offshore wind observations are taken from ships; the number of observations per 1° square per month varies from 13 to 1839, with the median number being about 120. Squares from 24°-30°N and 92°-98°W which include at least some shelf area are considered. The number of observations is generally greatest toward the north and east and least toward the south and west, and is less close to the lease area coast than farther offshore; overall the number of observations is clearly sufficient to develop a reliable offshore wind climatology.

Figures 81-92 display monthly mean wind vectors for all the above-mentioned subsquares along with vector means for 1965-74 from the coastal stations of Brownsville, Corpus Christi and Port Arthur. Vector speed, mean scalar speed, mean direction, and number of observations are indicated for each square.

The general characteristics of the wind alluded to in sec. II are evident in the figures. In the winter season, migrating weather systems with frequent periods of strong northerlies alternating with strong south-southeasterlies, combine to give a high mean speed, but a small vector net wind. In the lease area, a rapid transition toward summer-type conditions occurs in March and by April, winds are predominantly southeast, being very steady from June-August. In September, the winds become much less steady and blow more from the east over the entire Texas offshore area; at the same time sea level rises significantly (sec. II C). This pattern persists into November, and is followed by a rapid transition to winter conditions.

The winds are correlated with mean pressure patterns in all seasons. Even in the winter months of December-February a weak anticyclonic circulation around the weak secondary high pressure system centered over the southeastern United States is evident. In the fall (September-November) the easterly winds can be associated with the weakening and development of a secondary High in the eastern U.S. The April-August circulation is dominated by a southeast flow around the Bermuda High. At all times a frictional departure of 10°-20° from geostrophic flow parallel to the isobars if evident. The most important characteristics of the wind in each month are given below. In general, land station data are compatible with Gulf data. The differences between land stations and open-Gulf squares is not notably greater than that between nearshore and offshore squares in the lease area.

January: Winds show a broad anticyclonic sweep from the east to east-northeast, as would be expected from the weak high pressure center over the southeastern U.S. Also as would be expected from the migrating weather systems characteristic of the winter season, average speeds are high and steadiness is low, the magnitude of the vector mean being less than one-third of the scalar mean in almost all cases.

February: February continues the characteristics of the winter months; high speeds and low steadiness.

March: The winds in March show the beginning of the transition to warm season conditions. Mean winds are mostly from the east, and have moderate steadiness in the southern portion of the area.

April: The mean circulation around the Bermuda High is well established in April over the entire northwest Gulf but steadiness is only moderate; some frontal activity still occurs in April.

May: Steadiness increases, particularly in the southern and western portion of the area where steadiness is generally greater than 2/3.

June: Winds are quite steady from the southeast south of 28°N, with steady summer circulation completely established. In the northernmost region, winds are more south-southeast, and somewhat less steady. Winds at Port Arthur are considerably less steady than those in the adjacent Gulf. This pattern persists throughout the summer months and through September.

July: The winds assume a more southerly orientation, particularly over the northern region. The steady sweep around the Bermuda High is evident.

August: A noticeable change from July is a decrease in mean speed. Winds are somewhat less steady, most noticeably so in the northern and eastern portion of the area.

September: A major shift in the wind pattern is evident over the entire region. The winds back in a pronounced manner into the east and become less steady. This shift is associated with an elongation of the Bermuda High and the development of a weak secondary High over the Middle Atlantic States.

October: The trend of September continues, with winds continuing to back somewhat into the east-northeast. A tendency for mean winds to circulate around the climatological High centered over the Middle Atlantic States, somewhat south of its September position is evident, with noticeable departures in squares adjacent to land stations, although not of the land stations themselves.

November: Steadiness continues to decrease. Although mean speeds are generally higher than in October, vector means are only about half the magnitude of June-July in southern and western areas.

December: The general winter pattern of January and February is evident in December; high speeds, low steadiness and mean circulation about the southeast U.S. anticyclone.

2. Statistical Winds and Waves

Wind and wave data were obtained from the National Climatic Center. The time period covered all data sources between 1884 and 1973 from Marsden Square 82, Subsquares 45-47, 55-57, 65-67, 72-77, 82-87, and 92-95. The location of Marsden Square 82 and the above-named subsquares are shown in Figure 93. The data were obtained from the following sources: ship logs, ship weather reporting forms, published ship observations, automatic observing buoys, and teletype reports. It is understood that there is a bias towards better weather conditions as ships tend to avoid severe weather. Also the greatest number of observations come from shipping lanes. The data used here is sufficient to give general conditions for the South Texas lease area, and surrounding regions.

Figures 94 through 97 show monthly wind and wave statistics for data taken between 1884 and 1973 for the indicated subsquares. Monthly median values for all observations taken during this time period are shown in Figures 94 and 95; the values given for wind and wave statistics in Figures 96 and 97 are such that 95% of all observations are less than or equal to the value indicated.

Over the western Gulf of Mexico wind speeds range from calm to greater than 68 km/h. Minimum wind speeds occur from July through September, the lowest being in August. Maximum wind speeds occur from November through February. Generally wind speed increases seaward and to the south. During the winter months (December to March) highest wind speeds occur in a band between latitudes 26°N and 28°N from the Texas coast seaward in an east-west direction. As summer approaches the orientation of this changes to a more northwesterly-southeasterly direction. By August this band of highest wind speeds diminishes to a small area near the Texas coast (Figures 94 and 95).

Median wind velocities average between 19 and 30 km/h for most months. The higher wind velocities are predominant in the winter months covering most of the shelf area; they become less significant during the summer and occupy a small area near the coast.

Generally, 95% of the recorded observations fell below 67 km/h from November through February. Maximum recorded wind velocities occurred in December along the South Texas coast near Brownsville. Maximum winds show a decrease in March and continue to decrease through August where 95% of the recorded observations fall below 30 to 33 km/h.

Percent occurrence of wind speeds by month is shown in Table 9 and displayed in Figures 98b and 99b. From November through March wind speeds range between 13 and 31 km/h approximately 52% of the time. The frequency increases to greater than 60% from April through October. Wind speeds between 0 and 13 km/h occur 15% of the time from November to April, greater than 20% in May, and reach 31% by August. The occurrence of wind speeds greater than 31 km/h is highest in December (33%) and lowest in August (7%); from October through May the average is 27% and from June through September the average is 12%.

Minimum wave heights occur during the summer, predominantly during July and August. Maximum wave heights occur offshore south of 28°N during the winter months from December through February. Highest wave heights recorded from the Western Gulf of Mexico were greater than 6.4m and occurred in February. Generally wave heights increase from north to south and seaward for all months. During May, July, and August an increase in wave height is found nearshore off the Tecas coast south of 28°N and in November off the Texas coast between longitudes 95°W and 96°W and latitudes 28°N and 29°N (Figures 96 and 97).

Median wave heights average between 1 and 1.5m from November through May and between .5 and 1.1m from June through October. Ninety-five percent of all wave height observations generally fell below 2 to 3.7m from November through February. These statistics begin to show a decrease in maximum wave height in March to minimum values in July when the observations ranged between 1.2 and 2m.

Percent frequency of wave heights by month is shown in Table 10 and displayed in Figures 98a and 99a. Approximately 55% of the time wave heights range from 1 to 2m for most months. During July and August this falls below 50% when calm waters (0 to 1m) become predominant. Calm conditions exist about 25% of the time from October through May. The frequency increases from June through September and is greatest during July and August at around 50%. Wave heights greater than the 2m range occur 24% of the time in February to 4% in August.

E. Currents

1. Drifter Surveys

a. Surface currents as deduced from drift bottles

As part of an expanded research effort in 1962 (Kutkuhn, 1963), the National Marine Fisheries Service initiated a drift bottle study to determine the direction and rate of flow of surface waters in the northwestern Gulf of Mexico. The ultimate goals of this study were: (1) to document on a monthly basis surface current direction and velocity; and (2) to attempt to relate monthly variations in current direction and speed with the successes or failures of the yearly shrimp crops, i.e., the young shrimp (larvae) are planktonic, and may be dependent upon currents for transportation to the estuarine nursery grounds. This study began in 1962 and continued through 1963.

Seasonal differences in direction and speed of surface currents in the Gulf of Mexico have been generally described by Smith, Medina, and Abella (1951), Leipper (1954), Curray (1960), and Ichiye (1962). More recent works on currents include those by Drennan, 1963; Watson and Behrens, 1970; Ichiye and Sudo, 1971; and Moore, 1973. Few of the above studies, however, were conducted in the south Texas BLM OCS study area, nor were they extensive enough to depict monthly conditions over an extended time period. The data considered herein have been analyzed to illustrate monthly conditions over a 2-year period, and are directly applicable to determining the fate of surface oil when and if an oil spill occurs.

Cruise Coverage--Cruises were conducted monthly with chartered shrimp vessels from February 1962 to November 1963. This schedule was followed as closely as possible, the only exceptions being due to adverse weather conditions or mechanical breakdowns. Operations were similar between years except that fewer stations were occupied in 1963, and one vessel was used to cover the entire study area rather than two as in 1962. The general overall effects of these modifications were that in 1963 the area coverage was slightly reduced, and the time required to complete a cruise (all 10 transects) was increased. The latter effect explains some discrepancies in the date labeling of figures used in the analysis to follow. For example, in several instances a monthly cruise in 1963 frequently extended into the following month.

Drift Bottles--Drift bottles used throughout this study were made of clear glass, about 22 cm in height, 6 cm in diameter, and had a capacity of 2.4 dl. Each bottle contained a bright reddish-orange card on which was a brief message in Spanish and English. A reward of 50 cents was paid for the return of the card with information on location and date of recovery. Half the bottles released at a station were ballasted (odd numbers) and half were unballasted (even numbers). Those ballasted floated at or just under the surface.

The number of bottles released during each cruise varied during the 2-year study. Generally, 12 bottles were released at each station in 1962; 4-10 bottles were released per station in 1963. This modification did not affect the rate of recovery of bottles within 30 days after release for, as shown below, the percent recovered in 1963 was greater than in 1962.

	Year	
	1962	1963
Total released	2402	629
Total recovered	381	234
Percent recovery	15.9	37.2

The increase in percent recovery was probably due to greater public awareness of the program in 1963 than in 1962.

Data Analysis--Recovered bottles were grouped into two time periods of 15 days each, i.e., 0-15 days and 16-30 days. Bottles recovered after more than 30 days out were not considered. Each bottle was considered separately and plotted as a straight line connecting the points of release and recovery. Bottles in the 0-15 day group were plotted as a solid line, and were the only ones considered in determining rates of drift that are reported in kilometers per day. Bottles out 16-30 days were plotted as dashed straight lines. The reasons for the above groupings and the exclusion of bottles recovered after 30 days was the existence of the sand or sand-shell beaches throughout the northwestern Gulf of Mexico, and the possibility of bottles drifting ashore, remaining intact, but not being found until some later date.

Daily wind data from the climatological records published monthly by the U.S. Weather Bureau were used to depict prevailing wind conditions over the study area during each cruise (U.S. Department of Commerce, 1962 and 1963). This information was generated at the International Airport at Corpus Christi, Texas. Because the time spent in the study area varied during each cruise, it was arbitrarily decided to construct resultant wind vectors for the cruise period as well as 15 days before and after. These data were converted to Beaufort units and incorporated into progressive vector analyses that indicate average wind direction and speed for every period under consideration.

Although the rate of bottle recovery varied between months, cumulative totals for the 2-year period show that 20.3% of the bottles released were recovered within 30 days. These recoveries are listed by cruise and station in Tables 5 and 6.

Surface Currents--In general, monthly surface currents were markedly similar between years, both in direction and velocity. Because of this, specific months have been grouped for discussion purposes, although illustrated individually. These groupings, irrespective of years, are: January-February; March-May; June-July; August; and September-December.

January-February: Currents during this period were generally southwest along the Texas coast (Figures 100, 101 and 102). Slight deviations from this directional pattern were apparent in January 1963 when currents east of Corpus Christi were more westerly and onshore, and in February 1962, when one bottle, released just off of the beach, moved northward in an apparent inshore counter-current.

Current velocities of the dominant flow decreased generally between January and February. In January velocities ranged from 17-22 kilometers per day with an overall average of about 19, while in February they ranged from 4-17 averaging 11. (All following references to current velocity are reported in kilometers per day.)

The analysis of wind data revealed a marked directional shift during the January-February period. Winds were predominantly northerly in January, particularly during the 15 days prior to the release of drift bottles, but shifted to easterly in February. This change may have accounted for the decrease noted in current velocities.

March-May: Drift bottle movements indicated a transitional period for surface currents in the study area during both years (Figures 103-108). The dominant flow was westerly and onshore but with no definite clearly defined north or south component during any of the specific time periods. Consideration of the data by the 0-15 and 16-30 day groupings illustrate the seeming divergence of currents, particularly in March 1962, 1963 and April 1962 (Figures 103, 104 and 105). In March of both years, the 0-15 day grouping indicated a dominant southwesterly flow over the shelf whereas the 16-30 day grouping revealed not only a westerly drift, but in some cases a northwest to north movement of surface waters.

Of particular interest was the recovery of several bottles deposited at the edge of the continental shelf during this time (Figure 105). These bottles moved northward and were recovered out of the immediate study area, thus suggesting the existence of yet another current system, one which may originate in the oceanic waters of the Gulf of Mexico. From this set of data, it appeared that in the surface waters three current systems may have been present in the study area: the nearshore counter-current, the shelf current, and a deep-water oceanic current.

Despite the fact that surface currents were ill-defined during this period, there was a general overall shift in direction from southwest alongshore to westerly onshore and finally northwesterly onshore.

Velocities of the dominant surface currents differed markedly between years, particularly in March and April (Figures 103-106). In each instance those observed in 1962 were lower than those in 1963. Velocities in 1962 ranged from 4-19 and 4-7, averaging 11 and 6 in March and April, respectively, whereas in 1963 they ranged from 9-46 and 7-32 averaging 22 and 20 for the respective months. Rates of 46 and 32 were exceedingly excessive (original data recheck verified accuracy), but even after elimination of these figures, velocities were still greater in 1963. In May, although only one bottle was recovered in 1962, current velocities were similar, ranging from 4-13 and averaging about 9. Overall current velocities, however, tended to decrease from March through May.

Wind direction during this period had shifted from the east (as noted during the January-February time period) to the south-southeast, a condition that is prevalent in this area during the summer months. The only exception to this was the prevailing east wind in March 1962. A comparison of wind forces (Beaufort units) in 1962 and 1963 revealed that winds were generally less in 1962 than 1963, thus providing a partial explanation for the differences observed in current velocities for the respective years.

June-July: Following the March-May transitional period, surface currents flowed north, either onshore or paralleling the Texas coast (Figures 109-112). This condition became even more pronounced as summer conditions became firmly established; average current velocities increased slightly from about 7 in June to 15 in July. The rate of average surface drift was slightly lower in June 1962 than in June 1963.

Prevailing winds during this period were from the south-southeast with very little daily variation. Wind force was greatest in July 1962. These winds, acting on a northeast-southwest shoreline, clearly augmented the northward flow of surface waters.

August: Drift bottles were released during this time period only in 1963, and their movements indicated still another transitional period in dominant current direction and velocity (Figure 113). Surface currents, rather than moving alongshore and to the north, had shifted to onshore toward the west; velocities had slowed to a rate of 4-6, a marked decrease from those velocities observed in the June-July period.

The direction and overall force of winds also shifted during this period. Winds shifted more to the east, and daily forces decreased, thus marking the deterioration of the summer conditions that resulted in a general north to northeast flow of surface waters.

September-December: The release and recovery of drift bottles indicated that surface currents returned to the dominant flow noted in January-February, i.e., a general southwesterly flow of surface waters (Figures 114-120). Several features of the circulation pattern, however, should be noted. First, the recovery of several bottles along the southern portion of the study area in 1962 indicated a westerly onshore movement that dissipated as the season progressed (Figures 114, 116, 118 and 120).

Second, the onshore component of the prevailing southwest current was not as apparent in 1963 as in 1962 (Figures 117 and 119). Few bottles released in the study area were recovered within 30 days, and of those that were, most were released at nearshore stations. Whether this was due to the lack of areal coverage or the total number of bottles released is not known, but the results were similar to those observed in December 1962 (Figure 120), a period when a large number of bottles were released and areal coverage was extensive. This absence of recoveries may indicate either an along- or offshore movement of surface waters.

Information on current velocities was generally restricted to the 1962 data, but no distinct trend was readily apparent. Ranges and averages for each month were as follows:

	1962		1963	
	Range (km/day)	Average	Range (km/day)	Average
September	2-19	9	13-19	17
October	2- 9	6	No data	
November	4-22	15	No data	
December	4- 7	6	No data	

In general, prevailing winds shifted to the east and finally to the northeast during this period. Overall force was considerably less than that observed during the June-July period.

SUMMARY

1. The analysis of 1962 and 1963 drift bottle data indicated that surface currents were similar between years; they shifted seasonally, and, in general, were related to prevailing winds over the study area.

2. Dominant currents from September-February were generally southwest with indications of a southerly alongshore or offshore movement in November and December.

3. In March-May, a period of transition, surface currents shifted onshore to the west and eventually to the northwest.

4. Surface currents flowed north and east alongshore in June-July.

5. The second transitional period was noted in August when currents became westerly and onshore.

6. The analysis of drift bottle release and recovery data indicated the presence of three current systems--inshore, shelf, and oceanic--during the March-May transitional period.

b. Recent Drifter Surveys

Drift bottle releases along the South Texas coast between Brownsville and Corpus Christi have been discussed by Watson and Behrens (1970), Hunter, Hill and Garrison (1974), Kimsey and Temple (1962, 1963), and others. Kimsey and Temple also included the area east to the Mississippi River, studying drifter movement over the width of the shelf. They noted a seasonal shift of surface currents with wind regimes and found a westward to southward surface drift in the winter correlating with north to easterly winds and a northward to eastward surface drift in the summer with predominantly southerly winds. Hunter, et. al., also noted the "seasonally changing pattern of coastwise water movement." Their results are summarized below. Watson and Behrens studies drifter movement from nearshore regions for drifter released in depths of 2, 4, and 5m (approximately 32km from shore). Their major conclusion was that nearshore circulation is influenced by wind circulation.

Hunter, et. al., made seasonal releases of drifters in the study area between 1970 and 1973. The releases were made from an airplane in water depths of 9, 30, 40, and 60m (approximately 56km from shore). Their results are shown in Figures 121 and 122. Hill, Garrison, and Hunter (1975) extended the drifter study of Hunter, et. al., from Corpus Christi to Galveston, Texas. They also released drifters from an airplane in 9, 20, 30, and 45m of water seasonally from July 1973 to January 1974. Their results are shown in Figure 123. Also shown in Figure 123 is an insert map depicting the study area. Tabulated results of bottle recoveries of both studies are given in Table 11.

As stated above, the drift bottle studies of Hunter and Hill both observed the seasonally changing pattern of surface drift with the change from a winter wind regime to a summer wind regime. Transitional periods were found to occur during the spring and fall, and the prevailing surface currents during these periods tend to oppose the prevailing winds. These conditions result in a convergence on central Padre Island. Hunter, et. al., observed that the surface drift convergence along the South Texas coast shifts to the north in the spring and to the south in the fall.

In addition to surface drifter observations, Hunter, et. al., also studied bottom drifter movement. They found a bottom convergence zone which at times occurred several kilometers south of the surface convergence area. This was found on occasion to occur north of the surface convergence. They also observed that in the winter a greater number of bottom drifters were recovered while in the summer a greater number of surface drifters were recovered.

Winter (December-January): Both surface and bottom drift was southward. Few surface drifters were recovered while a larger number of bottom drifters were found. A northward drift was found nearshore.

Spring (April-May): The surface drift was predominantly southward for the northern part of the study area and northward in the remainder of the area in April. By May the surface drift was predominantly northward over the entire area. Only a small area in the northernmost region showed a southerly drift. Bottom drift was recorded as southward in 1970, northward in 1971 and 1972, and southward again in 1973. This season is considered a transitional period.

Summer (July-August): Surface drift was predominantly northward, with a slight southward surface drift in the northern region of the study area. There was a greater number of surface drifters recovered in July than August. Few bottom drifters were recovered.

Fall (October-November): Early fall (October) showed the surface and bottom drift to be southward over the shelf region. Late fall (November) showed a more confused drift pattern with a tendency toward a southward drift in the northern part of the study area and a northward drift in the southern part of the area.

In general the Hill study agreed with the previous study of Hunter, et. al., along the South Texas coast. Differences included an absence of a complex convergence zone and a more extensive southward surface drift in the fall and spring. Both Hunter, et. al., and Hill, et. al., calculated net drift velocities. Drifter velocity ranged between .2 and 60km per day along the south Texas coast between .1 and 46km per day along the north central Texas coast.

Drifter movement and daily wind vectors for the South Texas Lease Area are given below. The results are summarized from the Hunter, et. al., survey. Daily wind vectors were plotted for April, July, and November 1970 in order to correlate with the Hunter, et. al., data. Wind data was obtained from the Brownsville and Corpus Christi airports. These data are shown in Figure 124; the arrow indicates the direction which the wind is blowing. The beginning and ending dates are shown on the vector diagrams. The underlined numbers show the release data and the tenth day after release. The monthly resultant wind speed and direction for these months are shown in the table below:

	Brownsville		Corpus Christi	
	Resultant Direction	Resultant Speed (km/h)	Resultant Direction	Resultant Speed (km/h)
April	150	16.3	140	16.5
July	140	12.5	140	13.1
November	160	4.2	120	5.1

April 1970: The winds were predominantly southeasterly while the surface drift was southward over most of the shelf. In the nearshore zone, surface drift was northward. Bottom drift was generally southward over the entire area except for a small nearshore zone off of the southern end of Padre Island where the bottom drift was to the north. The resultant wind direction was southeasterly with winds at Brownsville being slightly more southerly. The resultant wind velocity was about 16 km/h. Wind direction changed to northerly on May 1 and 16 lasting 4 to 5 days each time during the study period. The local wind variation probably influenced the nearshore surface drifters but apparently had little or no effect on the offshore drift pattern. April is a transition month between winter and summer wind regimes; the response time of the water to the wind is probably what is being seen in the surface drift results.

July 1970: Wind direction was steady and southeasterly for both Brownsville and Corpus Christi. Surface currents south of 27°N were northeastward and north of 27°N were predominantly southwestward. Bottom drift was mainly southward. The surface convergence zone was located around central Padre Island. Resultant direction for both locations was 140° and resultant wind velocity was around 13 km/h.

November 1970: Wind direction and speed were highly variable during November although the resultant direction was southeasterly at Corpus Christi and southerly at Brownsville. Resultant wind velocity was slightly less at Brownsville than Corpus Christi but averaged near 5 km/h. During the first 10 days from the release date the wind changed direction continuously from northerly to southerly such that it did not blow for more than 3 days in any one direction. From the 25th of the month to around December 5th the winds blew steadily from the southeast. Surface drift was also highly variable. It appears, though, that south of 27°N the currents were westward to northward and north of 27°N the currents were southward.

A drift bottle survey was conducted during the SEADOCK program from July through September 1973. Drift bottles were released at various intervals from July 11 through September 25 at or near the SEADOCK proposed terminal site. Some releases were made from the Buccaneer platform. The general release area is indicated in Figure 125 and the results are tabulated in Table 12.

Their results showed that, with southerly to westerly winds, the drifters moved north to northeastward and, with southerly to easterly winds, drifter movement ranged from westward to southwestward. Generally, with southeasterly winds, the surface drifters were found along the South Texas coast between the Rio Grande and Aransas Pass. When the winds became more easterly to northeasterly, the drifters moved west toward Matagorda Bay. Areas 1 through 4 as indicated in Figure 125 show the range of recovered drifters with changing wind patterns.

Hill, et. al., show surface drift for July 1973 (Figure 123). The two studies are in agreement. Generally for July the surface drift was northeastward along the north-central Texas coast. A few surface drifters around Corpus Christi tended southward.

2. Ship Drift

The U.S. Naval Hydrographic Office has compiled several thousand ship drift reports for the Texas continental shelf, and has grouped them by month and by 1° subsquare, giving prevailing currents where sufficient observations exist. The ship drift currents are computed by dead reckoning, and do not include the effect of wind.

The lack of consideration of wind effects has cast doubt upon the reliability of ship drift reports, as actual shift drift is, in some sense, the result of both current drift and wind drift. Despite wind effects, errors and general noise, however, Stidd (1975) finds that the ship drift data accurately indicate zones of upwelling and downwelling near the equator. Stidd concludes moreover that in moderately high latitudes, where ship reports are plentiful, reasonable confidence can be placed in the data. In areas of plentiful data in the Gulf, the greatest net effect of wind will be during steady summer conditions, when the wind may enhance currents by 10-20%.

Ship drift data is plentiful in northern and eastern portions of the Texas continental shelf and slope but is sparse to very sparse in much of the South Texas area. By considering both abundance of data and general current characteristics, the data have been grouped into zones. The zones and their general characteristics of data amount and currents are shown in Figure 126. Because of the paucity of data in critical regions, particularly zones 1 and 3, the data do not present a clear, self-consistent picture. The data have been supplemented with prevailing direction and speed from the current meter mooring at Buccaneer. (See the next section for a further discussion of these data.) These serve to illustrate the complexity of the currents in this region. The Buccaneer data are often inconsistent with the ship drift data. This may be due to the short record at Buccaneer, may indicate current complexities greater than can be revealed by ship drift, and may be connected with the small number of ship drift reports in the region. In the lease area, the characteristics of zone 2 support the idea of a general north set in the southern part of the lease area and of some kind of convergence zone in the northern part at certain times of the year, but the small amount of data from zones 1 and 3 prevents definite conclusions from being drawn.

The ship drift data provide a useful supplement to information from drifters and current meters. Figures 127-138 show monthly prevailing ship drift and Buccaneer currents. A discussion for the monthly data is given below.

January-June: A broad sweep to the west to west-northwest is evident over the northern portion of the shelf. The flow is mostly longshore north of 28°N, but has a strong onshore component in zone 2, in the northern part of the lease area. This onshore component, combined with the north set of zone 1, indicates a possible convergence in zone 2.

Although the wind pattern changes dramatically over this period, there are no dramatic changes in current set with the possible exception of zone 3, where the data are sparse. Buccaneer data are not consistent with ship drift in winter, having a surprisingly northerly set, but are consistent in March-May. In June the current set becomes somewhat more northerly; the bimodal Buccaneer distribution may be an indication of transition conditions.

July-August: Ship drift in general has a more northerly set than in any other month. In July, in particular, the data support the notion of a broad sweep to the north and east; the Buccaneer data are consistent with this. The general west set along the north coast continues, however, pointing to a possible convergence in this region.

September: This is a transition month for winds and currents. In the 27°-29° shelf band a strong tendency to set west is evident. Transition conditions can also occur in August (note the SEADOCK drifter data). On the other hand the Buccaneer set to the northeast (from a limited amount of data) may show that the transition can be delayed.

October-December: The October-December patterns are consistent with the general "winter" set to the west, north of 27°N; the sparse zone 3 data, however, are not always consistent with this, and neither are the Buccaneer data. The problem of constructing streamlines of flow for shelf surface currents remains unclear.

3. Current Meter Records

The only extensive set of current meter records for the Texas OCS is the record from the Buccaneer platform (Hall, 1972). Three meters, located near the surface (1.7 m until 7/73 at 3.7 m thereafter) at mid-depth (10 m) and near the bottom (17 m), have been in place since October 1971 between two oil rigs in 18 m of water, about 50 km south of Galveston. A summary of these observations from October 1971-August 1973, along with other studies, has been given by SEADOCK (1975) in support of their application for a deepwater port license.

The location of the current meters is well north and east of the lease area, and, considering the strong spatial variability in Texas OCS current structure and the special lease area convergence regions discussed above, the results cannot be expected to apply quantitatively to the lease area. Nevertheless, the current meter records are highly useful both for comparison with currents delivered by other methods and for comparison with mean winds. Any difficulties encountered may well be present in the lease area also.

The Buccaneer record is too short for climatological deductions to be made even for its location. It should be kept in mind that the spring of 1973 produced the largest outflow ever recorded from the Mississippi system; this may have affected the observed currents. For some months, particularly for the bottom meter, only a part of a single calendar month is represented. Despite this, comparison of the currents with mean winds can give a first indication of the relationship between the two.

In Figures 139-150, monthly surface, mid-depth and bottom current roses are given, along with a mean wind rose (giving direction toward which the wind is blowing) for Marsden subsquare 094.

It is evident from the figures that a simple relationship between wind and current does not exist in this region. In the winter, near surface current directions favor the northeast and west quadrants which may be related to the tendency of the wind to blow from the southeast quadrant (during Tm air masses) and the north quadrant (during Pc and A air masses after cold front passages). In the spring, there is a predominant set to the west at all depths which may well be related more to river runoff than to the southeast winds. Winds are predominantly from the south quadrant in July and August and probably account for the strong northeast set (but see below for poor spatial coherence even at this time). The stronger bottom currents may indicate significant baroclinicity (see Section II B). The strong northeast set in September is not clearly related to wind or runoff; by November currents at all depths are showing the bimodal quality characteristic of the winter.

Several short term studies were conducted by SEADOCK at locations other than the Buccaneer platform. The most comprehensive of these were a seven day study in September 1973 and a five day study in December, both at the site of the proposed deep water port terminal, about 50 km southwest of the Buccaneer platform as simultaneous observations from Buccaneer were also recorded. These studies are particularly useful for examining spatial coherence. The data from the studies is shown in Figures 151-154. It is seen in Figure 154 that the wind was highly coherent between the two stations during the December study; it can be expected to have been so during the September study as well. Directional coherence between the two stations is poor for all three depths in both the September and December studies.

The relationship between variations in the winds and currents is not clear in the September study. In the December study, three distinct strong wind shifts related to frontal activity were accompanied by notable current shifts at the Buccaneer platform. Currents shifted from the north quadrant on the 14th to the west quadrant on the 15th, accompanying a wind shift from south to north-northwest. A return to south winds on the 17th was accompanied by a shift to a steady northeast set at Buccaneer. The wind shifted strongly to the north on the 19th, and the set at Buccaneer turned into the west. The directional response at the terminal site was quite different, although probably also related to the wind; from a southeast set on the 14th, to south on the 15th and to west on the 17th-19th. These distinctly different directions at the two locations illustrate clearly the difficulty in predicting near-surface pollutant movement.

These short series of simultaneous observations serve to illustrate the complexity of the current regime on the Texas continental shelf. The tide, which is somewhat complex in the observation area will influence individual observations. For overall net flow one must apparently consider not only the direct effects of wind and stratification, but also the large scale influences of the open Gulf. The influence of the West Gulf anticyclonic flow (Nowlin, 1972) appears to be present in the spring and summer, and may cuase an offshore northeast set on the shelf which can at times oppose the nearshore current. Conditions of similar complexity can be expected to apply in the lease area.

III. MODELLING STUDIES

A. Seasonal Variation of Water Characteristics

The sorted Nansen and STD cast observations were divided into four zones to facilitate the anlysis of water chacteristics. Zone 1 extends from the coastline to the 18 m isobath and zone 2 covers the region between the 18 and 45 m lines. Zone 3 is delineated by the 45 and 180 m isobaths while zone 4 incorporates the area between the 180 and 1,830 m isobaths.

The thermohaline indices (temperature-salinity values) from within each zone, for each month, were plotted with a symbol corresponding to the zone number on a temperature-salinity (T-S) diagram. These are shown in Figures 155-160. The minimum salinity was taken at $18^{0}/oo$ since there are few observed salinities less than $18^{0}/oo$. The salient features of the T-S plots are not affected by excluding these data.

The reader is advised that the actual temperature-salinity values are situated at the lower left-hand corner of the rectangle occupied by the number plotted.

For each month the largest range in salinity is given by the zone 1 thermohaline indices. The August distribution of indices is suspect, in this regard, because there are few data from zone 1 in this month. Generally, the range of temperatures is larger for zone 2 than for zone 3, but smaller than that for the nearshore zone.

The effect of increasing river offing from the Mississippi and Atchafalaya Rivers on the zone 1, 2, and 3 thermohaline indices is pronounced. From November through March and indices in the three shallowest zones range over a 10° to 11° C band and a salinity band of 8 to $12^{0}/oo$. Over the next two months, April to May, the variation in temperature is reduced sharply to an 8° C band. Just as abruptly, the salinity range increases to $17^{0}/oo$. Notice that, in March and April, a significant number of zone 2 indices are of the same character as the subsurface water of the open Gulf.

Starting in June, and continuing through October, the thermohaline indices for the three landward zones are grouped in a gradually increasing range of temperature and an even more slowly decreasing salinity band.

Throughout the year, the zone 4 thermohaline indices for temperatures less than 15° C are consistent with the deep-water T-S relation reported by Nowlin and McLellan (1967). Curiously, anomalous indices tend toward higher salinities. Above 15° C, seasonal influences cause considerable variation. However, in the period April through September, the largest change in the zone 4 indices is in the temperature.

The plot of thermohaline indices for December through March illustrate the difficulty in using T-S diagrams to quantify mixing of coastal, shelf, and oceanic water types. It might appear that zones 2 and 3 types are the result of mixing of the nearshore (zone 1) and oceanic (zone 4) waters. However, the Nowlin and Parker (1974) and Ichiye and Sudo (1971) show that in January and March the changes in the salinity and temperature within the interior zones are caused by local surface processes, not mixing.

B. Shelf Circulation

1. Seasonal Cycle of Temperature, Salinity and Circulation

INTRODUCTION

Detailed serial surveys of the continental shelf region of the northwestern Gulf of Mexico, conducted by the NMFS in 1963-1965, has afforded a special opportunity to describe the physical oceanographic conditions and variability in the South Texas lease area. Other sets of data, in combination with the results of these surveys, have been useful for understanding the shelf waters.

Serial Data From GUS III Surveys (1963-1965)

In 1963-1965, a unique time-series set of surveys was conducted in and adjacent to the South Texas lease area by the Galveston Laboratory of the Bureau of Commercial Fisheries (now the National Marine Fisheries Service) using the R/V GUS III. During the three years, standard stations were occupied about monthly over the Continental Shelf of Texas and Louisiana. Included in the data collected were temperature observations from mechanical bathythermographs and salinity determinations from Nansen Bottle samples. Harrington (1966) presented a preliminary report on a portion of these cruises.

For this study, temperature and salinity data from the three years of the GUS III surveys were used from the 19 stations along the four transects between Galveston and Brownsville (Figure 161). During the period of February 1963, through December 1965 all, or most, stations were occupied during each of 28 cruises. Five other cruises provided partial coverage of the stations. The hydrographic observations from the GUS III surveys were made available by the NMFS Gulf Coastal Fisheries Center, Galveston, Texas.

Other Data

To explain the seasonality and other variations appearing in the GUS III records, the following additional data were used:

- mean monthly atmospheric pressure and derived wind-driven (Ekman) transport data provided by the NMFS Pacific Environmental Group Monterey, California; based on data files of the U.S. Navy Fleet Numerical Weather Central, Monterey, California,

- offshore oceanographic data acquired from the historical files of the National Oceanographic Data Center (NODC),
- local weather records for the 1963-65 period provided by the National Climatic Center (NCC),
- river discharge rates for 1963-1965 as reported by the U.S. Geological Survey,
- long-term, monthly averages of water temperature structure derived from the published atlas of Robinson (1973).

TEMPERATURE CYCLE

Throughout the study area, surface water temperatures from the GUS III surveys closely paralleled air temperatures (Figure 162), but over the outer shelf portion of the area, the temperatures below the surface have a distinctly different seasonality. Most all fluctuations in surface water temperature showed a correlation with either monthly mean air temperatures, or with daily averages for the day of station occupation. Seasonal changes in surface temperatures moderated offshore and down the coast to the southwest, as did air temperatures going from Galveston to Corpus Christi, and to Brownsville.

An exception to the parallelism of surface water temperatures and air temperatures was in the time of occurrence of minimum temperatures offshore in the winter (Figure 2), where there was about a two month lag (February offshore versus December in nearshore waters and in air temperature records).

The most distinct contrasts between years in temperature conditions during the 3 years were in winter (Figure 2). Air temperatures at Galveston, Corpus Christi and Brownsville were coldest in the winter of 1962-63 and progressively warmer in each succeeding winter, through the end-of-year, 1965. Surface water temperatures from the GUS III in the winter of 1963-64 were colder than in 1964-65, and those from March, 1963, indicate that the preceding winter may have been even colder. Furthermore, the GUS III observations in December, 1965, suggest that the following winter was the warmest of the series.

Subsurface water temperatures over the outer shelf, at depths greater than 27 m, were highest in fall and lowest in spring (Figure 162). From the time of the spring minimum (in March or April for the four GUS III transects), bottom temperatures increased gradually through summer until overturning resulting from surface cooling made the water column almost isothermal and raised bottom temperatures to their annual maximum. Further cooling through the winter tended to decrease temperatures through the water column in unison, but continuation of the cooling of the bottom waters offshore in the spring apparently resulted from annually recurring upwelling. Persistence of the upwelling through August each year is suggested by the fact that temperatures increased much more gradually at the bottom than at the surface. The relatively low bottom temperatures at the nearshore station in Figure 162, during July, 1963, and June, 1965, indicate that the upwelled water extended will onto the inner shelf in those years, but not during the summer of 1964.

Variations in the vertical temperature structure at the deepest station (south of Galveston) of the four GUS III transects is exhibited in Figure 163. Figure 163a displays the vertical temperature structure. Figure 163b shows the strength of seasonal thermal structure (temperature at each depth subtracted from the surface value during each station occupation). Figure 163a is contoured for the rate of change of temperature at each standard sampling depth (temperature difference between successive occupations at each depth level divided by number of days lapsed between occupations).

The vertical gradient portion of the Figure 163b shows the development of a strong thermocline and, thereby, high vertical stability during spring and summer. In the fall and through the winter, vertical mixing due to overturning virtually destroyed all thermal structure and stability of the water column. The rate of change of temperature in Figure 163c emphasizes the periods of warming and cooling, and the contrasts between upper waters and bottom waters. Times of maximum warming rates were in spring for the upper waters and in fall for subsurface waters. Highest cooling rates were during fall or winter at the surface and during summer sub-surface. The high rate of cooling throughout the water column in June, 1965, probably resulted from intense upwelling that extended to the surface as well as almost to the coast (Figure 162b).

For comparison to the three years of GUS III observations, long-term averages of water temperatures were examined for the upper 150 m at 27° N latitude, 96° W longitude from the atlas of Robinson (1973), and time sections complementary to Figure 163 (a and c) were drawn (Figure 164). Comparison between Figures 3 and 4 indicate that the 1963-1965 period was not atypical for the area. The GUS III data from the fall of 1963 through summer of 1964 are the most comparable to the atlas data.

SALINITY CYCLE

Figure 165 illustrates (1) the cycle of salinity at the nearshore and offshore stations on the GUS III transect off Pass Cavallo (Transect 8), and (2) the river discharge rates for Texas and Louisiana rivers based on records of the U.S. Geological Survey. The principal periods of decreased salinity seem to be mainly governed by the discharge from the Mississippi River, with a lag of about one month nearshore and 1 1/2 months offshore.

The discharge rates from the "Louisiana Rivers" (which includes discharge into Sabine Lake) were more than an order of magnitude greater than from the "Texas Rivers", and the Mississippi River typically contributed 75%, or more, of the fresh-water discharge from the Louisiana Rivers. The profile labelled "Texas Rivers" (Figure 165a) is the combined discharge from all rivers from the Rio Grande around to Galveston Bay. Of these rivers, the Trinity contributed at least half, whereas the Rio Grande always made up less than 10% and typically less than 2%, during the three years.

Subsurface salinities in offshore waters remained high (about $36.5^{\circ}/oo$) throughout the three-year period, while surface salinities reached minimum values each spring, at the time of peak discharge from the Mississippi River. The degree of spring freshening in the GUS III records also corresponded to the magnitude of outflow from the Mississippi, with the greatest discharge occurring in 1965 and the least in 1963 (Figure 165c).

The weakest correspondence between salinity and river discharge was in the fall and winter (Figure 165b). During each of the years of the GUS III surveys, salinity decreased sharply in September, remained low through January, and increased in February, whereas river discharge rates decreased through the fall of 1963 and 1964, but were increasing by January-February of 1964 and 1965. Apparently, a shift in currents developed in the fall which carried brackish water westward and down the coast. Lack of a parallel cycle in the surface waters offshore, indicates that there was also an onshore drift, acting to hold the lower salinity water nearshore. The February increase in salinity at the inshore stations, despite increases in discharge beginning two months earlier, is evidence that the westward flow of the fall ceased and probably reversed direction in February.

SEASONAL TEMPERATURE AND SALINITY STRUCTURE

Vertical cross-sections of temperature and salinity along transect 8 of the GUS III cruises in 1964 (Figure 166) display the seasonally changing dynamics in the study area. During winter (Figure 166a) surface cooling produced cold water ($< 17^{\circ}C$) nearshore which sank and flowed offshore along the bottom. In the upper waters there was an onshore drift of warm, saline water ($> 36.5^{\circ}/oo$), producing a packing of isotherms around the 25 m isobath. This circulation would be associated with a westward flowing geostrophic current over the outer shelf.

The sections in May (Figure 166b) show upwelling along the bottom that extends shoreward as far as the nearshore station. In the upper waters there was divergence nearshore and convergence offshore such as would be associated with a general flow to the eastward. The low salinity water from spring runoff was held offshore by the offshore drift.

The July sections (Figure 166c) indicate eastward flow because of the distinct upwelling, which extends to the surface over the 25 m isobath. By late September (Figure 166d) the slope of isotherms had reversed, which is indicative of convergence toward shore at the surface and offshore drift along the bottom. For geostrophic balance this circulation would require a return to westward flow.

The pattern described here consists of divergence in the upper waters over the outer shelf in spring and summer, with associated northward and eastward flow, and convergence toward shore during fall and winter, with westward and southward flow.

Long-term monthly temperature means for the waters of the Gulf (Robinson, 1973) indicate that the seasonal reversal of circulation in the northwestern Gulf, as described above from GUS III data, may be a typical pattern and is associated with conditions extending over most all the western Gulf. Figure 167 reproduces from Robinson (1973) her maps of monthly mean temperatures in the Gulf at 150 meters in April and October. In the April map, a zone of warm water convergence (> 18° C) extends from off the central Mexican coast over to the shelf off western Louisiana, and a large cell of cool water is located in the northwestern Gulf, centered over the shelf-break. For geostrophic balance, such a temperature distribution requires flow to the north and east along the Continental Slope and in the offshore waters of the northwestern Gulf. In the October map (Figure 167) the temperature pattern over the northwestern Gulf is reversed, with cold water off Louisiana and warm water off South Texas, requiring flow to the south and west off South Texas.

The seasonal pattern from the series of monthly mean temperature maps in the Robinson atlas indicates flow to the north and east from March through August and to the west and south from October through January. September and February appear to be transitional months.

CIRCULATION PATTERNS

For each cruise conducted in the GUS III surveys, the general pattern of circulation throughout the water column was inferred from the distribution of temperature, salinity, and density (sigma-t) in vertical and horizontal sections. The circulation pattern representative of the entire water column, along with the surface salinity distribution, for each of the 33 GUS III cruises is presented in Figure 168.

Clear seasonal patterns of surface salinity distributions are apparent in the GUS III data. In winter, isohalines parallel bathymetry, with low salinity water near the coast and high salinity water (> 36.5°/oo) covers the outer shelf. During spring salinity decreases as fresh water discharge from the rivers increases, and spreads offshore between Corpus Christi and Brownsville; also, the higher salinity water offshore shifts eastward. Through summer water of greater than 36°/oo covers most of the shelf, with remnants of the low salinity water appearing to have been pushed back to the east. In fall, despite the fact that river discharge is at near minimum amounts, the area of low salinity water again increases, and spreads to the west and south over the inner shelf.

The circulation patterns inferred from the vertical and horizontal distibutions of water properties from the GUS III surveys (Figure 168) agree well with results from drift bottle studies (Kimsey and Temple, 1964; Watson and Behrens, 1970; Hunter, et. al., 1974). The maps in Figure 168 (a-f) indicate that over the outer shelf, flow was to the north and east from mid-March through September, and to the west and south from October through February.

In the nearshore waters, from Galveston to near Port Aransas, flow was typically to the southwest from October through mid-June, and northeastward only in July and August.

In the southern area, from Port Aransas to Brownsville the occurrence and non-occurrence of an eddy, apparently at irregular times, is the principal variation of flow. Such an eddy seemingly could develop during any season and is probably related to locally interacting flow patterns.

From the GUS III analyses, a zone of convergence developed in the waters of the inner and middle shelf and was most pronounced in spring. The nature of this zone is similar to that described by Hunter, et. al. (1974) in that the nearshore location of the convergence zone tends to shift up the coast during spring through early summer. From the GUS III observations, it seems as though the convergence develops because of contrasting flows of nearshore and offshore water. The former flow being westward, while the latter (as well as all the waters in the southern sector) moves north and east. Such a zone of convergence is absent from October through February, because the flow is to the west and south throughout the study area.

DEEP WATER CIRCULATION

To examine the relation of the seasonal current reversals over the Continental Shelf to offshore dynamics, listings of oceanographic station data were acquired from the historical data files of NODC. The listings were limited to stations with sampling to 500 m, or greater, and lying within the area of 25°-30° N latitude and 90°-100° W longitude. For each cruise computed dynamic heights at the surface, referenced to the maximum common NODC Standard Depth, were examined to ascertain the direction of geostrophic flow. Directional tendencies from the dynamic height evaluations are summarized in Table 13, based on whether the flow was part of a cyclonic or anticyclonic circulation. Cyclonic flow would be similar to the fall-winter (October-January) circulation pattern on the shelf and anticyclonic flow would relate to the spring-summer (March-August) shelf circulation.

The data in Table 13 show that circulation in the deep-water of the northwestern Gulf exhibits much the same seasonality as described from GUS III data for the shelf area. February and September again appear as transition months. There are two exceptions to this pattern in the Table: March-April, 1935, and November, 1970. Apparently, the shelf water circulation is part of a larger-scale system active over most of the northwestern Gulf.

WIND-DRIVEN CIRCULATION

Relations between surface wind-stress and flow patterns have been noted in a number of previous studies of the northwestern Gulf. Franceschini (1953) related surface currents from ship drift and temperature distribution to wind-stress patterns, defining a center of convergence in wind-stress on the shelf that shifts seasonally. He concluded that the circulation in the western Gulf is largely wind-driven. Ichiye (1962), working with data from the ALASKA and JAKULLA cruises of 1951-1955 developed a wind-driven model for the Gulf and found good agreement with isohaline patterns over the northern shelf of the western Gulf. From drift-bottle studies in the shelf waters, Kimsey and Temple (1964), Watson and Behrens (1970), and Hunter, et. al. (1974) were able to associate some details of the variations in circulation with local winds.

Wind-driven transport data have been examined in this study as a possible explanation of the seasonal reversal of currents in the northwestern Gulf as described in the analyses of the GUS III shelf surveys and the historical oceanographic station data in offshore, deep waters. Maps and listings were acquired of mean monthly and long-term mean monthly values of surface atmospheric pressure and meridional and zonal components of wind-driven (Ekman) transport, on a 3° latitude and longitude grid. These values, which were supplied by the NMFS Pacific Environmental Group, Monterey, California, are based on data files of the U.S. Navy Fleet Numerical Weather Central, Monterey, California. Mean monthly values were generated for each month of the three years of the GUS III surveys (1963-1965), as well as 10-year monthly means for 1964-1973 and long-term (1946-1969) monthly means.

Long-Term Monthly Means (1946-1969)

Seasonality of atmospheric conditions is distinct in the long-term monthly mean field of surface atmospheric pressure. Beginning in October high pressure is centered over the southeastern United States and dominates the northern Gulf, with isobars aligned almost due east-west from Florida to the coast of Mexico (Figure 169, November). In this pressure field, geostrophic winds in the northwestern Gulf would blow from east to west and Ekman transport in deep water (directed 90° to the right of the winds) would be northward. Basically the same pressure pattern persists through January.

By March, and continuing through August (Figure 169, May), the high pressure center shifts eastward, becoming part of the Bermuda-Azores High, and a low pressure cell develops over northern Mexico. With this re-arrangement of the pressure field in spring and summer, isobars rotate clockwise, producing an increased pressure gradient over the northwestern Gulf with stronger winds and wind direction from southeast. The resulting transport in deep water also increases in the spring and summer, with flow toward the northeast.

February and September are typically transition periods in the fields of long-term monthly mean surface pressure and Ekman transport.

Monthly Means - 1963-1965

Figure 170 illustrates the correspondence in seasonality of (1) direction of shelf-water circulation, based on the GUS III data, and (2) the direction and magnitude of the wind and Ekman transport in the northwestern Gulf.

Typically beginning in March, and persisting through August, Ekman transport increased about three-fold over October-January values (Figure 170a), while wind direction shifted from about east to southeast (Figure 170c). Coincidentally, flow over the outer shelf shifted from north and west to east and south (Figure 170b).

During the fall-winter period, the Ekman transport not only diminished (Figure 170a) but also was nearly constant in magnitude along the entire shelf region off Texas and Louisiana. A general northward drift onto the shelf from deep water would, therefore, be expected during this period. For continuity of mass, an organized flow to the west or east is required on the shelf. As water depth decreases across the shelf, the direction of wind-driven transport becomes more aligned with the winds (Ekman, 1905). Because the monthly mean winds in fall and winter were typically from the east (Figure 170c), westward flow would develop on the shelf. The resulting circulation would tend to be cyclonic over the northwestern Gulf, made up of northward transport of water onto the shelf off Louisiana which would sweep westward across the shelf and then flow southward in the western margin of the shelf, yielding the west and south circulation seen in the analysis of GUS III data in fall and winter (Figure 170b).

In spring and summer, the sharp increase in Ekman transport off south Texas (Figure 170a) was not matched by similar increases at wind analysis grid points off east Texas and near the Mississippi Delta. (Transport magnitudes from 10-year monthly means were about twice as large as at 27° N, 93° W and 27° N, 90° W for each month of the spring and summer). Therefore, off south Texas, the spring-summer circulation over at least the outer shelf would be governed by Ekman transport moving water north and east. On the other hand, in the nearshore area and in the northeastern portion of the GUS III survey area, there was still a component of wind that would set up a westward flowing coastal current. Where this coastal current and the north and east flow from offshore meet, a zone of convergence would develop, as described in the circulation patterns derived from GUS III observations.

Values for 10-year (1964-1973) monthly means of Ekman transport and wind direction are shown in Figure 170 (a and c). Comparison with the values for the 1963-1965 period indicate that the wind-driven effects during the GUS III surveys were fairly similar to conditions prevailing during the subsequent decade.

Some noteworthy events are evident in Figure 170, during March and May, 1965:

- March, 1965: The GUS III analysis (Figure 170b) indicates the flow was still to the west and south, or atypical for that time of year. Transport and wind direction of values for the same month (Figure 170a and c) are consistent with the GUS III analysis, because they indicate that the usual spring shift in wind direction and transport magnitude was delayed at least a month.

- May, 1965: The magnitude of Ekman transport during this month (Figure 170a) - highest of the three-year period - provides an explanation for a decrease in water temperature that occurred throughout the water column during the following month, as shown in Figure 163c. In the section on the temperature cycle, this temperature decrease was attributed to intense upwelling.

2. Elementary Baroclinic Currents

Extensive observations of winds, density structure and currents in shelf regions have accumulated in recent years (e.g. Boicourt, 1973, Patchen, Long and Parker 1975, Huyer, Pillsbury, and Smith, 1975). However models of real time shelf circulation are fundamentally incomplete and basic questions concerning the relationship between seasonal mean flow and large synoptic flows observed in connection with the passage of storms (Beardsley and Butman, 1974, Bumpus 1973) remain unanswered. It appears (Smith 1974) that in the summer, off Oregon and Washington, the response to fluctuating winds is barotropic, and is superimposed upon the seasonal mean circulation, but whether this is true in more general conditions is not yet clear.

It is apparent from previous sections that the observed complex circulation system in the lease area can be produced by local and non-local effects. There are indications of a seasonal anticyclonic gyre in the open Western Gulf (Nowlin, 1972), and aspects of open-Gulf flow and, south of the lease area, flow on the shelf, may be related the distribution of wind stress vorticity over the Gulf (Sturges and Blaha 1975). Non-local effects, critical in enclosed basins (Pedlosky 1974) may be important in the Gulf.

Despite the complexity of the general problem, local effects have been determined to be important to dominant in many shelf areas. The local mean wind appears to directly determine the mean winter circulation in the New York Bight area whereas in summer, the density distribution is dominant (Bishop and Overland, 1975). Longshore sea level slopes may also be important (Stommel and Leetma, 1972).

Bishop and Overland generate a simple model of shelf circulation based on combining the elementary current system of Ekman (Neumann and Pierson 1966 p. 197 f) for a finite-depth sloping shelf with baroclinic currents generated diagnostically from observed densities, assuming no baroclinic motion at the shelf bottom.

With these considerations, an elementary current system can be generated for any point on the shelf, using the observed mean wind and density distribution from Section II. Currents derived from such computations must be used with caution, however. Near the shelf break non-local open-Gulf considerations are important, while close to shore (within 10-20 km, the Rossby radius of deformation, Allen 1973) the flow is more complex, the synoptic response being in many cases baroclinic (Walin, 1972 a, b) and non-linear.

With the above cautions in mind, it is still instructive to compute the surface elementary baroclinic current and to compare it to the observations of Section II. Section II provides the necessary wind and density data. The curvature of the coast, which may be important for non-local currents, cannot be directly considered. However, the effect of changing coastal orientation is taken into account by considering two points; one in the center of the lease area, at 27° N, where the coast is idealized to run approximately south-north, and one at 28.5° N, with the coast idealized to run southwest-northwest. Significant changes in surface currents between these points can indicate a complex current system between them.

Table 14 shows the surface currents for each season at each idealized offshore point. The current components are calculated as follows:

Longshore and Offshore Ekman (E and O): The shelf if considered to be sufficiently deep at the reference points so that the surface current will be at a 45° angle to the right of the wind; for lesser depths the angle decreases progressively. For computational purposes the stress formula of Steward (1974) is used:

$$\tau = 1.3 \times 10^{-3} \rho_a U_{10}^2$$

where τ is wind stress, U_{10}^2 the observed wind speed at 10 m height (m/s) and ρ_a is the air density. The mixing coefficient A is taken as 100 cm^2/s^2. The current magnitude, which is resolved into longshore and offshore components is then:

$$Vo = \frac{1.3 \times 10^{-3} \rho U_{10}^2}{(2 \rho A \omega \sin \phi)^{\frac{1}{2}}}$$

where ϕ is the latitude ω is the angular velocity of the earth, and ρ is the density of water.

Longshore Barotropic (G): This is based directly on Ekman's assumptions for a long straight coast. With no longshore slope in the sea surface, a barotropic longshore current must be generated to provide zero offshore-onshore mass flux. The magnitude of the current is:

$$V_G = V_O (2)^{\frac{1}{2}} \cos \Theta$$

where Θ is the angle between the wind and the coast. These considerations change in the presence of a mean longshore sea surface slope, as indicated by Stommel and Leetma. There is probably no net slope on an annual basis along the Texas coast (Balasz, 1973); however, there may be significant seasonal slopes (Section II C, Figure 76). The reality of these, and their role if they do exist are not clear; in the computations in Table 14, the longshore sea surface slope is taken as zero.

Longshore Baroclinic (B): On the assumption that the shelf bottom is a level of no baroclinic motion, the surface baroclinic current can be straightforwardly computed from the observed density distribution, and is given by:

$$V_B = \frac{gh}{2\,\bar{\rho}\,\omega\,\sin\phi}\;\frac{\partial\bar{\rho}}{\partial\eta}$$

where g (cm/s^2) is the acceleration of gravity, h is the water depth, η the outward normal direction to the coast and $\bar{\rho}$ is the mean density of the water column. The important factors in each season are:

Winter: The mean wind is of low strength and out of the east in the lease area, and more from the northeast in the northerly location. The result is Ekman flow onshore and to the right facing the coast in the lease area and weakly onshore and to the left at the upper location. The upper location flow is augmented by a barotropic current to the left. These mean barotropic currents will not generally be observed; they are products of the mean wind which itself is a weak resultant of stronger north-northeast and southeast winds. Thus the actual barotropic current at any time will vary between being strongly right and strongly left.

The magnitude of the mean flow, although probably not of the synoptic flow, is dominated by the baroclinic component, which for moderately offshore distances is rather strongly left.

The magnitude of the mean flow, although probably not of the synoptic flow, is dominated by the baroclinic component, which for moderately offshore distances is rather strongly to the left at the upper location, somewhat less so in the lease area. However, examination of offshore density characteristics (Section II B) shows that the baroclinic situation is actually quite complex. There is little if any vertical stratification on the shelf but an offshore density maximum points to a strong offshore-onshore gradient in the baroclinic mode, and therefore at the total mean flow. In the mid to outer portion of the shelf, the baroclinic component will vanish or become weakly to the right. The total mean surface flow will then become dominated by the weak frictional barotropic current with flow onshore and to the right at 27° N, and mostly to the left at 28.5° N with a probable convergence between the two points.

Spring: The spring situation is complicated by the inadequate number of density observations on the South Texas coast. With a small extrapolation, conditions will be dominated north of 27° N by baroclinic flow to the south and west, during the spring runoff season. The wind will oppose this tendency in the lease area, but not to the north. This points to possible complex conditions in the southern part of the lease area. Shore station observations indicate a weakening effect of runoff, and ship drift reports indicate a mean northerly set, so that strong southeast winds and weakening baroclinicity may produce a mean surface convergence in the lease area.

Summer: There is no evidence of significant baroclinic effects in the summer in the lease area; as a result the mean winds will drive the flow to the north in the lease area, with a weak offshore component. At the upper location, there are some indications of weak baroclinicity; winds are less parallel to the coast, producing a weaker flow to the right, with an onshore component.

Fall: Nearshore conditions are similar to those in the winter, but with a somewhat smaller and simpler baroclinic component. Lack of data is again a problem, as it cannot be said with any confidence, how far the mostly parallel-to-the-coast surface isopycnals extend south of 27° N. It is likely, from coastal and ship drift observations, that conditions change significantly to the south.

Overall, the results of these simple computations are encouraging. The longshore currents are qualitatively consistent with ship drift and drifter data. Where sufficient data are available, the currents also support the notions, deduced from other means, of convergence zones in or near the lease area. Work is presently underway to attempt to take into account the seasonal and year-to-year variability in wind stress and river runoff.

C. Oil Spill Centroid Trajectories

The problem of oil motion on the water surface in the South Texas lease area was initially addressed by a literature search for field and theoretical studies of shelf circulation and spill movement. There is a dearth of information in these categories. The trajectory calculations carried out by Ichiye et. al. (1973) used reported current values to estimate a current vector which represented motion over the entire region and computed trajectories on the basis of an addition of a vector computed as three percent of a wind vector. The trajectories presented in this report was based on analytical work by Reid (1975) and a numerical model developed by Whitaker and Vastano (1975). Steady-state currents computed for the shelf waters are derived through the equations of motion and correspond to a forcing function representing a steady field of wind stress. By neglecting field accelerations and lateral friction the (x,y) velocity components (u,v) satisfy:

$$-fv + g \frac{\partial y}{\partial x} = K \frac{\partial^2 u}{\partial z^2} \qquad (1)$$

$$fu + g \frac{\partial y}{\partial x} = K \frac{\partial^2 v}{\partial z^2}$$

where the fluid assumed to have a homogeneous density ρ and a constant value of the vertical exchange coefficient, K. A surface slope is permitted where η is water elevation relative to mean sea level and $\eta << D$, where D is variable field of depth. As stated, the equations represent the classical Ekman problem expanded to include the slope terms of the geostrophic relationship. The pertinent boundary conditions are:

$$\text{at } z = -D: \quad u = v = 0$$

$$\text{at } z = \eta = 0: \quad K \frac{\partial u}{\partial z} = Tx \qquad (2)$$

$$K \frac{\partial v}{\partial z} = Ty$$

where $T_x \equiv \tau_{xz}\rho^{-1}$ and $T_y \equiv \tau_{yz}\rho^{-1}$ are the kinematic wind stress components.

The complete solution for this system is:

$$V = \left| \frac{T_s}{K(1+i)\alpha} - \frac{igs}{f} e^{-(1+i)\alpha D} \right| \frac{e^{(1+i)xz}}{M} \qquad (3)$$

$$- \left| \frac{igs}{f} + \frac{T_s}{K(1+i)\alpha} e^{-(1+i)\alpha D} \right| \frac{e^{-(1+i)\alpha(Z+D)}}{M} + \frac{igs}{f}$$

where:

$$V = u + iv$$

$$s = \frac{\partial \eta}{\partial x} + i \frac{\partial \eta}{\partial y}$$

$$T_s = T_x + iT_y$$

$$\alpha = \left(\frac{f}{2K}\right)^{\frac{1}{2}}$$

$$M = 1 + e^{-2(1+i)\alpha D}$$

Application of this system to the South Texas lease area provides estimates of oil spill centroid trajectories <u>only</u> when the model assumptions are approximated and:

1. a steady-state wind field $\tau = \tau(x,y)$ exists over the region for approximately one week,
2. no other current movements are present,
3. the Stokes drift introduced by wave action can be approximated by the addition of three percent of the wind speed vector, and
4. the trajectories are not considered valid within 10 kilometers of the shoreline.

The depth field on a 16 x 30 grid extended seaward to include depths as great as 1,000 m on the slope and was brought to as shallow a depth as 4 m at the prototype shoreline. Due to discretization, the inner boundary (represented as a vertical wall) often extended behind the barrier islands. The grid interval of 10 km permitted coverage from Brownsville to a latitude slightly north of 28° N.

A suite of cases have been selected which correspond to prevailing winds over the region. Constant and uniform winds are introduced as forcing functions for the prototype. Two speeds, 5 and 10 m/s, and four directions, east, southeast, south-southeast and northwest, were programmed and each of the eight cases run on the computer to what was judged to be a dynamic equilibrium. Surface water velocity components from each run were combined with the Stokes drift vector to provide a total velocity vector in each grid square. Seven source locations were picked in the region and trajectory plots made for the centroid of the oil spill in each case. Figures 171 through 174 provide the trajectories indexed in terms of elapsed time in hours along the path.

Several general observations are possible. Under the assumptions and limitations of the model there does appear to be a significant difference in the trajectories for east winds at 5 and 10 m/s (Figure 171). Due to the strong geostrophic regime set up along the coastline, the movement of oil spill centroids toward the coast as in the 5 m/s case is augmented by a long sequence parallel to the coast. The implications are clear and need no elaboration. Northwest winds (Figure 174) will not generate a threat to the United States coastline during an oil spill. South-southeast winds (Figure 173) will bring the oil spill centroids to the immediate coastline in light winds. However, the stronger wind speed indicates movement toward the Texas coast north of this region can be expected for the seaward sites. The trajectories in the south-southeast - 10 m/s trajectory plot clearly indicate this separation. Southeast winds (Figure 172) can be expected to move the oil spill along trajectories which, for the greater part, will approach shore in the local area.

IV. RECOMMENDATIONS FOR FURTHER STUDIES

A principal objective of the physical oceanography program is to enable specific questions regarding movement of contaminants to be answered. The principal transport mechanism for spilled oil and other contaminants is the water movement on the shelf. Water movement data, if available, can assist in the planning stages of offshore development to minimize risks to environmentally sensitive areas; can provide pollutant trajectories which will be needed for contaminants and cleanup operations in the event of a spill; can assist in planning the location of long-term monitoring stations; and will be utilized in other disciplines, particularly fisheries.

The first year effort has consisted of historical analyses only. Although many important aspects of the physical oceanography of the region have been revealed, the results of this phase of the study provide only a partial climatological estimate of conditions and initial information needed for modelling and follow-up field studies. This is all that can be expected, considering the absence of open-shelf current data, and the sparse amount of other data available. There is not even sufficient hydrographic data in the lease area to develop a reliable climatology of the scalar fields. Moreover, it has been seen in Sections II and III that conditions can vary significantly from year to year. Predictive capability is not possible and essential casual questions arising from the more comprehensive geological, biological, and chemical studies are not presently answerable. Answers to these questions can only be given through the implementation of a comprehensive field program, supported by a significant modelling effort--both are essential to an understanding of the circulation. The most essential part of the program, and that requiring by far the highest level of effort, will be the obtaining of substantial amounts of processed and analyzed current data. These data are invaluable in themselves and are essential to all correlative analysis and modelling studies.

The program outlined below encompasses an extensive observational program coordinated with a significant modelling effort. An observational program alone would not be cost-effective. By combining observations with modelling, maximum progress will be made toward determining mean and seasonal structure and variation of currents and water masses in the region. It is this information which enables forecasts of pollutant trajectories to be made, while minimizing the requirements for observed data.

The program is outlined to provide for a 12-month field program and six months at follow-on analysis. However, it will probably require three years of field efforts and a five-year total analysis program to obtain a sufficient understanding of both mean conditions and variability.

A. Descriptive Observational Investigations

1. Eulerian Current Observations

The essential component of this effort is the occupation of a 12-month control station, located approximately in the center of the lease area, in at least 60 meters of water. This station would be instrumented with:

a. Five current meters at depths of 2, 10, 20, and 40 meters and one meter from the bottom.

b. Wind and wave sensors needed to adequately define conditions at the station.

This station will define the essential temporal scales of the flow. To define the spatial scales, four other stations, each with four to five current meters, should be moved throughout the lease area at 30/60-day intervals. Suggested configurations:

a. A normal-to-shore transect, including one station very close (5 km) to shore, and one near the shelf break. This transect can be moved from the center to the northern and southern regions every 30-60 days.

b. A diamond-shaped configuration, with onshore and offshore stations in a transect with the control station, and simultaneous stations in the northern and southern regions can be used for one/two 30-day periods.

c. Using these configurations throughout the year will define both onshore-offshore and longshore spatial scales. These are particularly complex in this region.

2. Langrangian Current Observations

Transponding surface and subsurface buoys, about 12 at a time, should be deployed monthly. In conjunction with the current meter stations, these will provide essential information on dispersion scales in the region, and will give essential supplementary information on spatial scales.

3. Hydrographic Measurements

Monthly temperature and salinity observations on a 15-20 mile grid out to 200-500 meter depth should be made as important climatological questions about temperature and salinity distribution remain unanswered from the historical analysis. A particular effort should be made to obtain supplementary data at certain critical times.

a. During the spring runoff period.

b. In the early summer after a period of strong south-southeast winds, and particularly in the southern area where there is indication of upwelling.

c. During periods just before, during, and after fall overturning.

d. Just before and just after passage of a strong winter Norther.

4. Tide and Pressure Observations

Measurement of sea level height, both onshore and offshore provides important information on the dynamic response of the region to meteorological influences, are an invaluable supplement to the current observations, and provide important input to models. Longshore and onshore-offshore sea level slopes are a critical element in coastal dynamics. Therefore, three onshore tide gages should be installed and maintained at exposed locations along the coast, and should be supported by one transect, with pressure sensors about 10 km offshore, and out near the shelf break.

5. Transmissivity and Extinction of Light

Extensive measurement of transmitted scattered and absorbed light, at a wide variety of wave lengths should be made in conjunction with hydrographic stations. Possibly a spectral radiometer should be employed. Results will aid in identifying and interpreting nepheloid layers, near-bottom dynamics, etc.

6. Supporting Data

In addition to wind and wave data at the control station, ongoing supportive observations are critical. It should be ensured that weather observations, river discharge measurements, and satellite imagery continue to be made available.

B. Modelling Efforts

1. Descriptive Modelling

Efforts initiated in the historical analysis phase, directed at describing water masses, local and non-local circulation, etc., should be continued and intensified using results of the observational program. These descriptions of the lease area will be an essential complement to more mathematical efforts.

2. Diagnostic Numerical Modelling

This effort should be directed toward modelling both short-term and seasonal water circulation. Observed density and wind fields can be used as input to drive short-term time dependent models and long-term quasi-steady seasonal models. Current and sea level measurements will be used to refine the model; model results, in turn, will assist interpretation of observational results and will guide the design of future efforts. During this phase, development of a complete predictive model, in which density structure can respond to changing wind and fresh water inputs, should be begun.

3. Dispersion and Oil Spill Trajectory Model

These efforts will be directed toward modelling trajectories of surface spills and movement of dissolved, suspended, and settled constituents. Initially, the preliminary model developed during the historical analysis phase will be combined with observational results, and will be refined sufficiently to generate statistically reliable trajectories for surface movement, and to enable some statistical analysis of movement of dissolved, suspended, and settled constituents to be made. A start will be made toward development of a complete distribution of variables model, from which three-dimensional predictive trajectories can be derived.

TABLES

Galveston (29°18'N, 94°50'W)

	J	F	M	A	M	J	J	A	S	O	N	D	ANN
T	12.8	13.9	16.1	20.0	24.4	27.8	28.3	28.3	26.7	23.3	17.2	13.9	21.1
P	8.9	7.4	7.4	6.6	7.1	6.6	12.2	11.2	13.0	7.4	9.1	9.9	106.8
D	10.0	9.0	8.0	6.0	6.0	6.0	9.0	9.0	9.0	6.0	8.0	10.0	96.0
%													
W	5.4	5.4	5.4	5.4	5.4	4.9	4.6	4.0	4.6	4.6	4.9	4.9	
PD	N	SE	SE	SE	SE	SE	S	S	SE	SE	SE	SE	
Q%	46.0	52.0	64.0	71.0	74.0	80.0	80.0	86.0	67.0	54.0	50.0	46.0	

Brownsville (25°54'N, 97°30'W)

	J	F	M	A	M	J	J	A	S	O	N	D	ANN
T	16.1	17.8	20.0	23.3	26.1	28.3	28.9	28.9	27.2	24.4	20.0	17.2	23.3
P	3.6	3.8	2.5	4.1	6.1	7.6	4.3	7.1	12.7	8.9	3.3	4.3	68.3
D	7.0	6.0	4.0	4.0	5.0	5.0	4.0	7.0	10.0	6.0	6.0	6.0	70.0
%													
W	5.4	5.4	6.2	6.2	5.8	5.4	4.9	4.9	4.6	4.6	4.9	4.9	
PD	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	N	
Q%	53.0	61.0	68.0	80.0	83.0	89.0	91.0	85.0	68.0	59.0	53.0	49.0	

Tampico (122°12'N, 97°30'W)

	J	F	M	A	M	J	J	A	S	O	N	D	ANN
T	18.9	20.0	21.7	24.4	26.7	27.8	27.8	27.8	27.2	25.6	21.1	20.0	23.9
P	4.6	1.8	1.5	1.8	4.8	18.0	16.3	14.5	29.2	15.0	4.3	3.0	114.8
D	7.0	4.0	4.0	3.0	5.0	11.0	13.0	10.0	16.0	11.0	8.0	7.0	99.0
%													
W													
PD	N	NE	NE	E	E	E	E	E	E	E	N	N	
Q%	35.0	44.0	45.0	66.0	74.0	67.0	54.0	49.0	51.0	41.0	40.0	43.0	

Corpus Christi (27°46'N, 97°30'W)

	J	F	M	A	M	J	J	A	S	O	N	D	ANN
T	13.9	15.6	18.3	22.2	25.6	27.8	28.9	28.9	27.2	23.3	17.8	15.0	22.2
P	4.1	4.1	3.6	5.3	7.6	6.1	5.8	7.1	11.2	7.1	4.3	5.3	71.8
D	8.0	7.0	6.0	5.0	6.0	5.0	4.0	5.0	9.0	7.0	6.0	7.0	75.0
%	9.7	9.0	5.3	4.6	3.6	2.6	1.4	3.1	6.0	4.3	5.3	7.7	
W	4.9	5.4	5.4	5.8	5.8	5.4	4.9	4.6	4.6	4.6	5.8	4.6	
PD	N	SE	SE	SE	SE	SE	SE	SE	SE	SE	N	N	
Q%	49.0	50.0	64.0	78.0	83.0	84.0	90.0	83.0	64.0	56.0	45.0	48.0	

MSS 076 (27°-28°N, 96°-97°W)

	J	F	M	A	M	J	J	A	S	O	N	D	ANN
T	18.3	18.3	19.4	22.2	25.0	27.8	28.3	28.9	28.3	25.6	22.8	17.2	23.9
P													
D													
%	9.1	7.1	3.6	4.2	3.7	4.1	3.3	6.7	6.6	1.9	4.7	9.7	
W	7.1	6.7	6.2	6.2	5.8	5.8	4.9	4.6	5.4	5.8	7.1	6.7	
PD	SE	SE	SE	SE	SE	SE	SE	SE	E	E	SE	SE	
Q%	48.0	50.0	60.0	75.0	80.0	90.0	86.0	81.0	70.0	64.0	55.0	41.0	

Table 1. Monthly mean temperature (T-°C), precipitation (P-CM), days with precipitation (D), percent of observations with precipitation (%), mean wind speed (W-M/S), prevailing direction (PD), and percent of observation from the PD quadrant (Q%), for Galveston, Brownsville, Tampico, Corpus Christi and Marsden subsquare 076.

Recurrence Interval (years)	10	25	50	100
Winds (m/s)				
highest 1 hr.	27.6	33.9	39.2	43.3
highest 1 min.	35.7	42.4	47.7	53.1
Waves (m)				
highest significant	10.4	12.5	14.0	15.6
highest	17.7	21.0	23.5	25.9

Table 2. Statistically estimated extreme winds (for the lease area coastal region) and waves (for the deep offshore area) by recurrence interval.

Date	Inland Movement and Location	Winds	Storm Surge	Remarks
1875 14-19, Sept.	from E over Matagorda Bay; recurved to ENE	est. 160 km/h		176 killed, $1M damage; 3/4 of Inianola destroyed by storm surge
1880 12-13, Oct.	from SE over Brownsville			Brownsville nearly destroyed
1886 19, Aug.	from ESE to SW of Matagorda Bay	115 km/h, higher gust S		Indianola destroyed by storm surge; NW wind, very low water at Corpus Christi
1916 18-19, Aug.	from SE over Corpus Christi	est. NE 160 km/h	1.8 m Corpus Christi	20 killed, $1.8M damage; rapid movement resulted in only moderate storm surge
1919 13-14, Sept.	from ESE, S of Corpus Christi	est. NE 160 km/h	4.9 m Corpus Christi, 3.7 m Aransas Pass, 2.4 m Port Isabel	300-600 killed, $20M damage, Corpus Christi
1933 3-5, Sept.	from E over Brownsville	170 km/h, est. max. 192-200 km/h	3.7-4.6 m Brownsville, 2.8 m Corpus Christi	40 killed, $12M damage
1942 20-30, Aug.	from SE over Matagorda Bay	est. 192 km/h at Port Lavaca	4.6 m Matagorda 2.8 m Port Lavaca	8 killed, $26.5M damage

26-27, Aug.	Matagorda Bay	Lavaca; 200 km/h Port Aransas	Lavaca; 3.0 m Matagorda	
1961 10-12, Sept.	from SE over Matagorda Bay	Gusts 280 km/h Port Lavaca 240 km/h Port Aransas	5.2 m Port Lavaca 4.6 m Matagorda 3.0 m Port Aransas	46 killed, $408M damage
1967 19-21, Sept.	from SE over Brownsville	est. 136-192 km/h gust 174 km/h at Brownsville	5.5 m Padre Island 3.7 m Port Isabel 2.4 m Corpus Christi	15 killed, $200M damage
1970 3-5, Aug.	from ESE over Corpus Christi	208 km/h, gusts to 258 km/h Corpus Christi, 200 km/h gusts 240 km/h Aransas Pass	2.8 m Port Aransas Beach 1.5 m Corpus Christi	11 killed, $453M damage
1971 9-13, Sept.	Moved to S SSE along coast	136 km/h, 160+ km/h gusts, Port O'Conner	1.2-1.8 m	2 killed, $30.2M damage, very heavy rains

Table 3. Most severe hurricanes which have impacted the coastal region bordering the lease area, 1875-1974.

Sector	1	2	3	4
Earliest Storm	8/4	6/23	6/23	6/22
Latest Storm	9/22	9/20	10/16	9/11
No. Tropical Cyclones	8	10	11	10
No. Hurricanes	7	6	6	8
No. Great Hurricanes	2	4	3	3

Table 4. Tropical cyclone characteristics 1886-1970 by 50 mile coastal segments North from the Mexican border to the mid-Texas shelf. Sector 2 terminates just South of Corpus Christi Bay; Sector 4 terminates midway between Matagorda and Galveston Bays.

MONTH		SURFACE TEMPERATURE No. of Observations	SURFACE SALINITY No. of Observations
January		657	150
February		443	97
March		669	222
April		285	89
May		593	114
June		391	136
July		129	95
August		284	120
September		362	111
October		251	129
November		272	227
December		216	124
	Totals	4,552	1,614

Table 5. The monthly distribution of surface temperature and surface salinity observations.

	J	F	M	A	M	J	J	A	S	O	N	D
Galveston	11.9	12.8	15.7	21.4	25.4	28.3	29.7	30.0	28.3	24.4	19.3	14.9
MSS 084	18.0	18.4	18.5	21.1	24.4	27.8	29.4	29.4	28.9	26.7	23.0	20.1

	J	F	M	A	M	J	J	A	S	O	N	D
Port Aransas	13.6	14.3	16.7	22.2	25.8	28.8	29.8	30.0	29.2	25.3	20.7	16.3
MSS 076	20.0	18.9	19.4	21.7	25.6	27.8	28.9	29.4	29.0	27.2	24.4	22.2

	J	F	M	A	M	J	J	A	S	O	N	D
Brazos Santiago	14.6	15.3	17.4	21.3	24.7	26.3	25.9	26.7	28.2	25.8	21.7	17.6
MSS 056/066	21.6	21.0	20.9	22.2	25.6	27.8	28.9	29.2	29.1	27.8	25.0	23.6

	J	F	M	A	M	J	J	A	S	O	N	D
Cuidad Madero	19.3	20.1	21.9	25.2	27.0	28.2	28.9	28.8	28.1	26.4	24.2	21.6
MSS 022	23.5	23.0	24.0	25.0	26.5	27.8	28.3	28.5	28.4	27.1	25.2	24.0

Table 6. Monthly mean temperatures (°C) at coastal tide stations and adjacent 1° squares.

	J	F	M	A	M	J	J	A	S	O	N	D
Galveston	29.1	29.1	28.4	26.1	24.8	28.2	31.8	33.3	28.6	28.5	29.7	29.5
Port Aransas	30.4	31.2	31.6	31.0	29.5	32.8	35.3	36.6	33.5	30.6	30.8	31.5
Brazos Santiago	32.7	33.2	33.8	34.1	34.1	35.9	36.6	37.0	35.8	34.0	34.4	33.2
Ciudad Madero	11.1	14.0	16.3	18.3	17.9	17.0	6.0	7.6	3.9	2.8	5.4	8.8

Table 7. Monthly mean salinities (0/00) at coastal tide stations.

JANUARY

Galveston

	1970	1971	1972	1973	1974	1975
Max T	13.9	16.6	18.9	12.8	17.2	17.2
Mean T	10.7	14.0	15.1	11.0	14.1	14.8
Min T	9.4	9.4	12.2	6.6	9.4	10.6
Max S	30.8	31.2	31.1	31.1	27.8	29.0
Mean S	29.1	29.1	25.1	25.1	22.4	23.9
Min S	25.1	27.1	20.4	21.2	15.7	17.7
Galveston WB						
Max T	18.0	19.2	20.8	18.9	20.0	20.0
Mean T	9.4	13.9	15.0	10.6	13.9	14.8
Min T	0.6	0.3	1.4	0.0	3.0	2.0
Precip.	37.3	4.6	93.5	81.0	83.3	85.3
Port Aransas						
Max T	13.9	----	----	14.2	16.6	18.6
Mean T	11.7	----	----	11.7	13.4	14.9
Min T	7.8	----	----	5.8	7.8	10.3
Max S	32.5	----	----	27.7	31.9	30.3
Mean S	31.0	----	----	25.4	24.7	25.9
Min S	29.7	----	----	21.2	16.6	21.2
Corpus Christi						
Max T	22.5	24.2	24.4	22.0	24.2	25.0
Mean T	10.6	16.8	16.4	11.0	14.4	15.4
Min T	1.1	2.5	3.0	0.6	2.8	0.6
Precip.	45.5	0.8	31.2	55.4	50.3	49.3

Table 8a.

JANUARY

Brazos Santiago

	1970	1971	1972	1973	1974	1975
Max T	17.8	20.0	20.0	16.1	20.0	20.0
Mean T	13.4	16.2	17.6	12.4	15.8	16.7
Min T	9.7	8.9	10.0	4.4	10.0	13.9
Max S	35.3	34.6	35.3	33.6	34.9	33.2
Mean S	32.7	32.4	31.8	30.8	32.1	30.7
Min S	31.6	31.5	27.2	29.0	27.8	28.6
Brownsville						
Max T	23.4	26.6	24.4	21.4	24.7	25.0
Mean T	14.2	19.2	18.9	12.5	16.4	16.5
Min T	4.7	2.5	5.8	1.4	5.8	2.8
Precip.	104.6	5.6	33.0	52.6	16.5	15.2

MAY

Galveston	1970	1971	1972	1973	1974	1975
Max T	27.2	27.8	27.8	----	28.4	28.9
Mean T	24.6	25.1	24.7	----	25.6	25.8
Min T	21.6	21.6	23.4	----	22.8	23.4
Max S	25.9	29.0	34.2	----	25.0	25.5
Mean S	22.7	27.2	26.8	----	19.6	17.7
Min S	19.6	22.4	23.4	----	13.2	9.8
Galveston WB						
Max T	26.1	26.6	27.5	27.0	28.4	27.5
Mean T	23.4	23.9	24.6	23.5	25.1	25.0
Min T	16.6	18.6	21.6	18.9	21.1	21.1
Precip.	110.0	33.3	161.8	40.9	199.1	274.1
Port Aransas						
Max T	26.6	----	27.5	26.1	28.6	27.8
Mean T	24.7	----	25.5	23.3	27.0	25.9
Min T	23.4	----	23.6	21.1	24.2	23.4
Max S	28.8	----	34.9	36.0	30.4	28.8
Mean S	26.8	----	26.1	27.5	24.3	22.4
Min S	24.8	----	4.8	21.0	20.3	15.8

Table 8b.

MAY

Corpus Christi

	1970	1971	1972	1973	1974	1975
Max T	27.5	28.6	27.2	30.0	30.0	29.2
Mean T	24.1	25.8	25.0	25.1	27.2	27.0
Min T	17.2	20.8	22.2	19.2	23.2	23.6
Precip.	99.6	115.6	153.0	14.7	107.7	42.4

Brazos Santiago

Max T	26.1	27.2	27.2	26.1	28.4	26.6
Mean T	23.6	24.5	25.8	23.4	25.9	24.7
Min T	20.3	23.4	23.9	21.1	23.9	22.2
Max S	36.6	36.8	35.5	35.7	35.1	34.0
Mean S	32.0	35.3	32.5	32.4	31.1	27.2
Min S	28.0	31.6	29.4	27.5	25.9	19.9

Brownsville

Max T	30.3	29.5	27.5	31.1	30.8	30.3
Mean T	24.7	26.4	25.4	25.6	27.6	27.7
Min T	17.5	20.3	23.4	21.1	24.5	23.9
Precip.	83.3	62.7	51.3	31.5	46.2	56.4

AUGUST

Galveston	1970	1971	1972	1973	1974	1975
Max T	32.2	31.1	30.6	29.4	30.0	30.6
Mean T	30.5	29.8	29.4	28.7	28.6	28.5
Min T	28.9	27.8	27.2	27.2	27.8	27.2
Max S	36.4	36.2	33.8	35.7	34.6	35.9
Mean S	34.1	34.9	33.2	27.5	31.0	29.9
Min S	30.7	31.8	32.4	21.2	27.8	14.8
Galveston WB						
Max T	30.3	30.0	29.7	29.2	29.7	30.8
Mean T	28.6	28.0	28.9	27.8	28.1	28.9
Min T	27.2	24.2	25.6	25.6	24.4	26.4
Precip.	34.8	91.7	35.6	260.4	205.2	167.1
Port Aransas						
Max T	----	----	29.9	30.0	30.6	30.0
Mean T	----	----	29.2	28.9	28.9	28.2
Min T	----	----	28.6	27.8	25.6	25.3
Max S	----	----	36.8	37.3	37.2	37.3
Mean S	----	----	35.9	31.2	37.0	36.0
Min S	----	----	34.4	27.1	36.0	34.8
Corpus Christi						
Max T	30.8	29.7	30.3	31.1	31.4	31.4
Mean T	29.0	28.2	28.8	28.2	29.6	28.5
Min T	25.6	25.0	27.8	27.0	27.0	24.4
Precip.	186.0	211.3	95.0	143.0	26.7	122.9

Table 8c.

AUGUST

Brazos Santiago

	1970	1971	1972	1973	1974	1975
Max T	30.8	29.2	29.4	30.0	29.2	27.8
Mean T	27.8	26.9	27.6	27.6	26.2	26.3
Min T	24.7	24.4	27.2	25.0	24.7	25.0
Max S	37.3	37.1	37.3	36.8	37.3	36.0
Mean S	36.8	36.7	36.7	36.2	36.8	34.0
Min S	36.3	36.3	36.0	33.6	36.6	32.7

Brownsville

	1970	1971	1972	1973	1974	1975
Max T	31.6	29.7	29.7	29.7	30.8	30.0
Mean T	29.8	28.4	27.9	27.5	29.4	28.0
Min T	27.2	26.4	24.7	26.1	27.8	25.3
Precip.	45.5	67.1	22.9	71.1	0.5	242.8

Table 8. Maximum daily monthly mean and minimum daily temperature (^{o}C) and salinity (o/oo) at coastal tide stations, together with maximum daily mean, monthly mean and minimum daily mean temperature and monthly precipitation (mm) at nearby meteorological stations (Galveston WB for Galveston, Corpus Christi for Port Aransas and Brownsville for Brazos Santiago).

	WIND SPEED (Km/h)			
Month	0-13	13-31	31-41	>41
January	18.0	52.6	16.0	13.4
February	16.6	51.7	17.2	14.4
March	16.5	56.6	17.2	9.6
April	14.7	61.0	17.2	7.1
May	21.4	59.7	13.8	5.3
June	20.7	64.0	11.4	3.9
July	28.3	63.2	7.0	1.6
August	31.3	61.7	5.7	1.3
September	22.0	59.6	12.4	6.1
October	19.8	59.9	13.0	7.4
November	16.3	52.5	15.6	15.6
December	14.6	52.7	17.4	15.3
Average Percent	20.0	57.9	13.7	8.4

Table 9. Percent frequency of wind speed by month.

	WAVE HEIGHT (m)			
Month	1	1-2	2-3	>3
January	26.2	52.6	16.5	4.7
February	23.2	52.9	16.6	7.3
March	28.1	53.6	14.8	3.5
April	26.8	58.7	11.1	3.4
May	28.5	58.8	10.9	1.9
June	32.5	60.0	6.3	1.3
July	48.6	46.6	4.2	.6
August	47.5	48.5	3.2	.8
September	36.1	51.7	9.3	2.7
October	30.3	55.2	11.8	2.7
November	27.0	51.0	15.8	6.2
December	23.2	53.7	16.8	6.3
Average Percent	31.5	53.6	11.4	3.5

Table 10. Percent frequency of wave heights by month.

		SOUTH TEXAS BROWNSVILLE - CORPUS CHRISTI DATE OF RELEASE												NORTH CENTRAL TEXAS CORPUS CHRISTI - GALVESTON DATE OF RELEASE				
		JAN 16 1970	APR 28 1970	JUL 13 1970	NOV 4 1971	MAY 27 1971	DEC 6 1972	APR 4 1972	AUG 29 1972	OCT 4 1972	JAN 18 1973	APR 7 1973	Average Of All Release	July 1973	Oct. 1973	Jan. 1974	April 1974	Average Of All Release
SURFACE DRIFTERS	INNER RELEASE LINE	21	60	50	33	45	48	50	15	58	57	45	45	33	48	27	43	38
	OUTER THREE RELEASE LINES	7	20	50	22	40	6	57	16	28	4	29	25	46	21	18	30	29
	ALL FOUR LINES	10	30	50	25	41	17	57	16	35	17	33	30	43	28	20	33	31
BOTTOM DRIFTERS	INNER RELEASE LINE	45	25 (5)	28	45	22	45 (2)	33 (1)	0	10	40	30	29	33	27	43	27	33
	OUTER THREE RELEASE LINES	4 (2)	7 (5)	1	1	5 (2)	3 (1)	2 (1)	1	4	6 (1)	2	3 (1)	7 (4)	10 (3)	14 (1)	2 (1)	8 (2)
	ALL FOUR LINES	14	12	8	12	9	14	10	1	5	14	9	10	13	14	31	8	14
ALL DRIFTERS ALL LINES		12	21	29	18	25	15	35	8	20	16	21	20	28	21	21	21	23

Table 11. Percentage of recovery of surface and bottom drifters for each date of release (percentages in parentheses are offshore recoveries).

Date Bottles Released	Number of Bottles	Cards Returned	% Return	Minimum Return Time in Days	Direction of Drift East or West	Wind Direction After Release	Location of Recovered Bottles along coast
July 11	60	16	27	17	N to NE S to SW	S to W	Galveston Bay - Sabine Pass Aransas Pass - Matagorda Bay
July 19	60	21	35	7	N, NE	S to SW	Galveston Bay
July 24	60	24	40	15	NE	S to W	Galveston Bay
July 27	20	5	25	15	N	S to W	Galveston Bay
Aug. 23	120	56	47	10	SW	S to E	Rio Grande - Aransas Pass
Aug. 24	46	3	6	9	W to SW	S to E	Aransas Pass - Matagorda Bay
Aug. 28	20	7	35	3	W to SW	SE to E	Aransas Pass - Matagorda Bay
Aug. 30	40	2	5	21	SW	SE to E	Rio Grande - Aransas Pass
Aug. 31	40	7	18	29	SW	SE to E	Rio Grande - Aransas Pass
Sept. 13	20	1	5	31	N	SW to N	Brazos River
Sept. 14	20	3	15	18	W to SW	N to S	Aransas Pass - Matagorda Bay
Sept. 18	15	3	20	17	W	NE	Matagorda Bay
Sept. 19	60	22	37	4	W	NE to SE	Matagorda Bay
Sept. 20	60	30	50	9	W	SE	Matagorda Bay
Sept. 21	60	20	33	5	W	E to S	Matagorda Bay
Sept. 22	60	13	22	3	W	S to NE	Matagorda Bay
Sept. 23	60	17	28	3	W	S to N	Matagorda Bay
Sept. 24	60	10	17	2	W to SW.	NE to S	Aransas Pass - Matagorda Bay
Sept. 25	50	9	18	11	SE	S to SE	Aransas Pass
Total	930	269	29%				

Table 12. Summary of Seadock drift bottle survey, 1975.

Vessel	Cruise Date	Flow Direction	
		Cyclonic	Anticyclonic
HIDALGO	Jan. 1962	X	
ALAMINOS	Jan. 1964	X	
ALAMINOS	Jan. 1966	X	
ATLANTIS	Feb. 1947		X
HIDALGO	Feb. 1959		X
ALAMINOS	Feb. 1966	X	
ALAMINOS	Feb.-Mar. 1968		X
ATLANTIS	Mar.-April 1935	X	
HIDALGO	Mar. 1962		X
HIDALGO	Mar. 1968		X
ALAMINOS	May 1970		X
ALASKA	June 1951		X
ALAMINOS	June 1966		X
ALAMINOS	June 1967		X
KNORR	June-Aug. 1969		X
ALAMINOS	June 1970		X
ALAMINOS	July 1969		X
ALAMINOS	Aug. 1965		X
ALAMINOS	Aug. 1967		X
ALAMINOS	Aug. 1968		X
ALAMINOS	Sept. 1965	X	
ALAMINOS	Sept. 1967		X
ALAMINOS	Sept. 1968		X
HIDALGO	Oct. 1961	X	
VIRGILIC URIBE (Mexico)	Nov. 1970		X
ALAMINOS	Dec. 1963	X	

Table 13. Direction of geostrophic flow in deep water (from NODC historical station data files)

Winter

	E	x	G	x	B	=	L	O
27°N, S-N	4.2		0		-13.8		- 9.6	-4.2
28.5°N, SW-NE	-3.7		-5.0		-20.7		-29.4	-0.9

Spring

	E	G	B	L	O
27°N, S-N	+6.6	+4.9	-27.6	-16.1	-1.7
28.5°N, SW-NE	+2.9	-1.8	-41.4	-40.3	-4.9

Summer

	E	G	B	L	O
27°N, S-N	+8.2	+6.6	0	+14.8	+1.5
28.5°N, SW-NE	+4.9	+1.9	-3.4	- 3.4	-2.8

Fall

	E	G	B	L	O
27°N, S-N	+4.8	0	-6.9	- 2.1	-4.8
28.5°N, SW-NE	-1.1	-5.0	-10.3	-17.4	-3.6

Table 14. Computed surface elementary baroclinic currents (cm/sec) by season at locations 50 km offshore in 75 m deep water. Longshore with the coast on the left and offshore are taken as positive. E is the Ekman spiral component, G is the barotropic component, B is the baroclinic component, L is the total longshore flow and O is the total (Ekman) offshore flow.

FIGURES

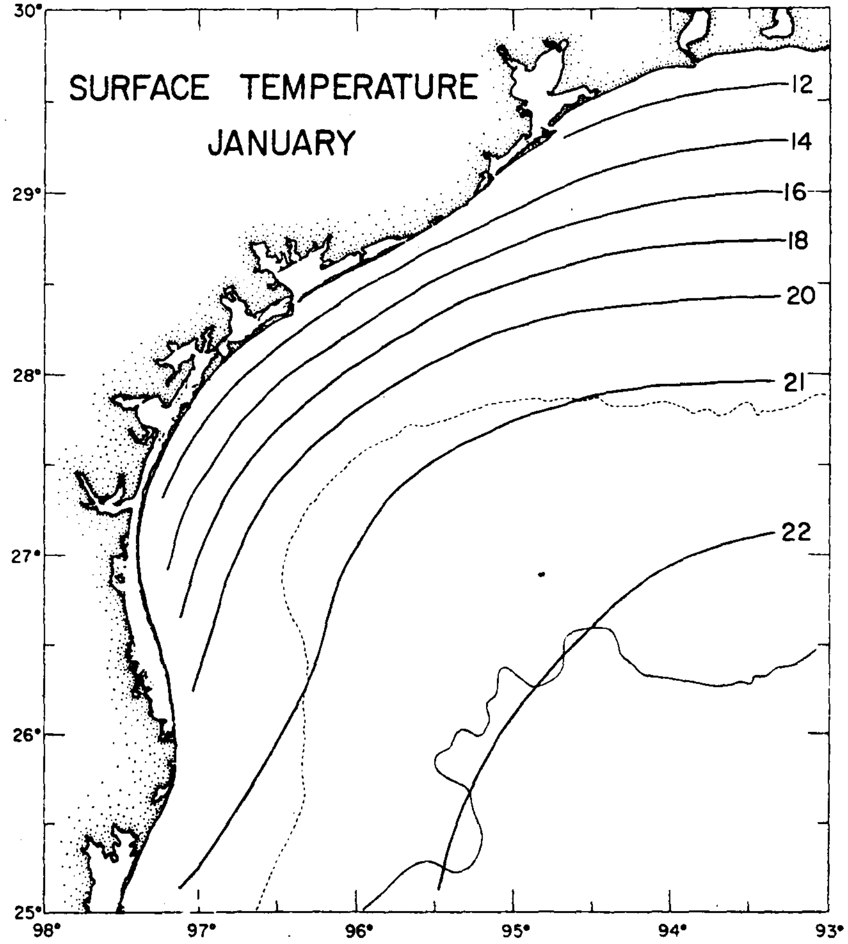


Fig. 1. January sea surface temperatures (°C)

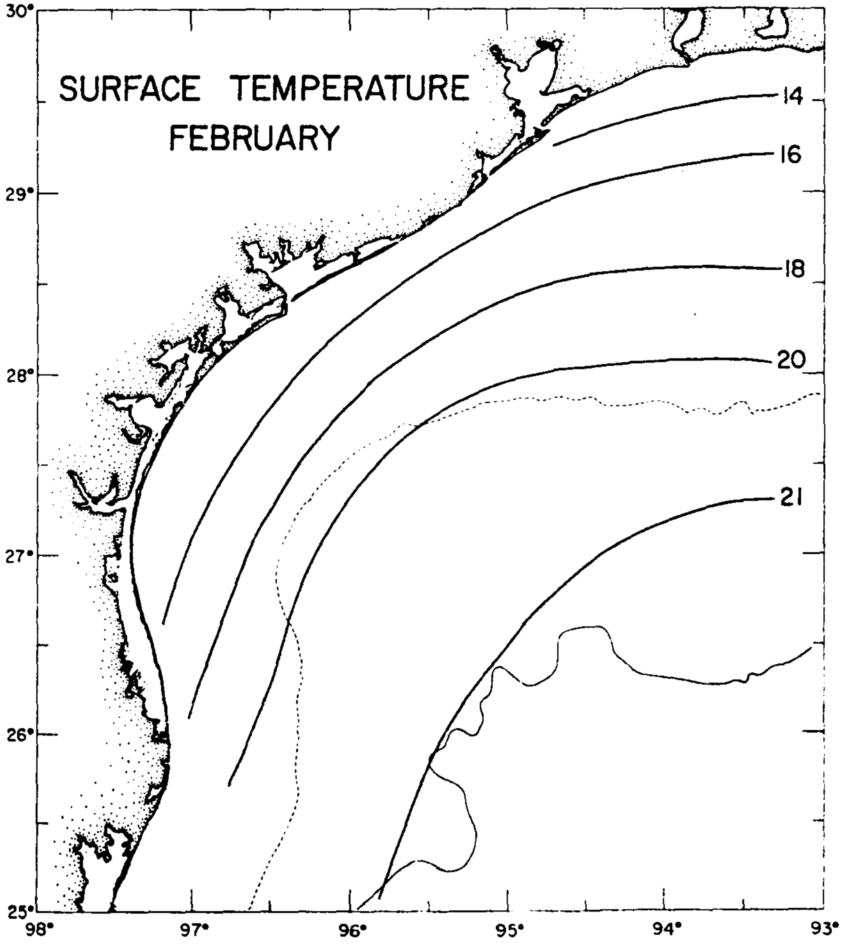


Fig. 2. February sea surface temperatures (°C).

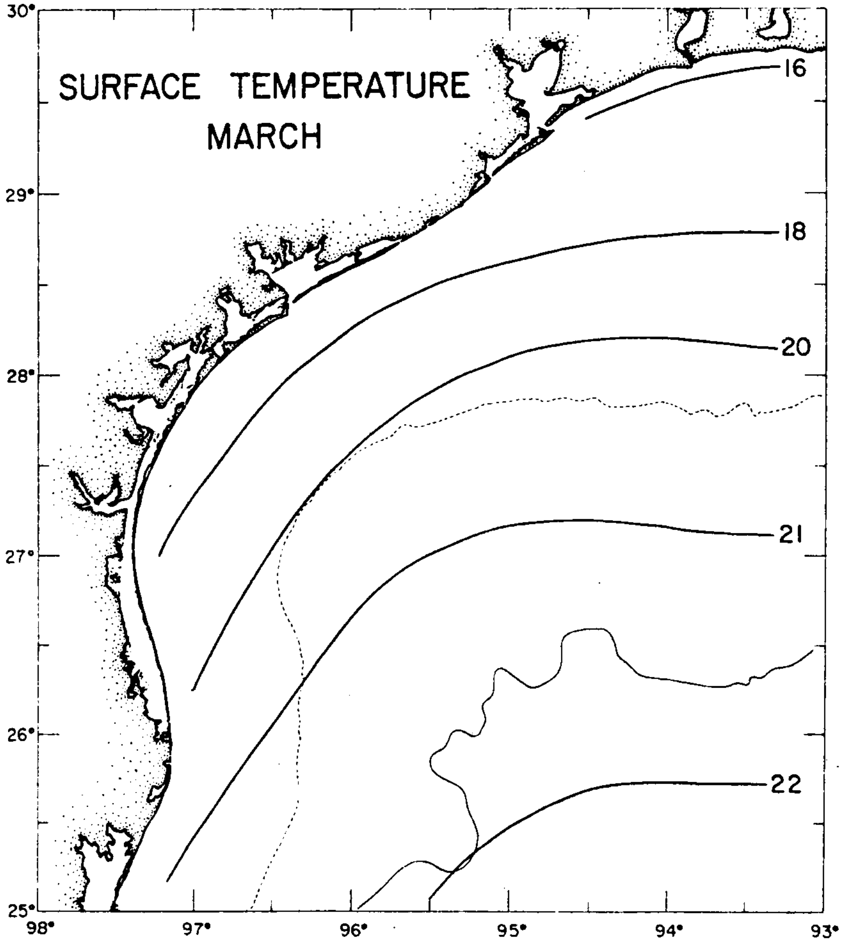


Fig. 3. March sea surface temperatures (°C).

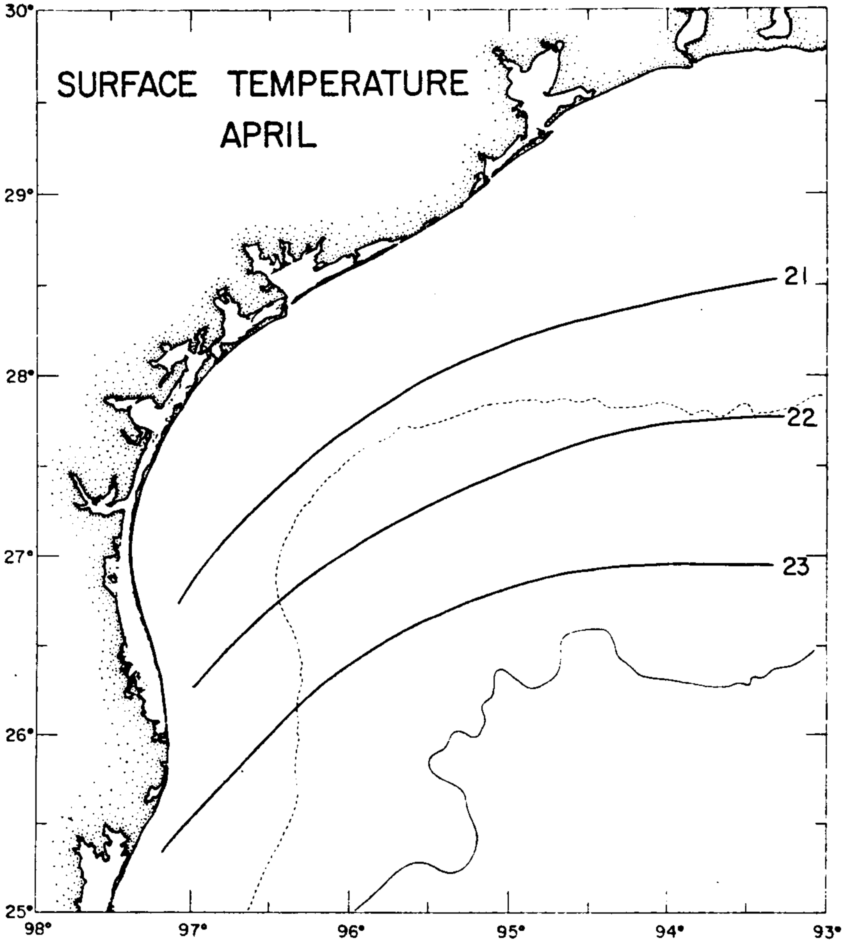


Fig. 4. April sea surface temperatures (°C).

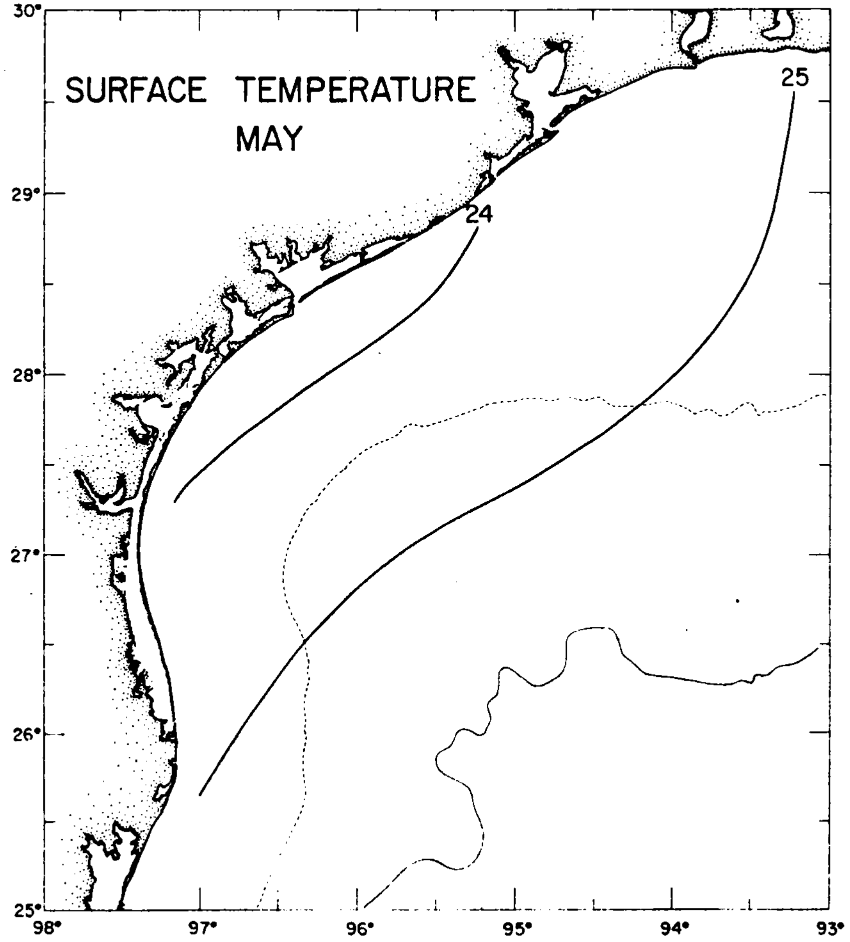


Fig. 5. May sea surface temperatures (°C).

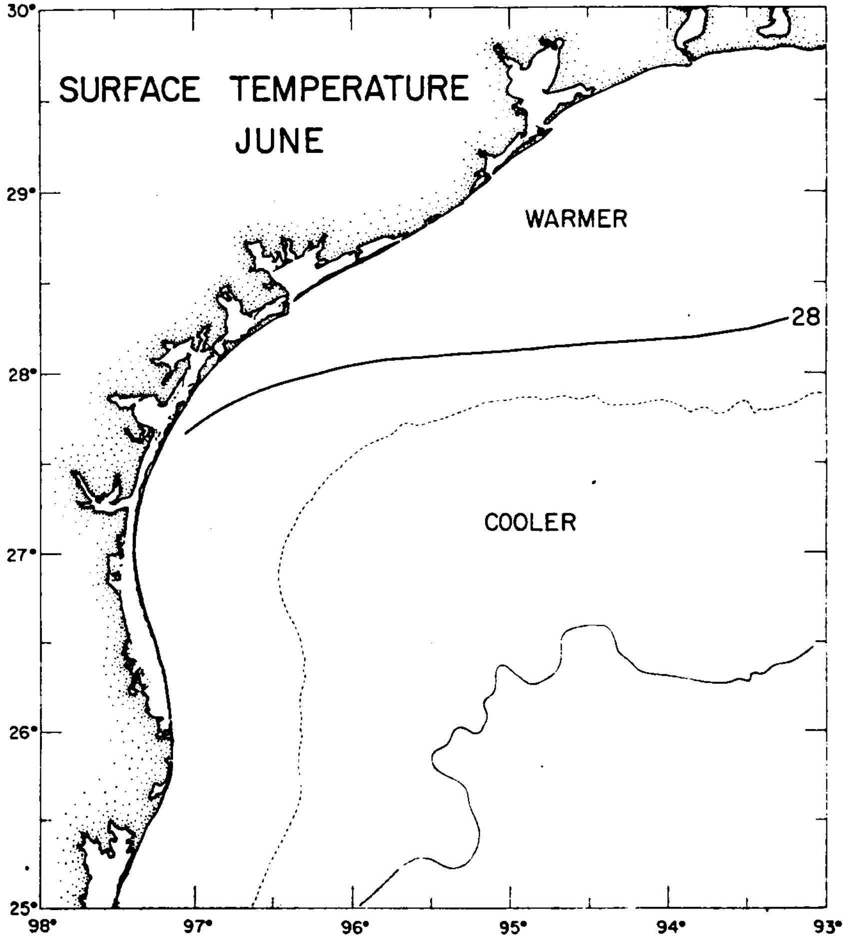


Fig. 6. June sea surface temperatures (°C).

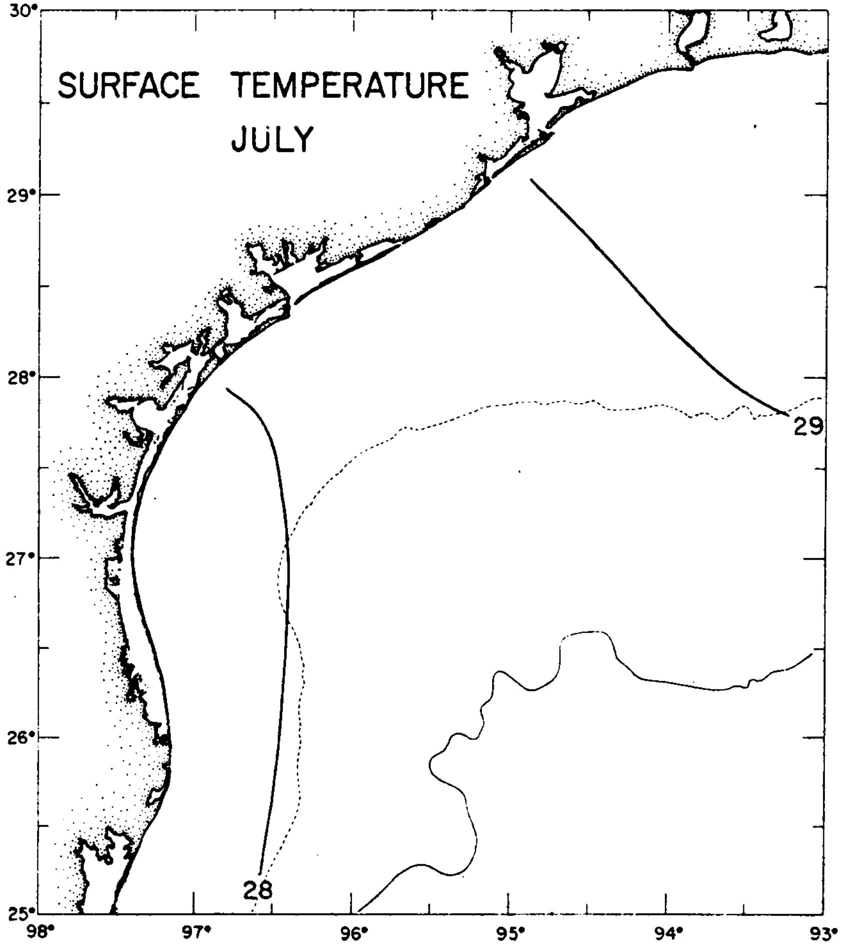


Fig. 7. July sea surface temperatures (°C).

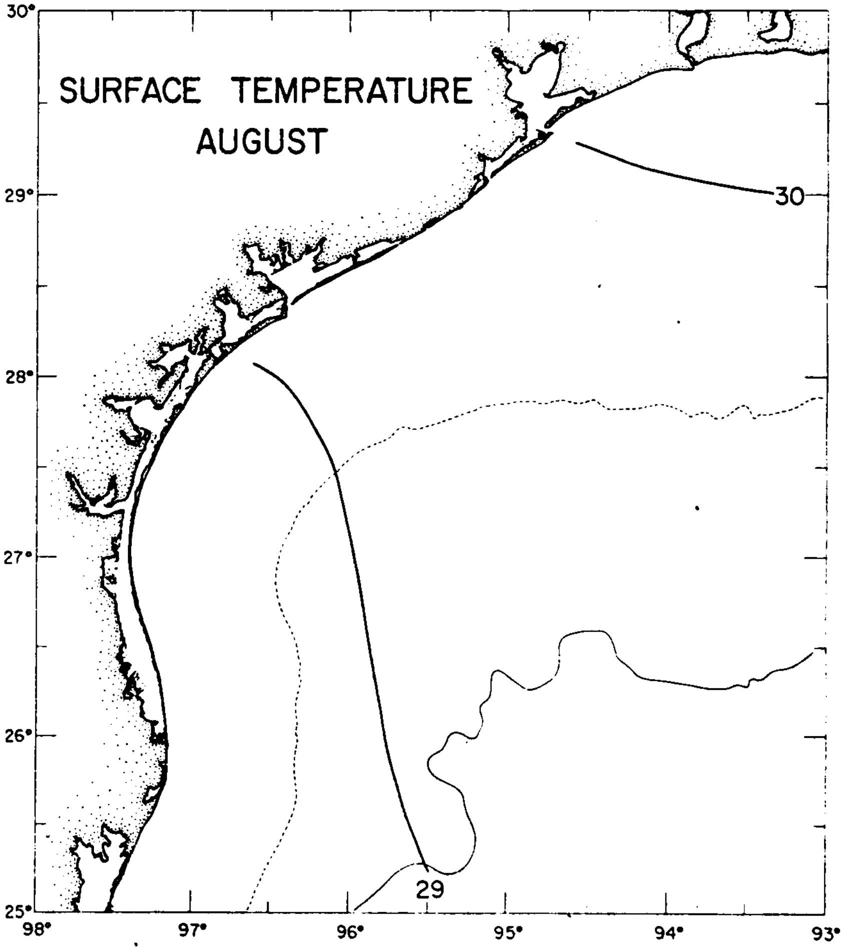


Fig. 8. August sea surface temperatures (°C).

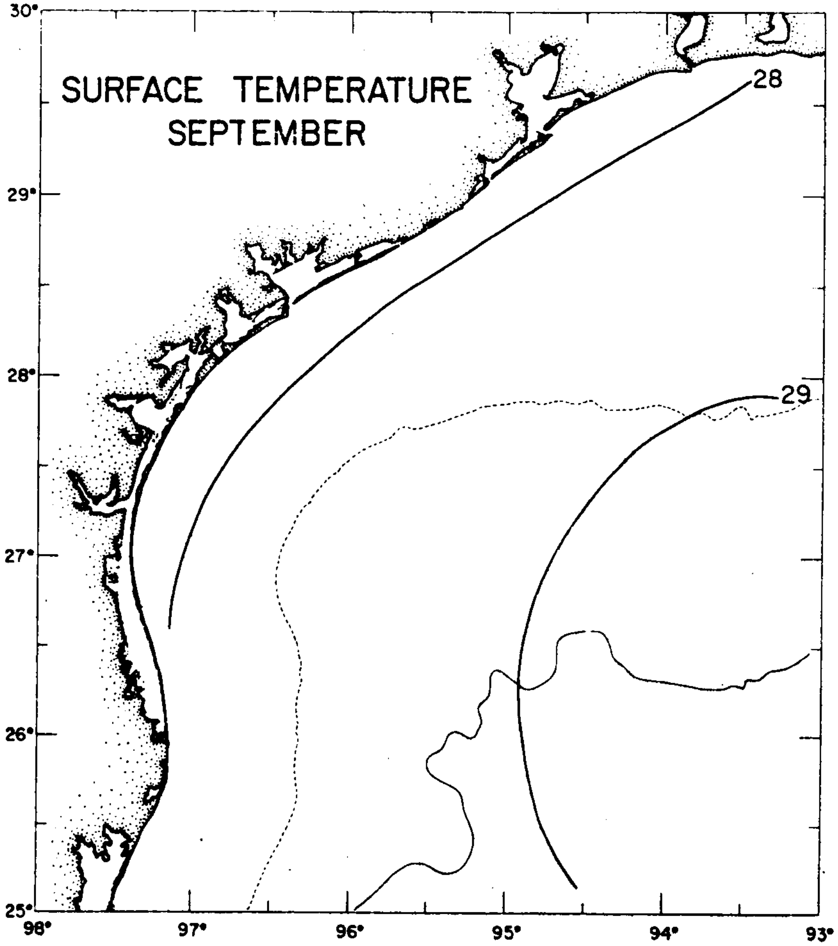


Fig. 9. September sea surface temperatures (°C).

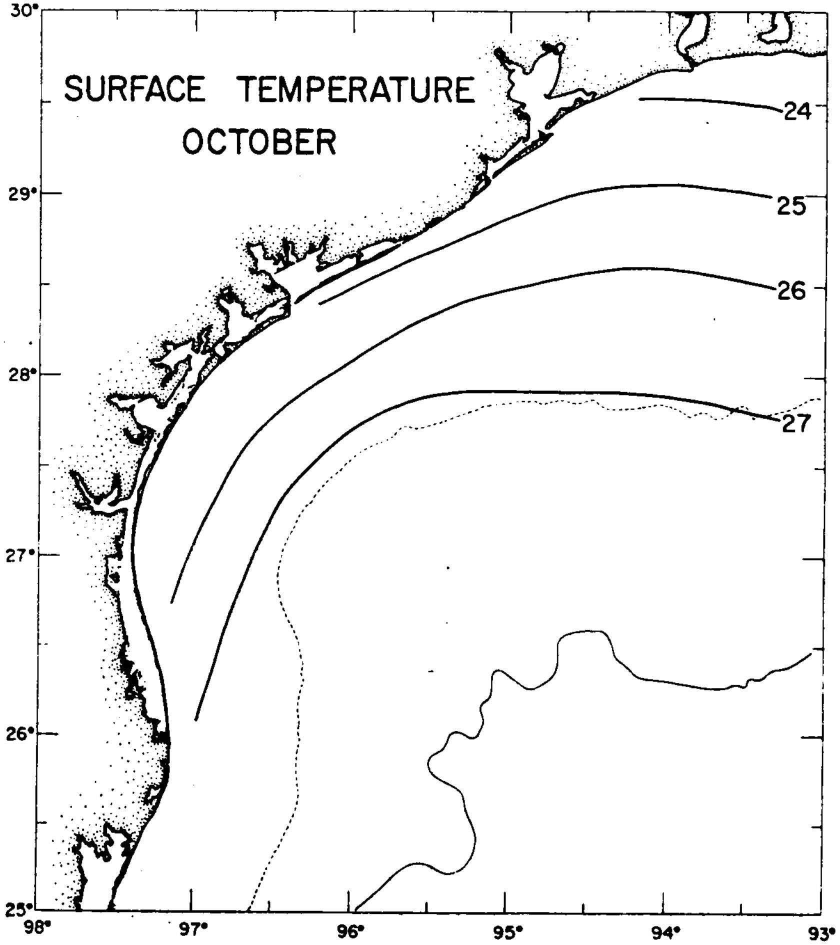


Fig. 10. October sea surface temperatures (°C).

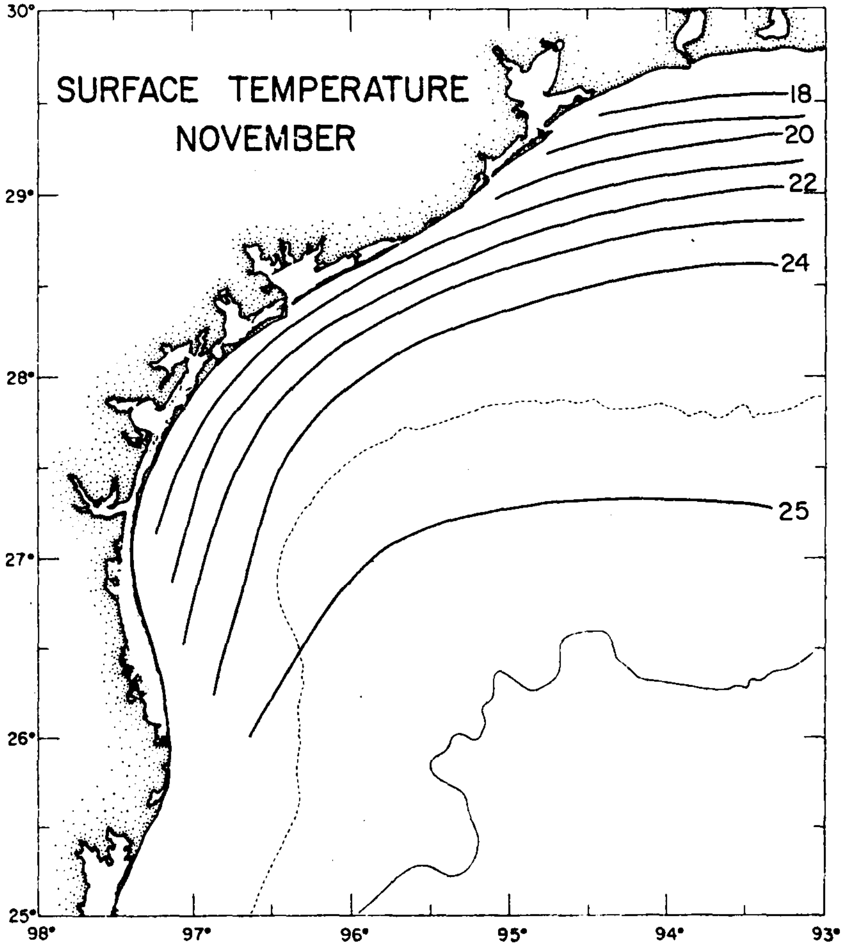


Fig. 11. November sea surface temperatures (°C).

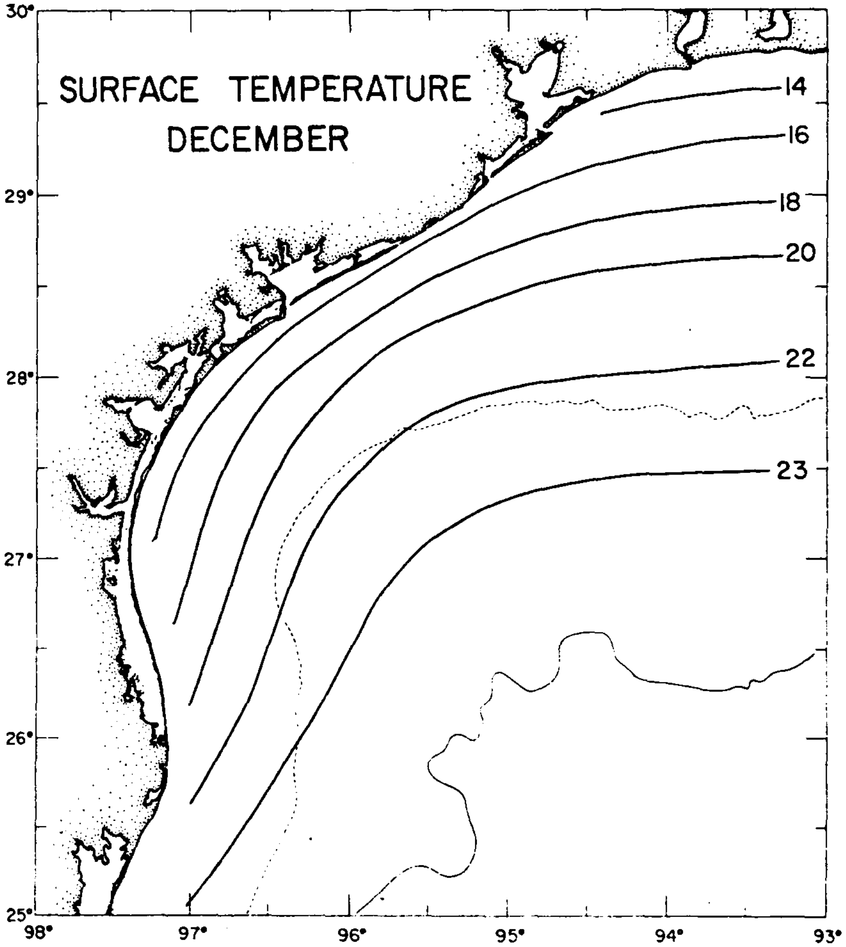


Fig. 12. December sea surface temperatures (°C).

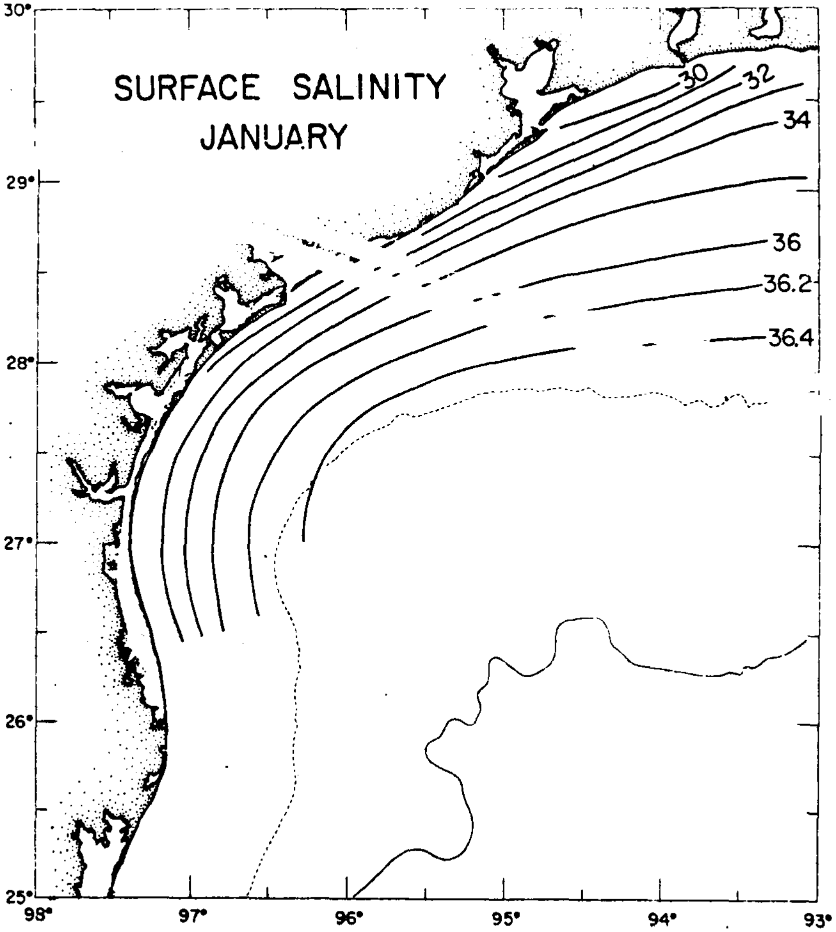


Fig. 13. January sea surface salinities (°/oo)

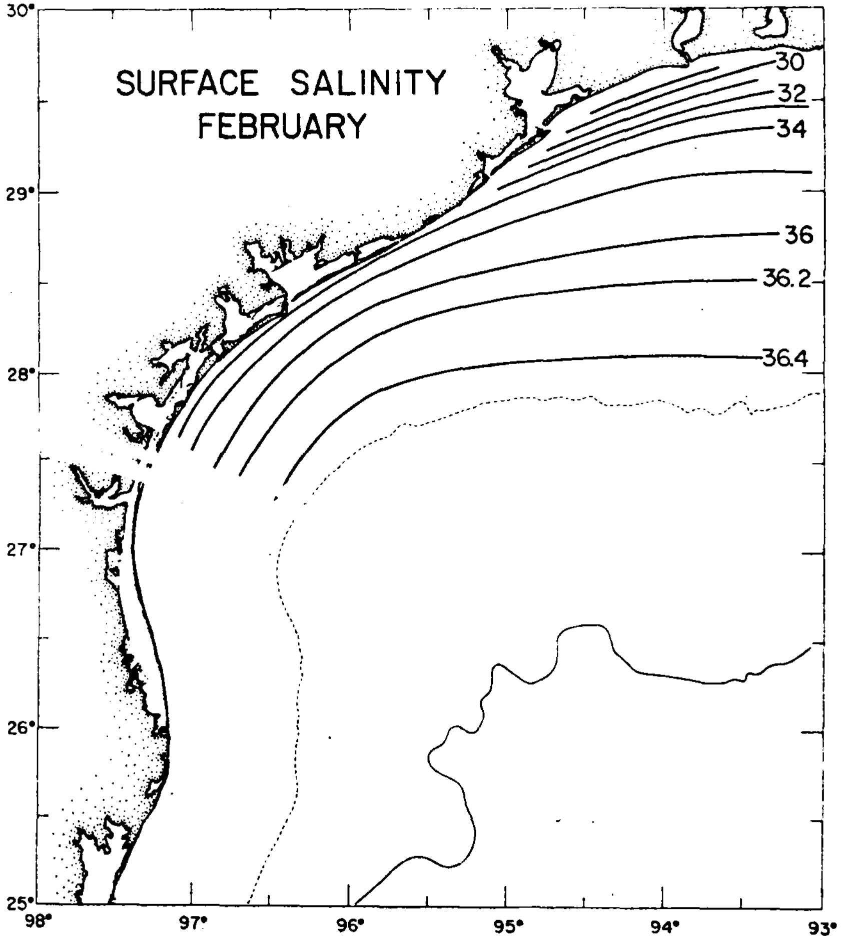


Fig. 14. February sea surface salinities (°/oo).

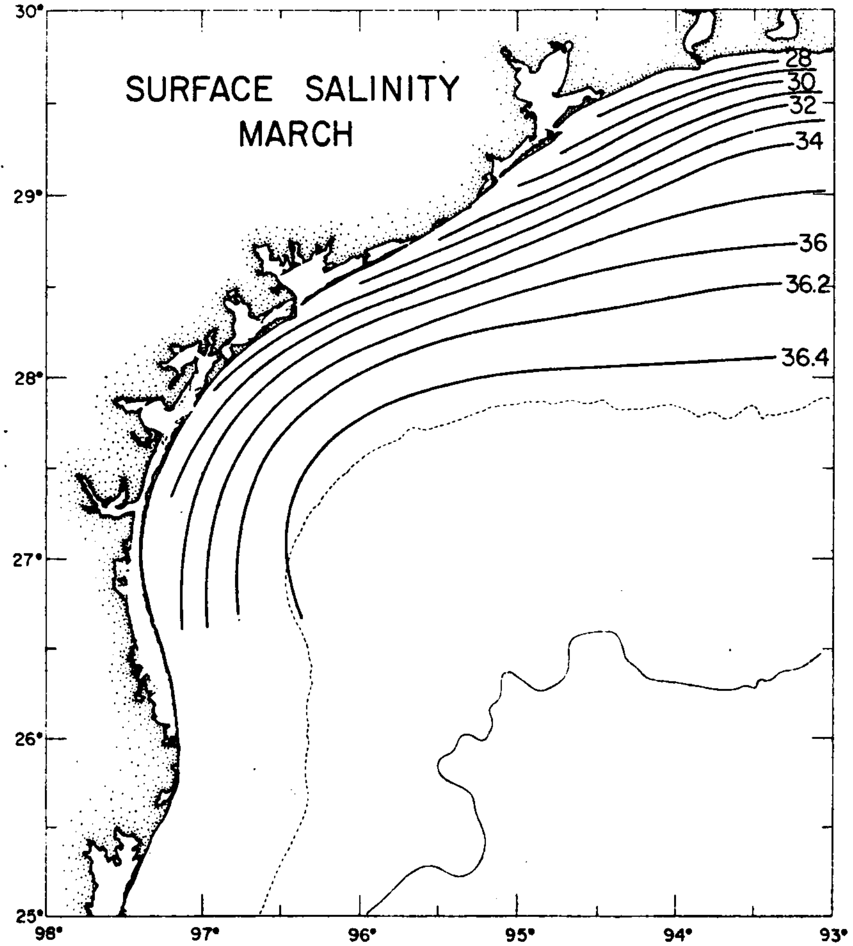


Fig. 15. March sea surface salinities (°/oo).

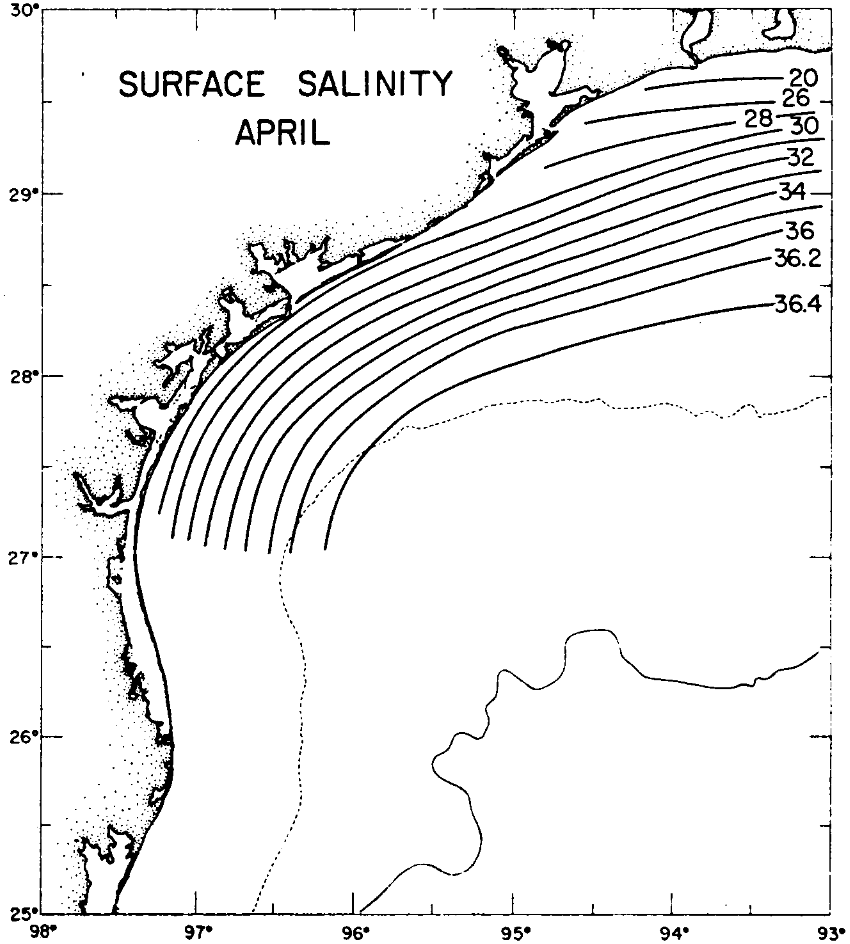


Fig. 16. April sea surface salinities (°/oo).

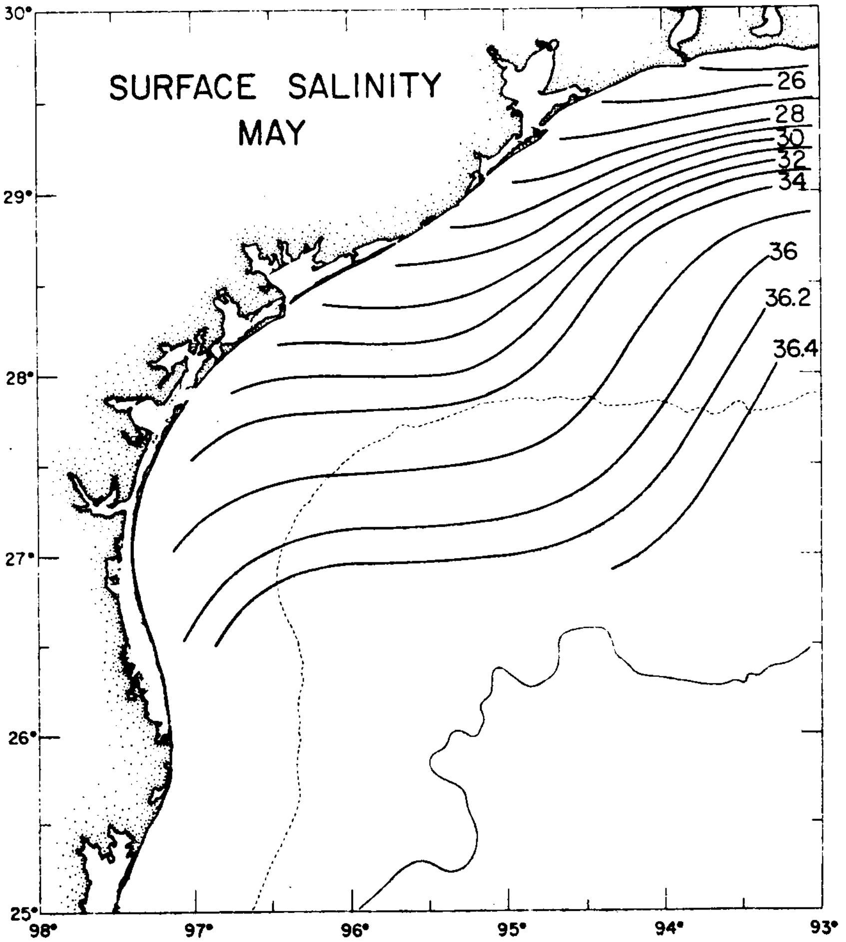


Fig. 17. May sea surface salinities (°/oo).

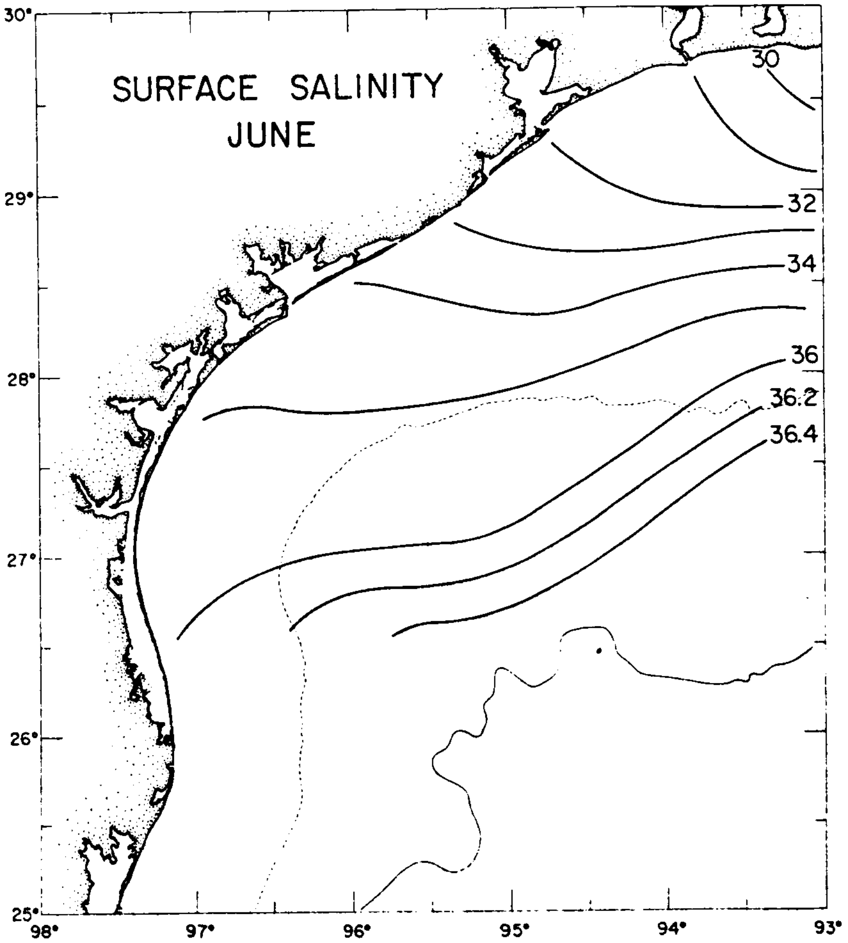


Fig. 18. June sea surface salinities (°/oo).

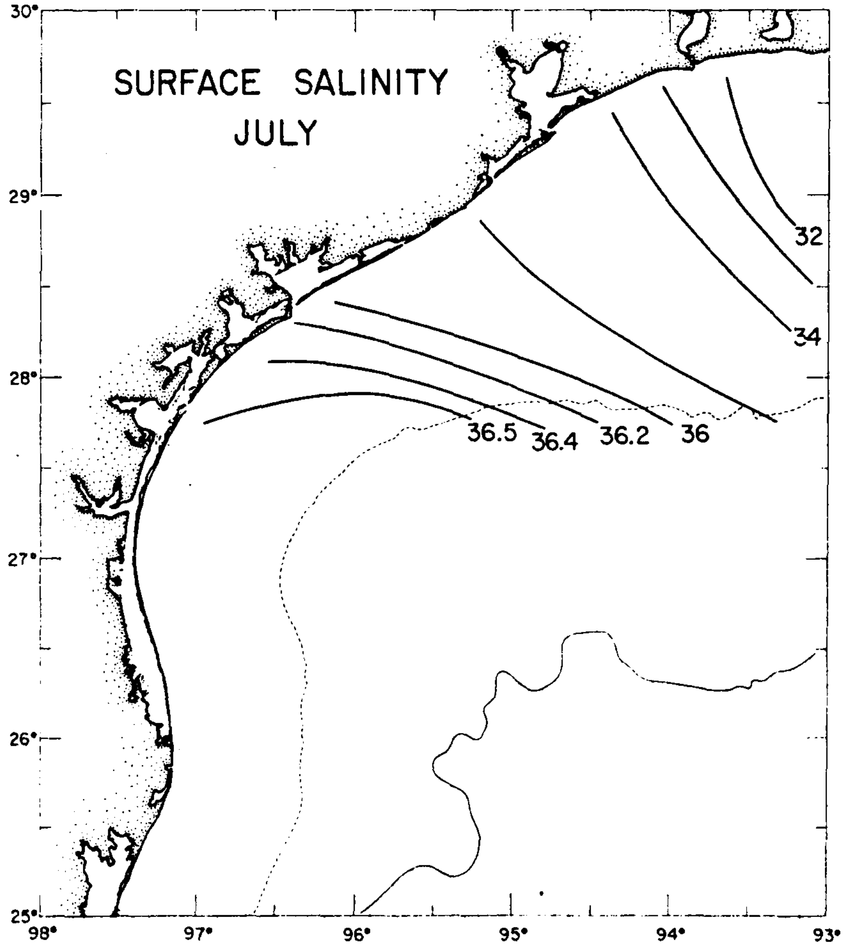


Fig. 19. July sea surface salinities ($^{o}/oo$).

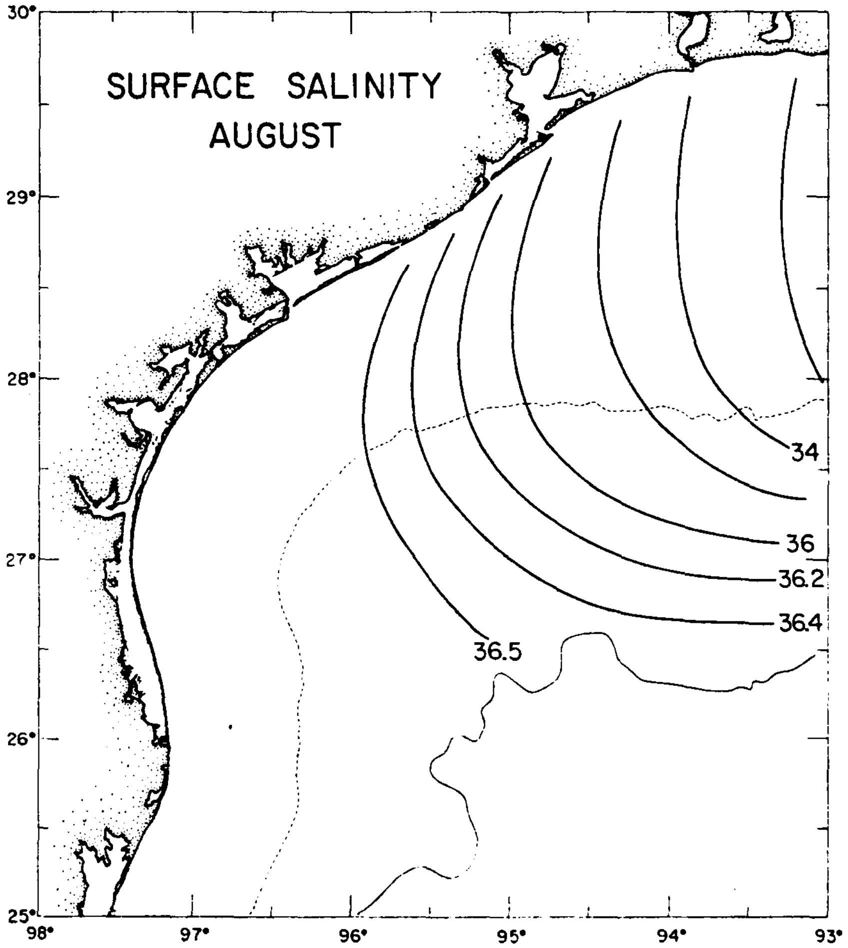


Fig. 20. August sea surface salinities ($^{o}/oo$).

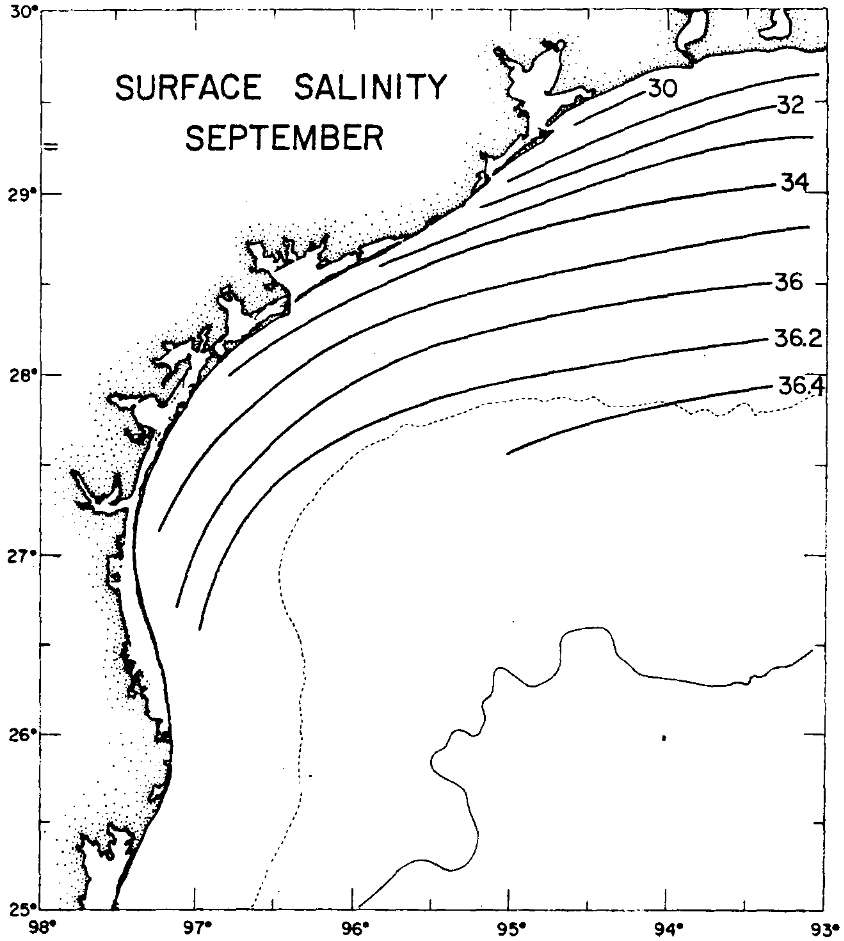


Fig. 21. September sea surface salinities (°/oo).

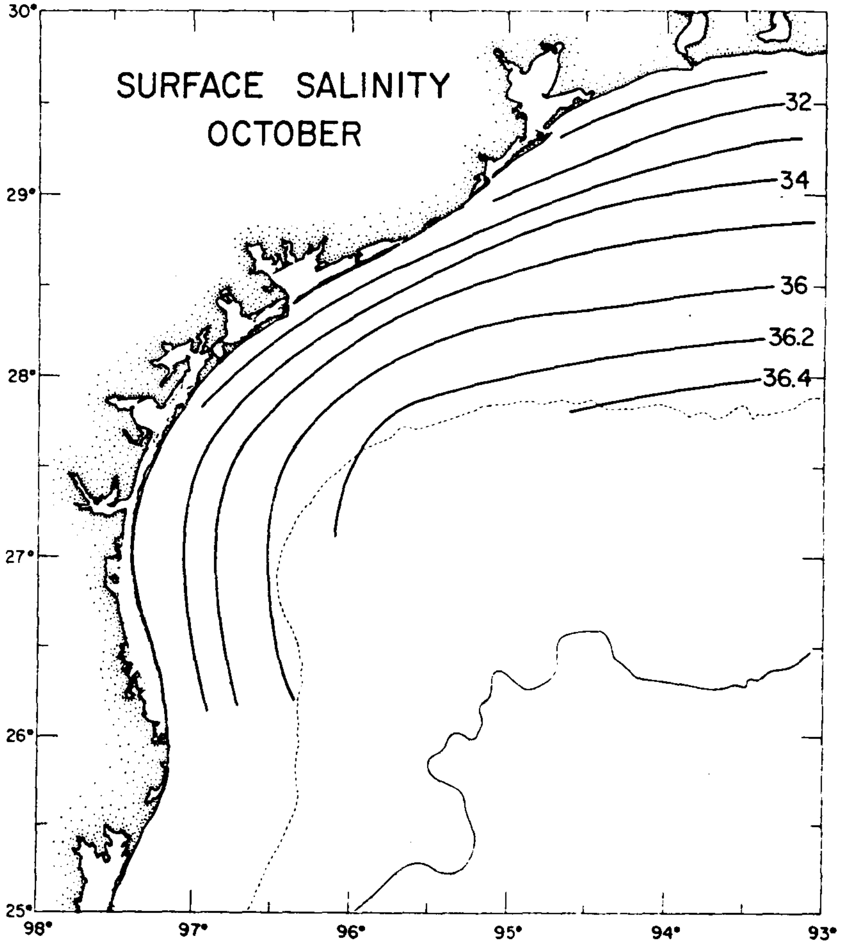


Fig. 22. October sea surface salinities (°/oo).

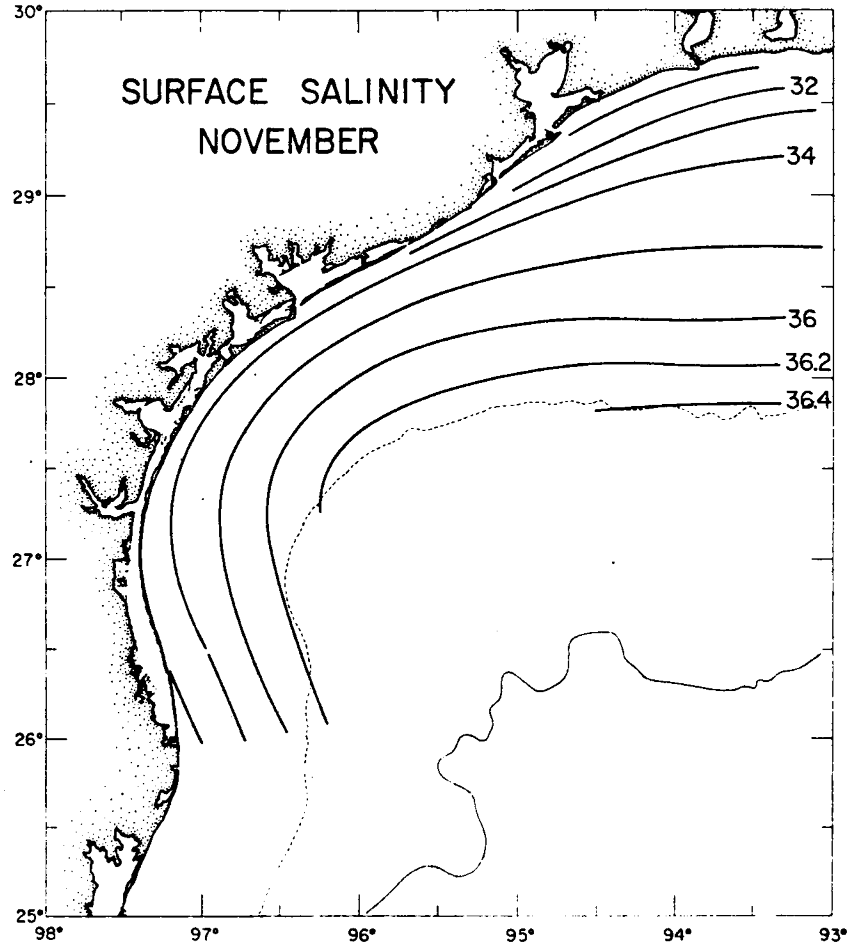


Fig. 23. November sea surface salinities (°/oo).

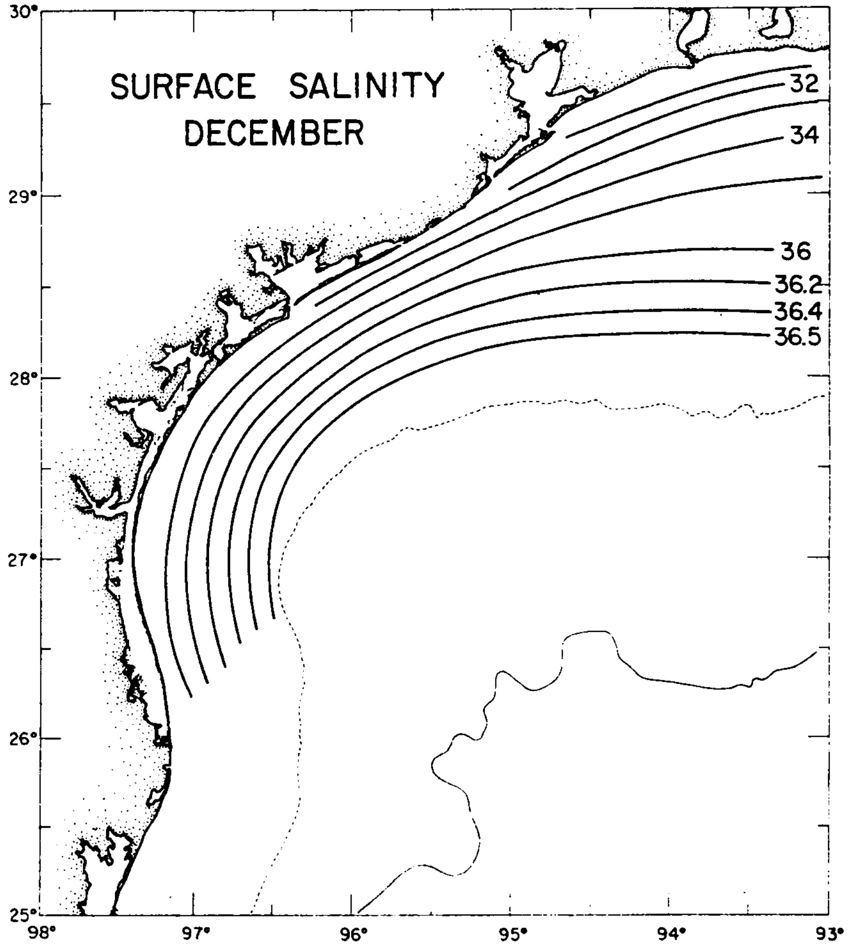


Fig. 24. December sea surface salinities (°/oo).

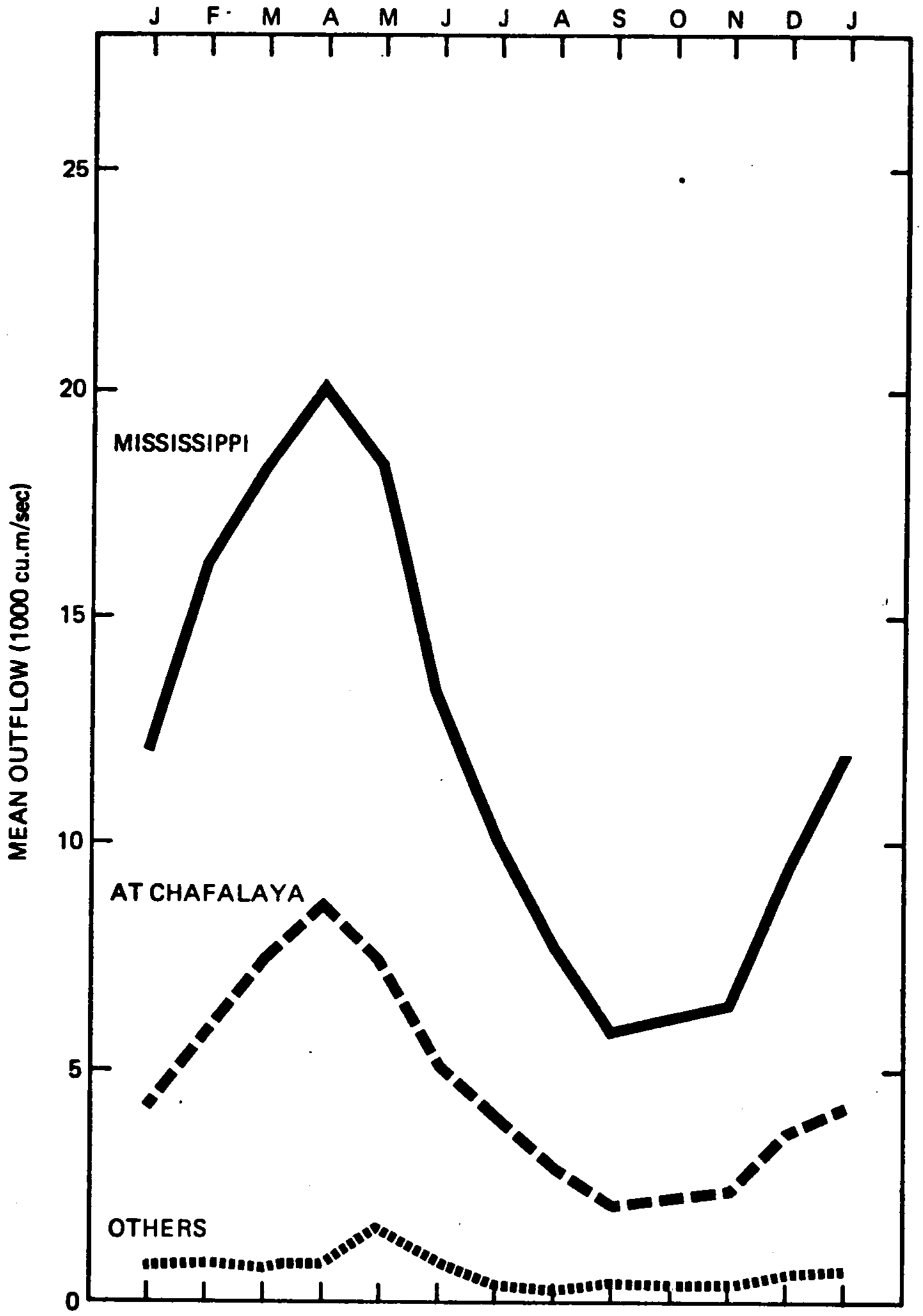


Fig. 25. Monthly mean river discharge from the Atchafalaya and Mississippi Rivers and the sum of the mean offings of the rivers west of the Atchafalaya to the Rio Grande (Source: U.S. Geological Survey Reports of surface water supplies of the U.S., 1950-1970).

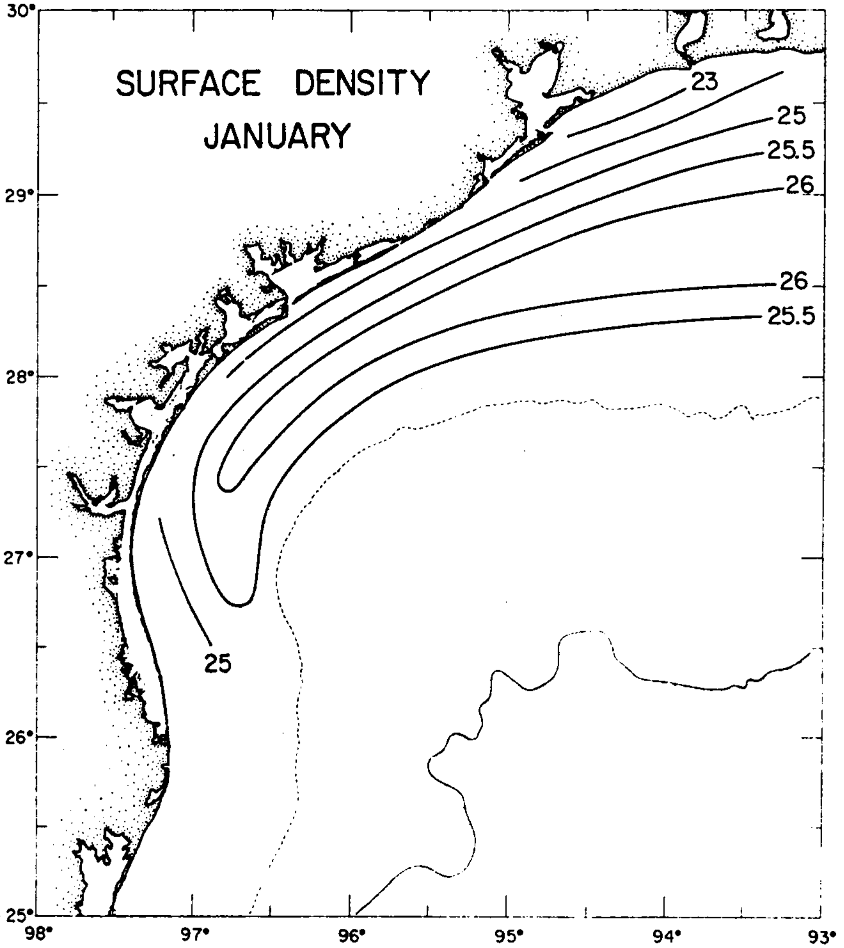


Fig. 26. January sea surface density.

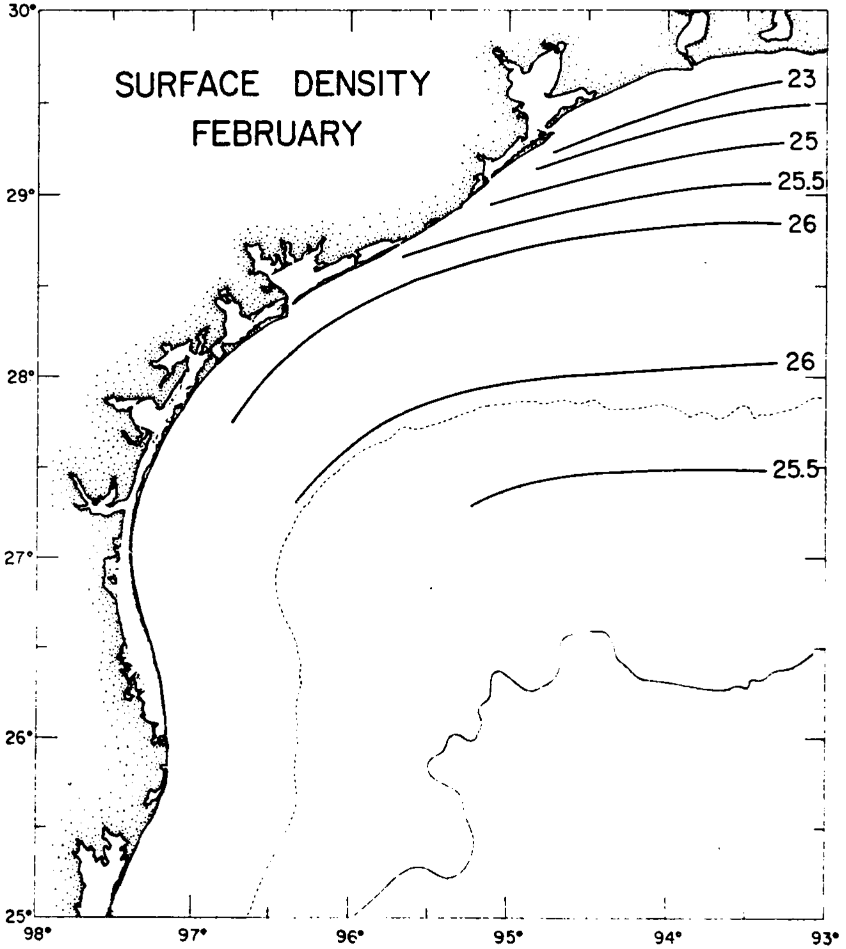


Fig. 27. February sea surface density.

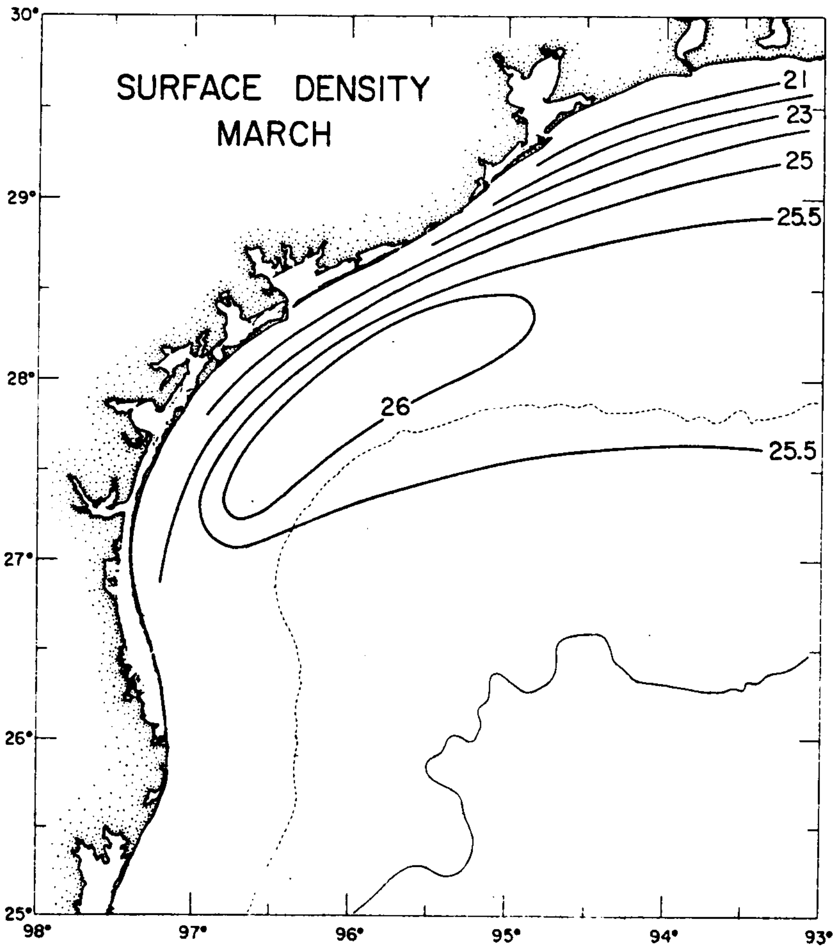


Fig. 28. March sea surface density.

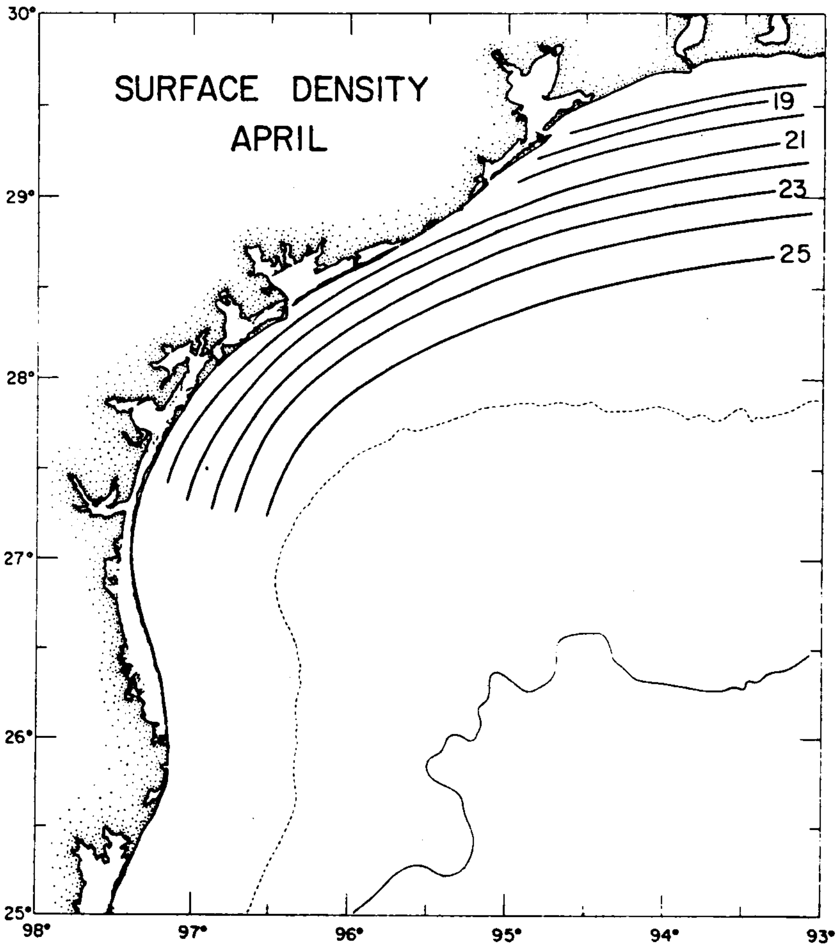


Fig. 29. April sea surface density.

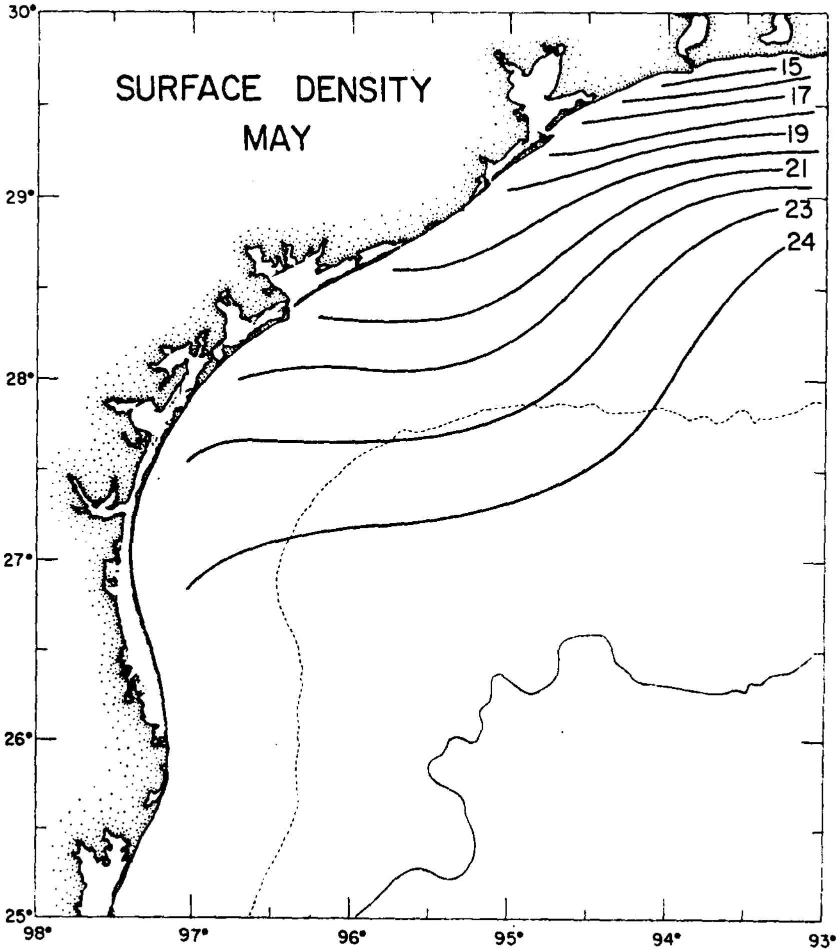


Fig. 30. May sea surface density.

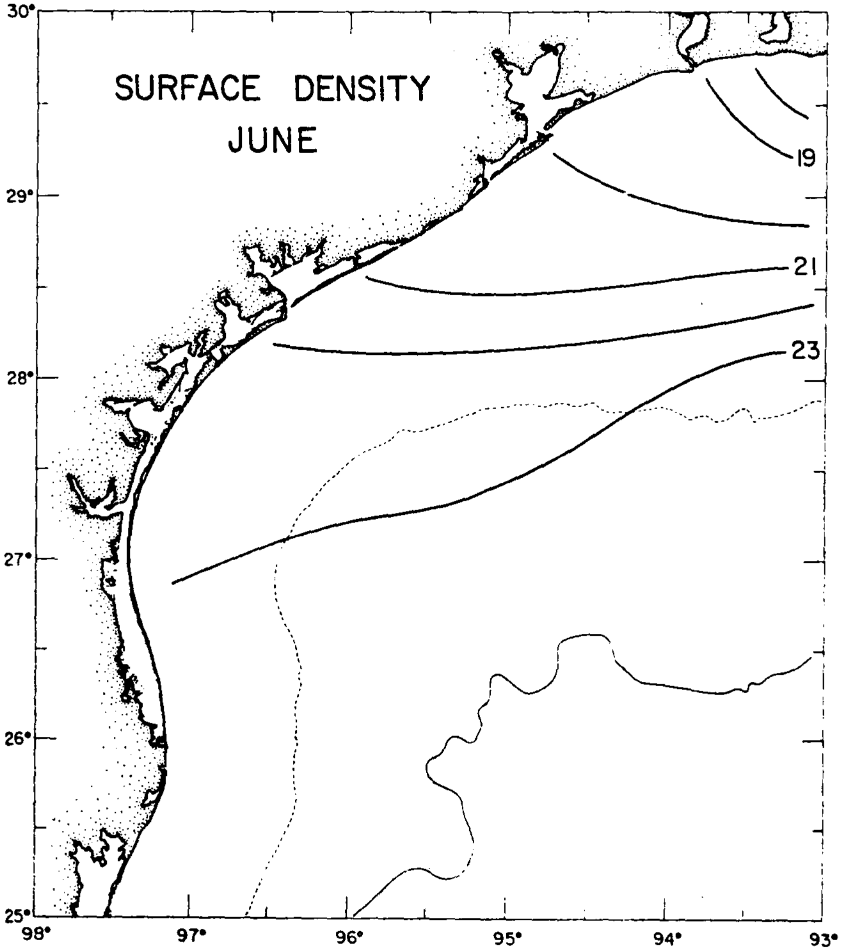


Fig. 31. June sea surface density.

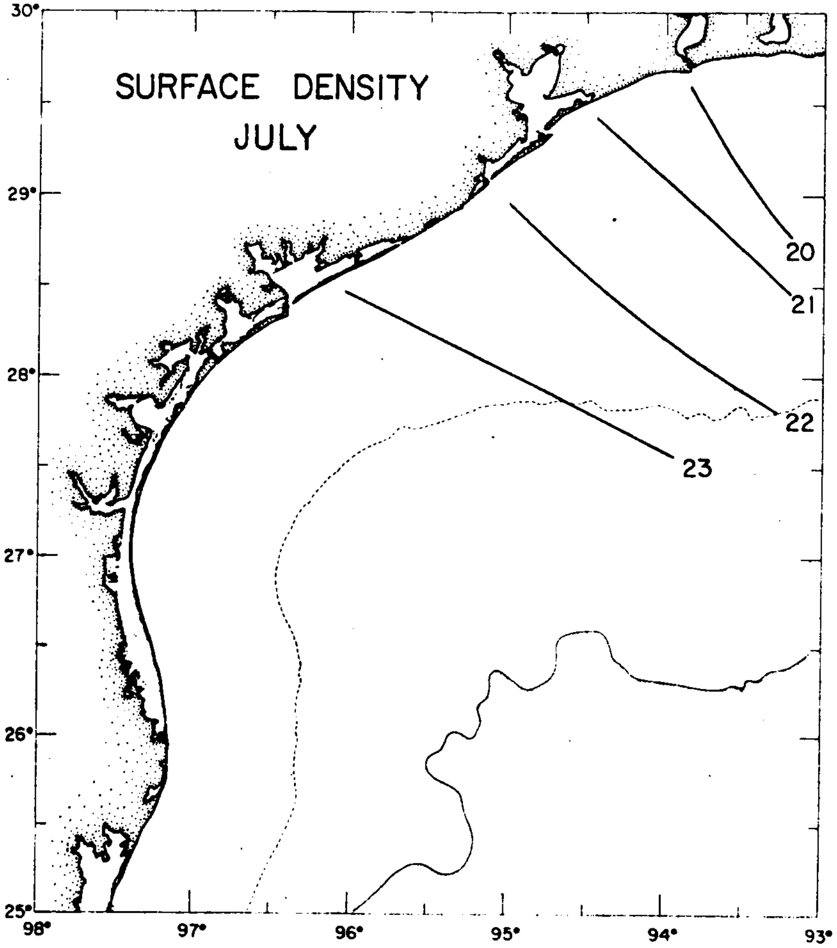


Fig. 32. **July sea surface density.**

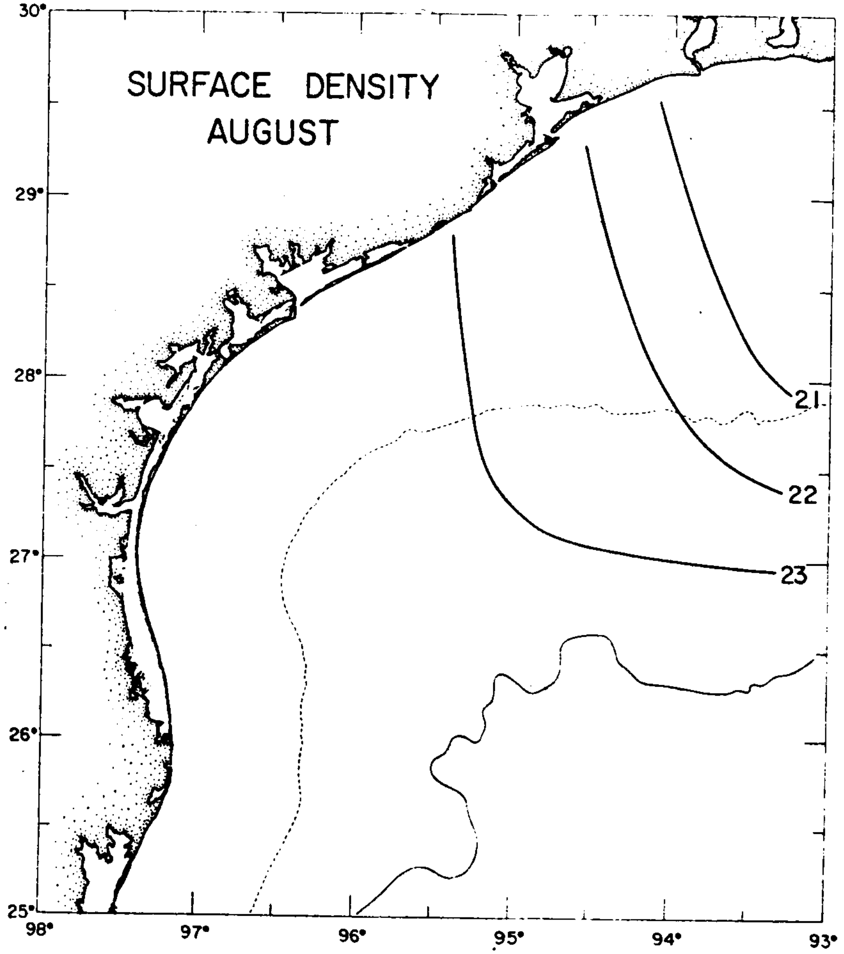


Fig. 33. **August sea surface density.**

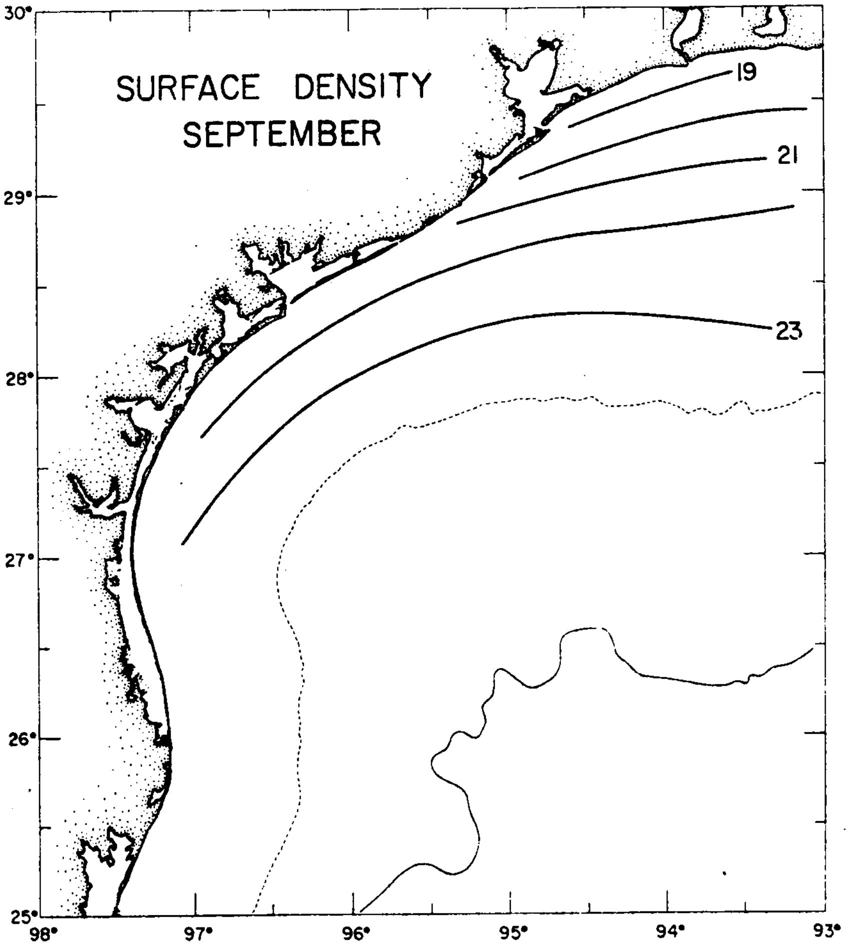


Fig. 34. September sea surface density.

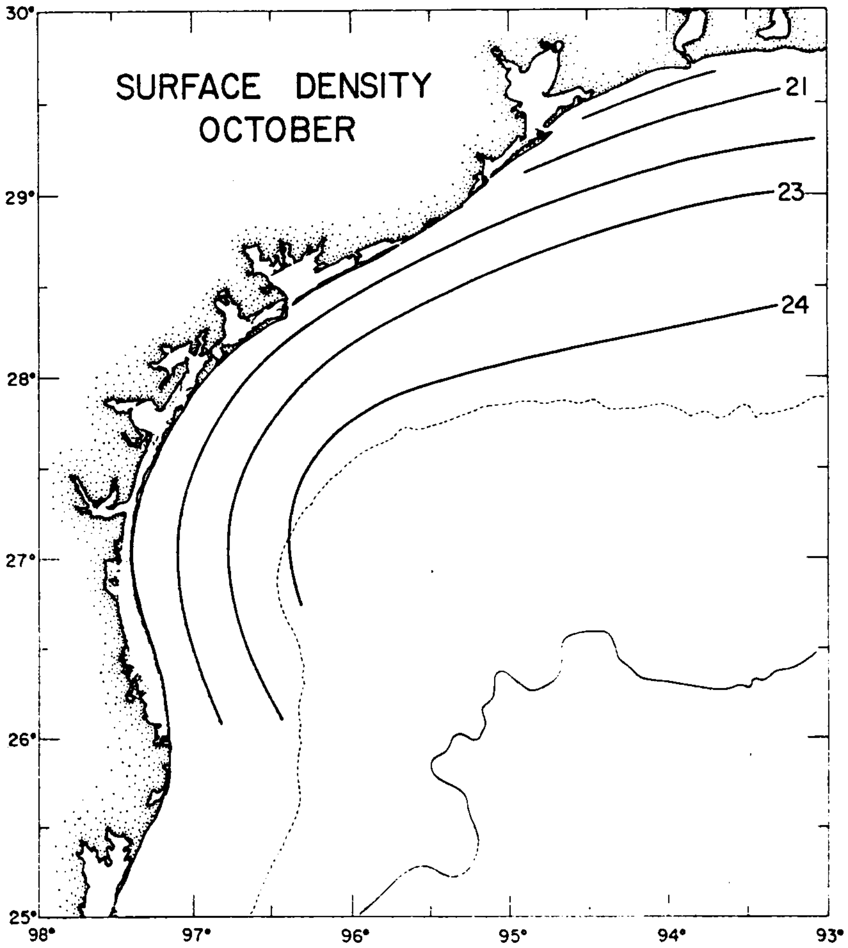


Fig. 35. October sea surface density.

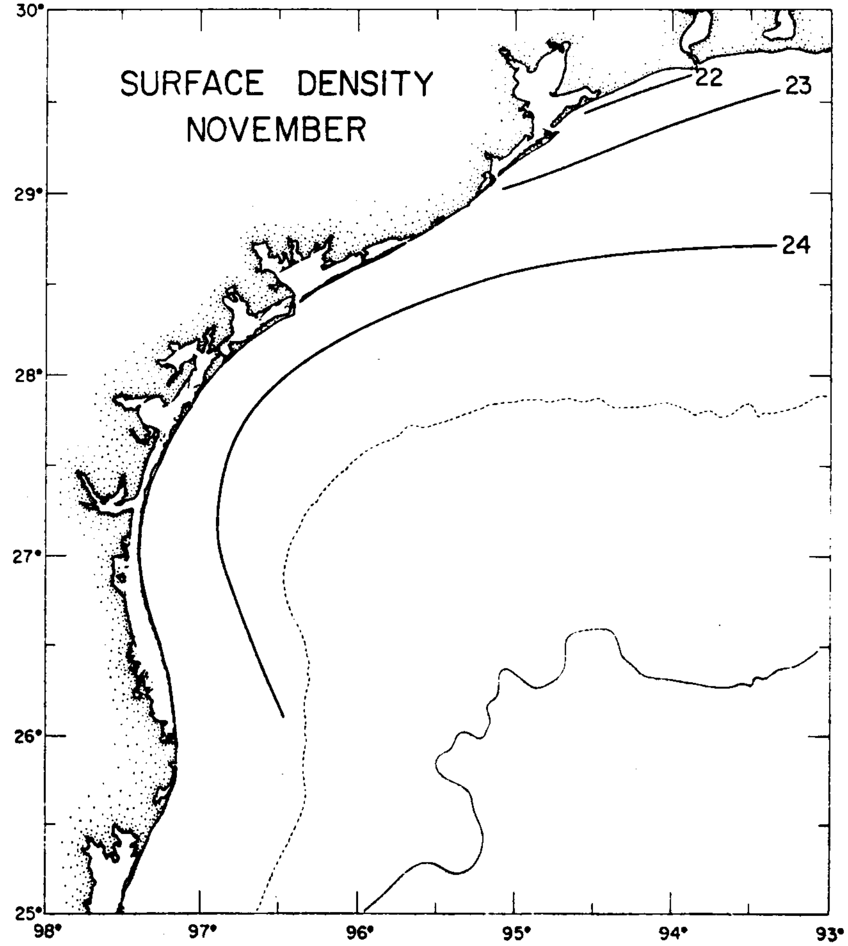


Fig. 36. November sea surface density.

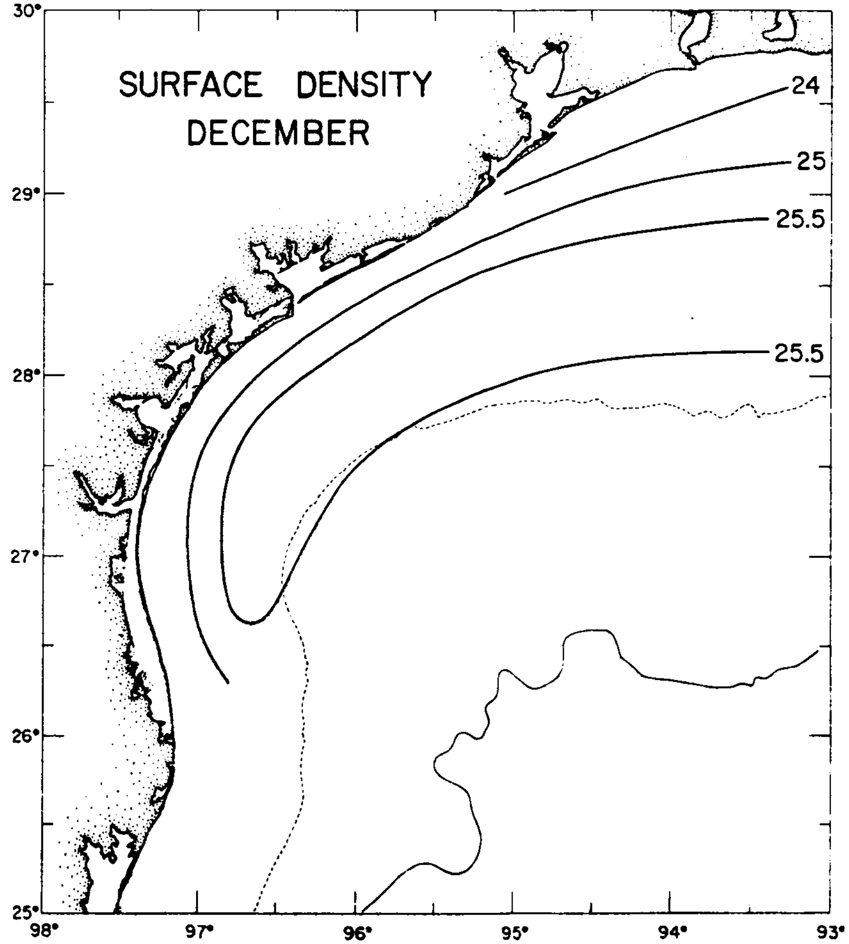


Fig. 37. December sea surface density.

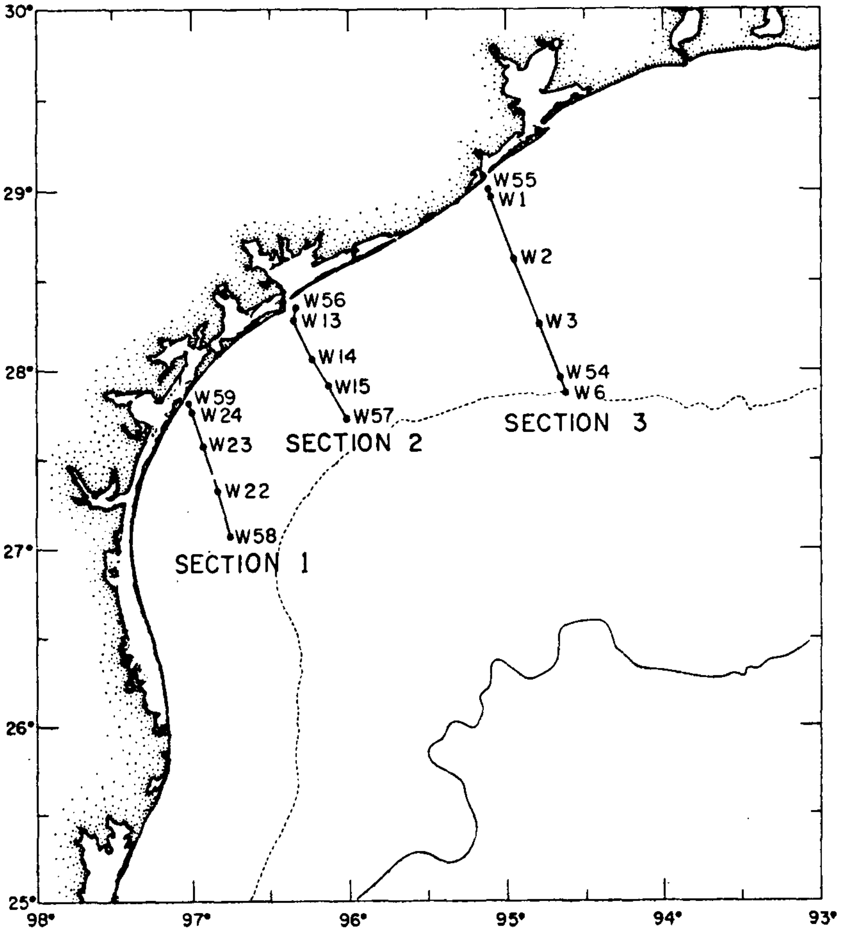


Fig. 38. Location of sections and stations. Stations designed by National Marine Fisheries Service, Galveston.

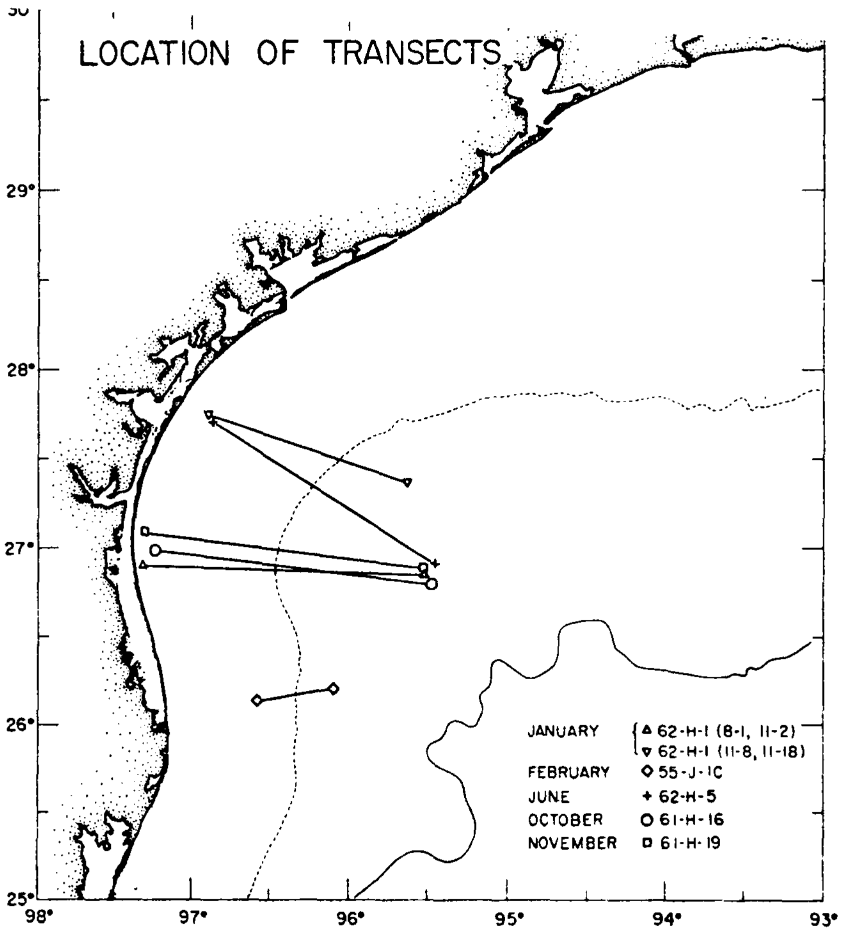


Fig. 39. Location of transects by Texas A&M University, Dept. of Oceanography cruises.

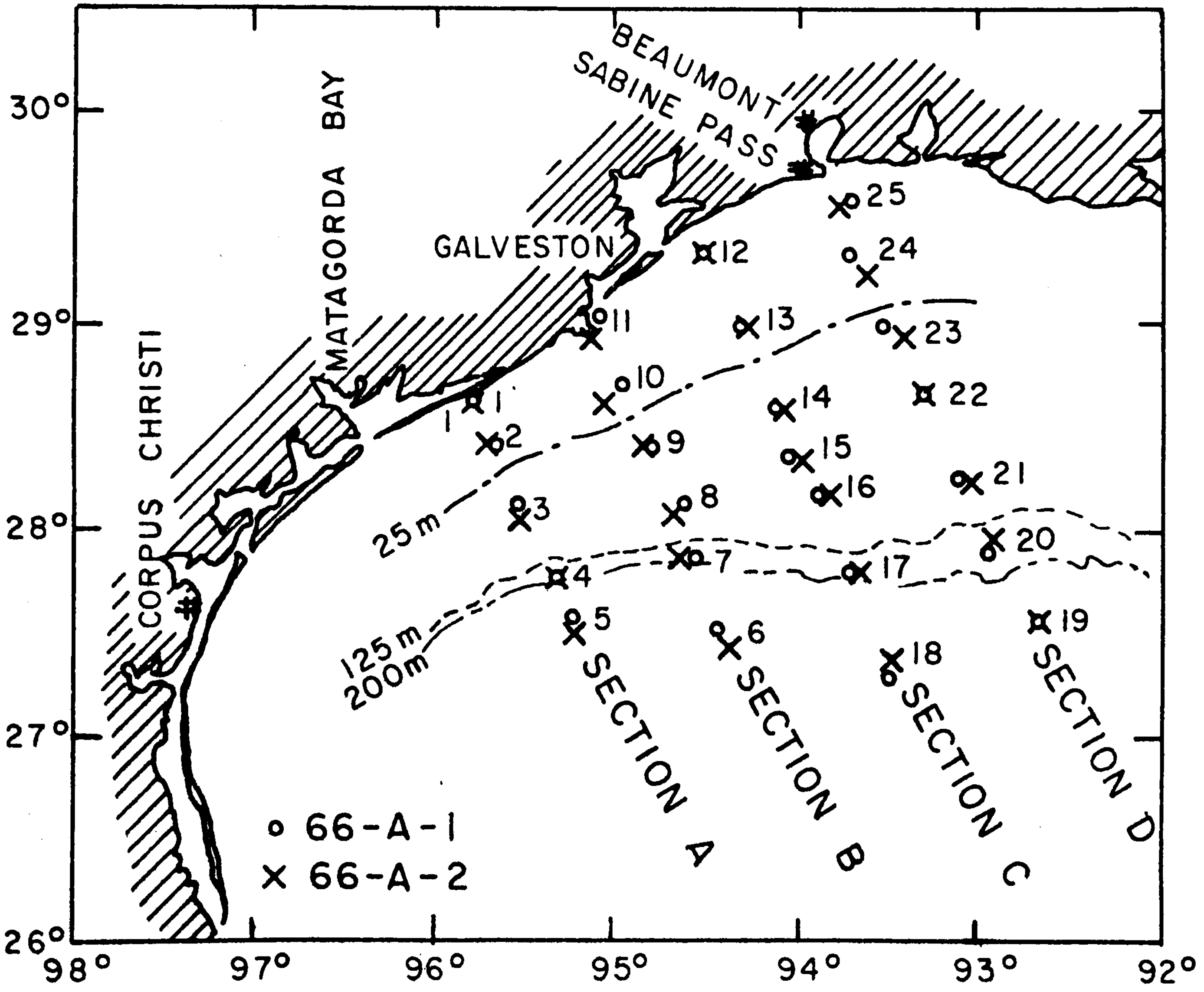


Fig. 40. Location of sections and stations. Texas A&M University, Department of Oceanography cruises 66A1 and 66A2.

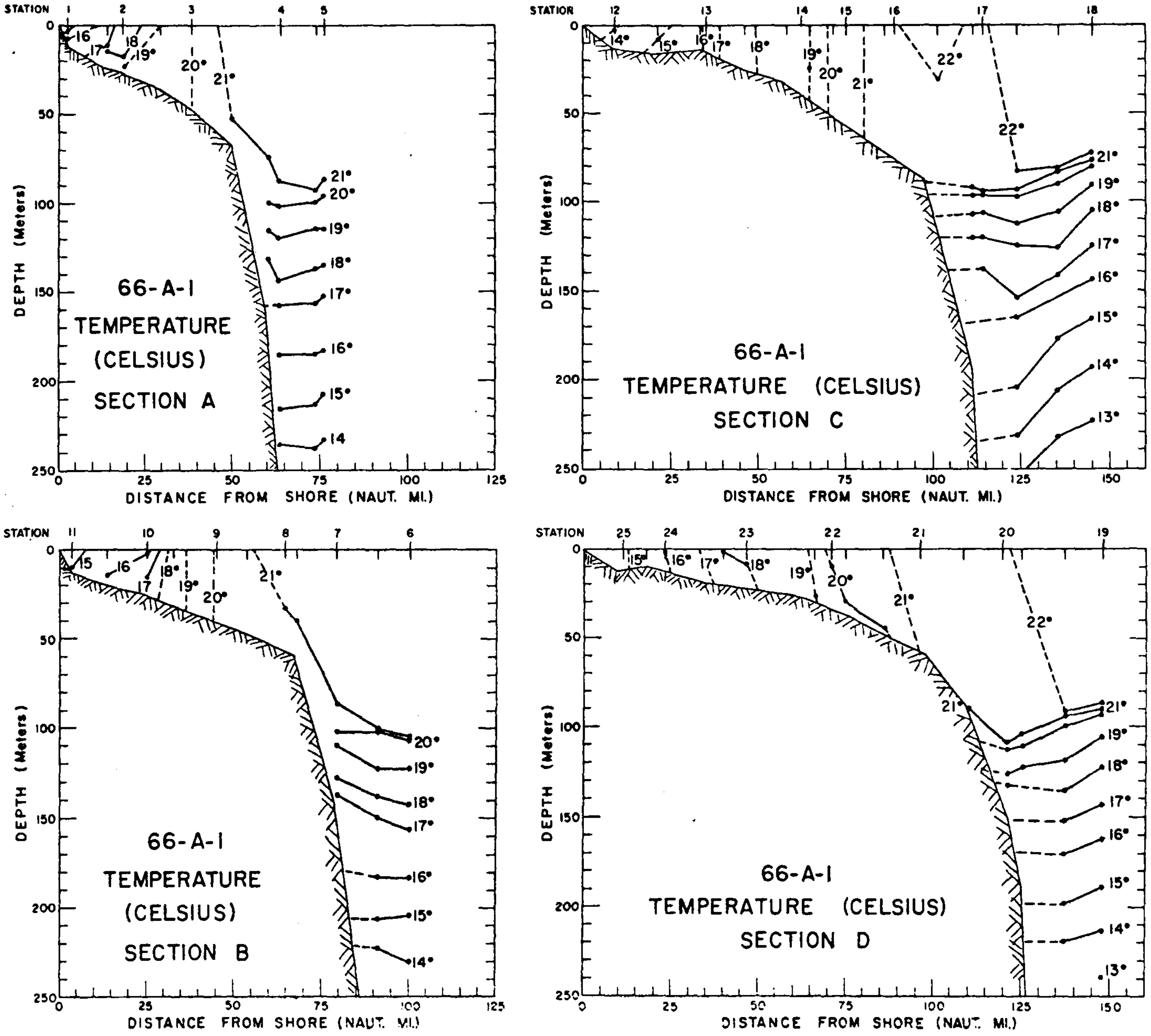


Fig. 41. Temperature sections for January, cruise 66A1 (from Nowlin and Parker, 1974).

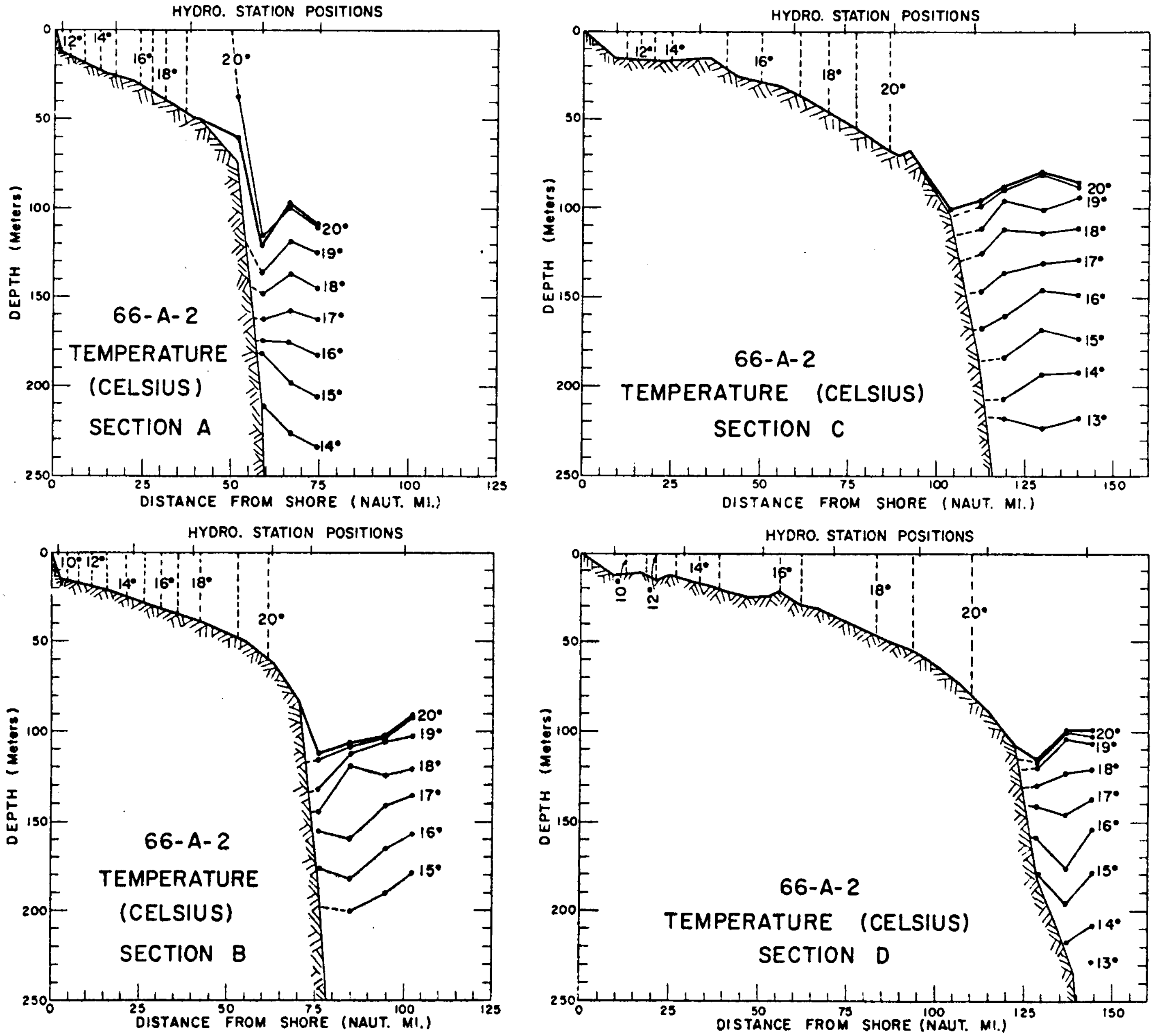


Fig. 42. Temperature sections for January, cruise 66A2 (from Nowlin and Parker, 1974).

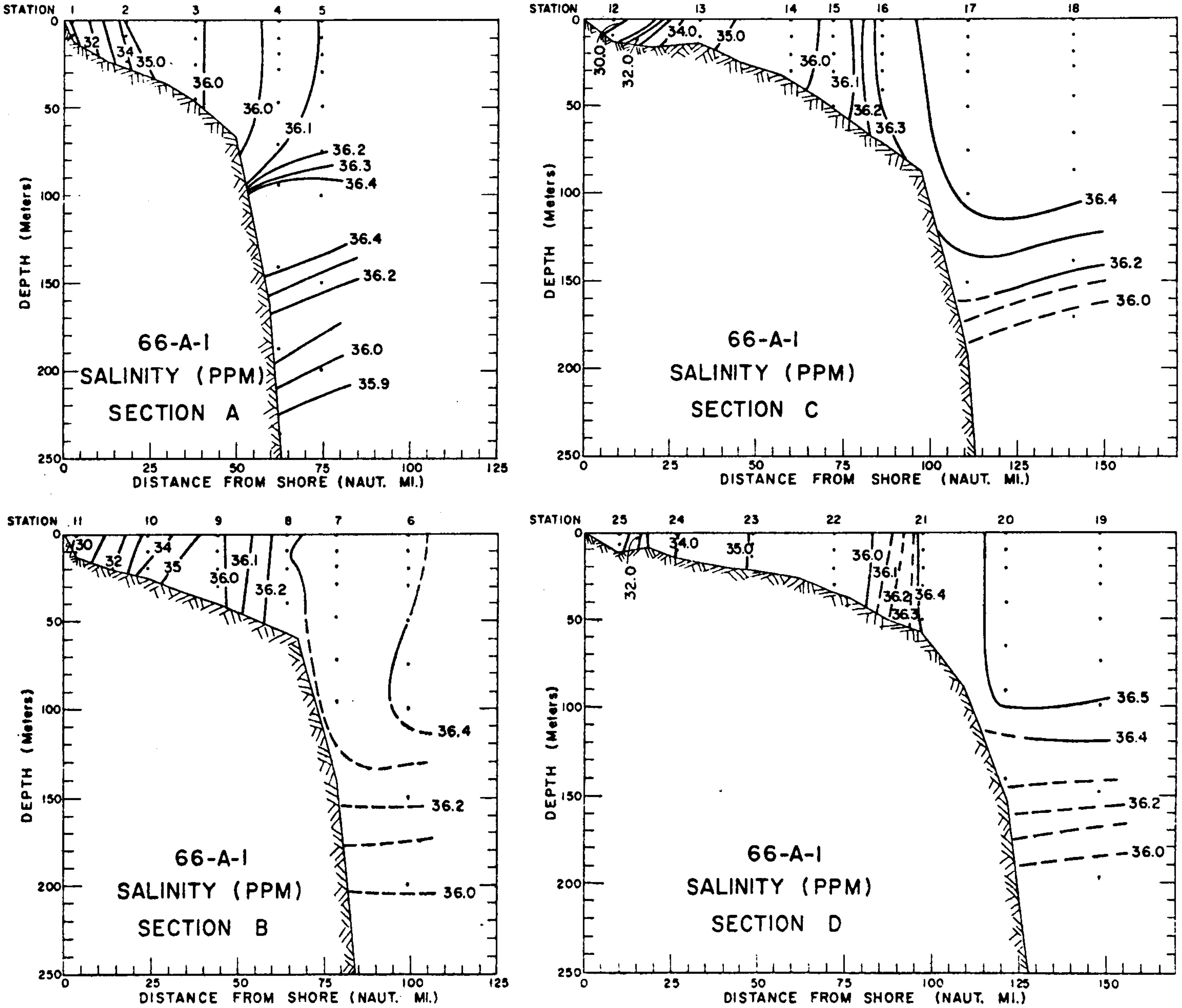


Fig. 43. Salinity sections for January, cruise 66A1 (from Nowlin and Parker, 1974).

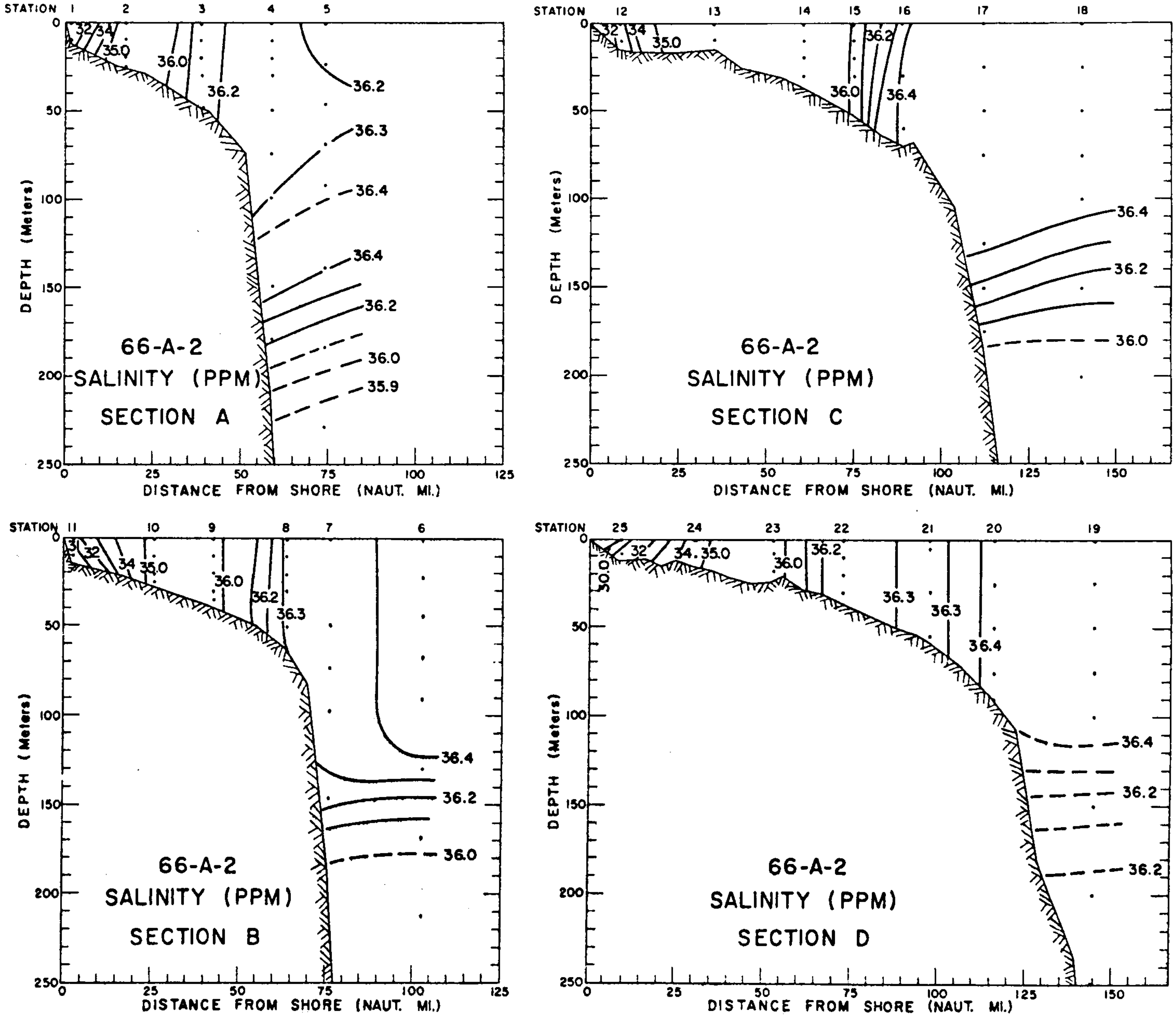


Fig. 44. Salinity sections for January, cruise 66A2 (from Nowlin and Parker, 1974).

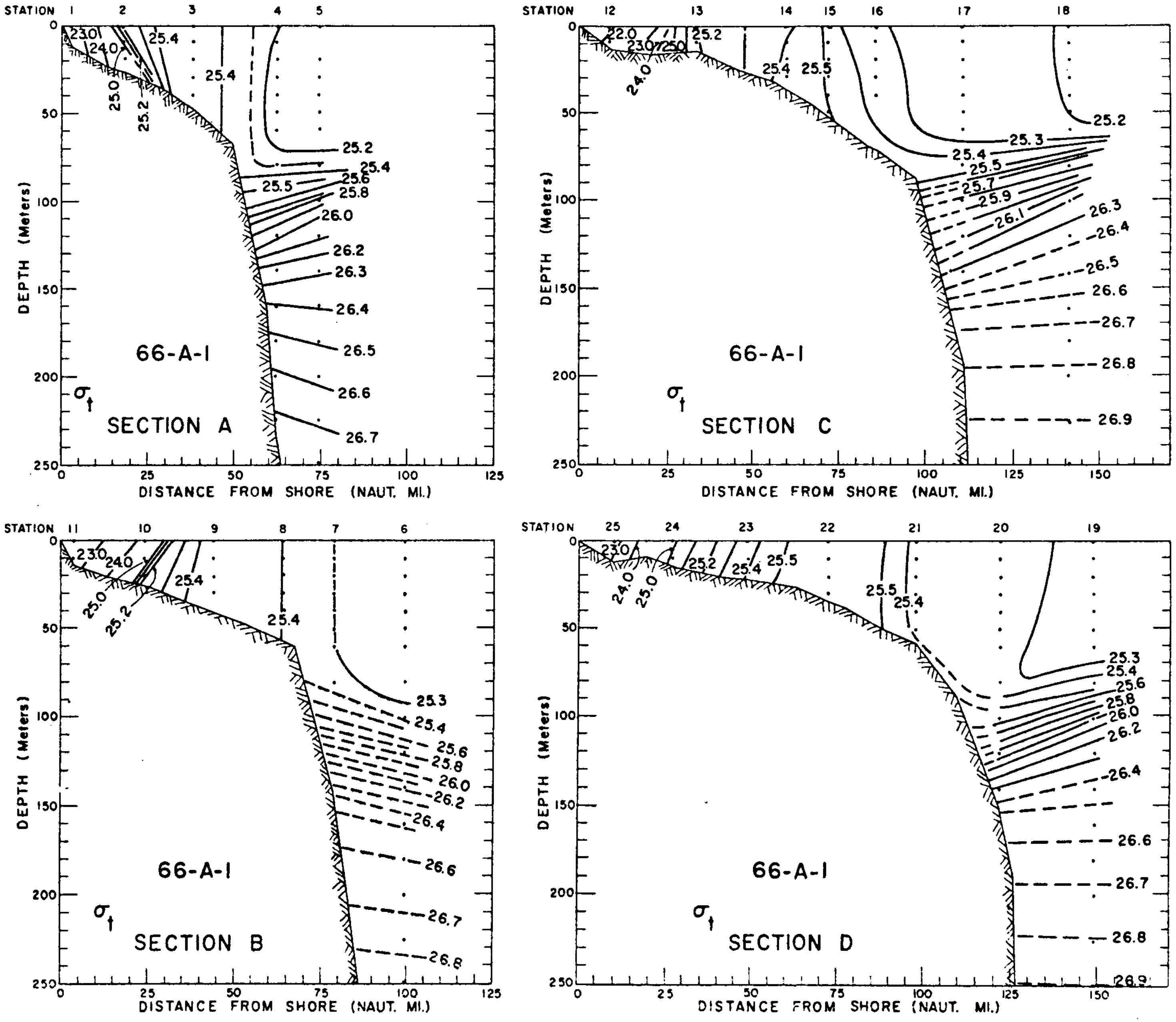


Fig. 45. Density sections for January (from Nowlin and Parker, 1974).

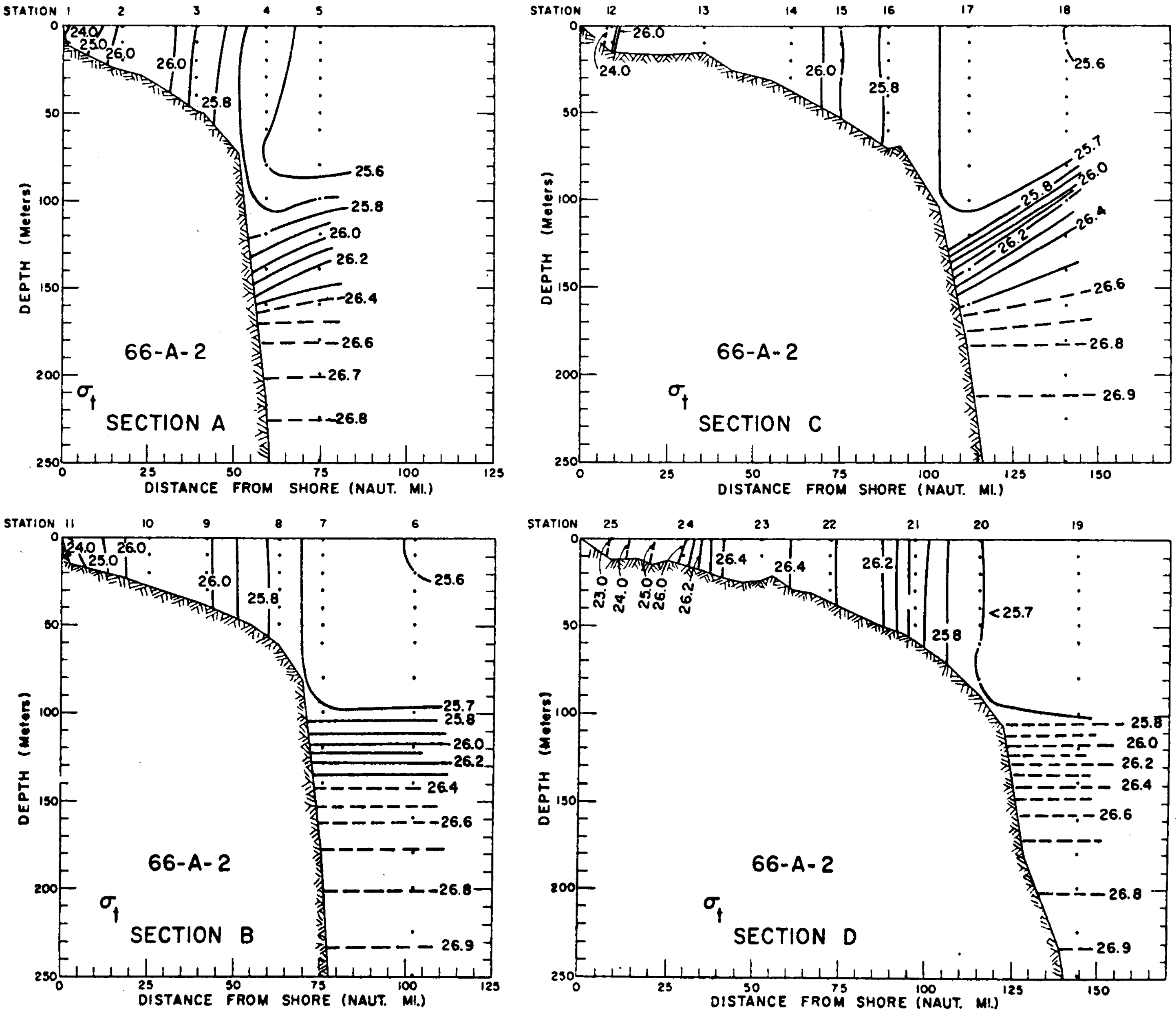


Fig. 46. Density sections for January (from Nowlin and Parker, 1974).

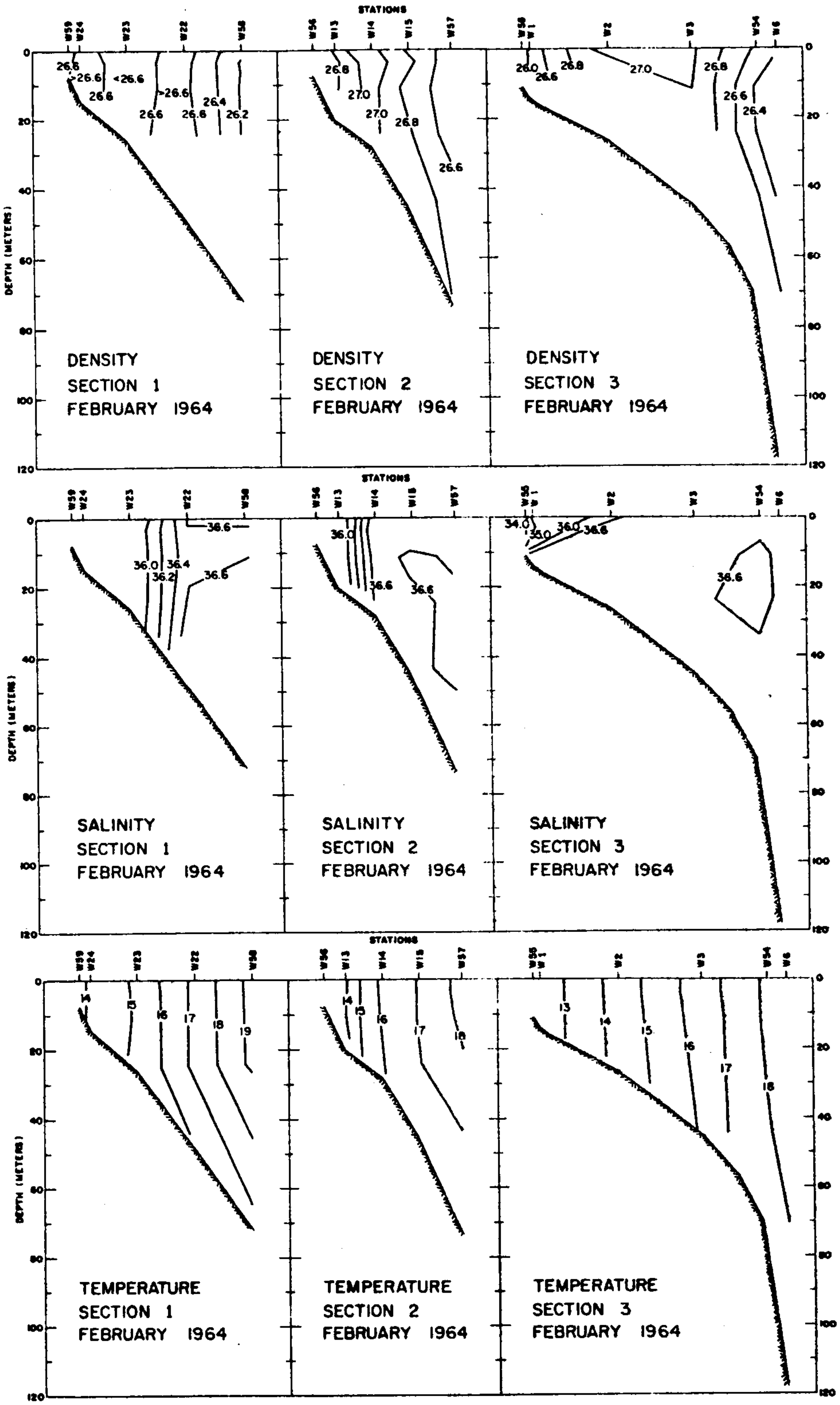


Fig. 47. Temperature (°C), salinity (‰), and density (σ_t) sections for February (data from NMFS, Galveston).

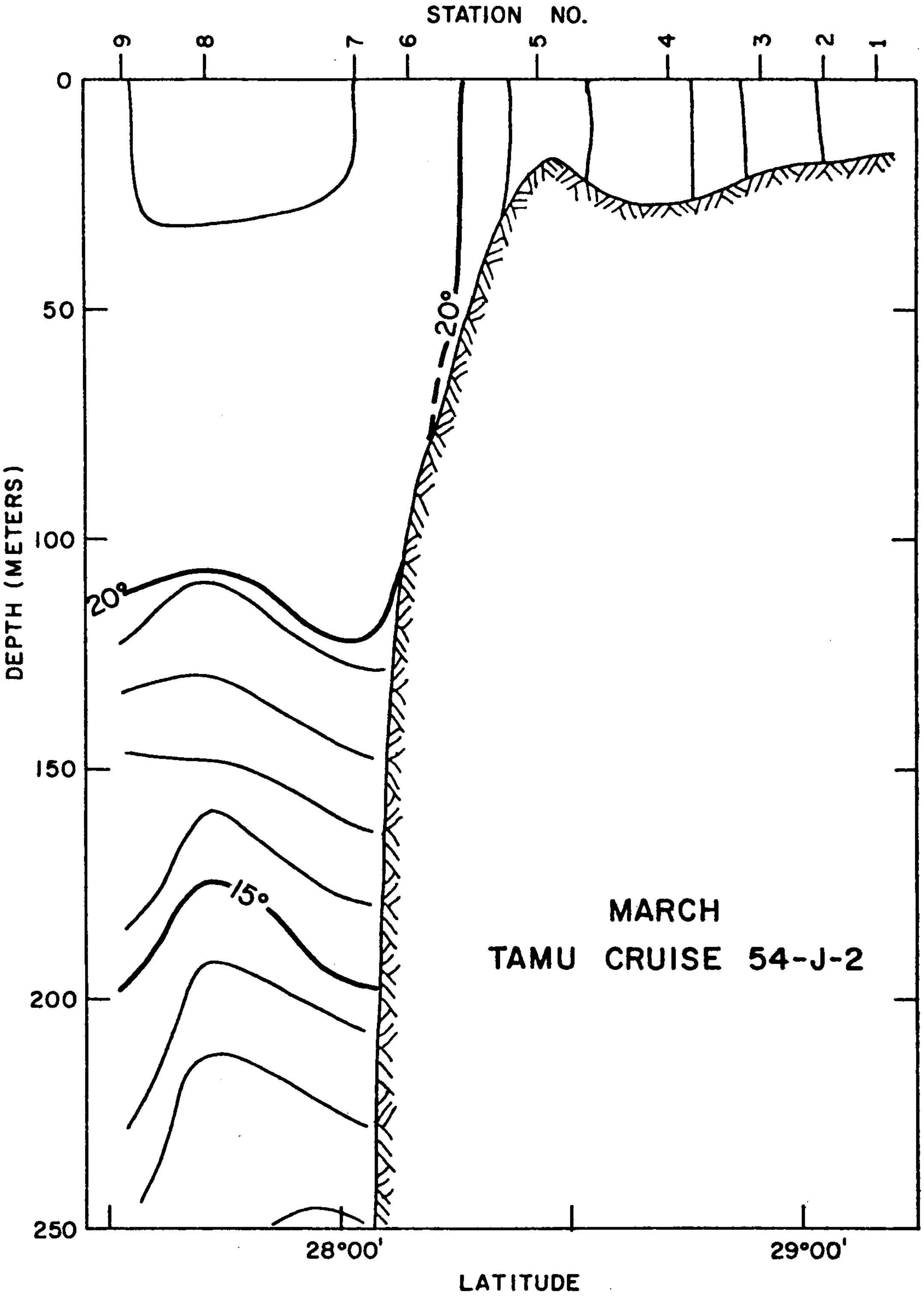


Fig. 48. Temperature (°C) section for March (from Etter and Cochrane, 1975).

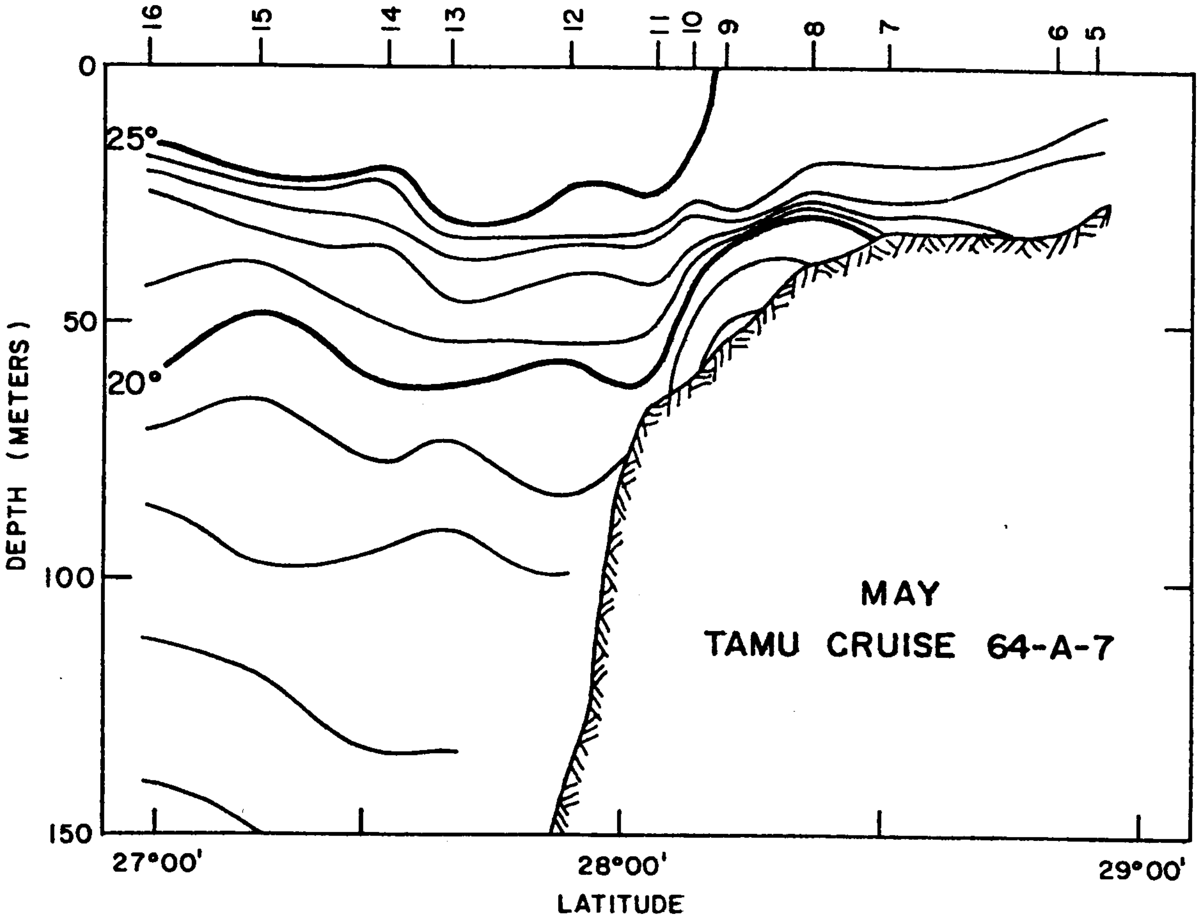


Fig. 49. Temperature (°C) section for May (from Etter and Cochrane, 1975).

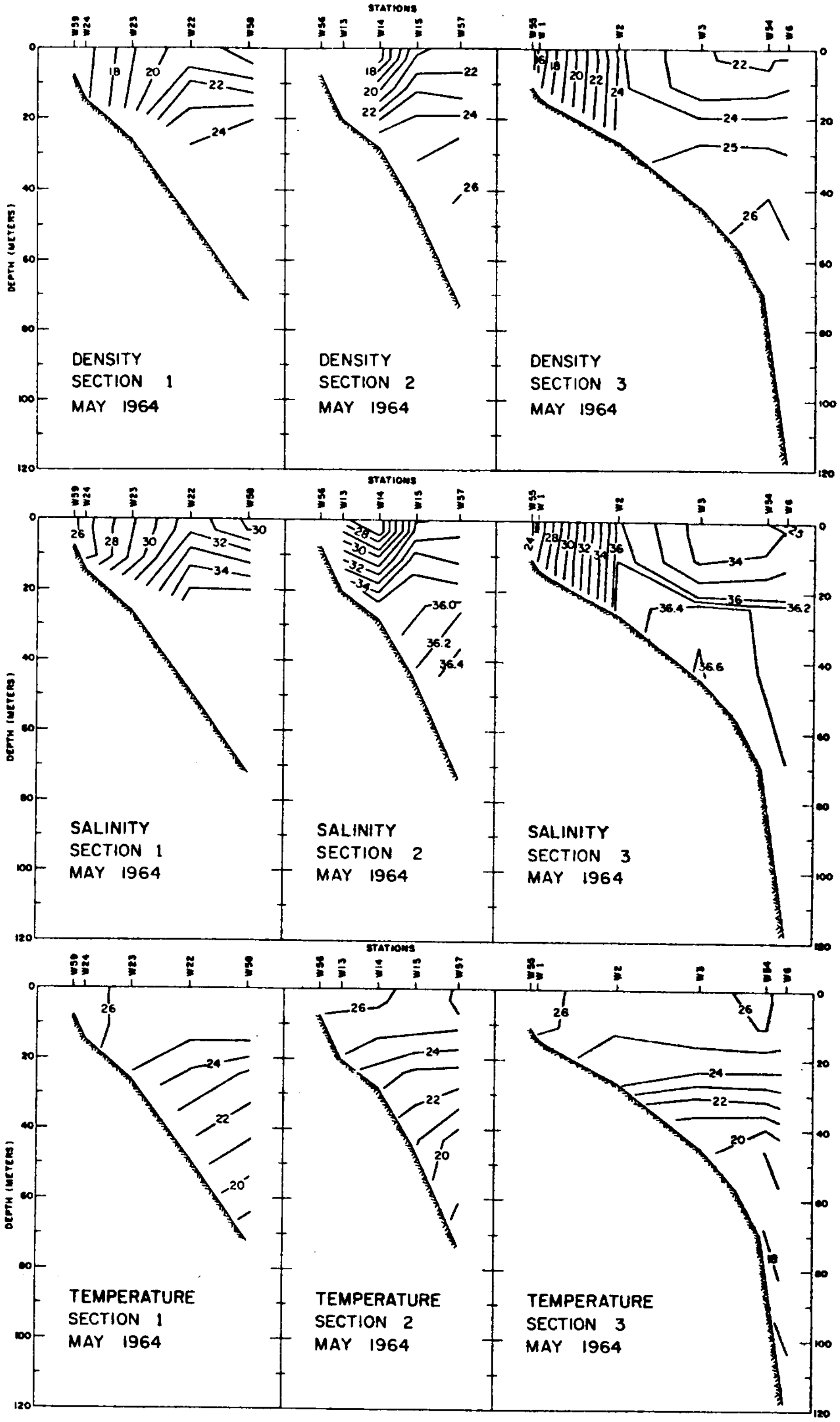


Fig. 50. Temperature (°C), salinity (°/oo), and density (σ_t) sections for May (data from NMFS, Galveston).

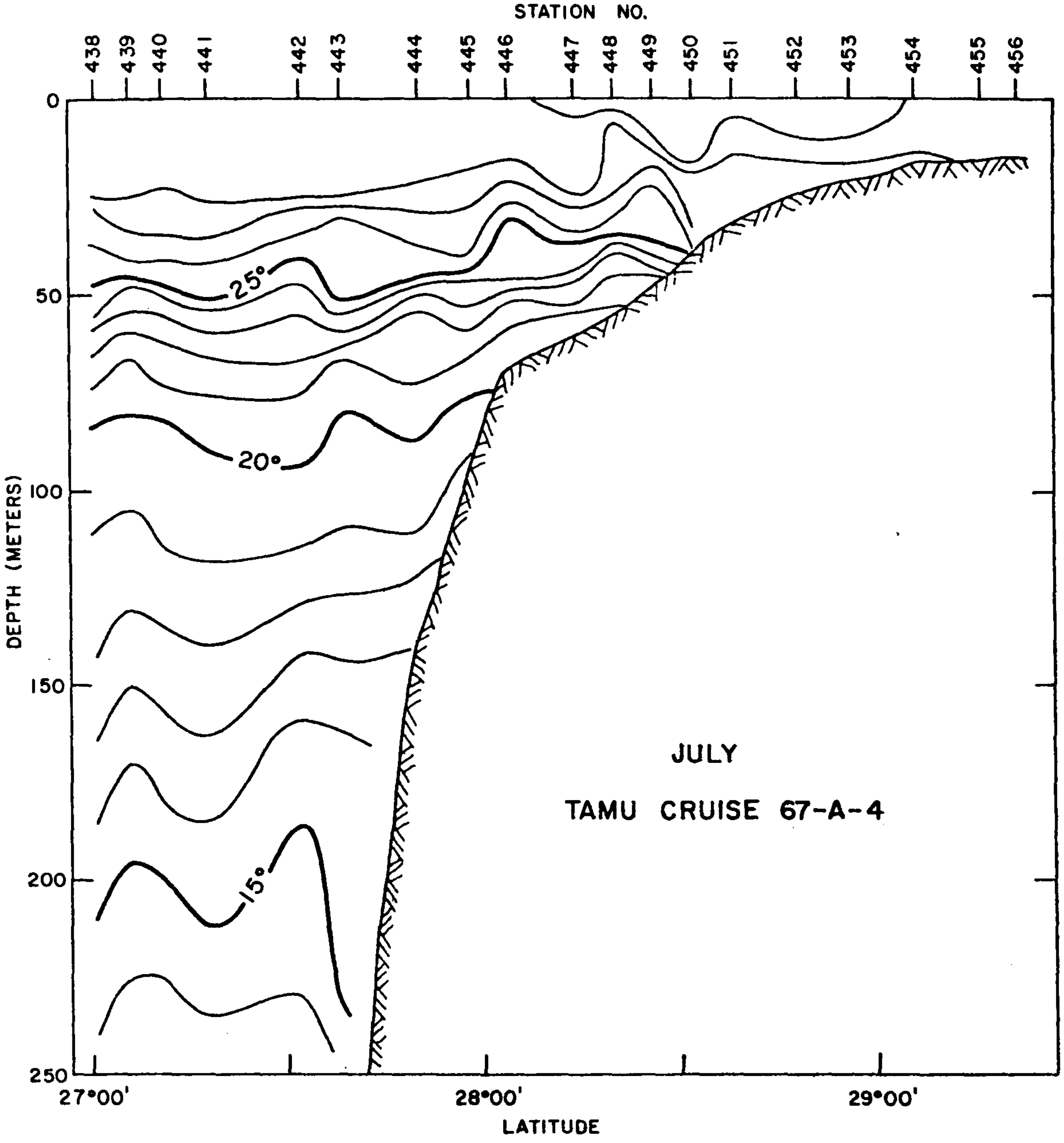


Fig. 51. Temperature (°C) section for July (from Etter and Cochrane, 1975).

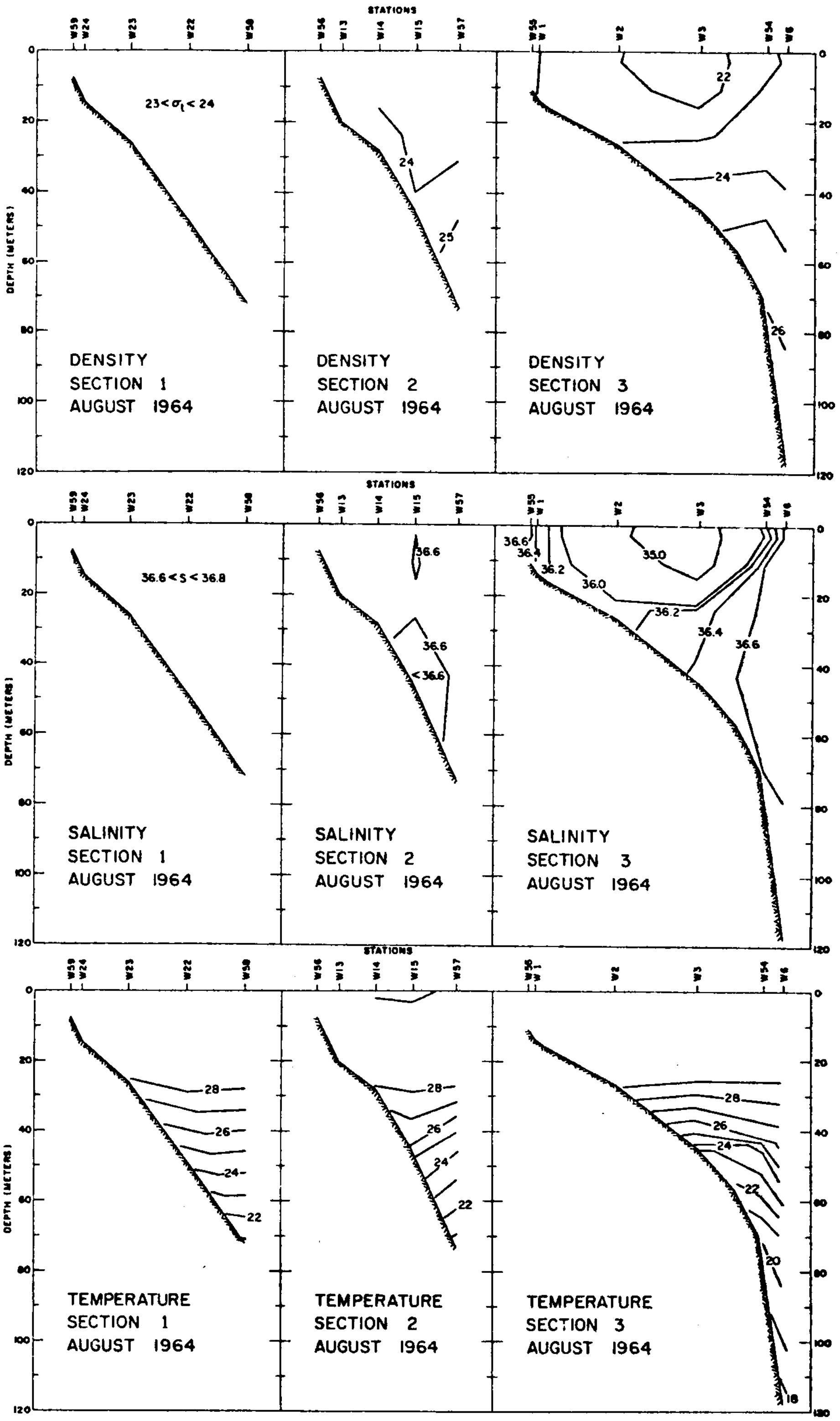


Fig. 52. Temperature (°C), salinity (°/oo) and density (σ_t) sections for August (data from NMFS, Galveston).

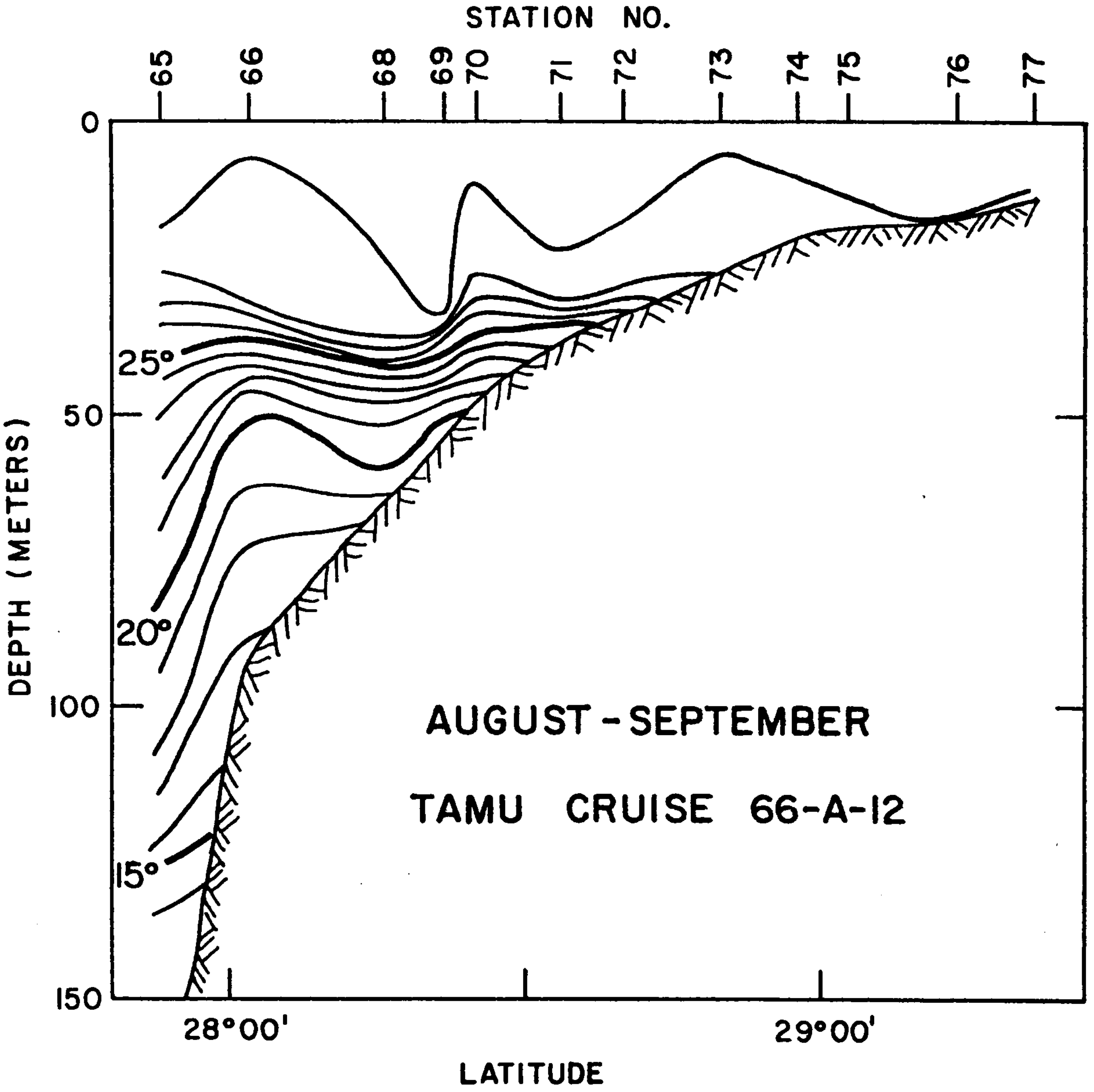


Fig. 53. Temperature (°C) section for August-September (from Etter and Cochrane, 1975).

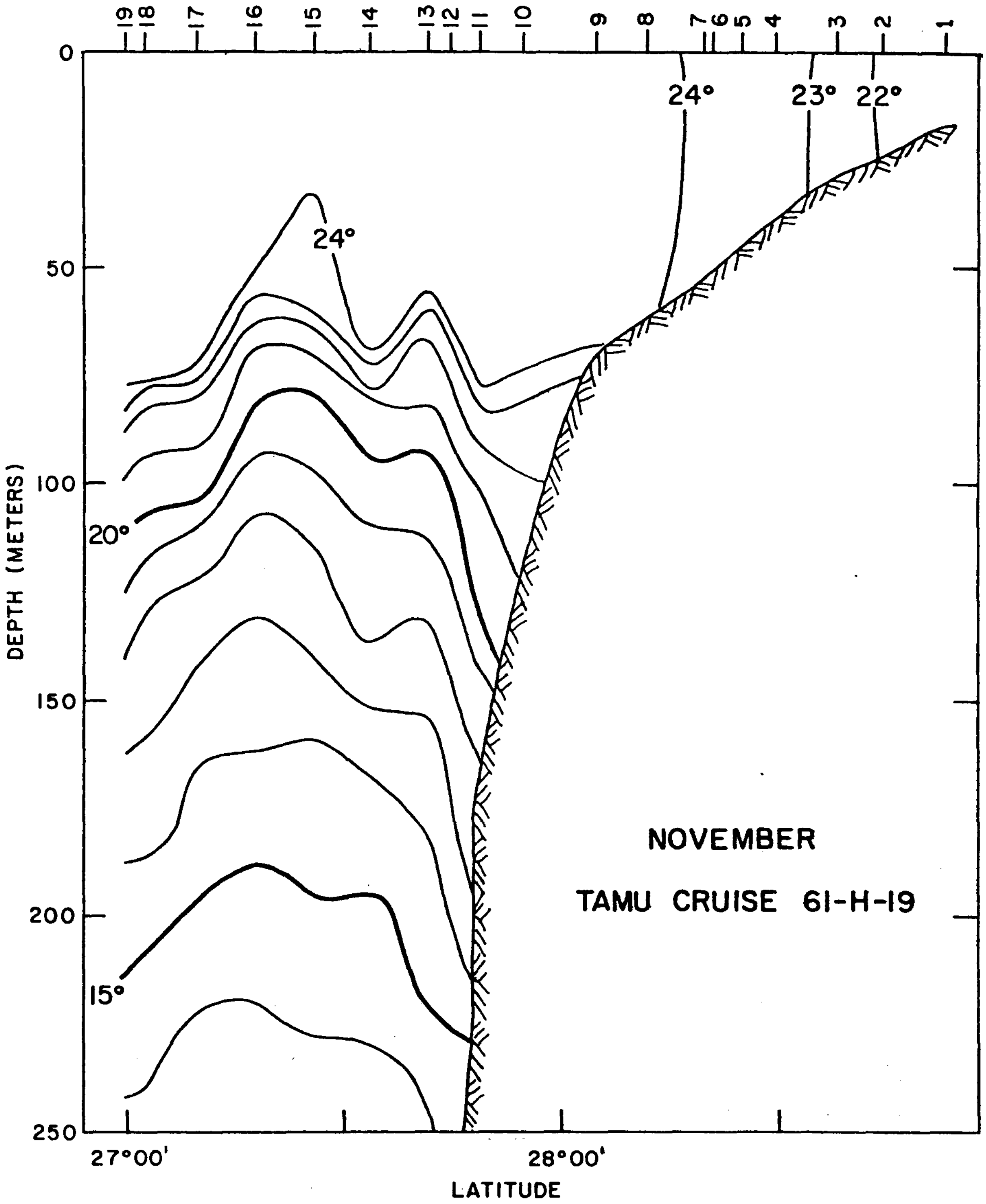


Fig. 54. Temperature (°C) section for November (from Etter and Cochrane, 1975).

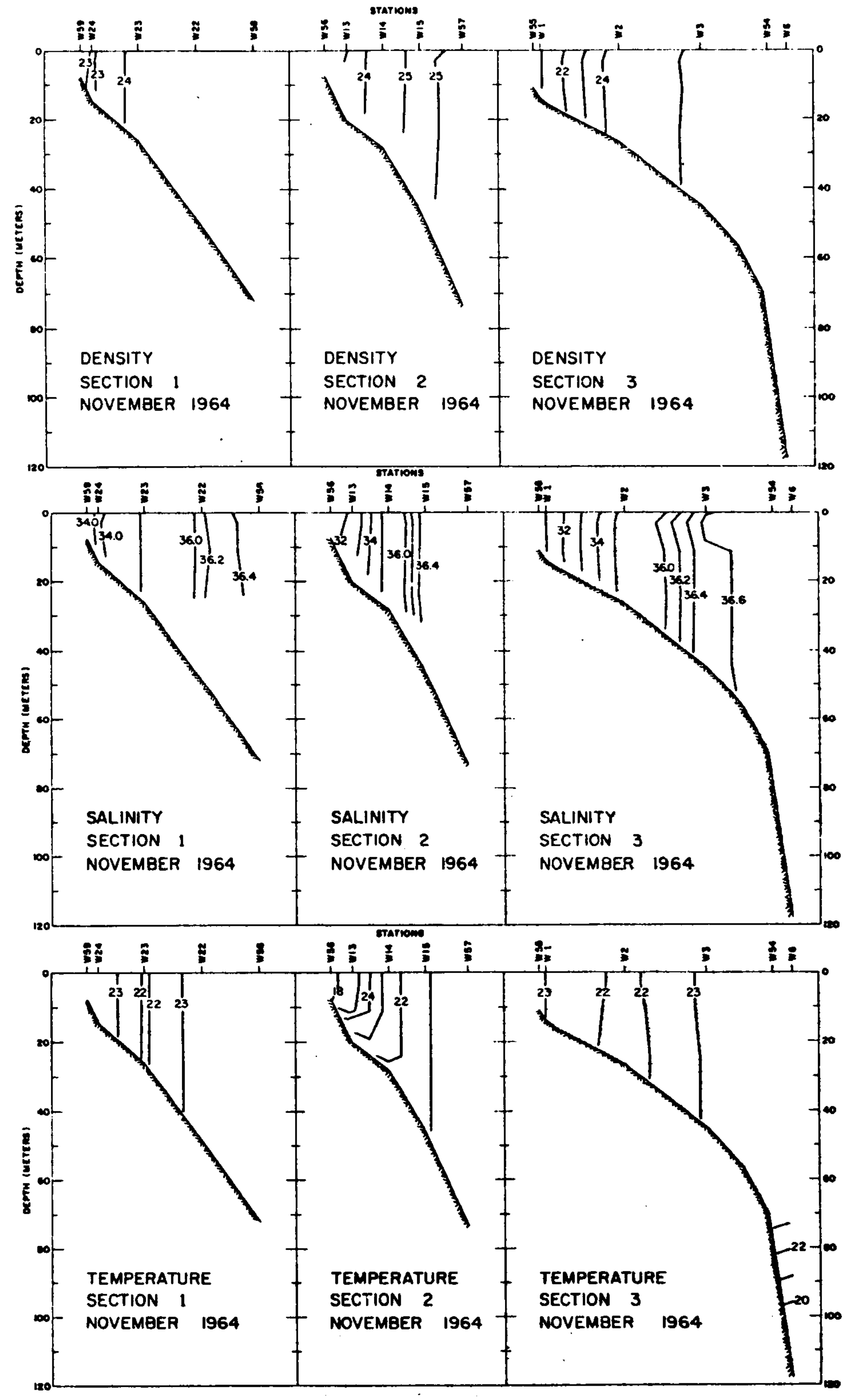


Fig. 55. Temperature (°C), salinity (°/oo), and density (σ_t) sections for November (data from NMFS, Galveston).

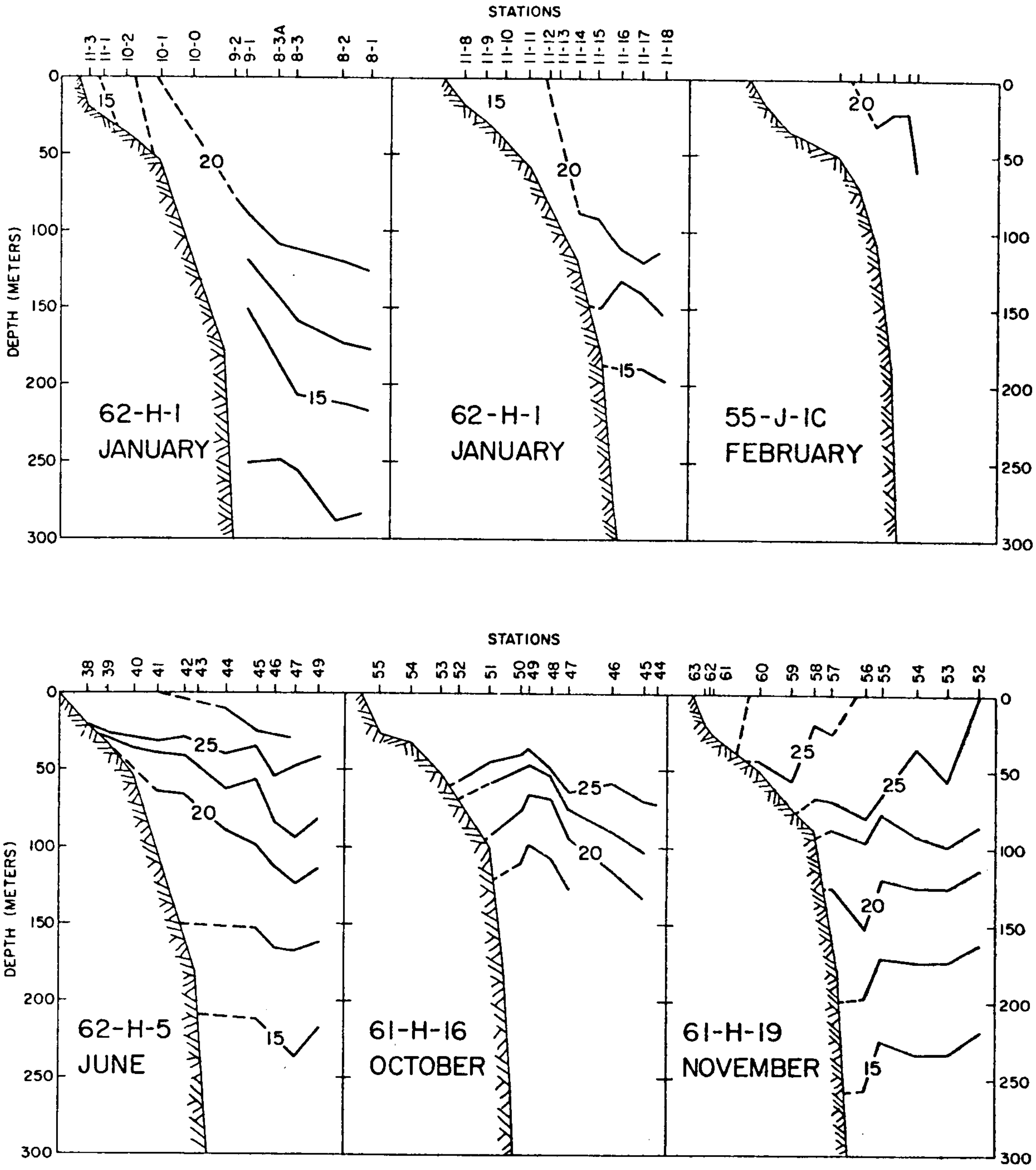


Fig. 56. Temperature (°C) sections for January, February, June, October, and November (personal communication, Paul Etter).

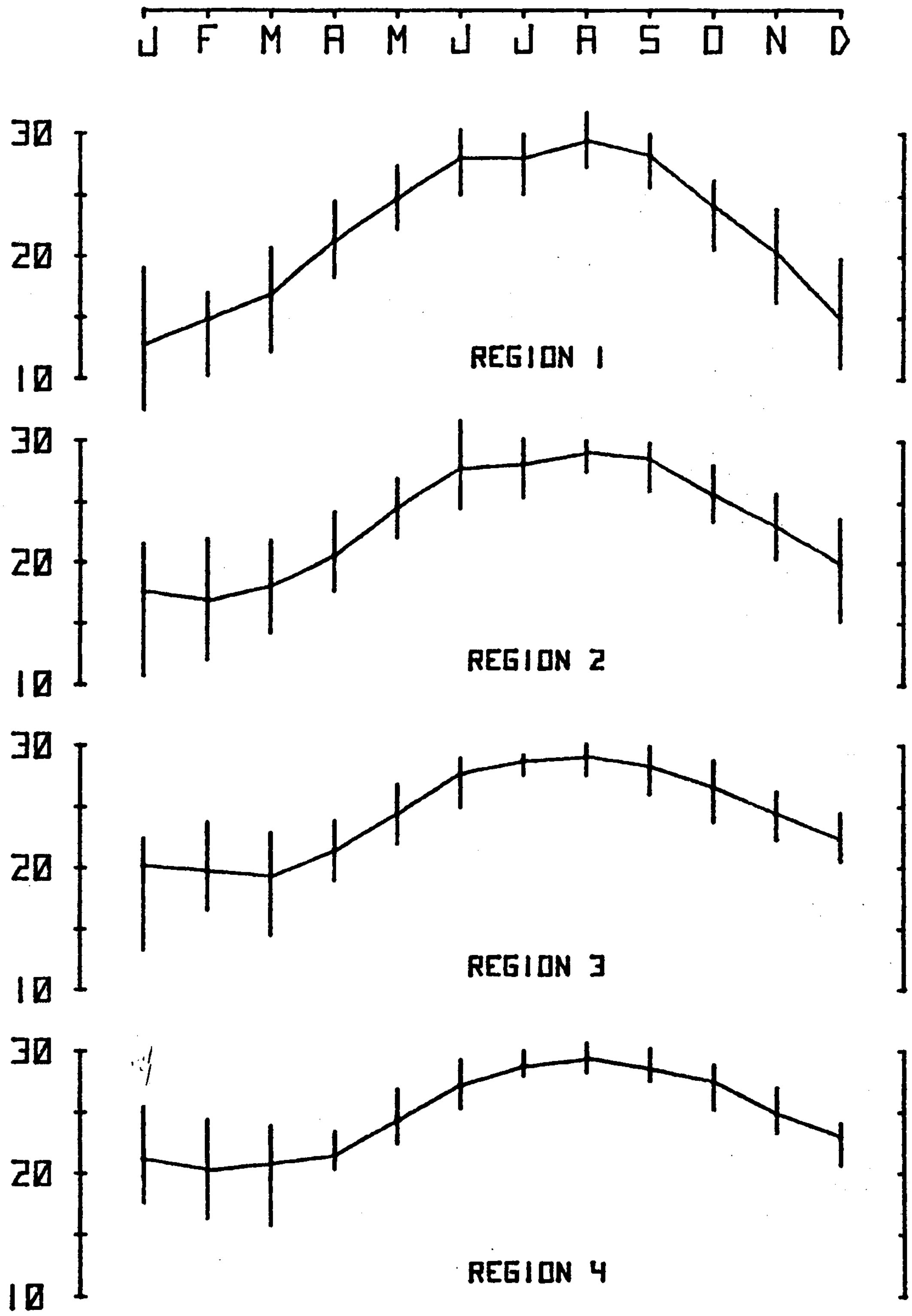


Fig. 57. Annual cycles of mean surface temperature (°C).

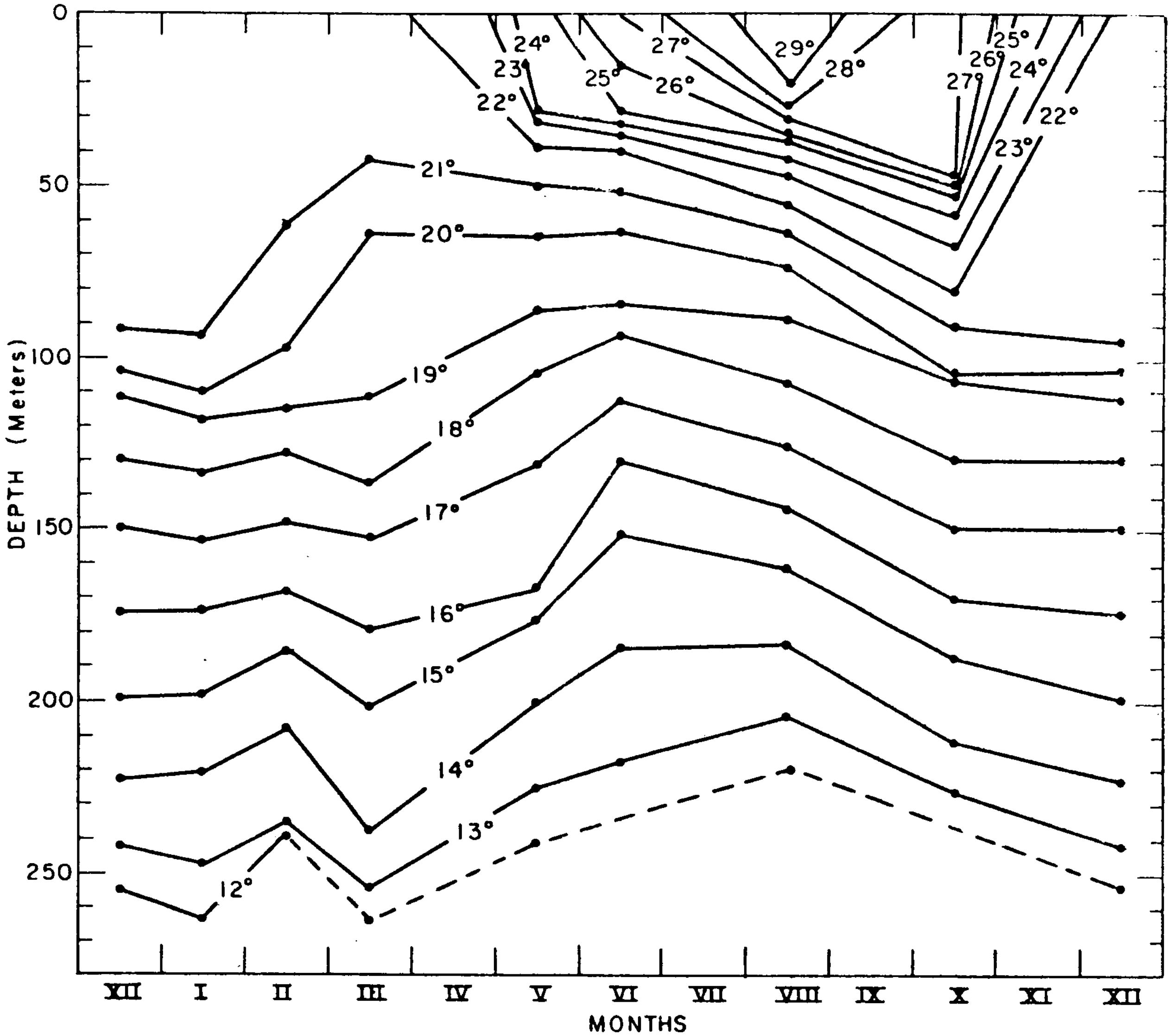


Fig. 58. Annual course of isotherm (°C) depths for the zonal band, 27°30'N to 27°50'N and 92 to 96°W (from Nowlin and Parker, 1974).

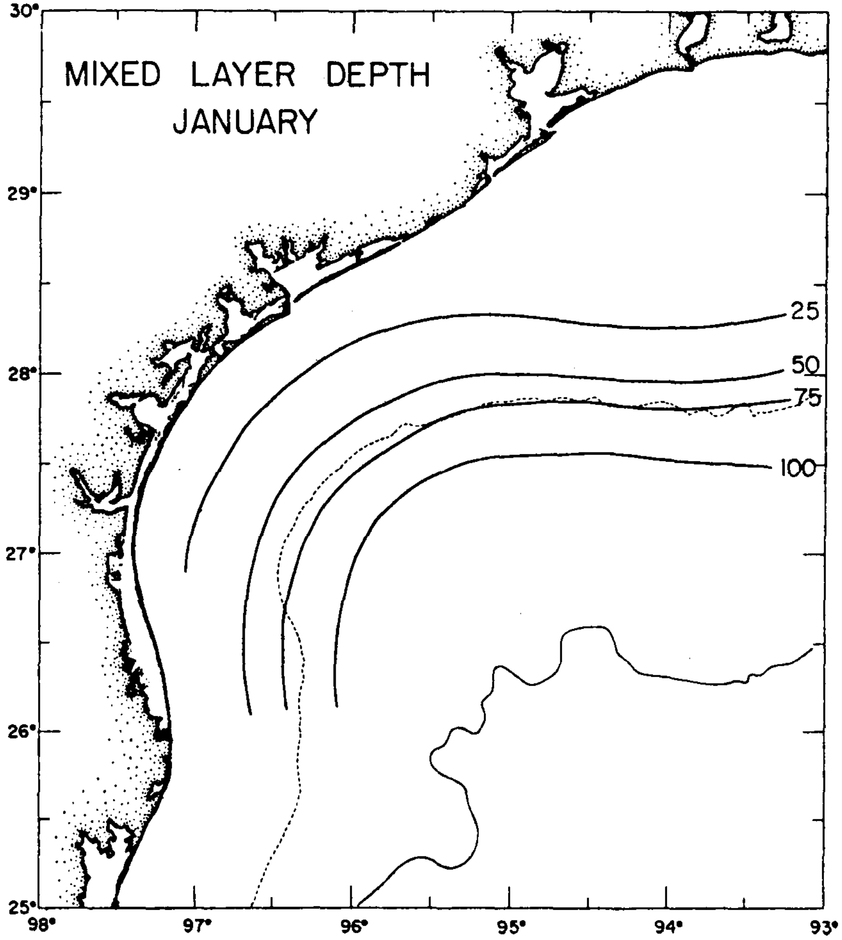


Fig. 59. January mixed layer depths (m).

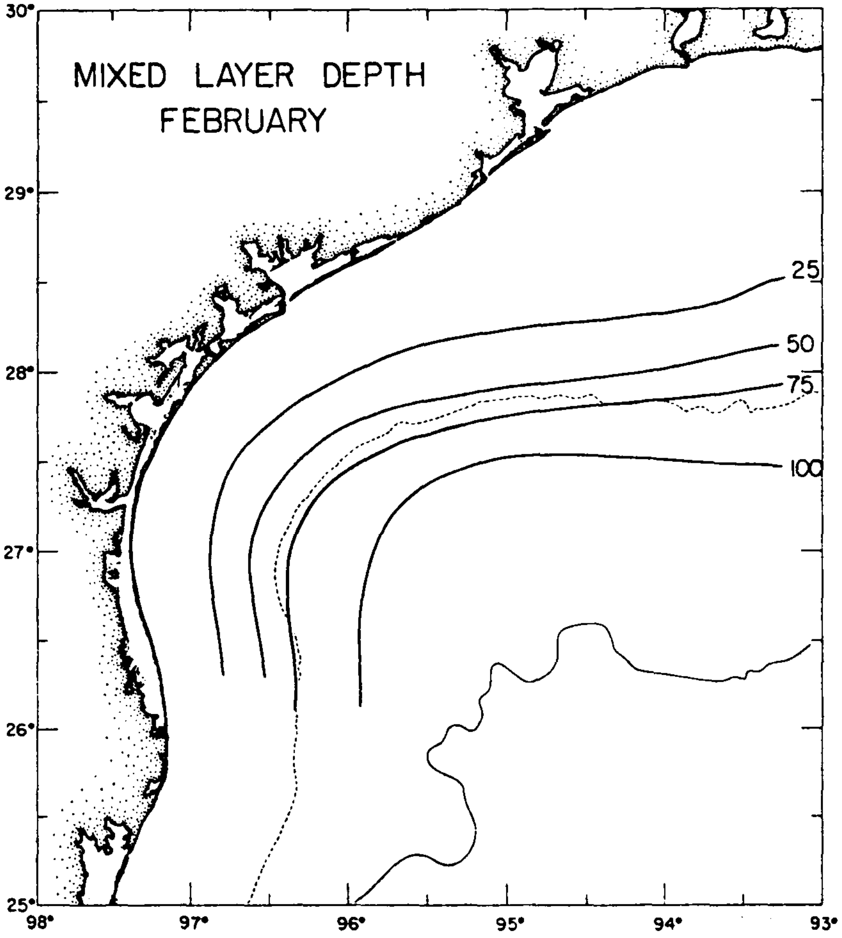


Fig. 60. February mixed layer depths (m).

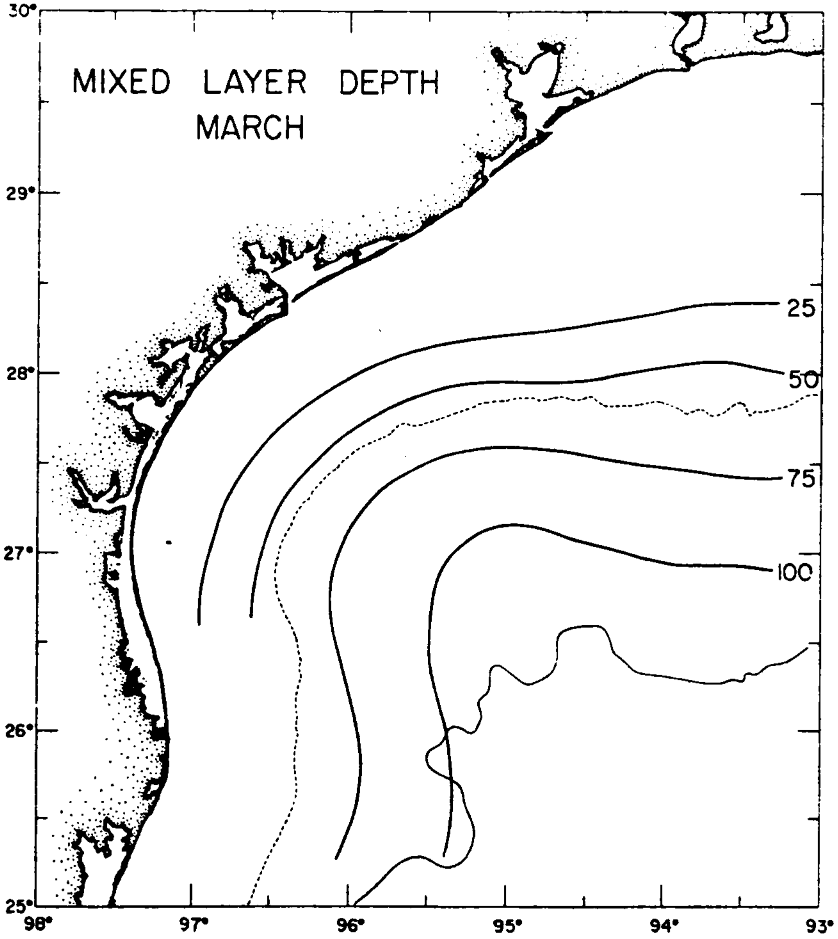


Fig. 61. March mixed layer depths (m).

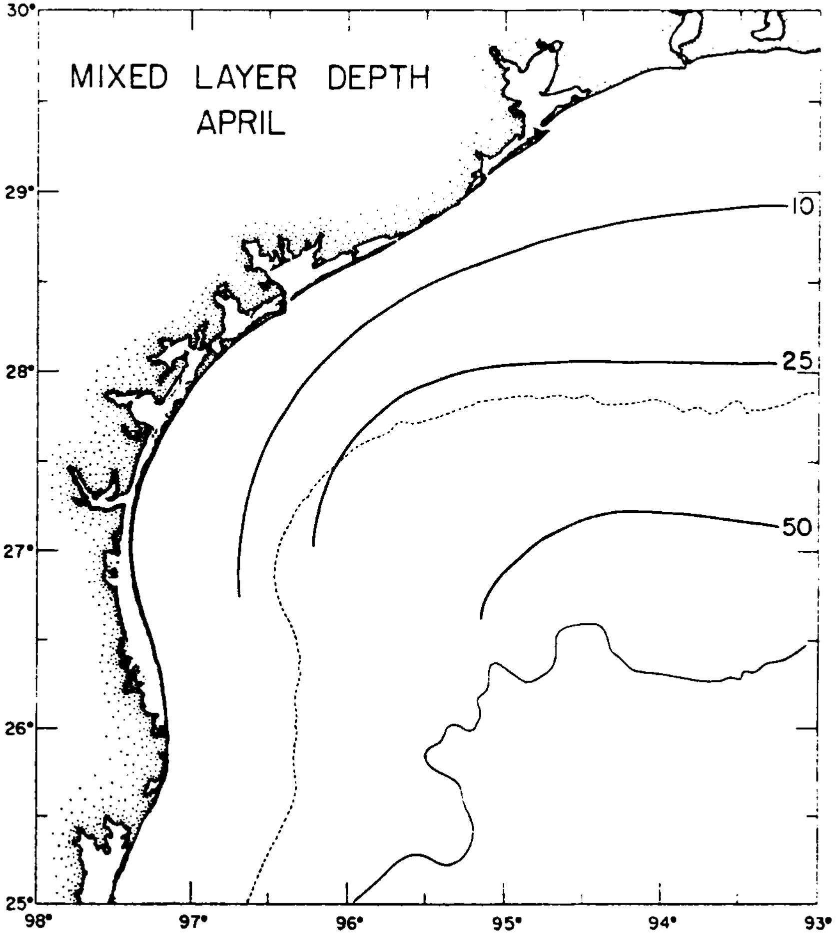


Fig. 62. April mixed layer depths (m).

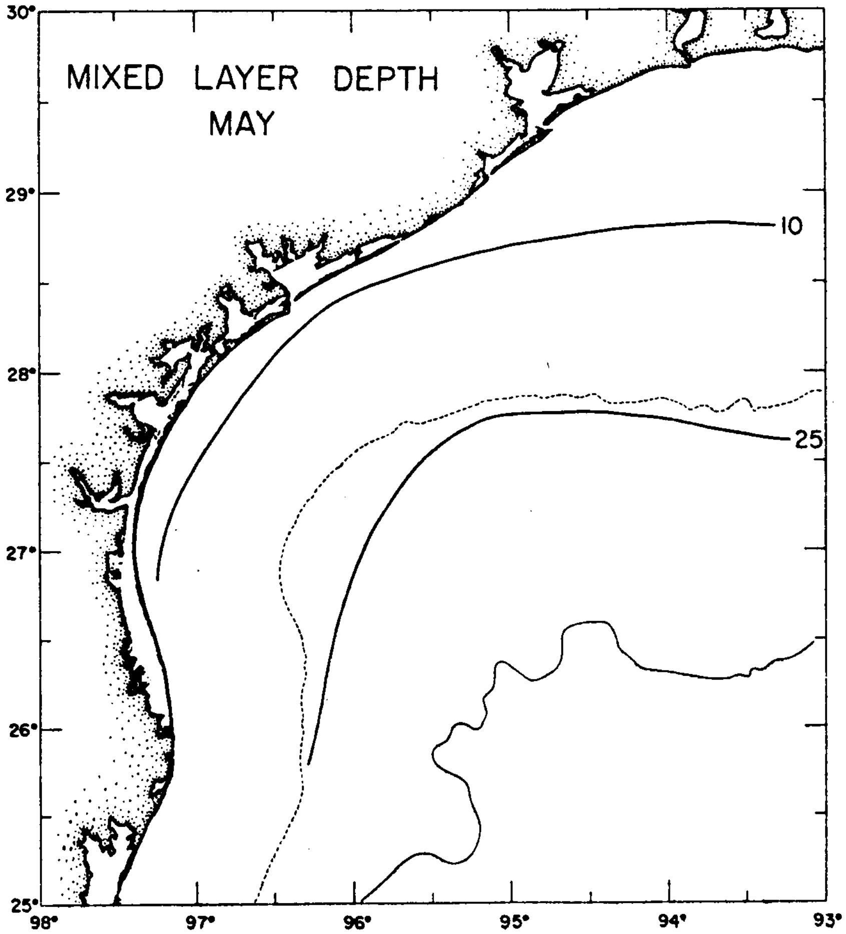


Fig. 63. May mixed layer depths (m)

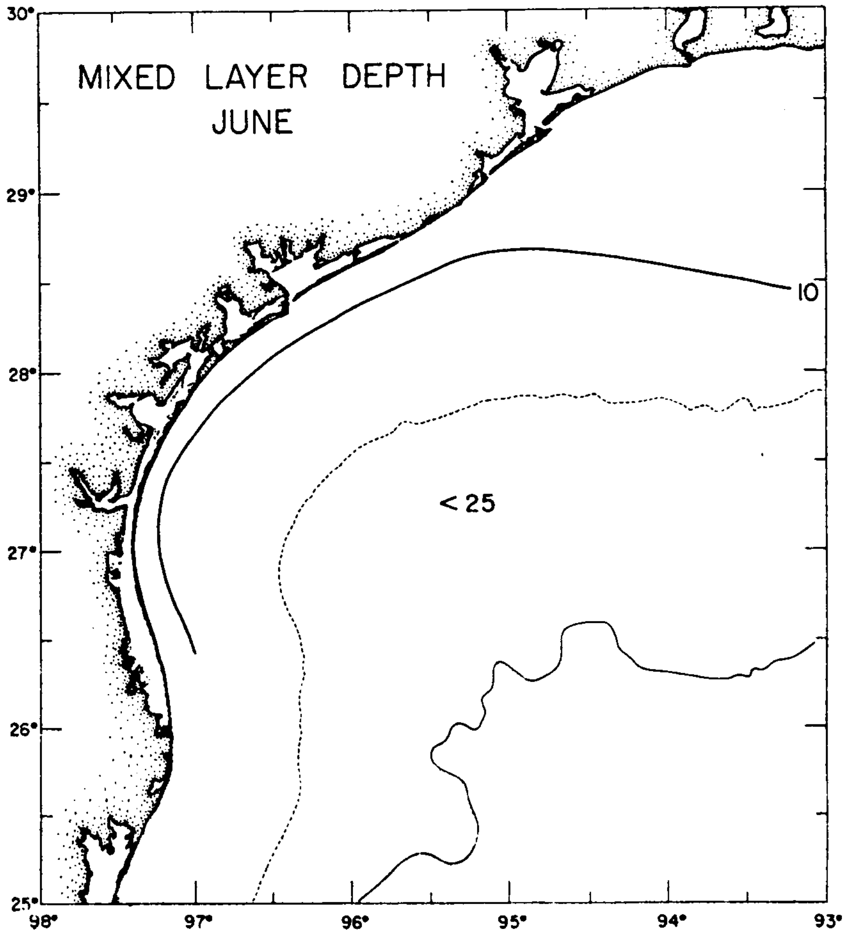


Fig. 64. June mixed layer depths (m).

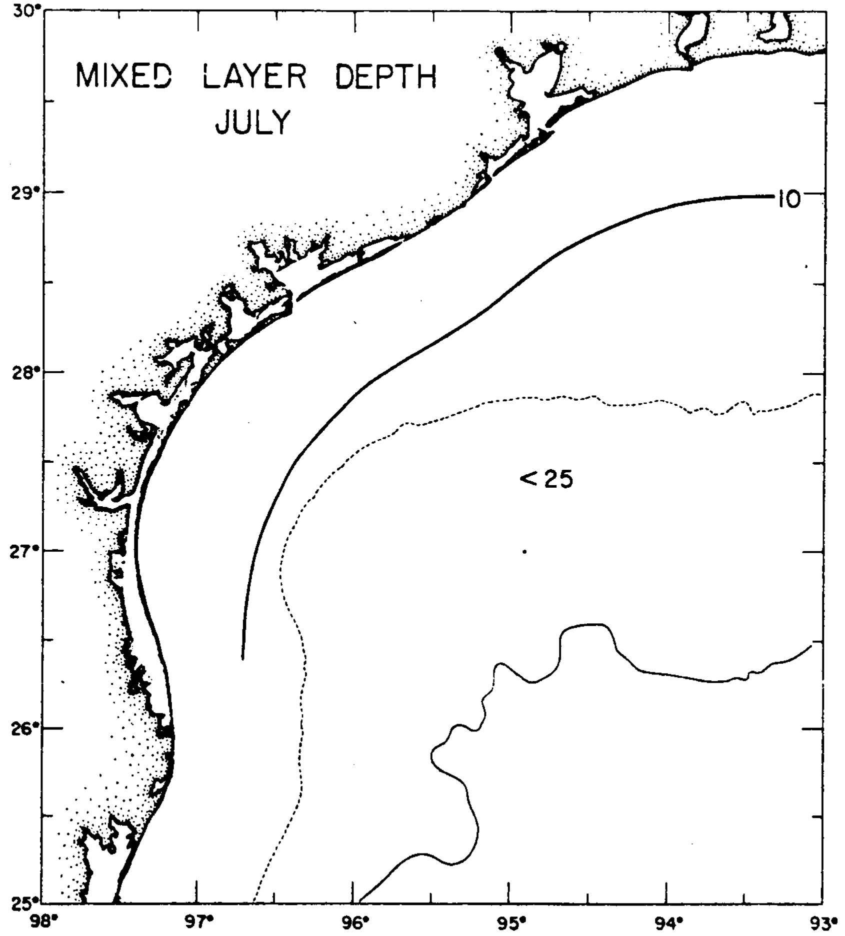


Fig. 65. July mixed layer depths (m).

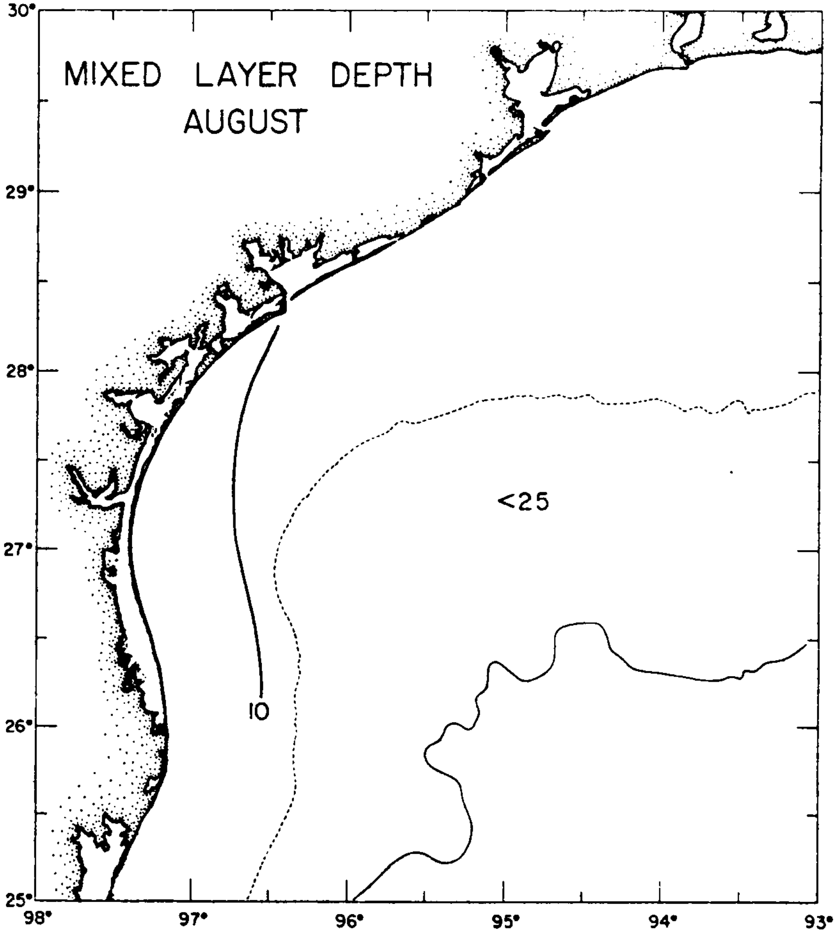


Fig. 66. August mixed layer depths (m).

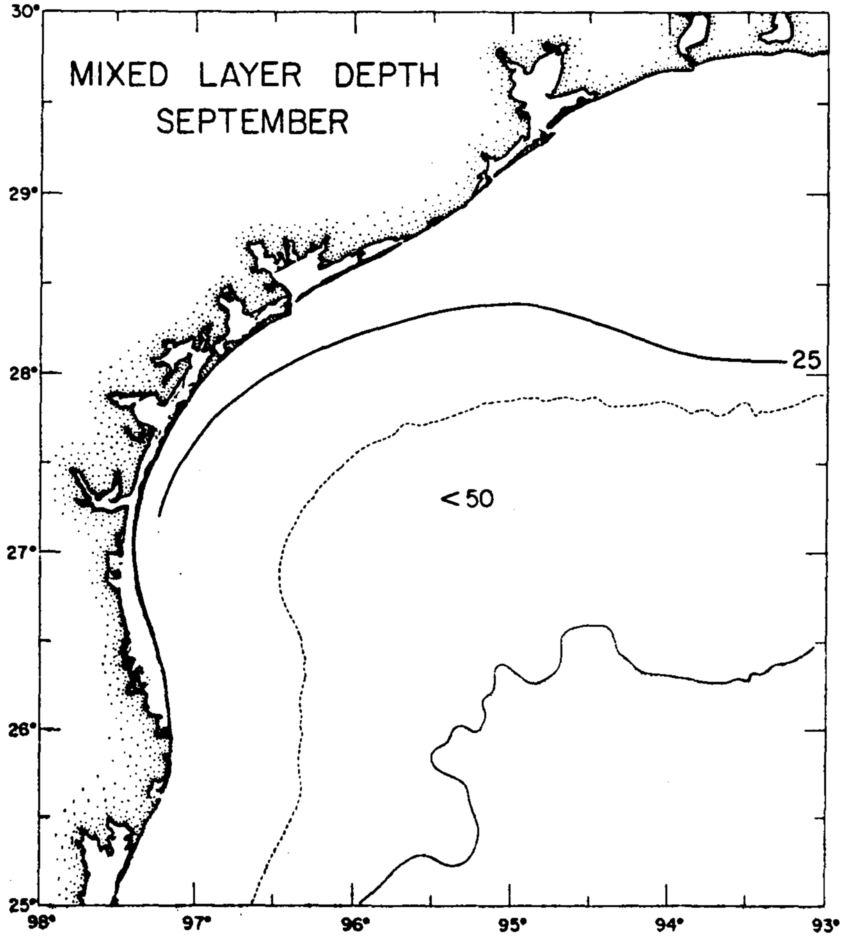


Fig. 67. September mixed layer depths (m).

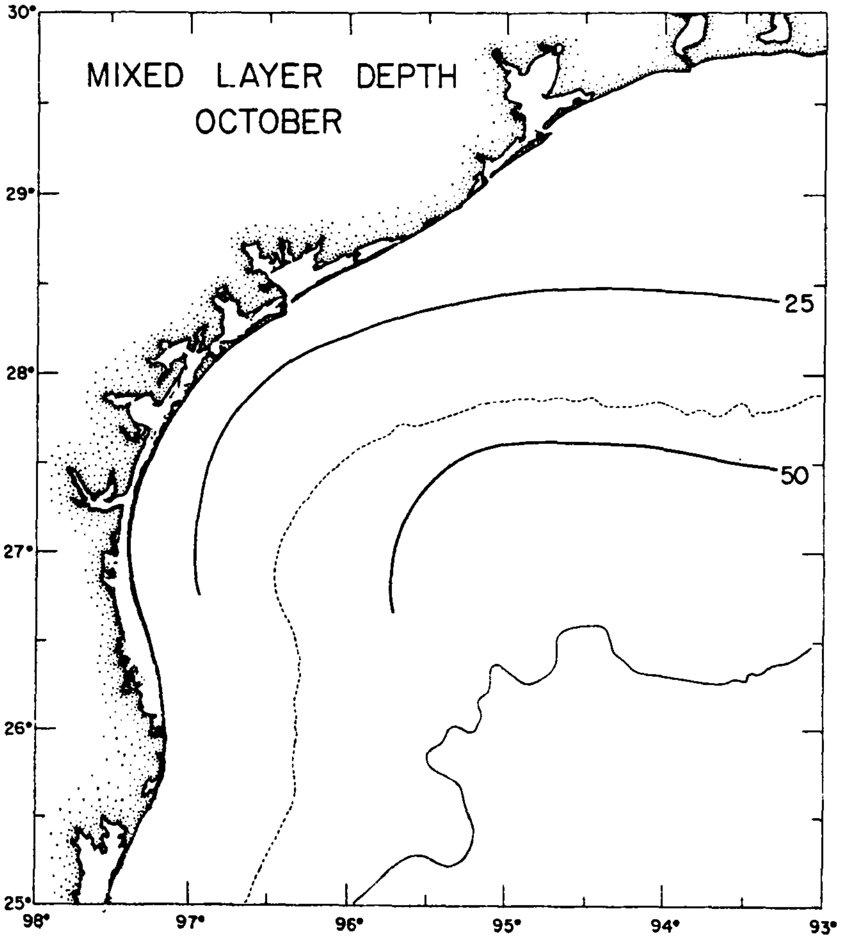


Fig. 68. October mixed layer depths (m).

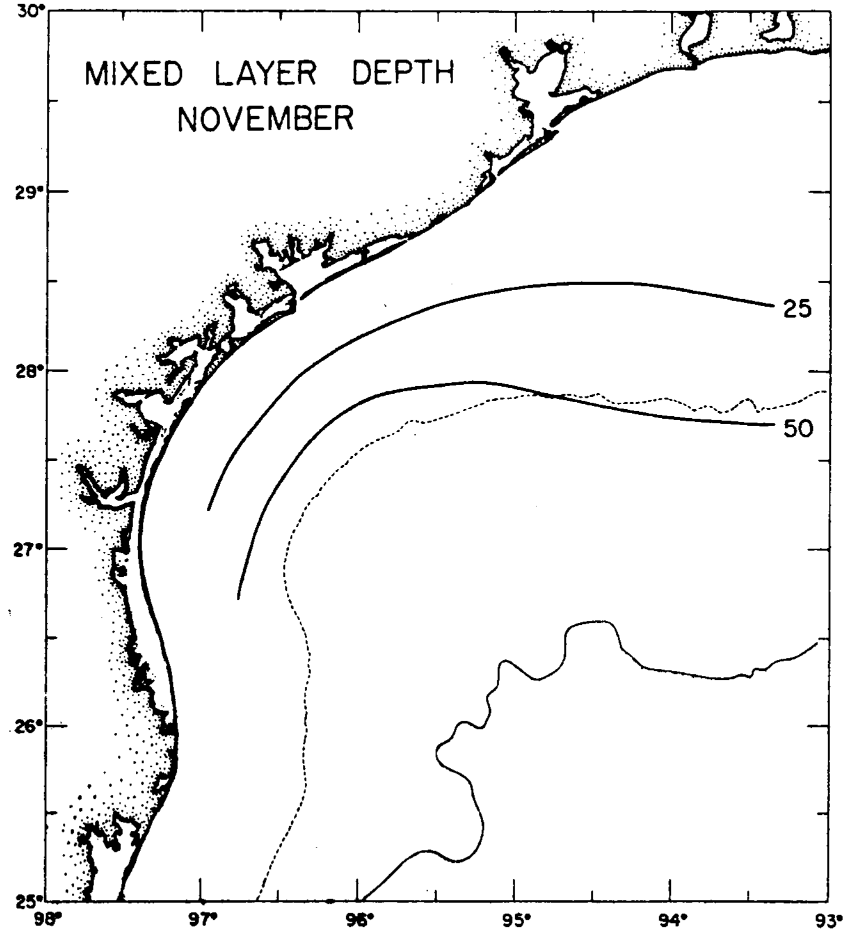


Fig. 69. November mixed layer depths (m).

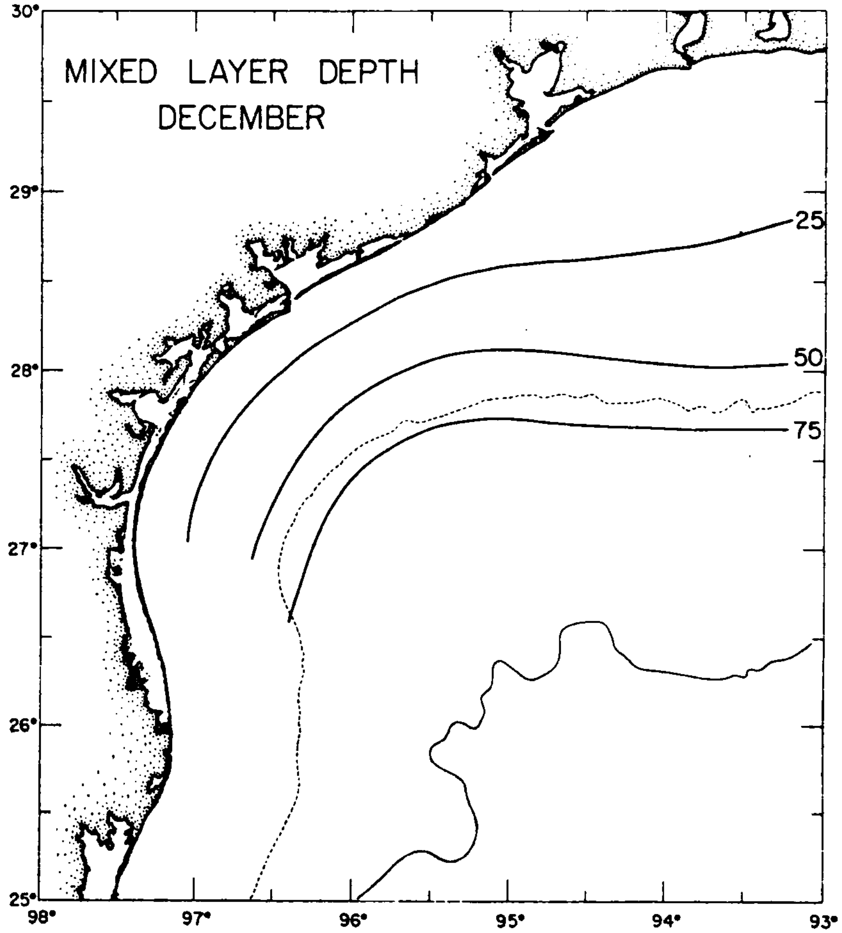


Fig. 70. December mixed layer depths (m).

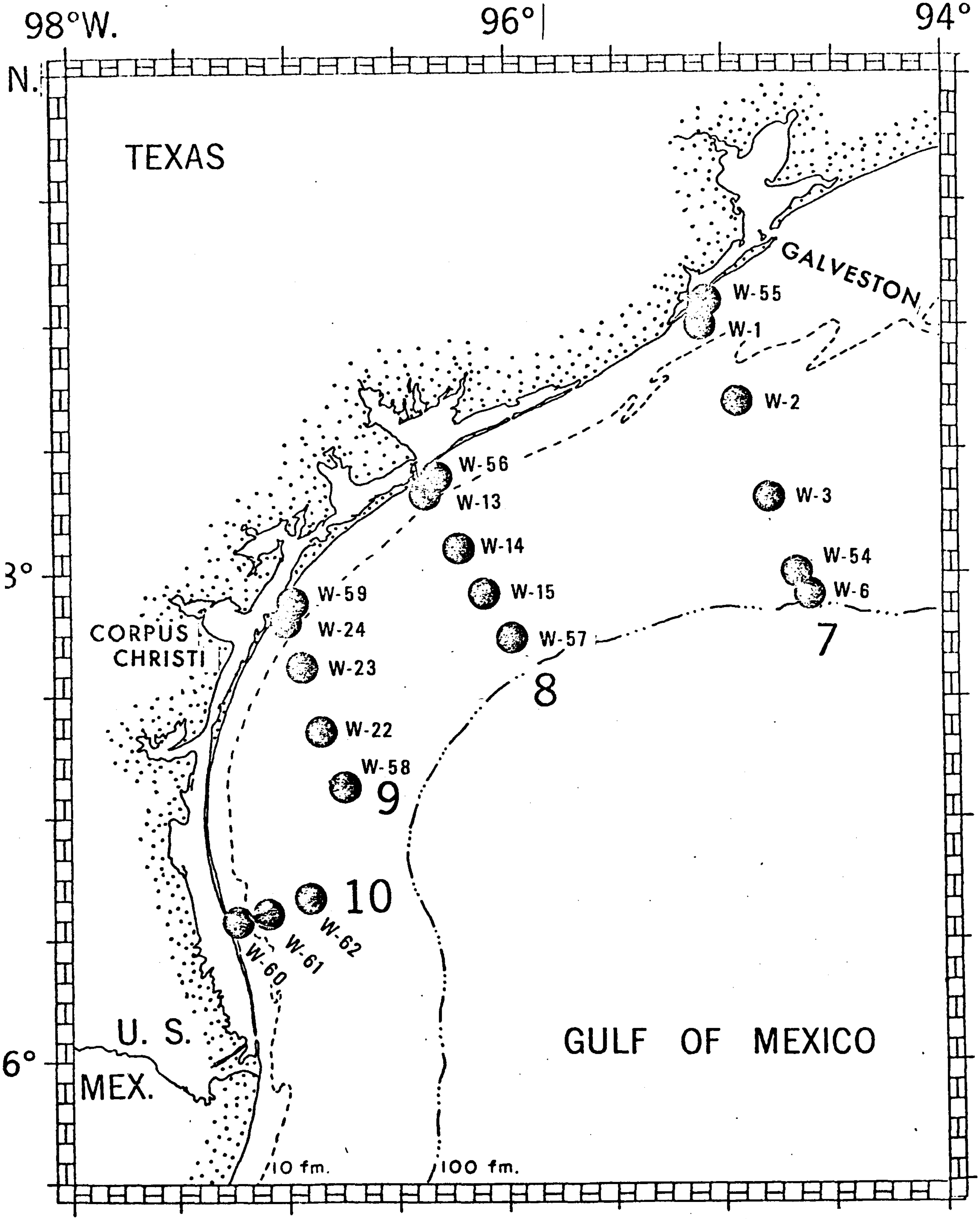


FIGURE 71. THE LOCATION OF TRANSECTS 7-10 WITH THE RESPECTIVE STATIONS AT WHICH MONTHLY SAMPLING WAS CONDUCTED BETWEEN JANUARY 1963 AND DECEMBER 1965.

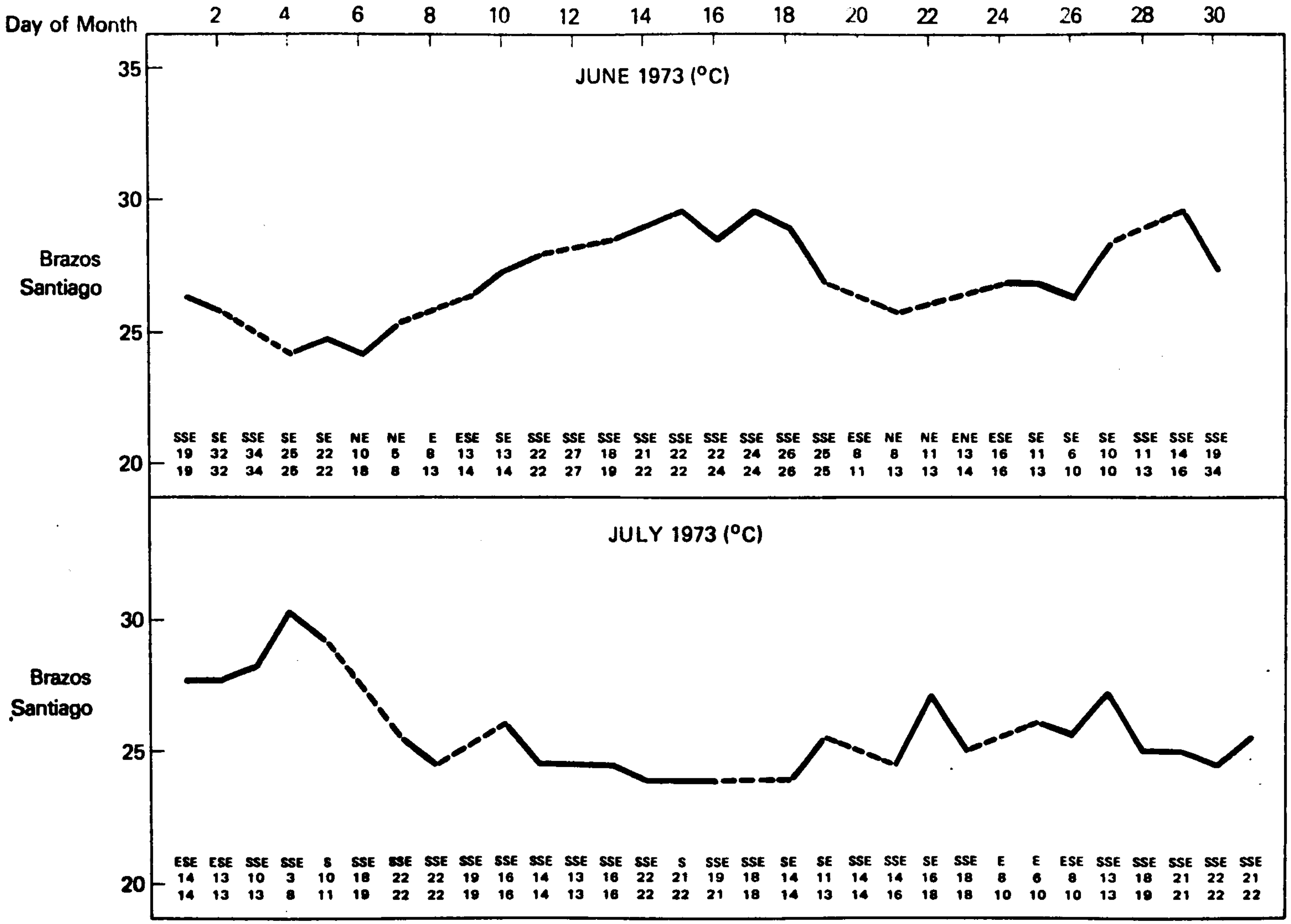


FIGURE 72. SEA WATER TEMPERATURE AND DAILY WINDS, BRAZOS SANTIAGO.

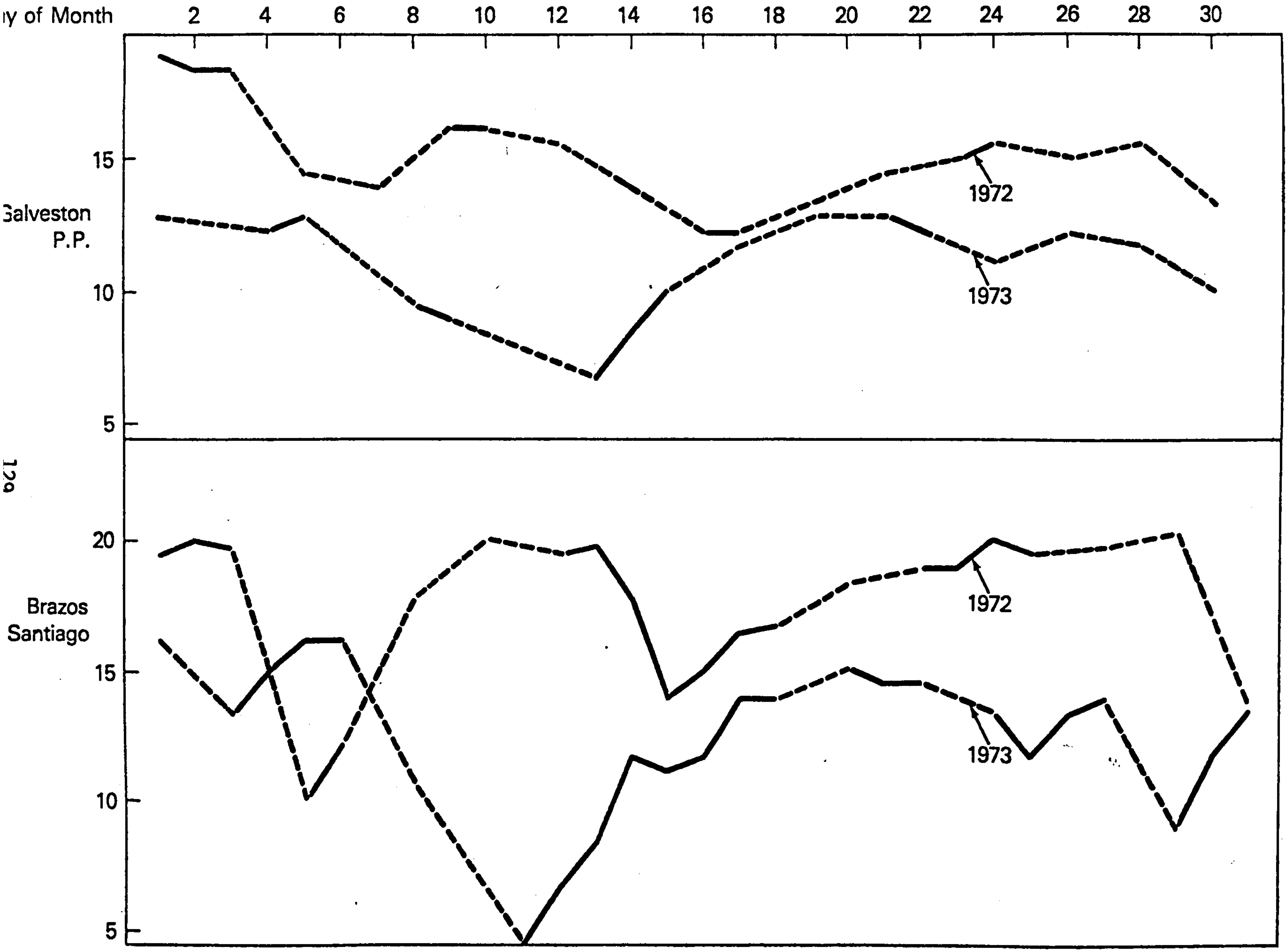


FIGURE 73. SEA WATER TEMPERATURES: JANUARY (°C).

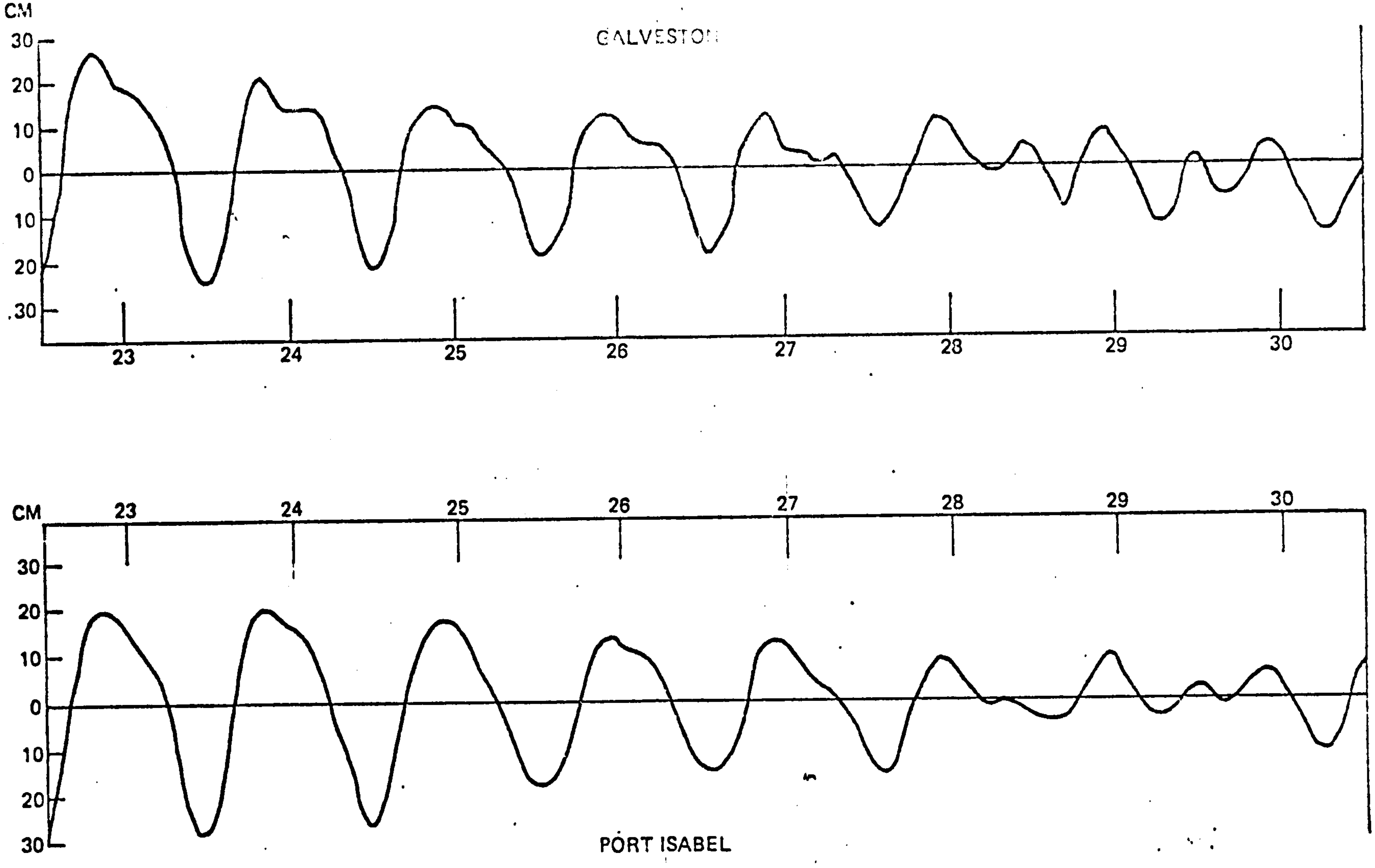


FIGURE 74. TIDE CURVES, GALVESTON AND PORT ISABEL, JUNE 23-30, 1948

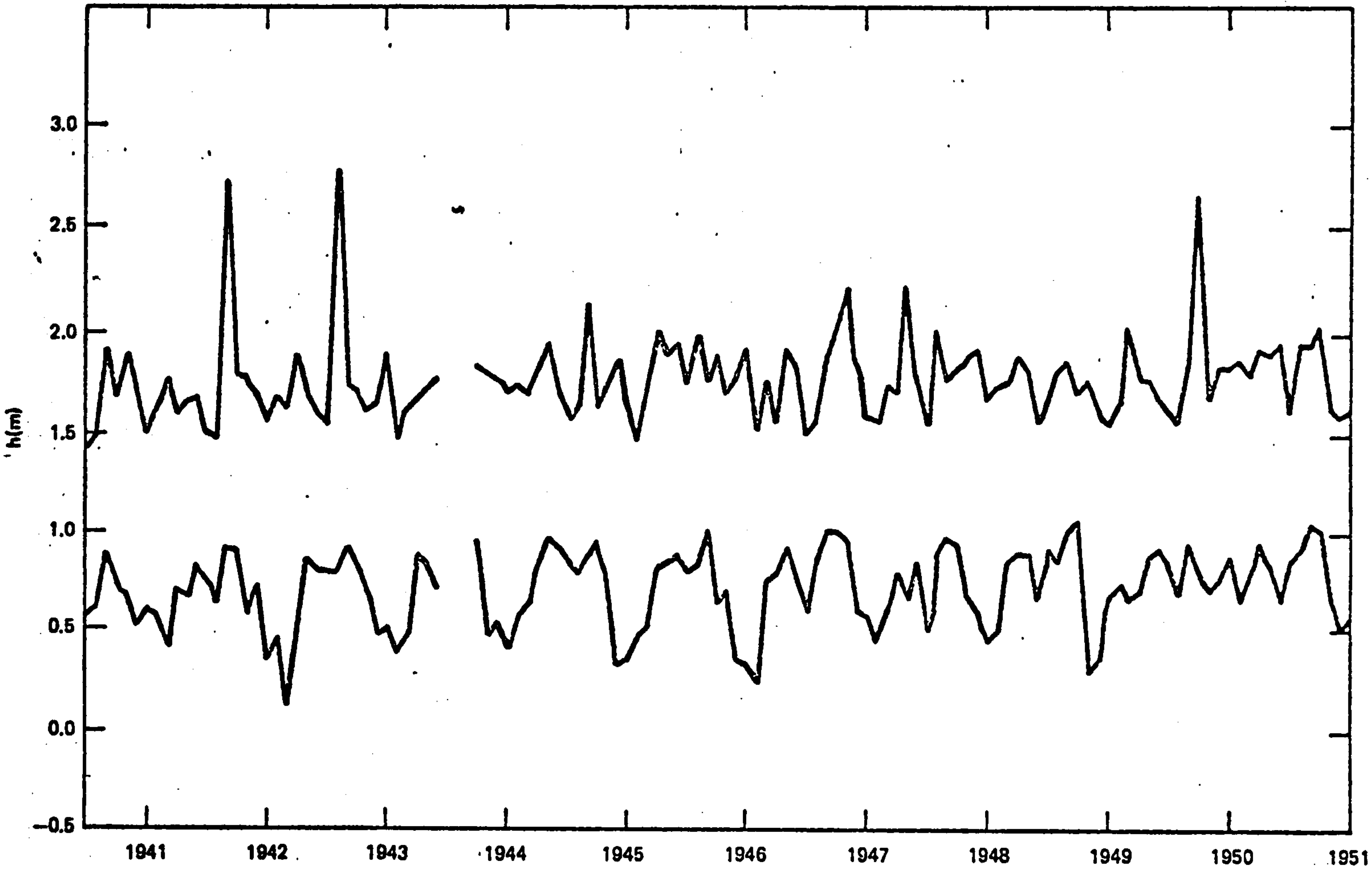


FIGURE 75. MONTHLY HIGHEST AND LOWEST TIDES :
GALVESTON.

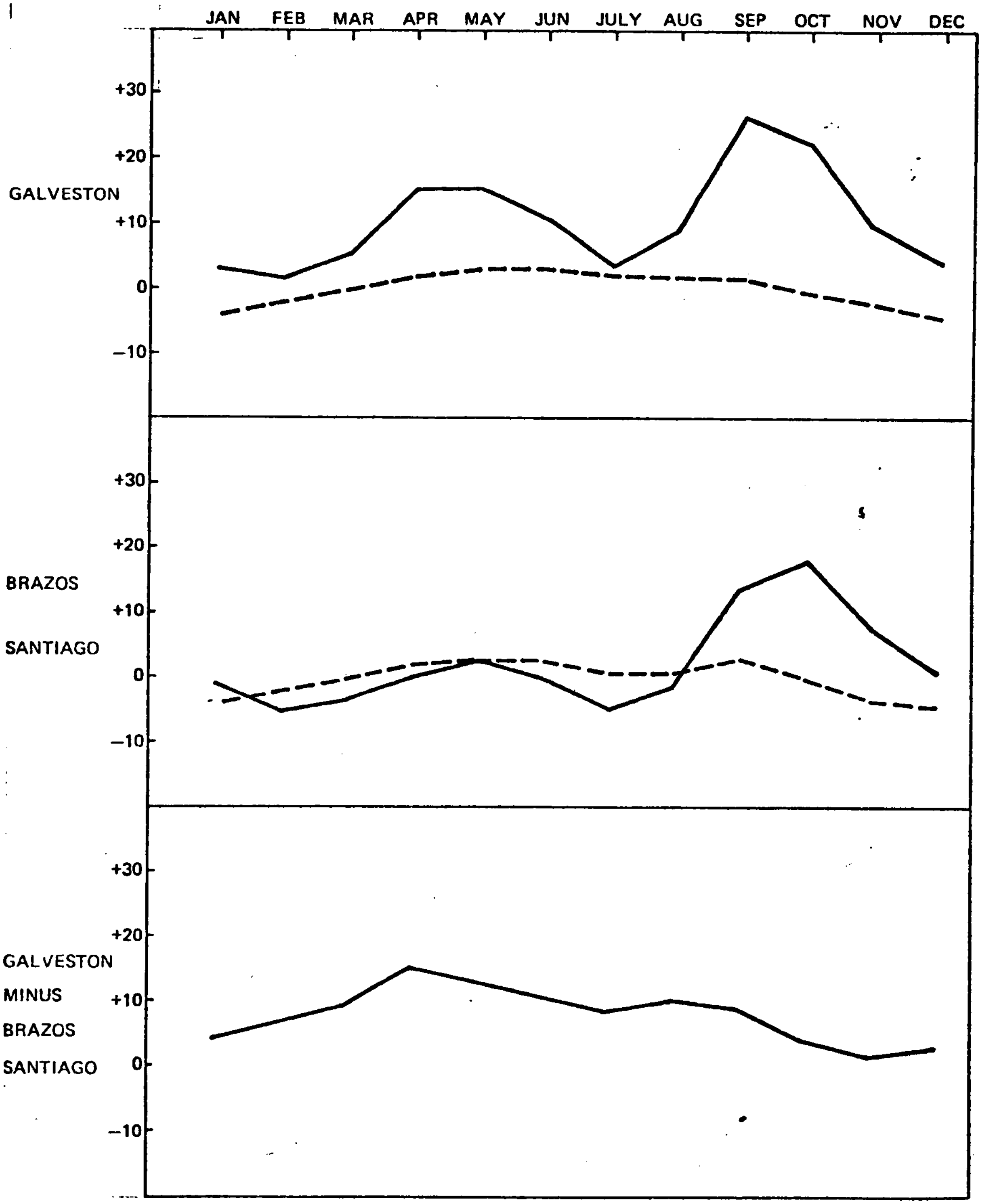


FIGURE 76. 1966-1973: MONTHLY MEANS OF SL (cm, solid line) WITH STERIC VARIATION (cm, dashed line).

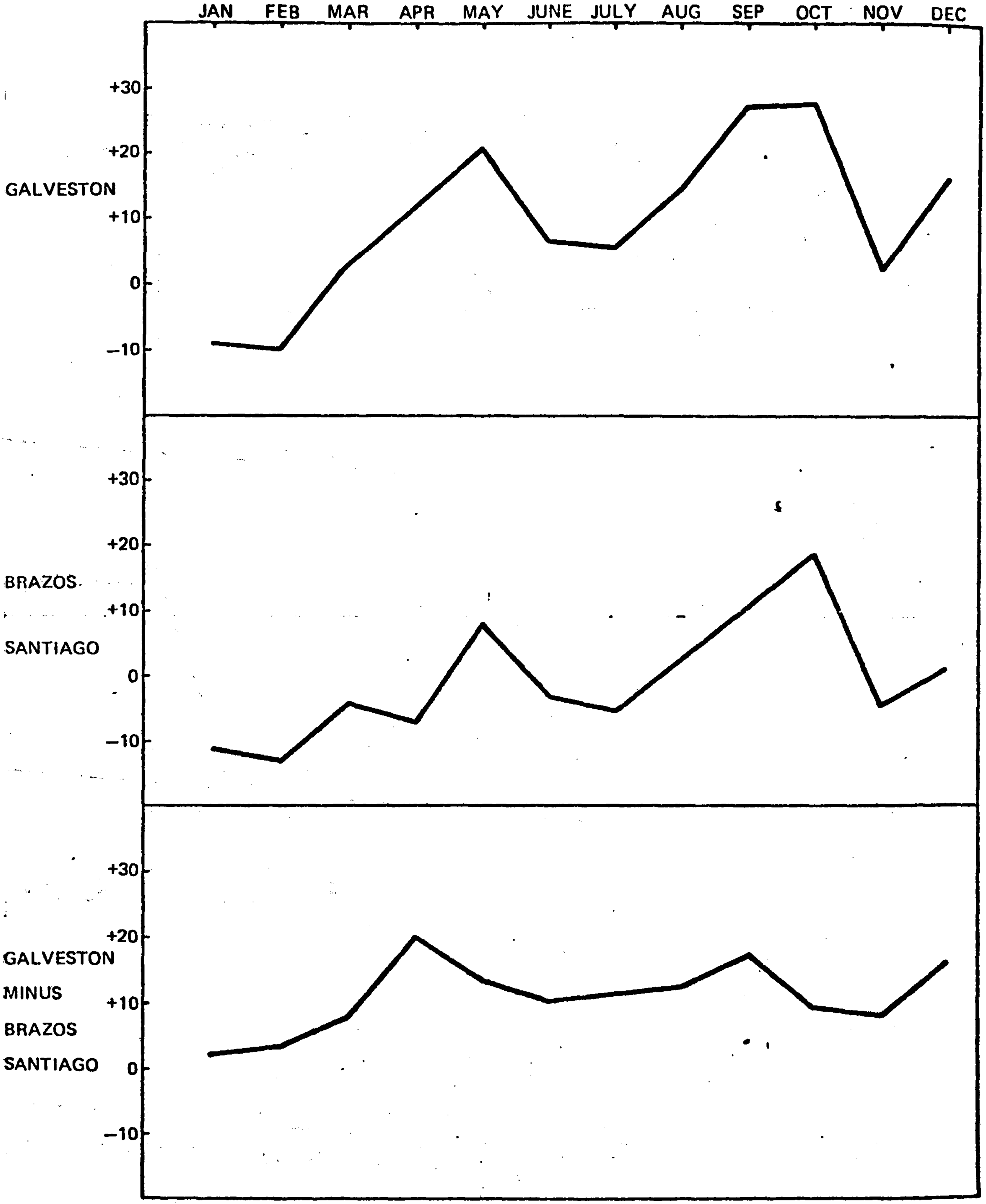


FIGURE 77. 1970 – MONTHLY MEANS OF SL (in CM)

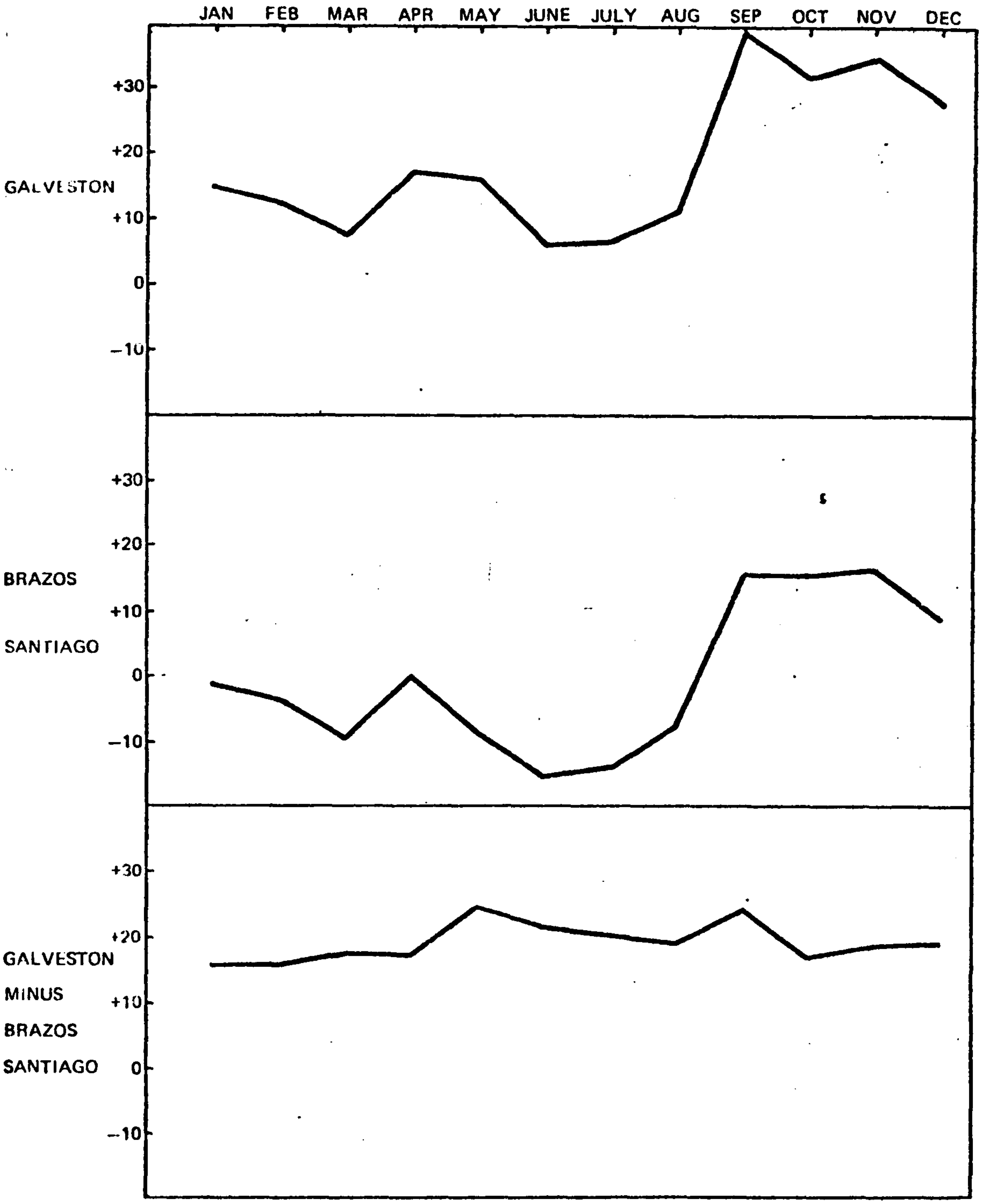


FIGURE 78. 1971 – MONTHLY MEANS OF SL (in CM)

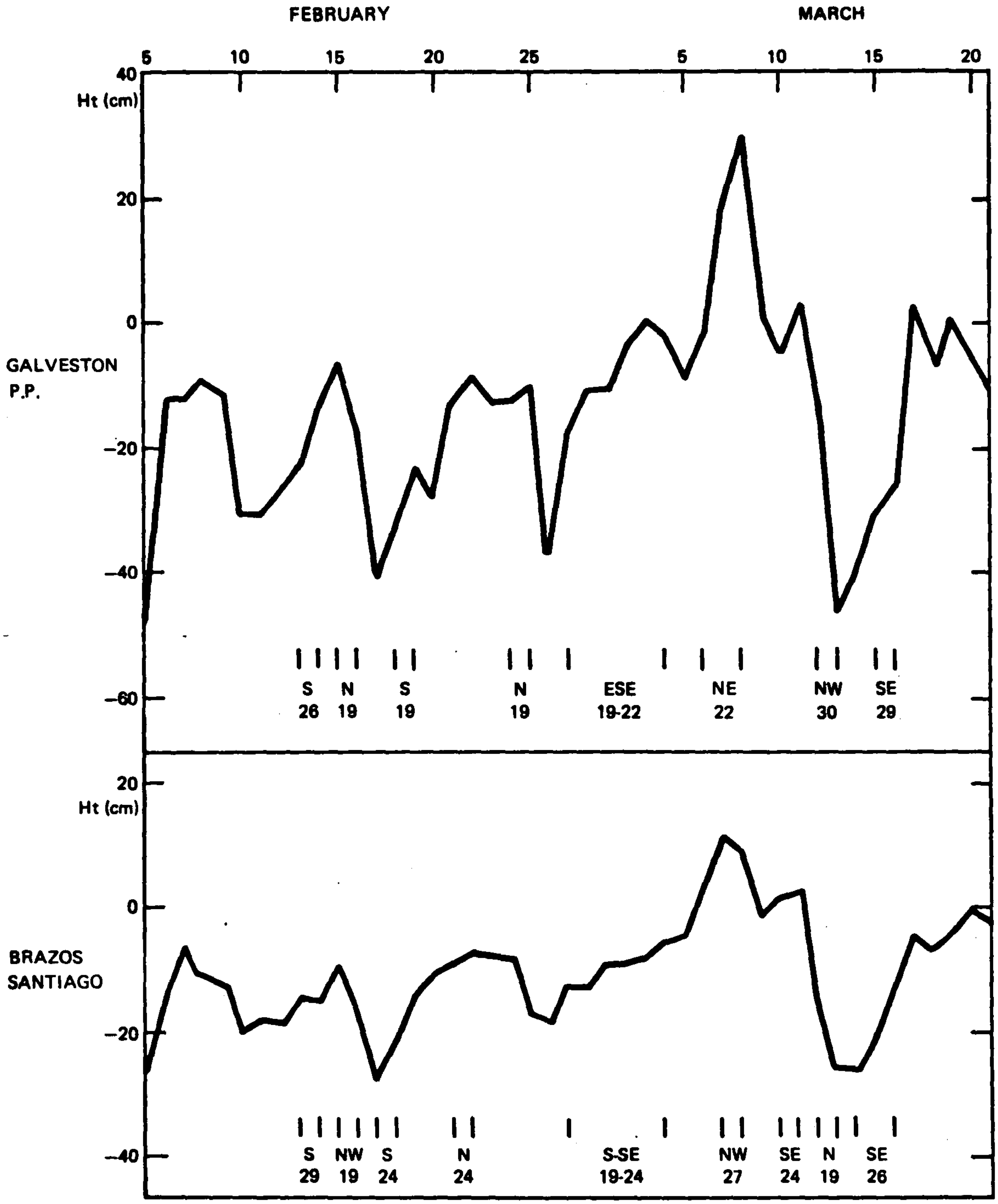


FIGURE 79. DAILY SEA LEVEL HEIGHTS (in cm) - 1970 AND SIGNIFICANT STEADY WINDS (km/hr).

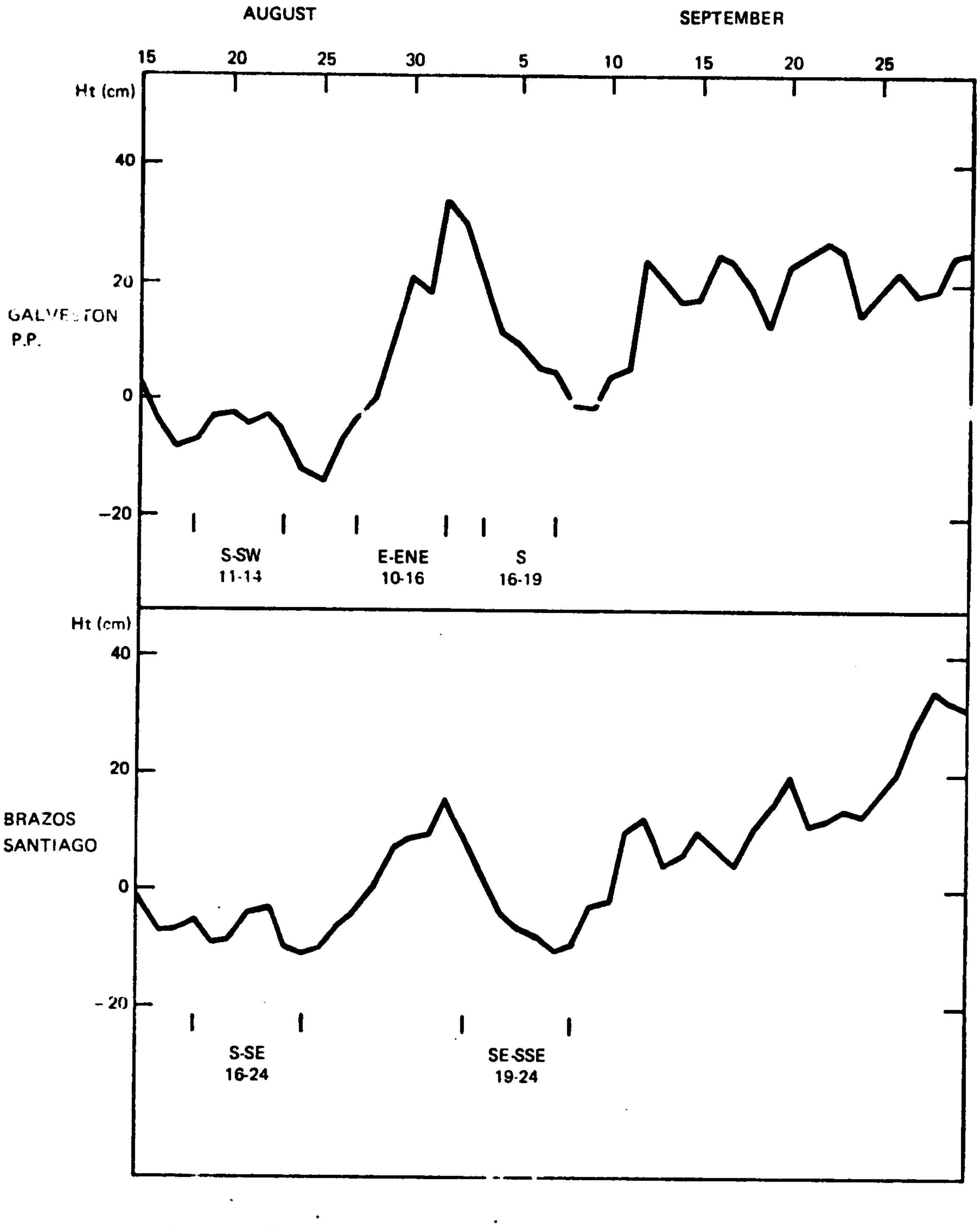


FIGURE 80. DAILY SEA LEVEL HEIGHTS (in cm) - 1970 AND SIGNIFICANT STEADY WINDS (km/hr).

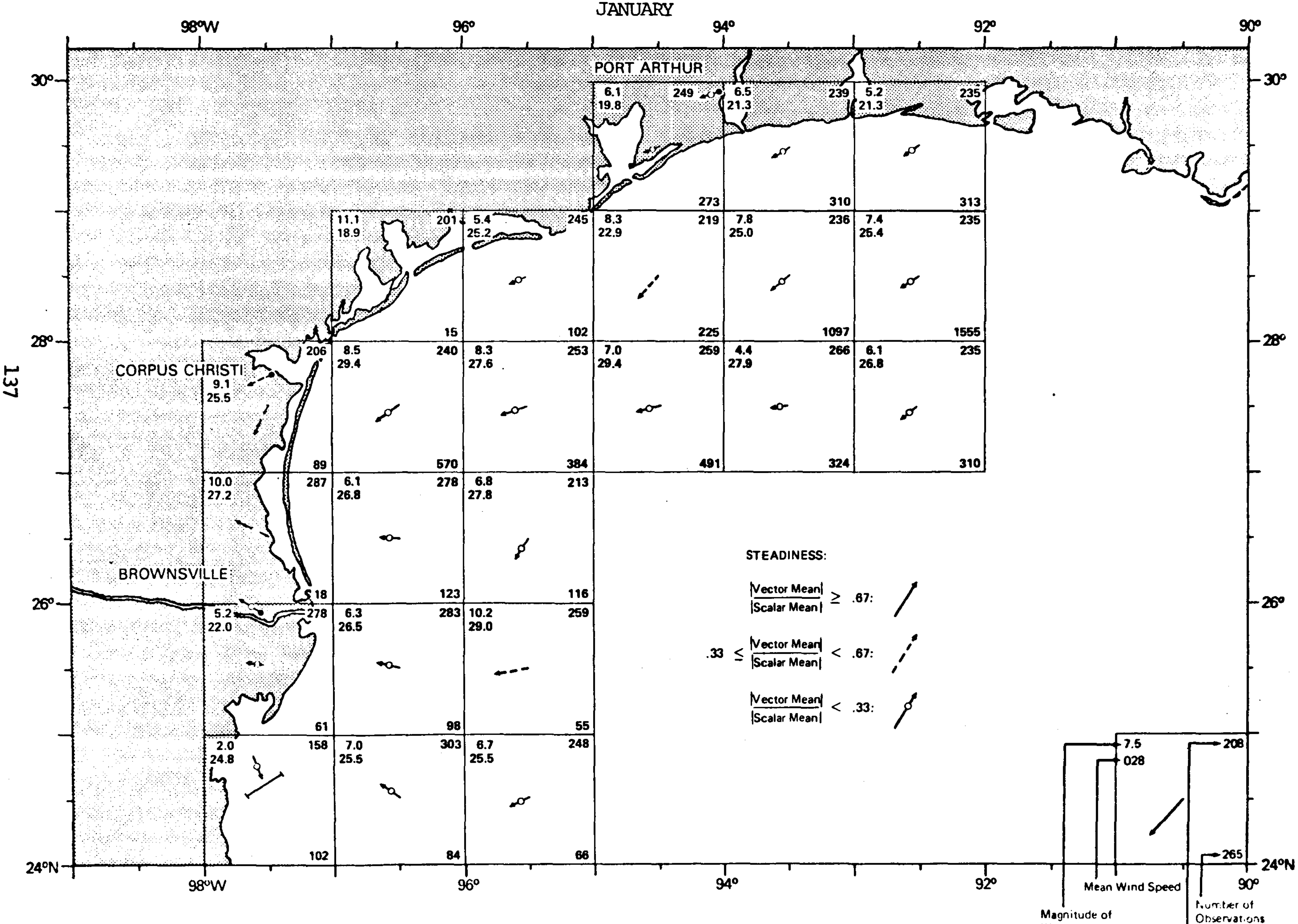


FIGURE 81. JANUARY MONTHLY MEAN WIND VECTORS.

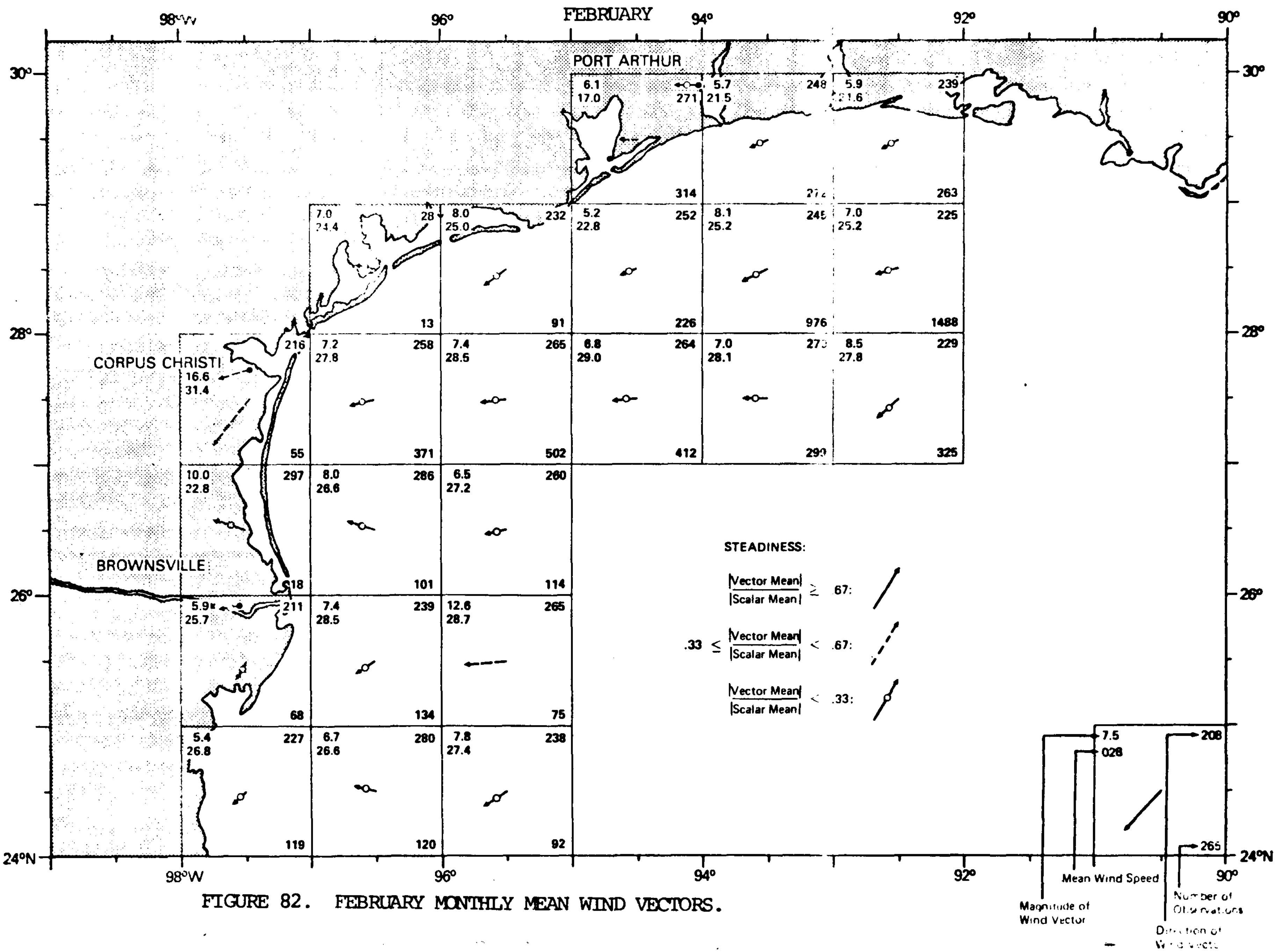


FIGURE 82. FEBRUARY MONTHLY MEAN WIND VECTORS.

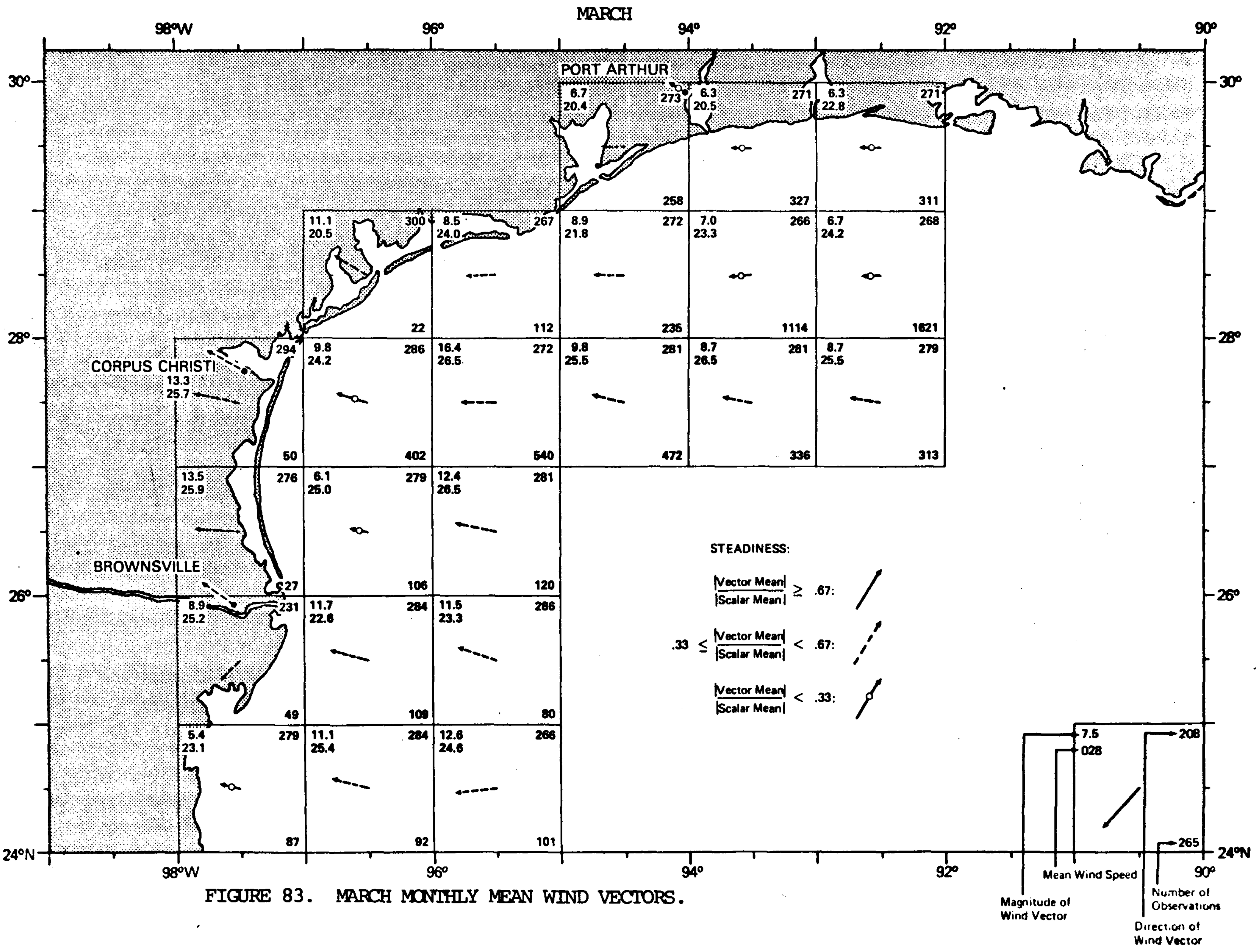


FIGURE 83. MARCH MONTHLY MEAN WIND VECTORS.

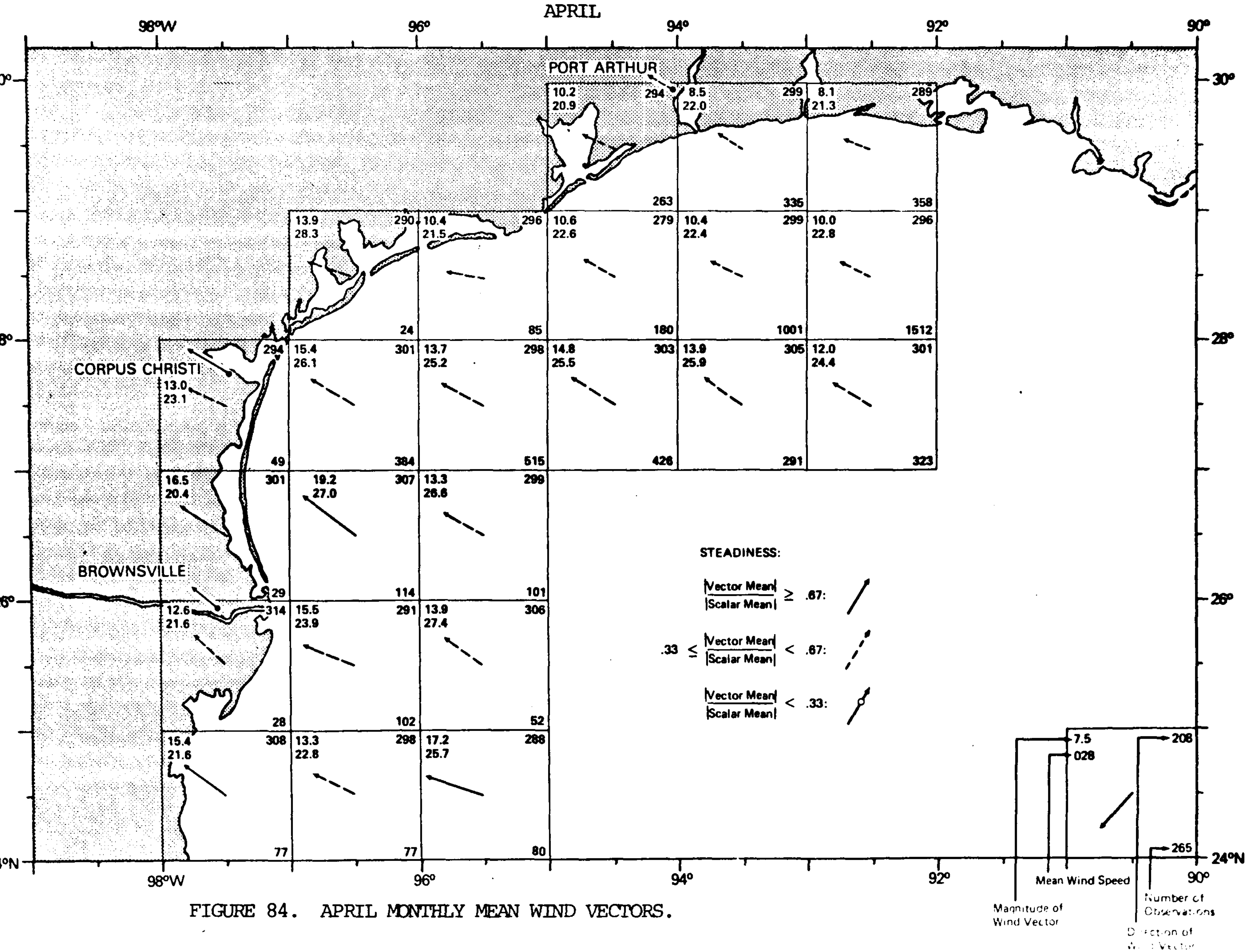


FIGURE 84. APRIL MONTHLY MEAN WIND VECTORS.

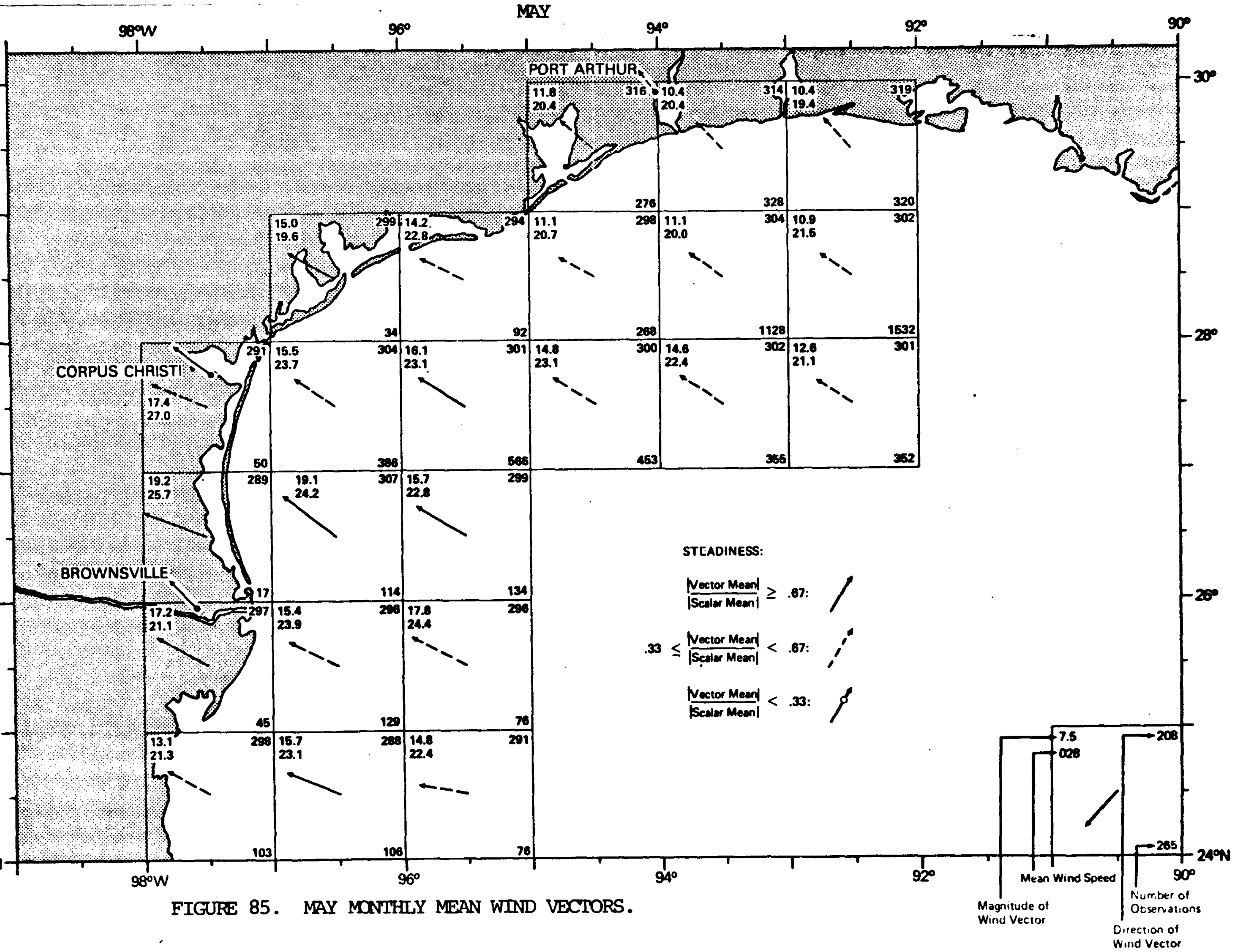


FIGURE 85. MAY MONTHLY MEAN WIND VECTORS.

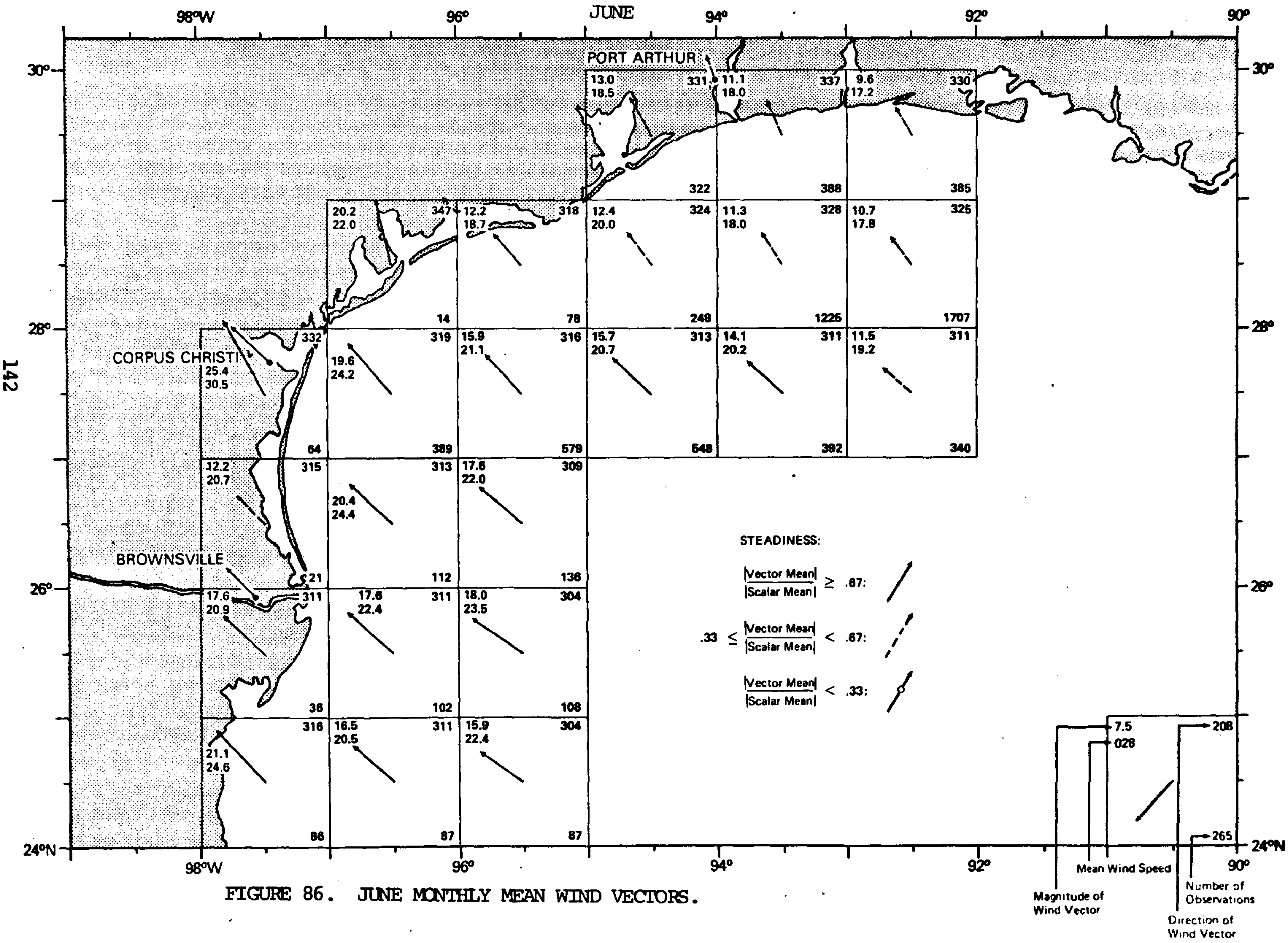


FIGURE 86. JUNE MONTHLY MEAN WIND VECTORS.

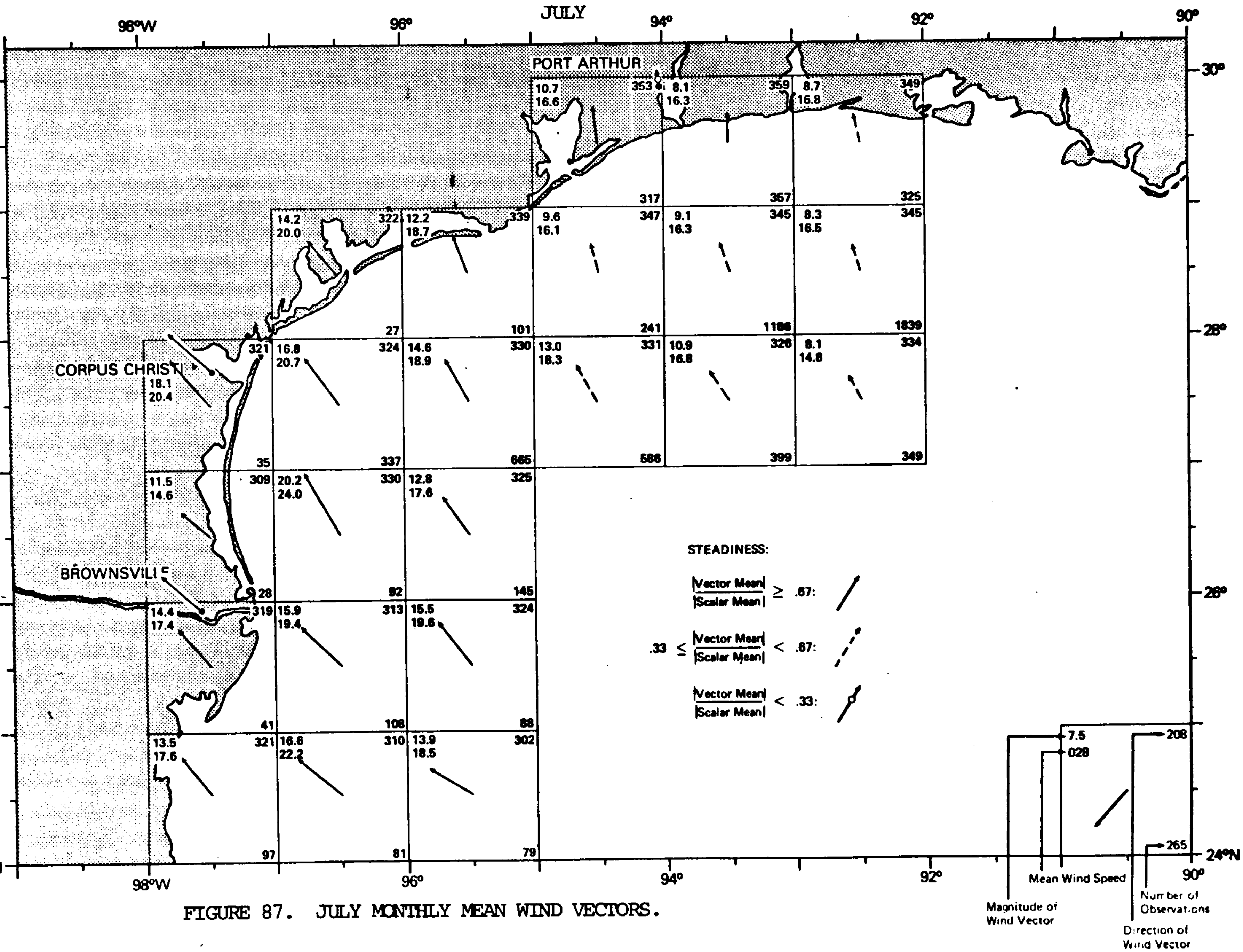


FIGURE 87. JULY MONTHLY MEAN WIND VECTORS.

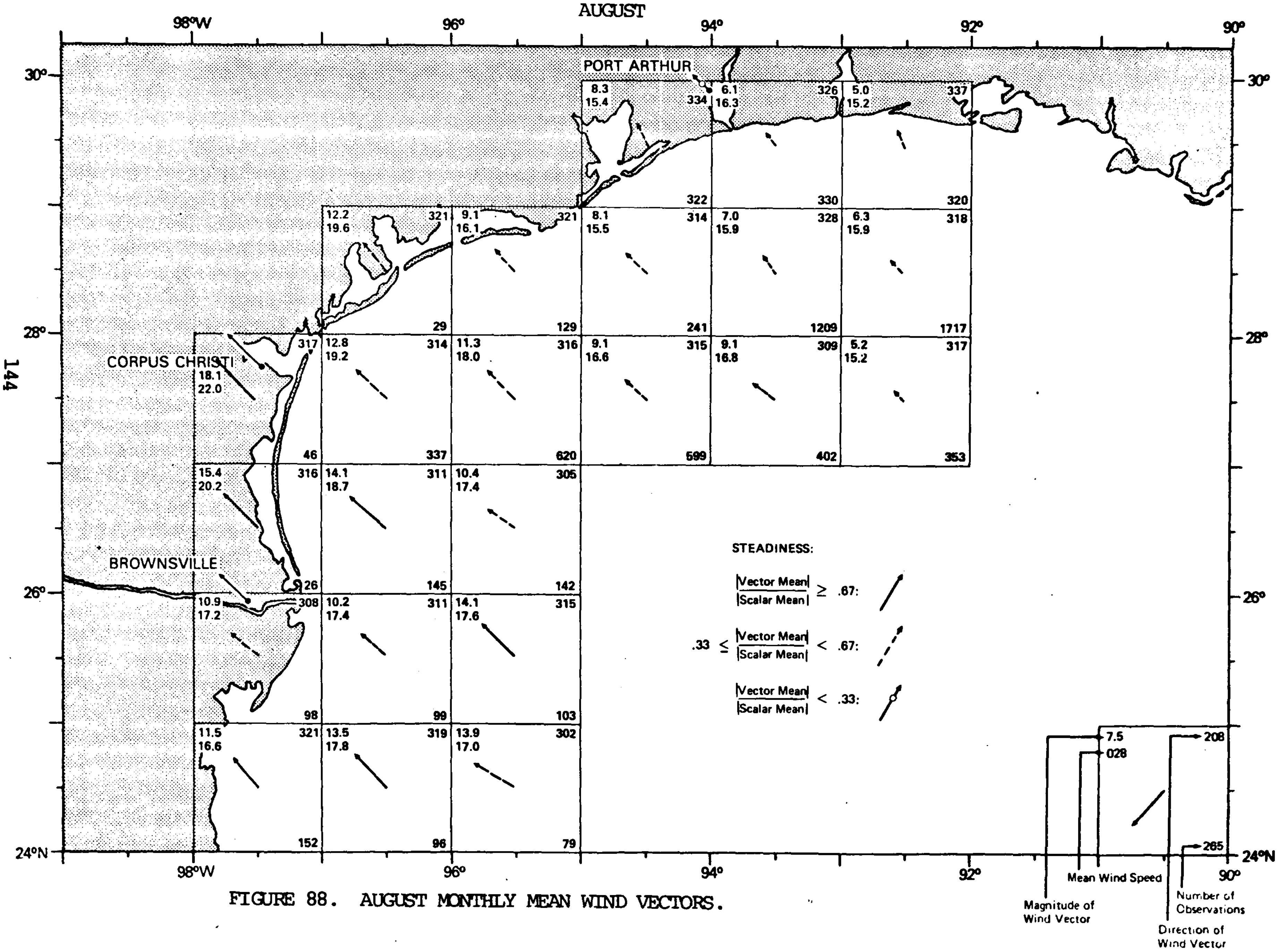


FIGURE 88. AUGUST MONTHLY MEAN WIND VECTORS.

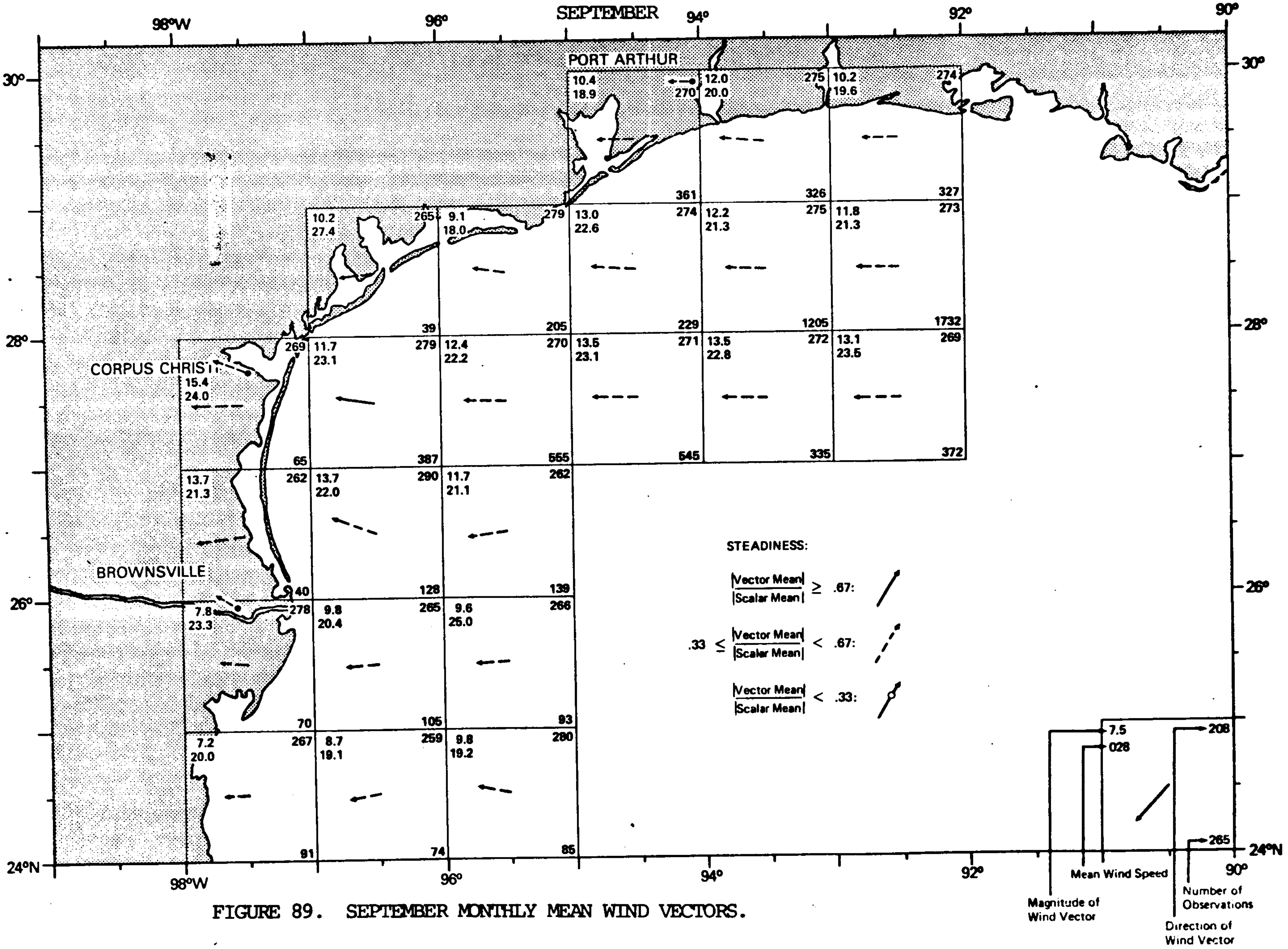


FIGURE 89. SEPTEMBER MONTHLY MEAN WIND VECTORS.

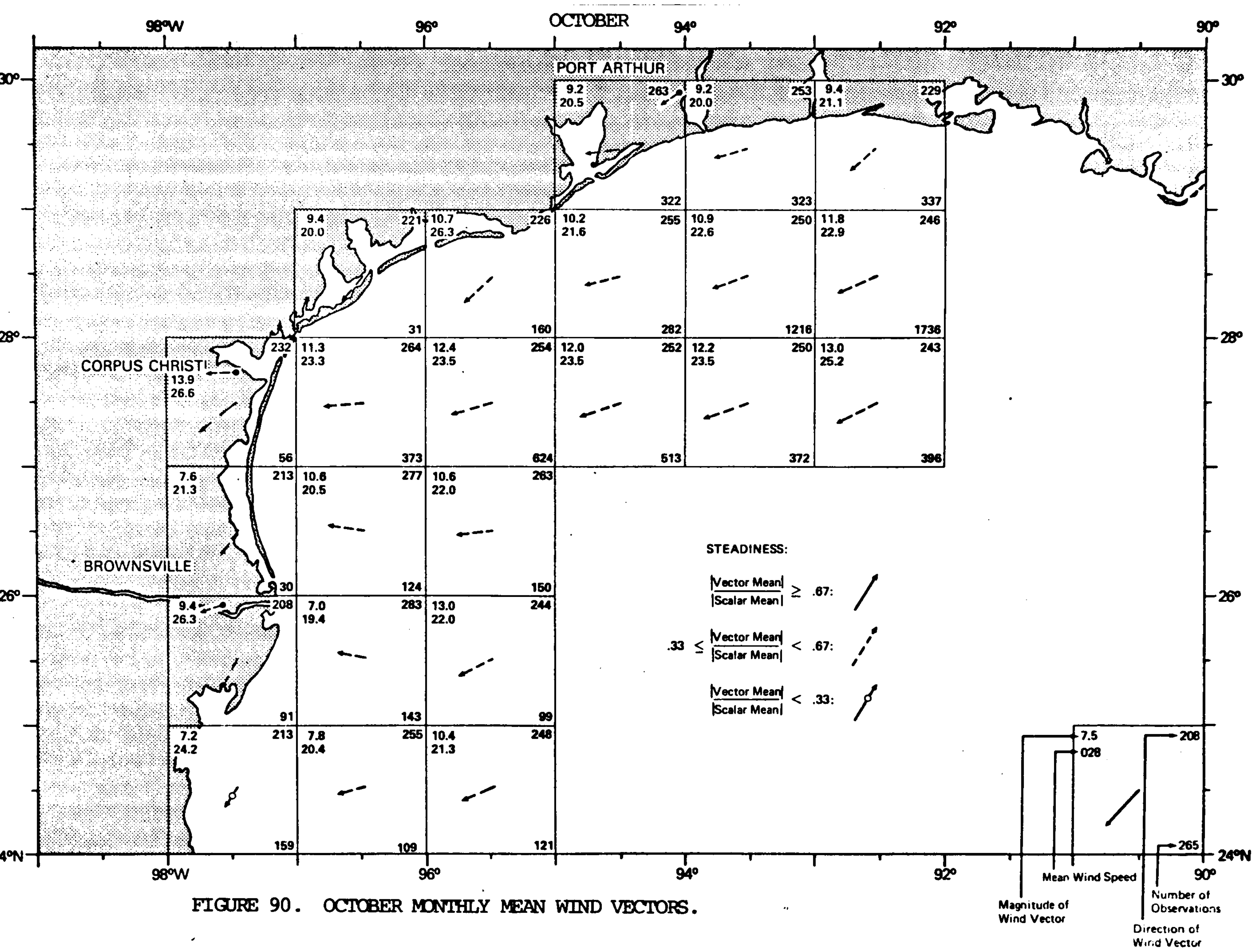


FIGURE 90. OCTOBER MONTHLY MEAN WIND VECTORS.

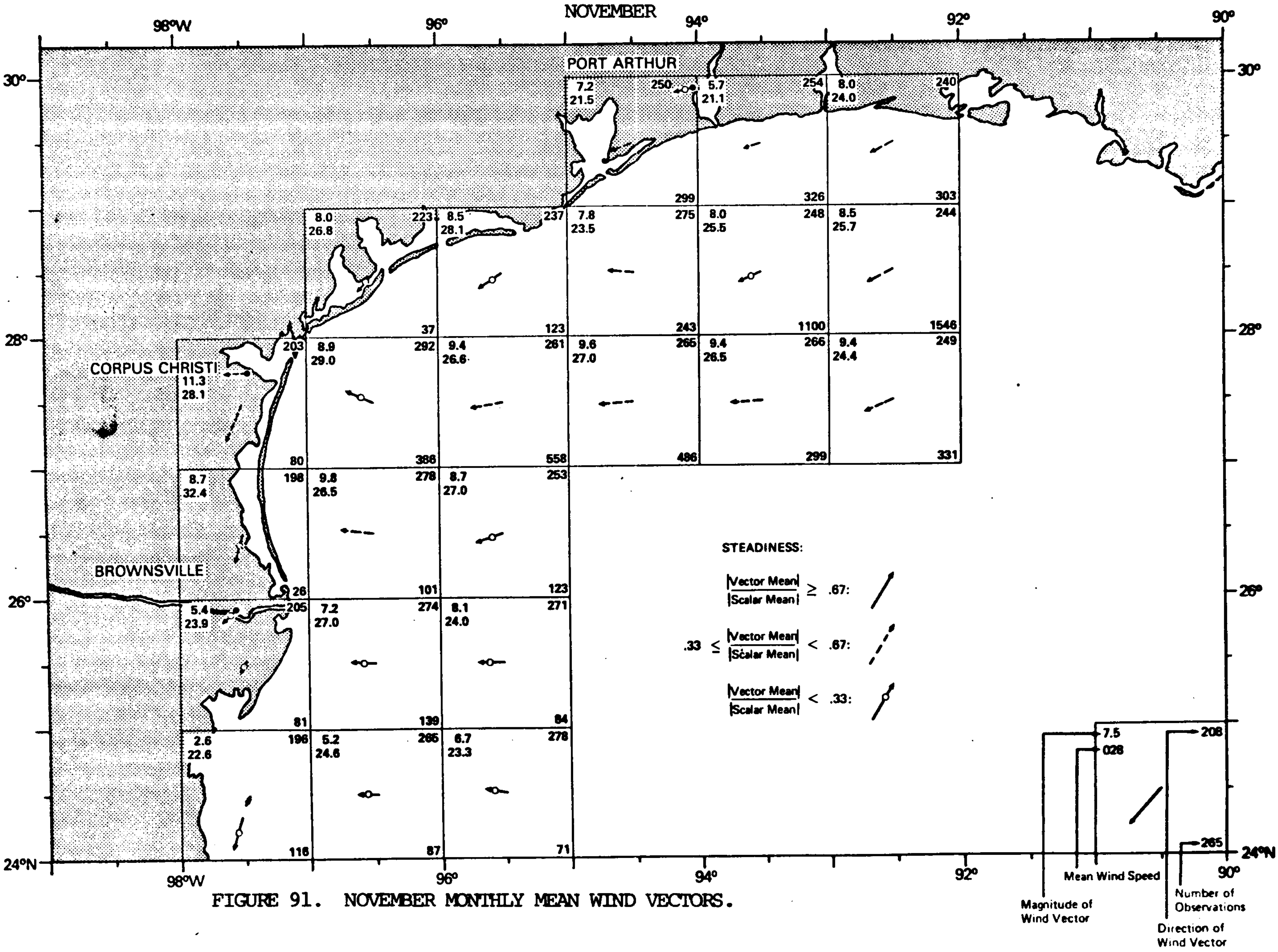


FIGURE 91. NOVEMBER MONTHLY MEAN WIND VECTORS.

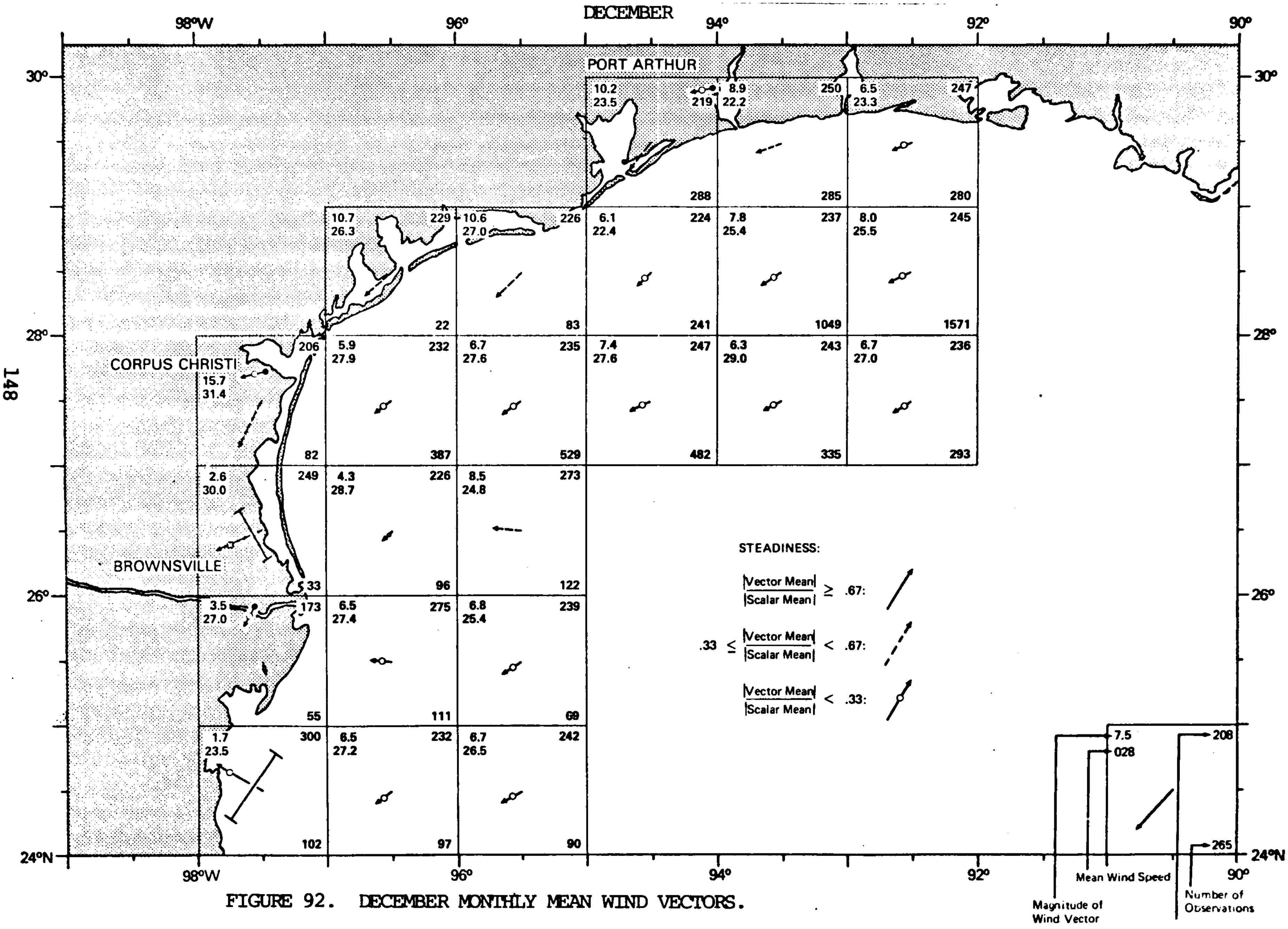


FIGURE 92. DECEMBER MONTHLY MEAN WIND VECTORS.

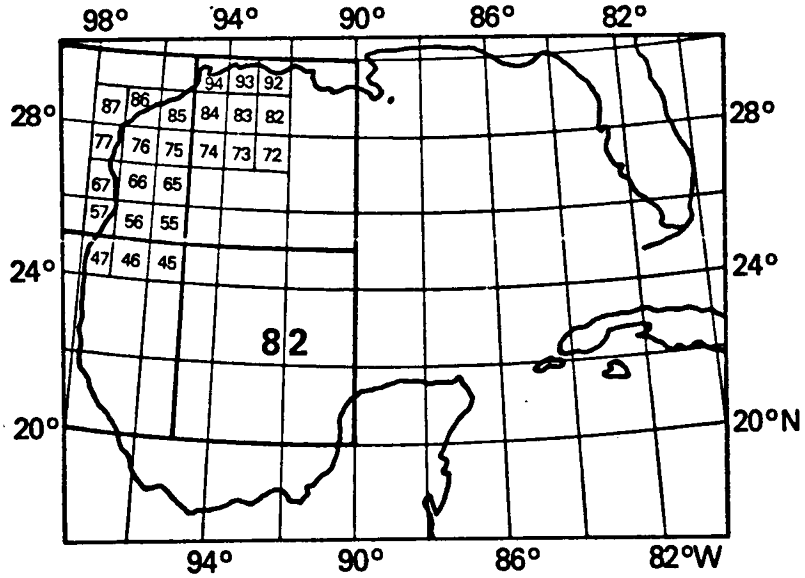


FIGURE 93. LOCATION OF MARSDEN SQUARE 82.

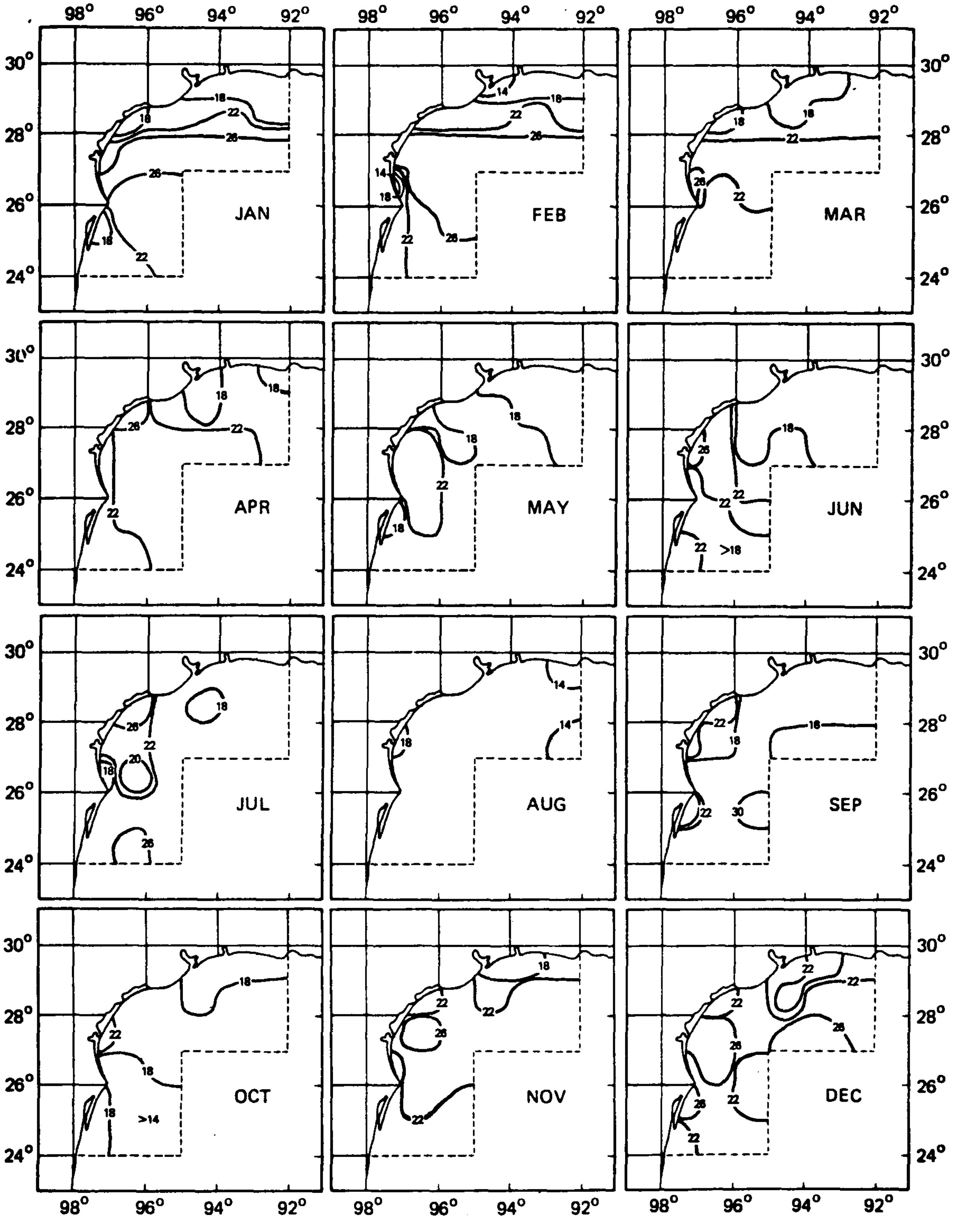


FIGURE 94. MEDIAN VALUES OF MONTHLY WIND VELOCITIES (knots) RECORDED BETWEEN 1884 AND 1973.

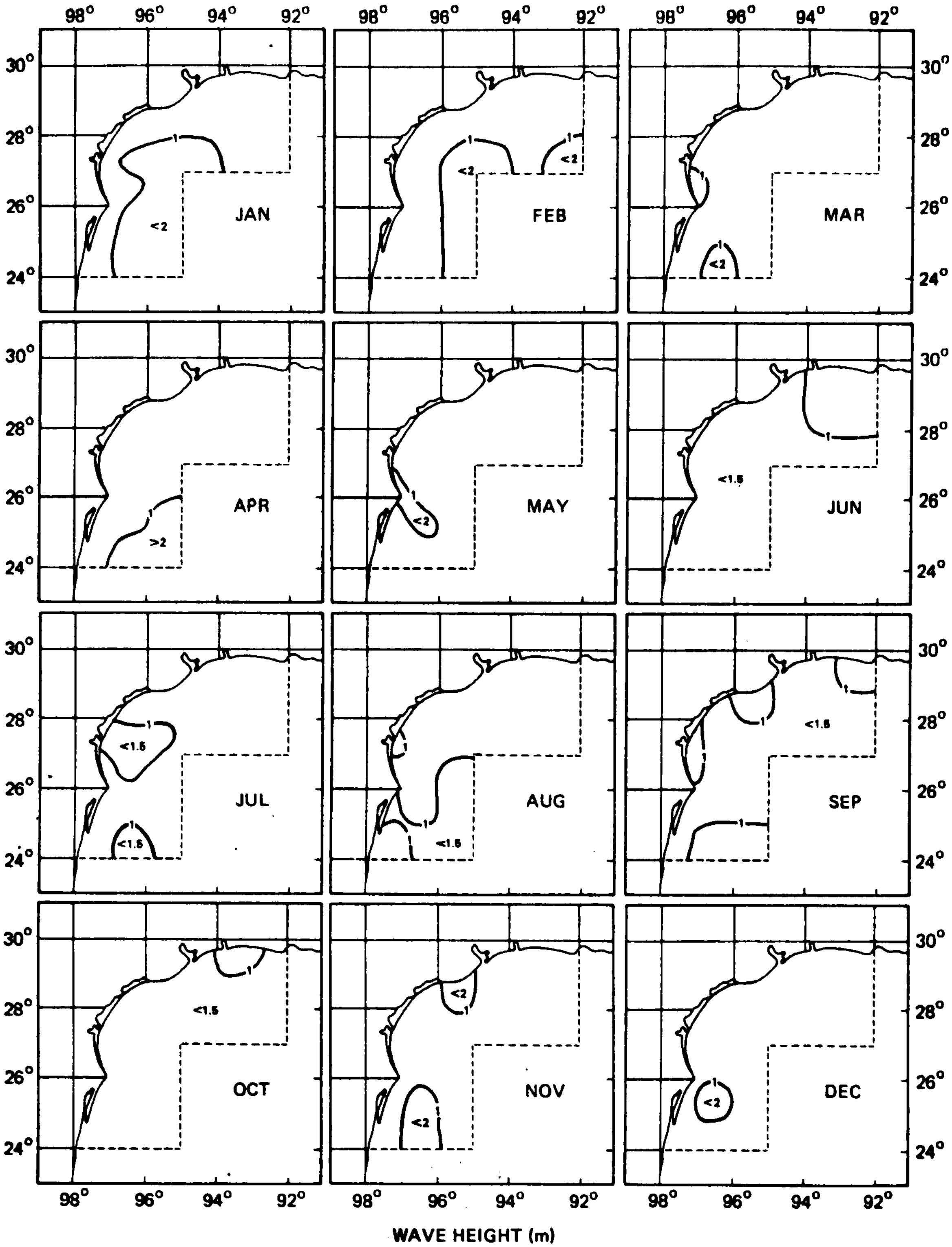


FIGURE 95. MEDIAN VALUES OF MONTHLY WAVE HEIGHTS (feet) RECORDED BETWEEN 1884 AND 1973.

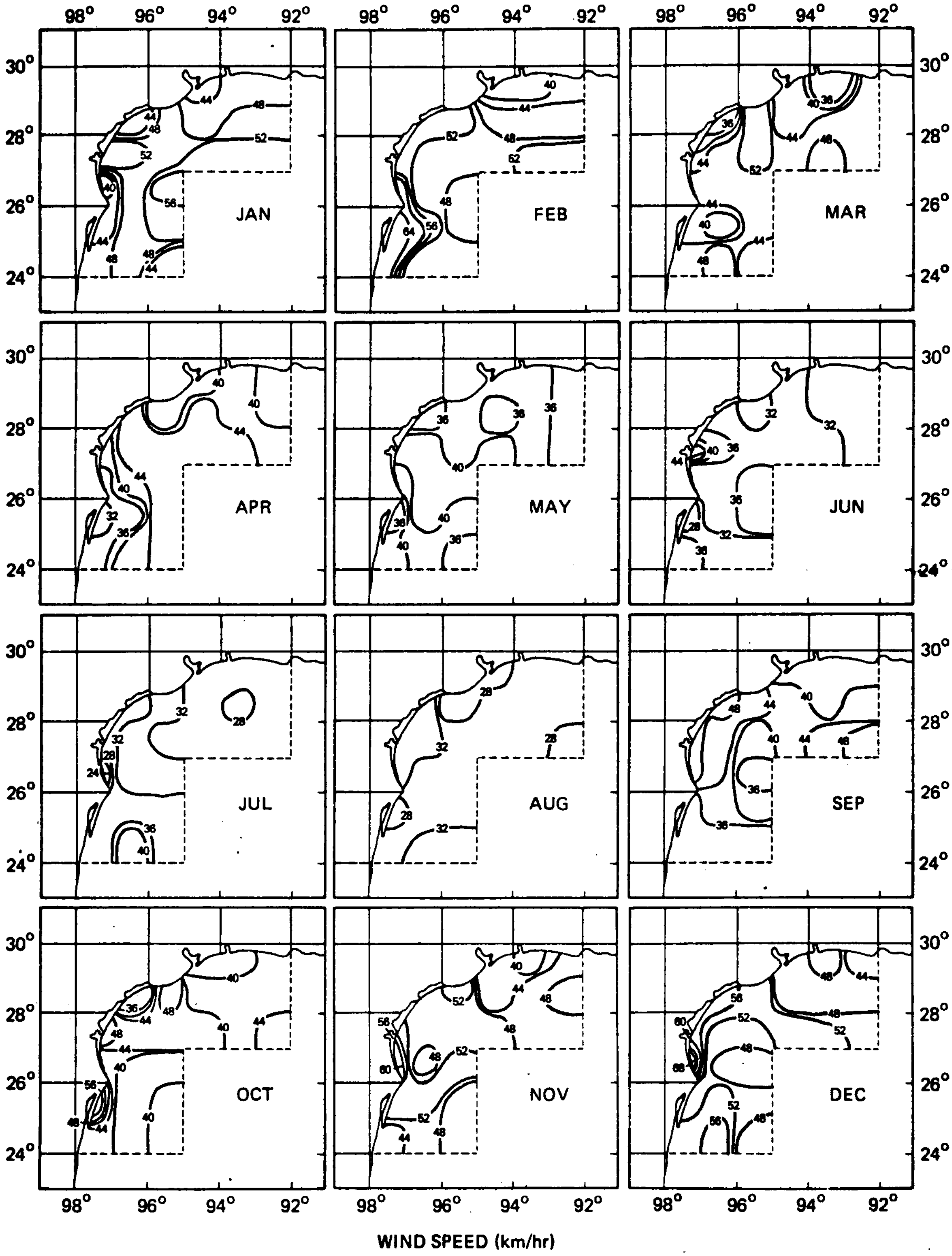


FIGURE 96. WIND VELOCITY (knots) STATISTICS IN WHICH 95% OF THE OBSERVATIONS TAKEN BETWEEN 1884 AND 1973 WERE LESS THAN OR EQUAL TO THE INDICATED VALUE.

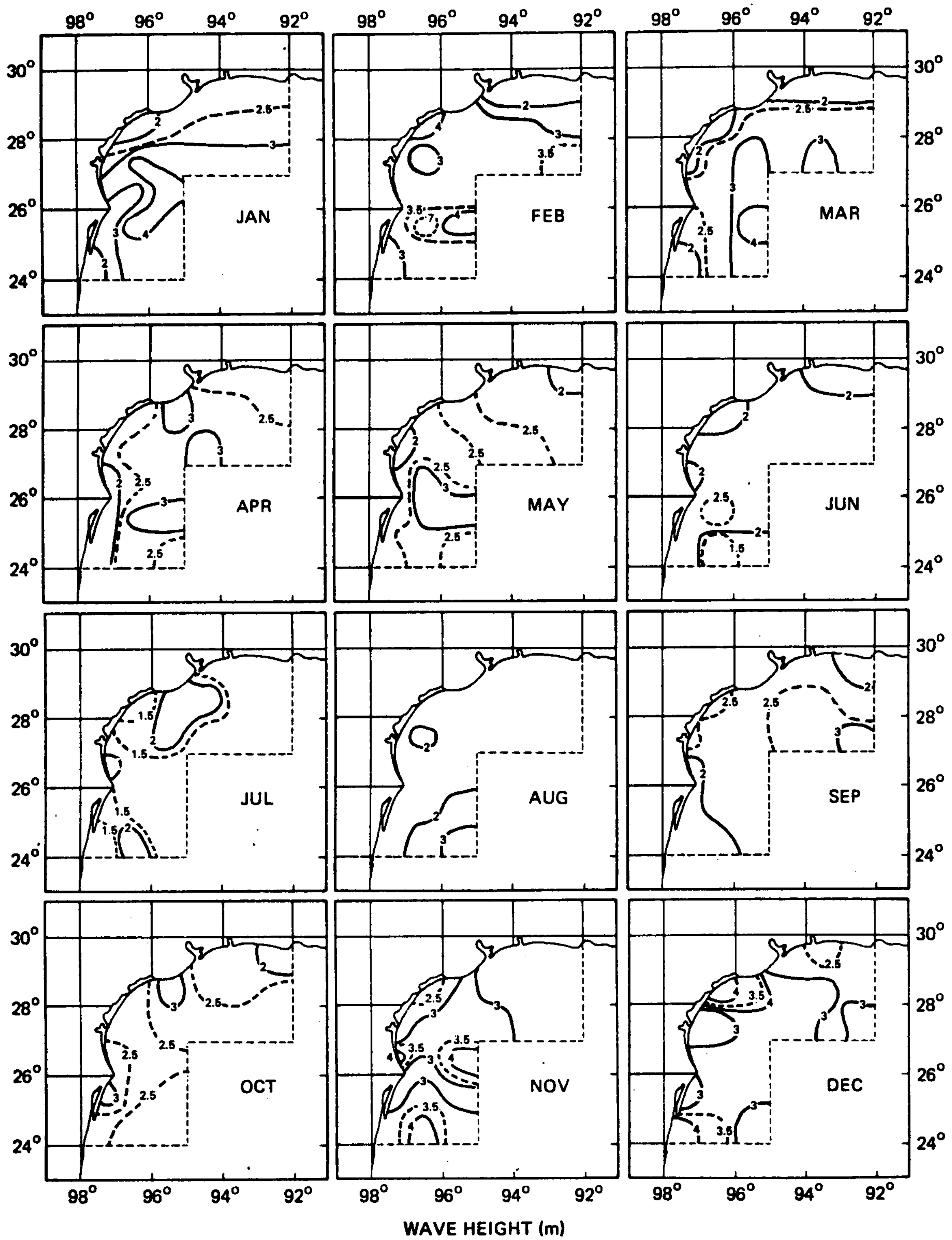


FIGURE 97. WAVE HEIGHT (feet) STATISTICS IN WHICH 95% OF THE OBSERVATIONS TAKEN BETWEEN 1884 AND 1973 WERE LESS THAN OR EQUAL TO THE INDICATED VALUE.

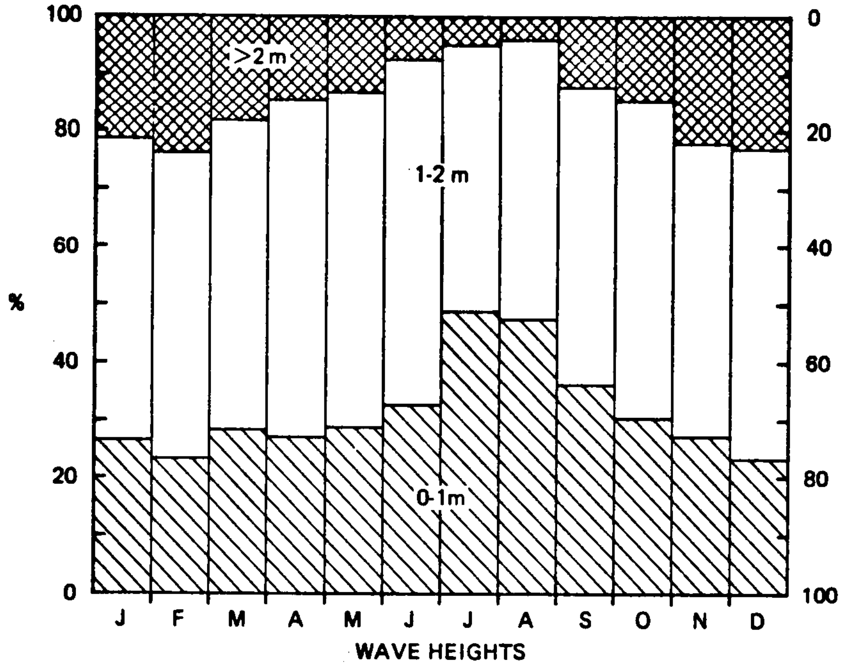


FIGURE 98(a). PERCENT OCCURRENCE OF WAVE HEIGHTS (feet) BY MONTH.

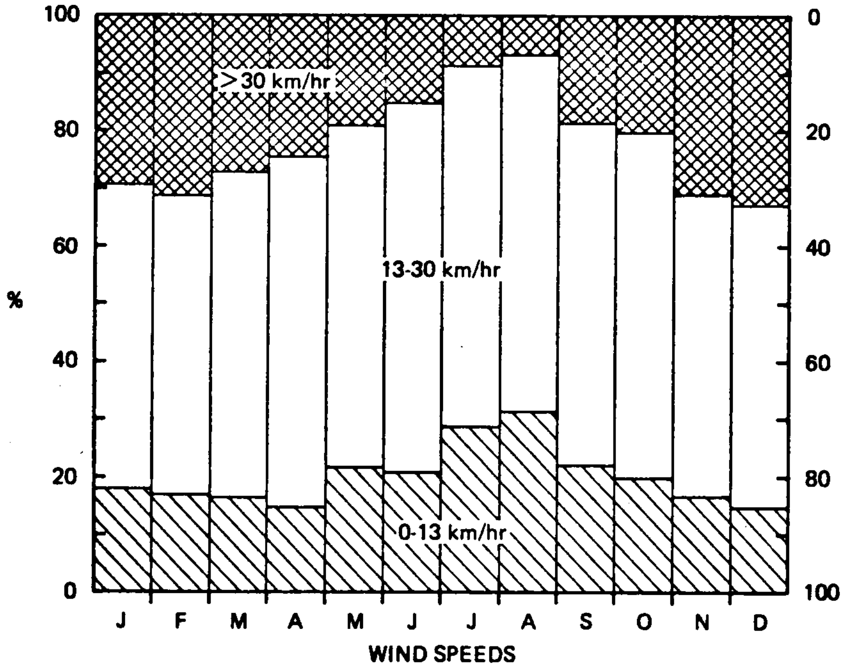


FIGURE 98(b). PERCENT OCCURRENCE OF WIND VELOCITIES (knots) BY MONTH.

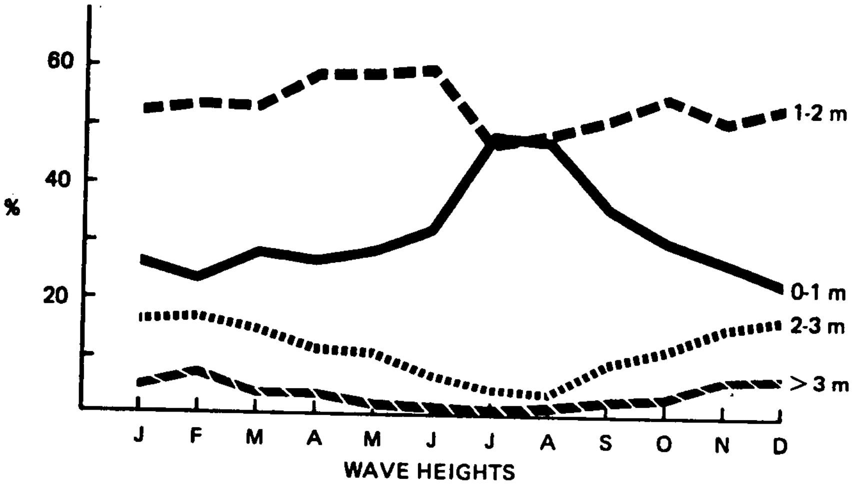


FIGURE 99(a). PERCENT FREQUENCY WAVE HEIGHTS (feet) BY MONTH.

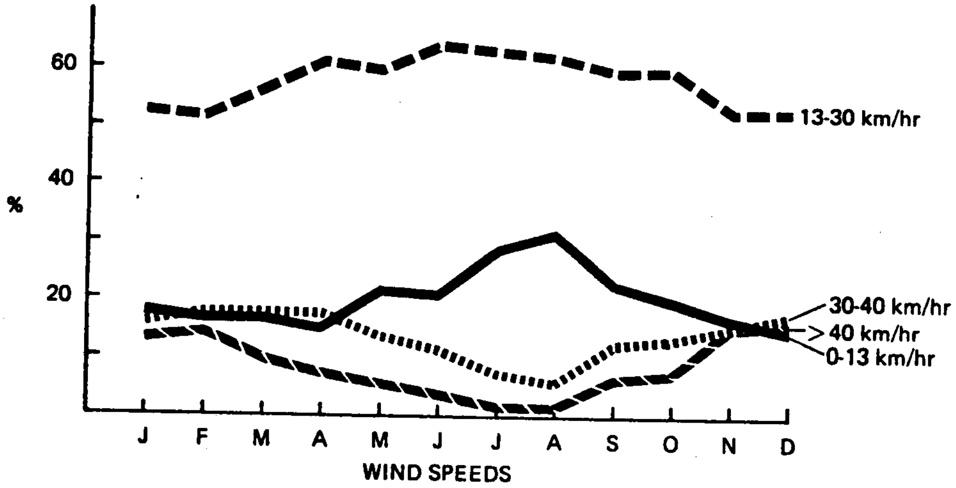


FIGURE 99(b). PERCENT FREQUENCY WIND VELOCITIES (knots) BY MONTH.

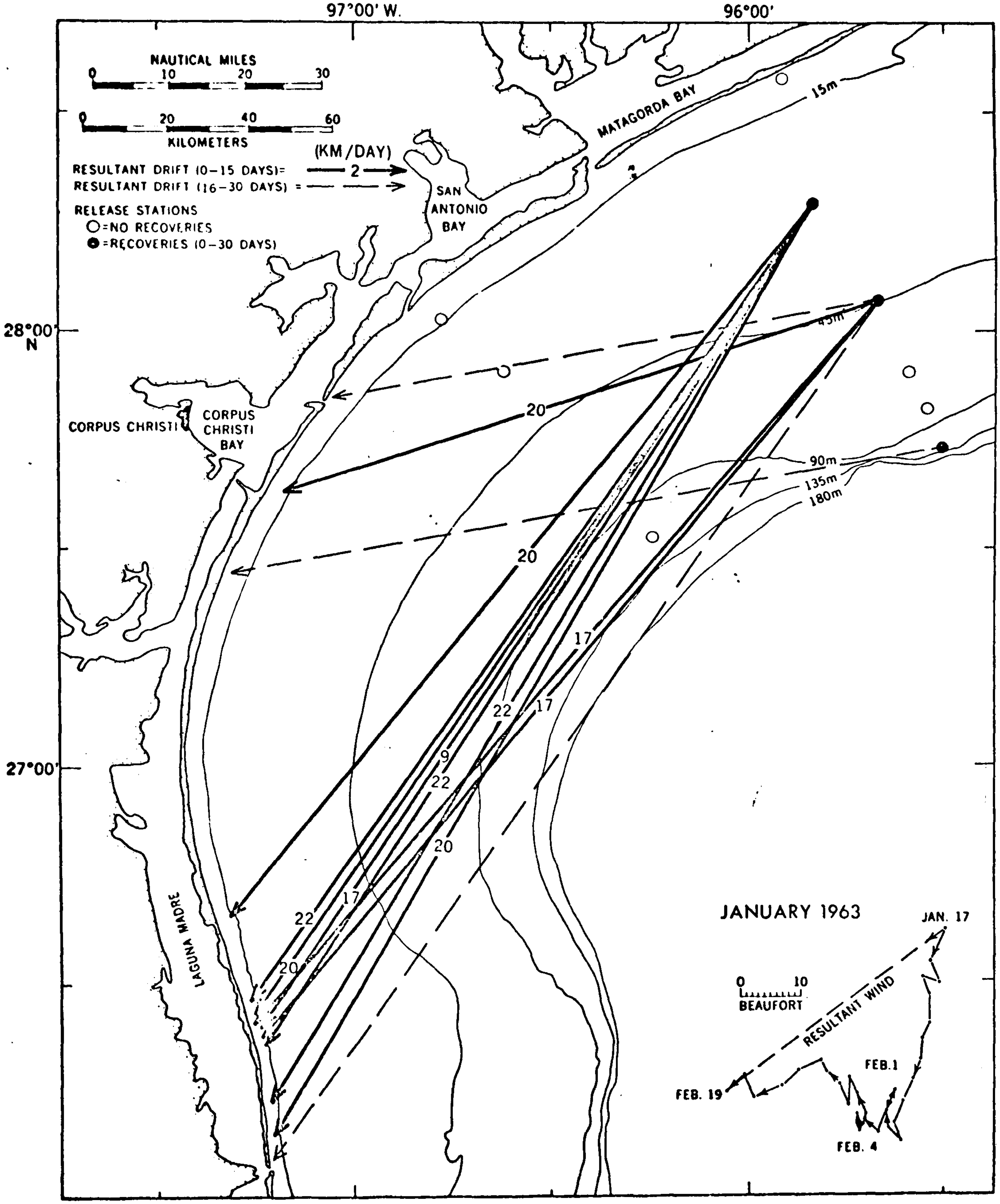


Figure 100. Surface circulation deduced from recoveries of drift bottles released on Cruise 1-63, February 1-4, 1963.

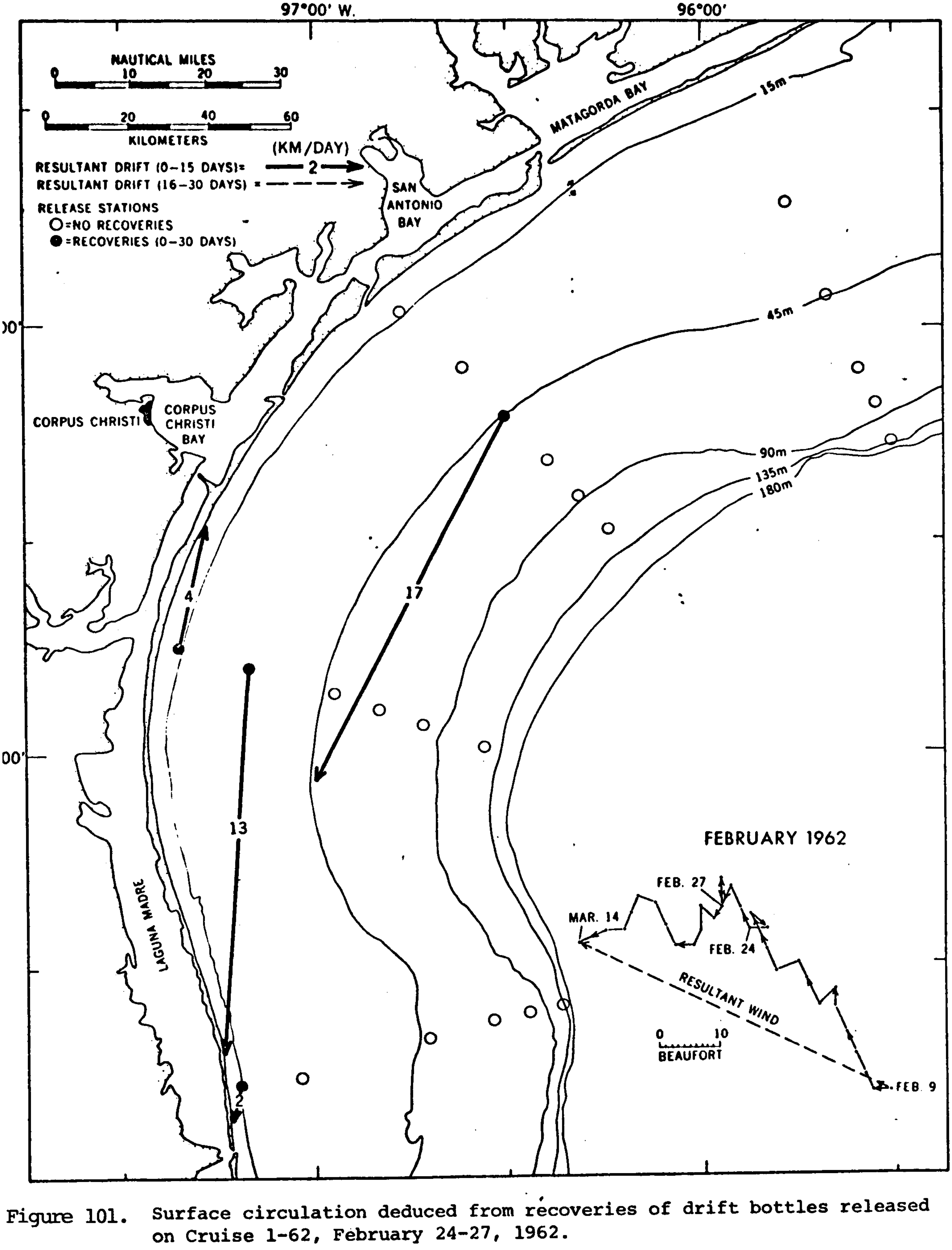


Figure 101. Surface circulation deduced from recoveries of drift bottles released on Cruise 1-62, February 24-27, 1962.

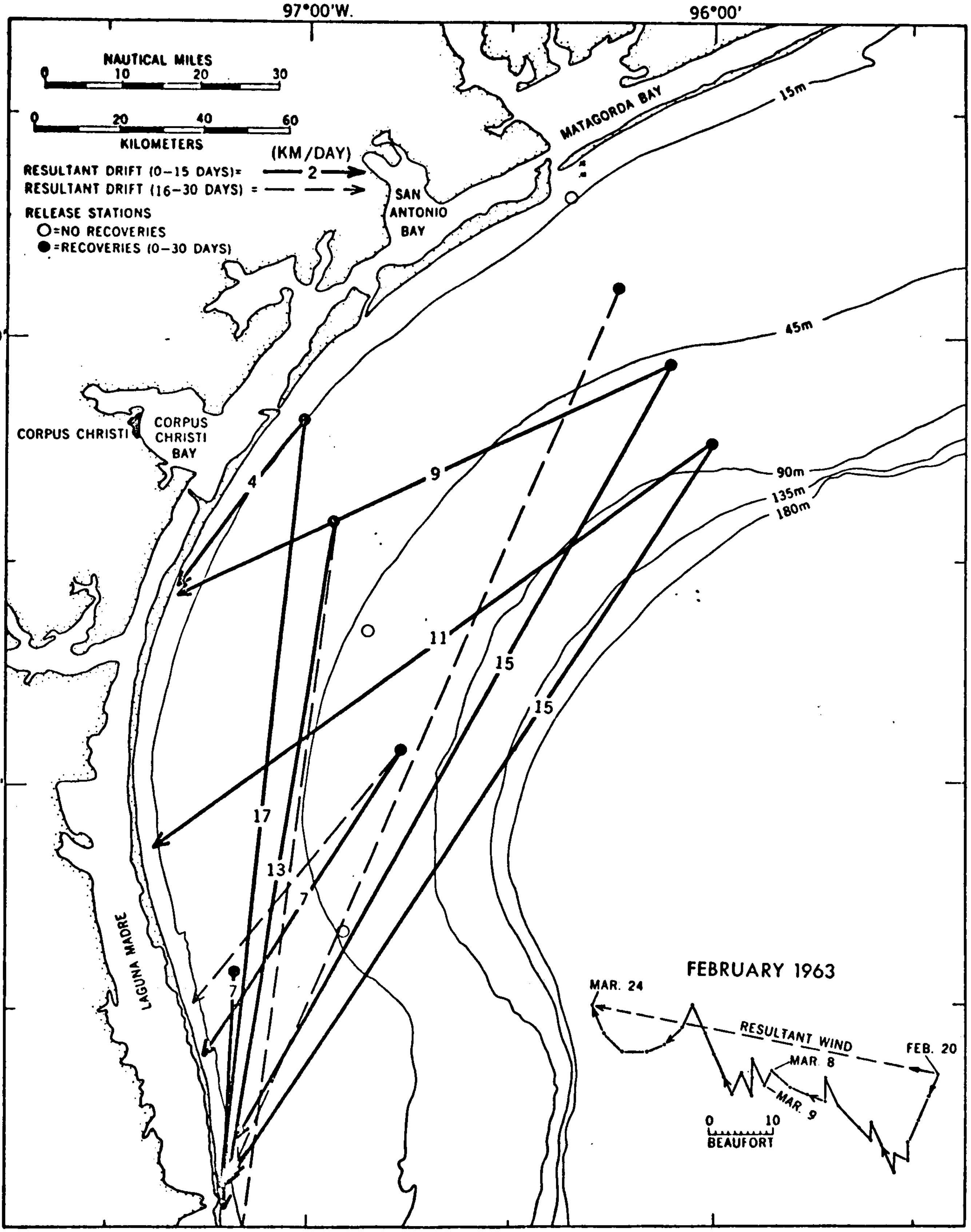


Figure 102. Surface circulation deduced from recoveries of drift bottles released on Cruise 2-63, March 8-9, 1963.

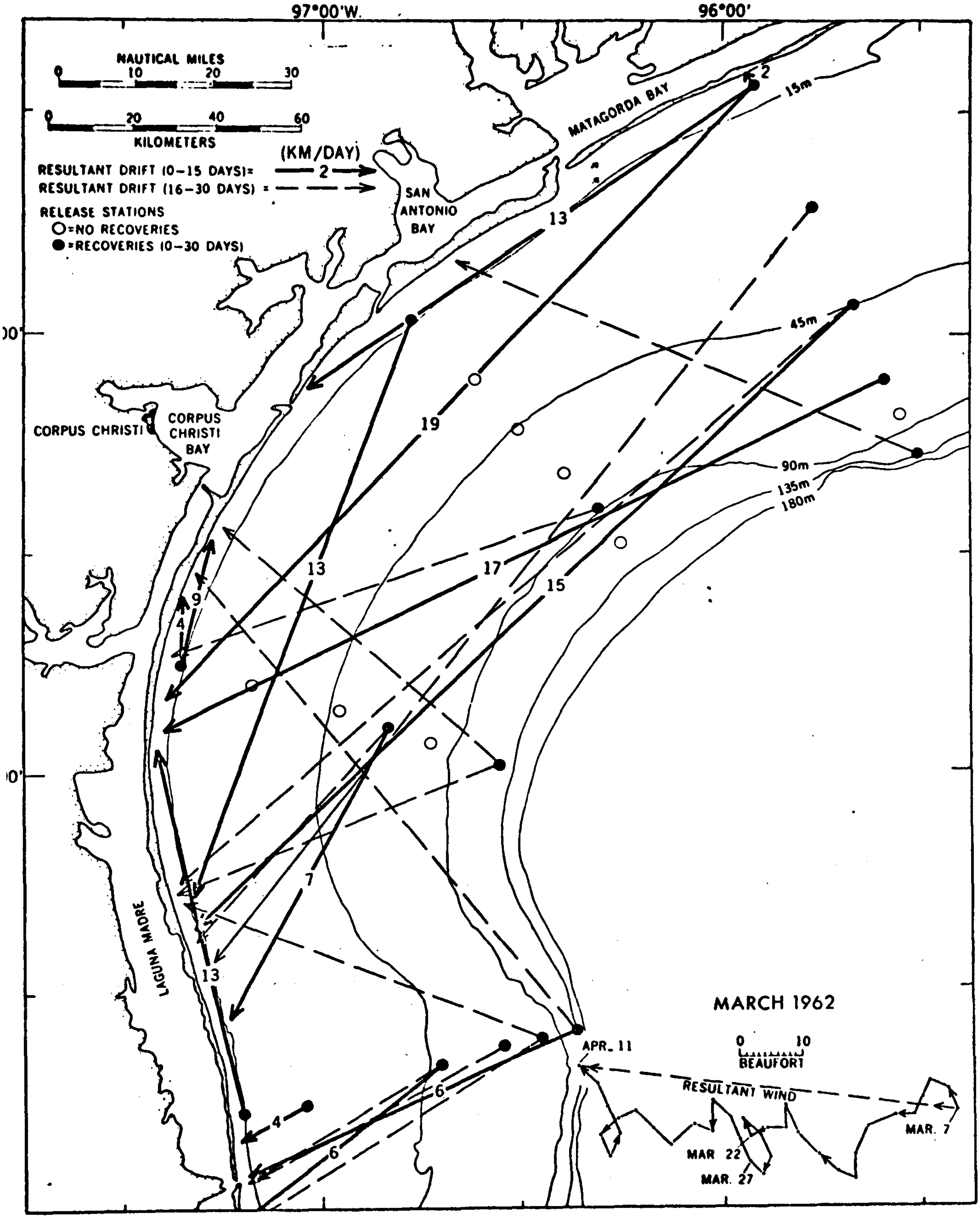


Figure 103. Surface circulation deduced from recoveries of drift bottles released on Cruise 2-62, March 22-27, 1962.

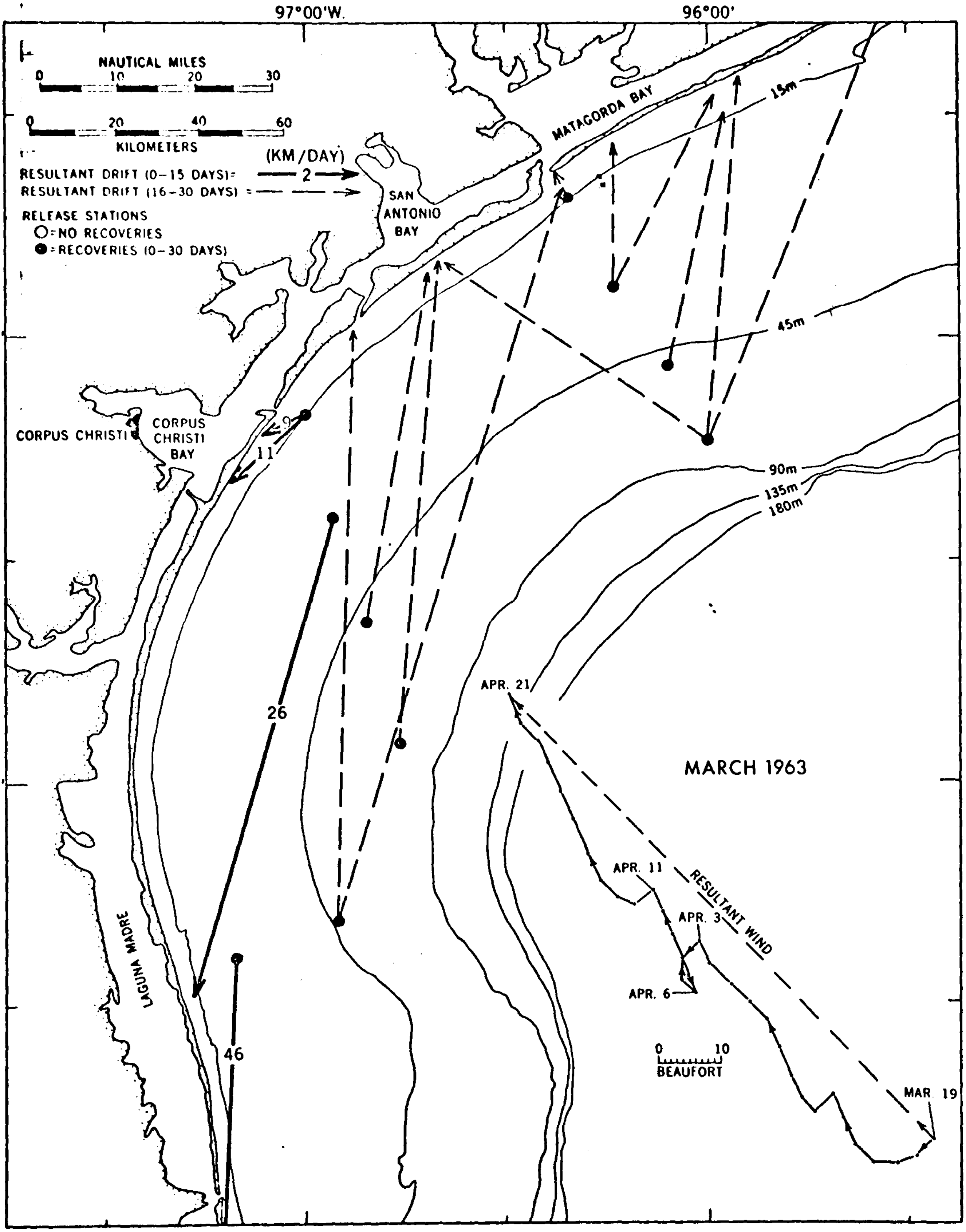


Figure 104. Surface circulation deduced from recoveries of drift bottles released on Cruise 3-63, April 3-6, 1963.

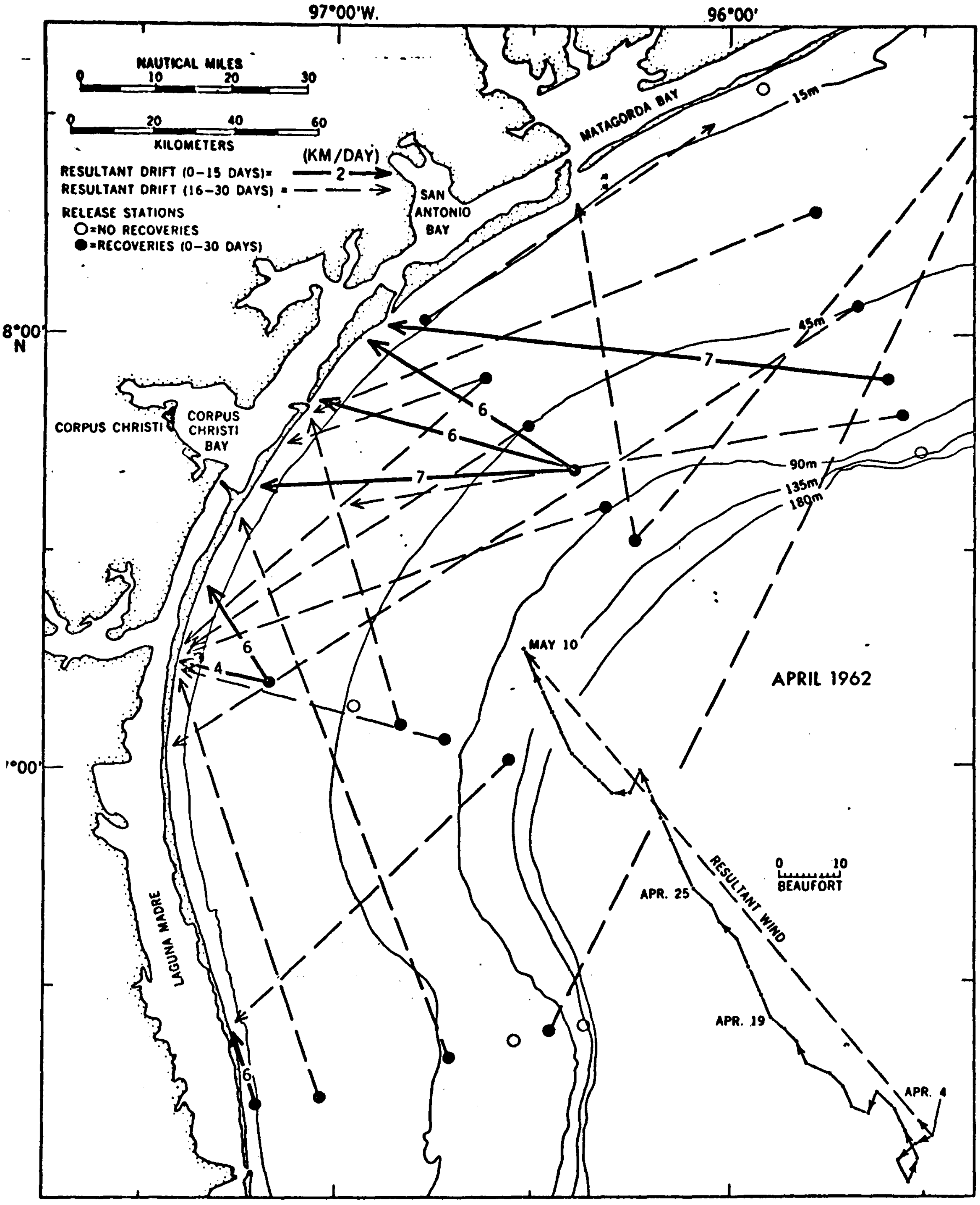


Figure 105. Surface circulation deduced from recoveries of drift bottles released on Cruise 3-62, April 19-26, 1962.

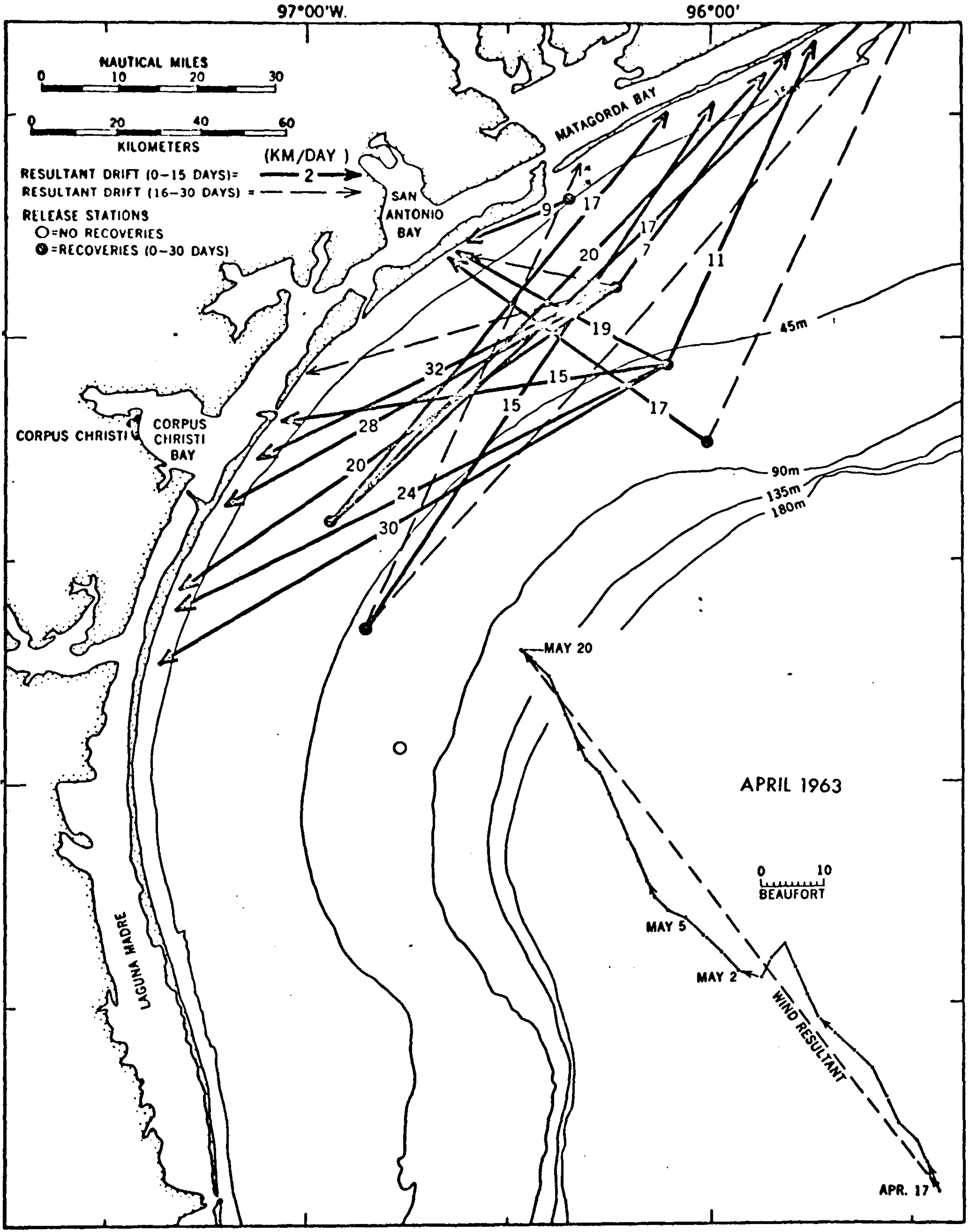


Figure 106. Surface circulation deduced from recoveries of drift bottles released on Cruise 4-63, May 2-5, 1963.

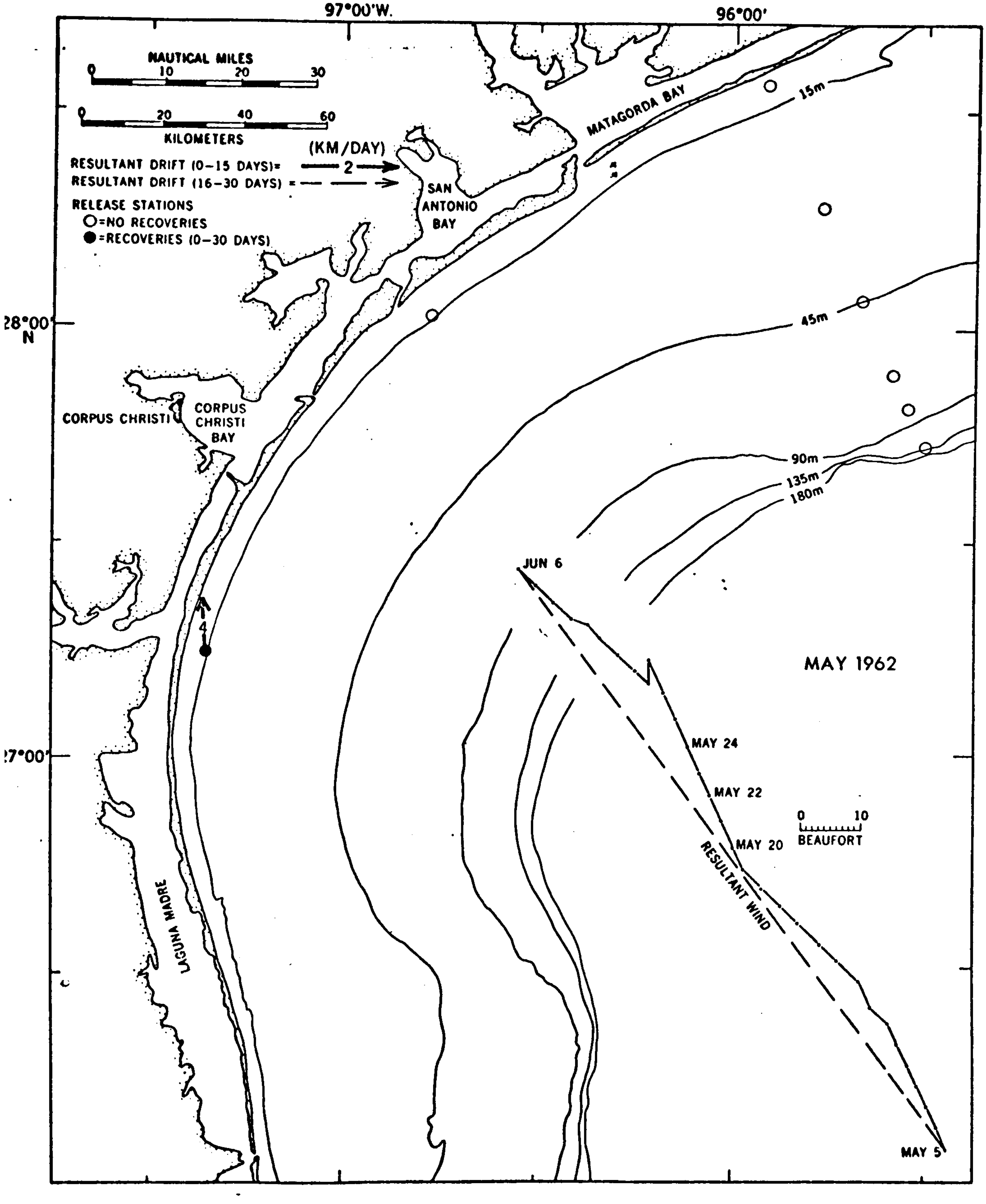


Figure 107. Surface circulation deduced from recoveries of drift bottles released on Cruise 4-62, May 20-22, 1962.

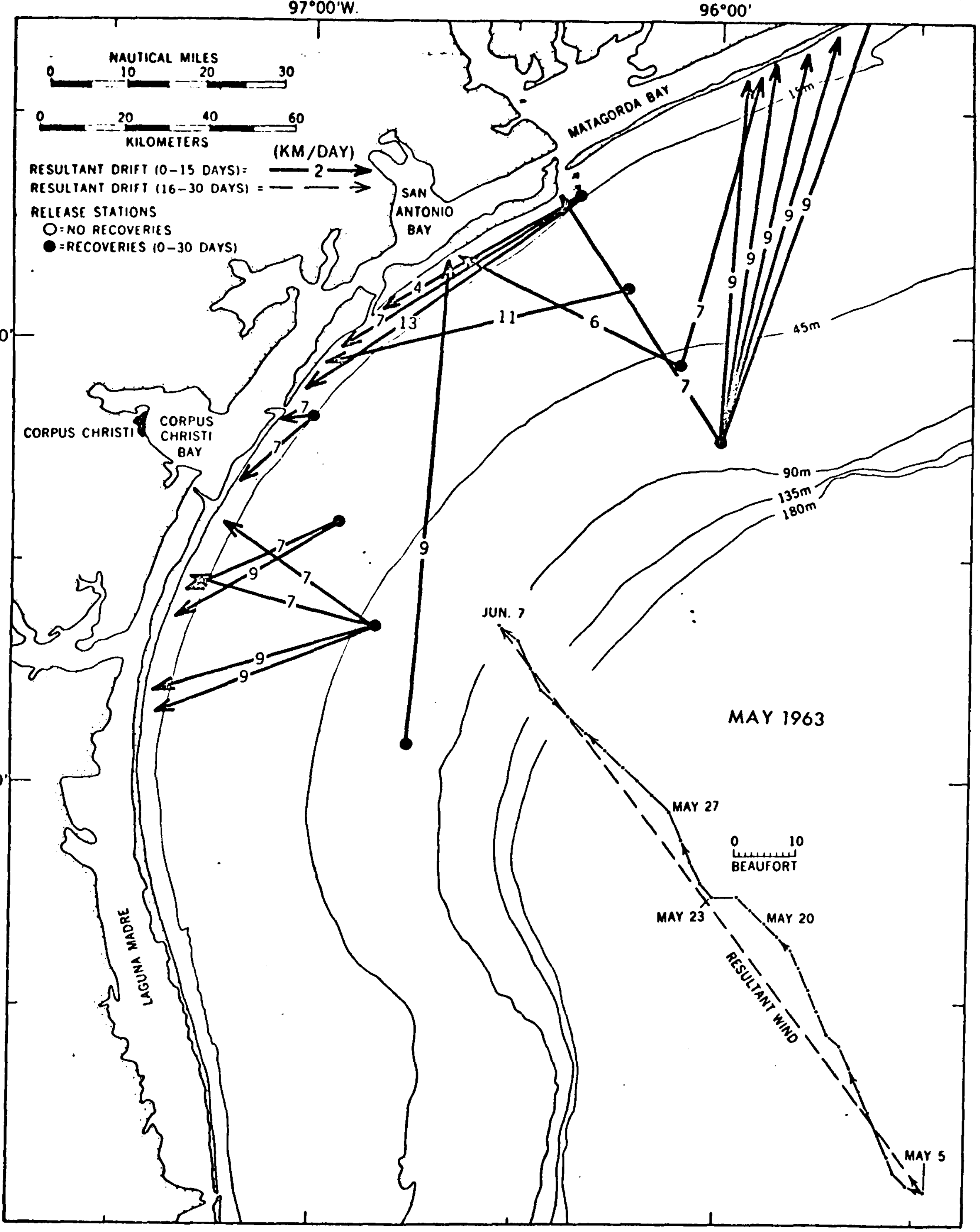


Figure 108. Surface circulation deduced from recoveries of drift bottles released on Cruise 5-63, May 20-23, 1963.

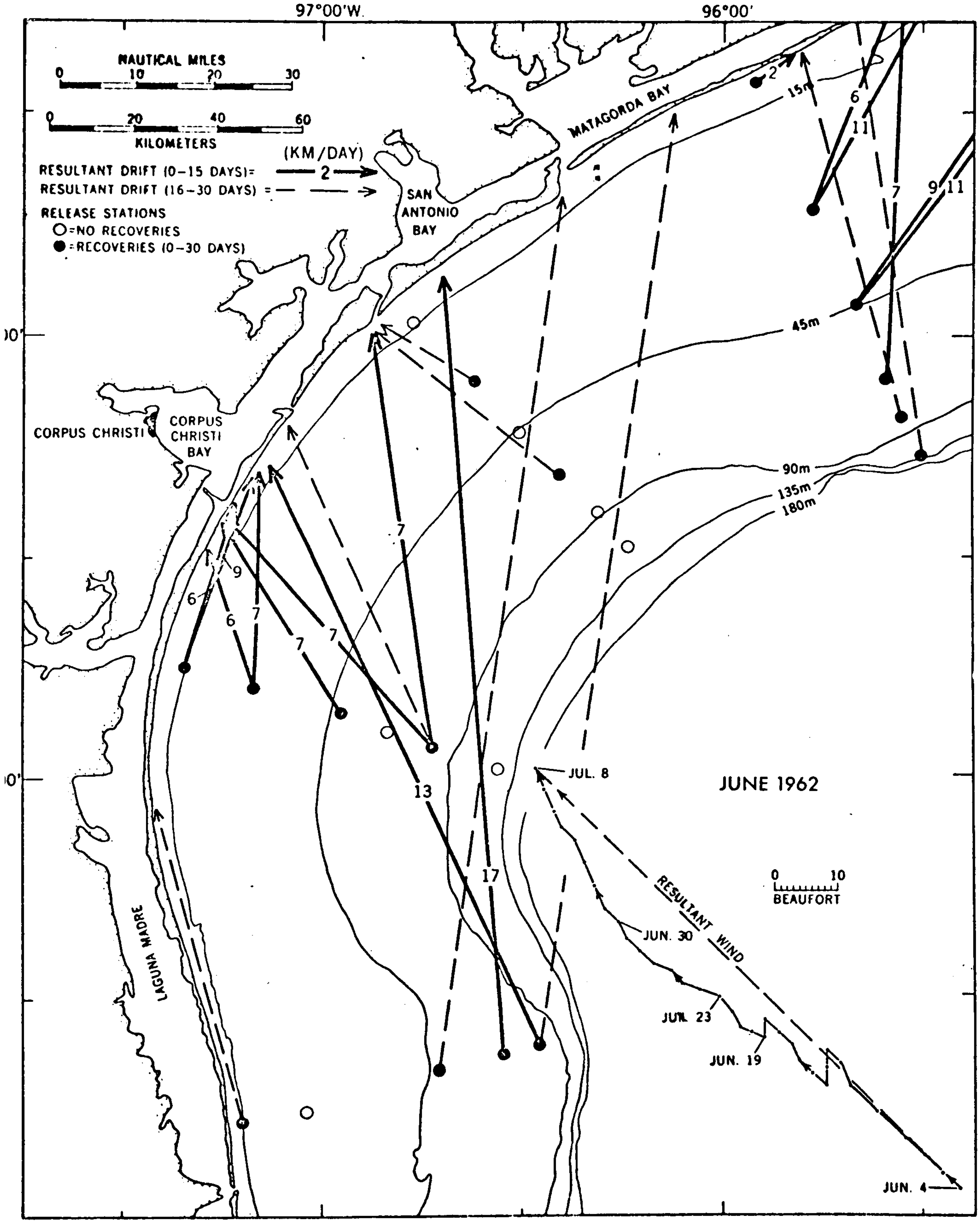


Figure 109. Surface circulation deduced from recoveries of drift bottles released on Cruise 5-62, June 19-23, 1962.

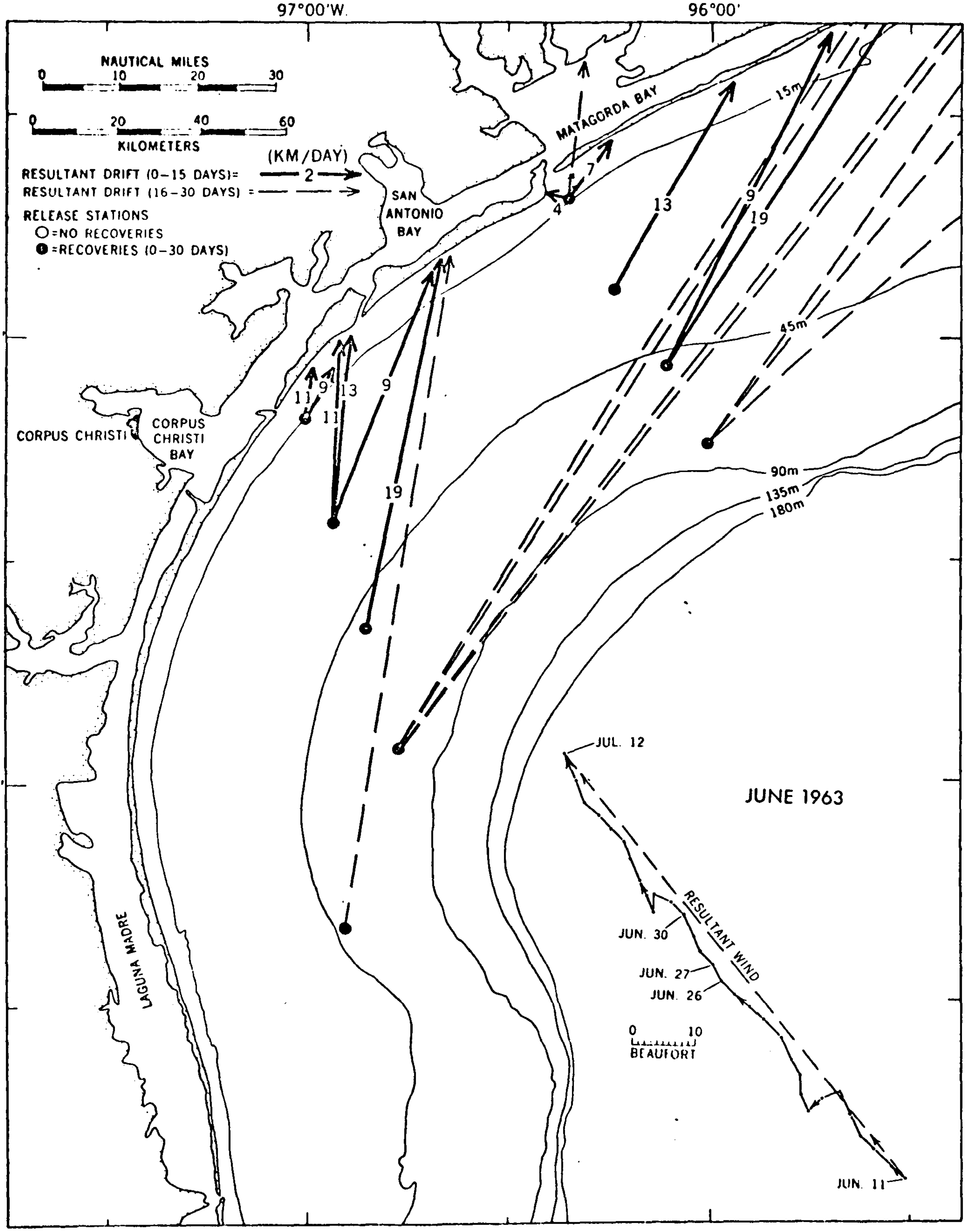


Figure 110. Surface circulation deduced from recoveries of drift bottles released on Cruise 6-63, June 26-27, 1963.

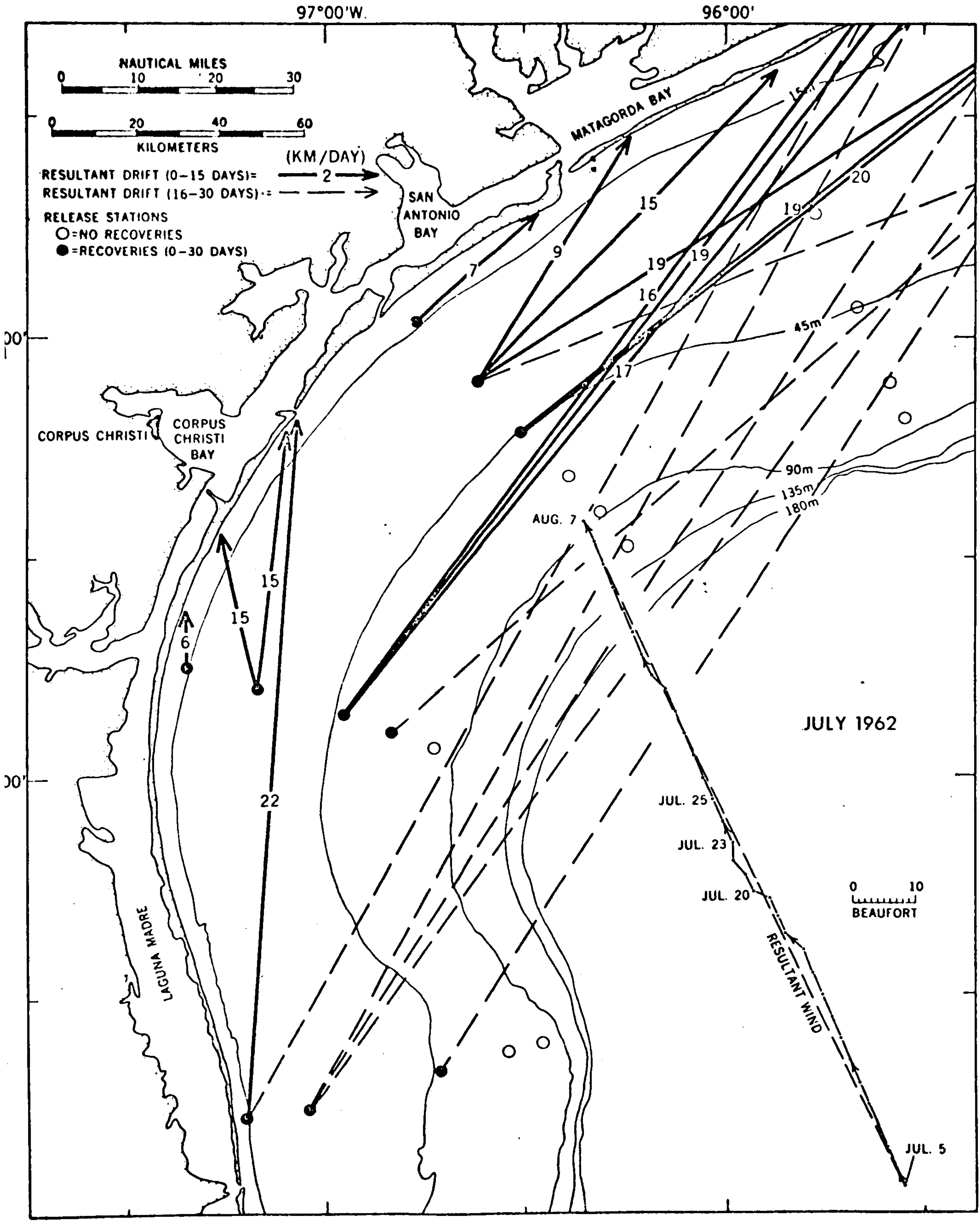


Figure 111. Surface circulation deduced from recoveries of drift bottles released on Cruise 6-62, July 20-23, 1962.

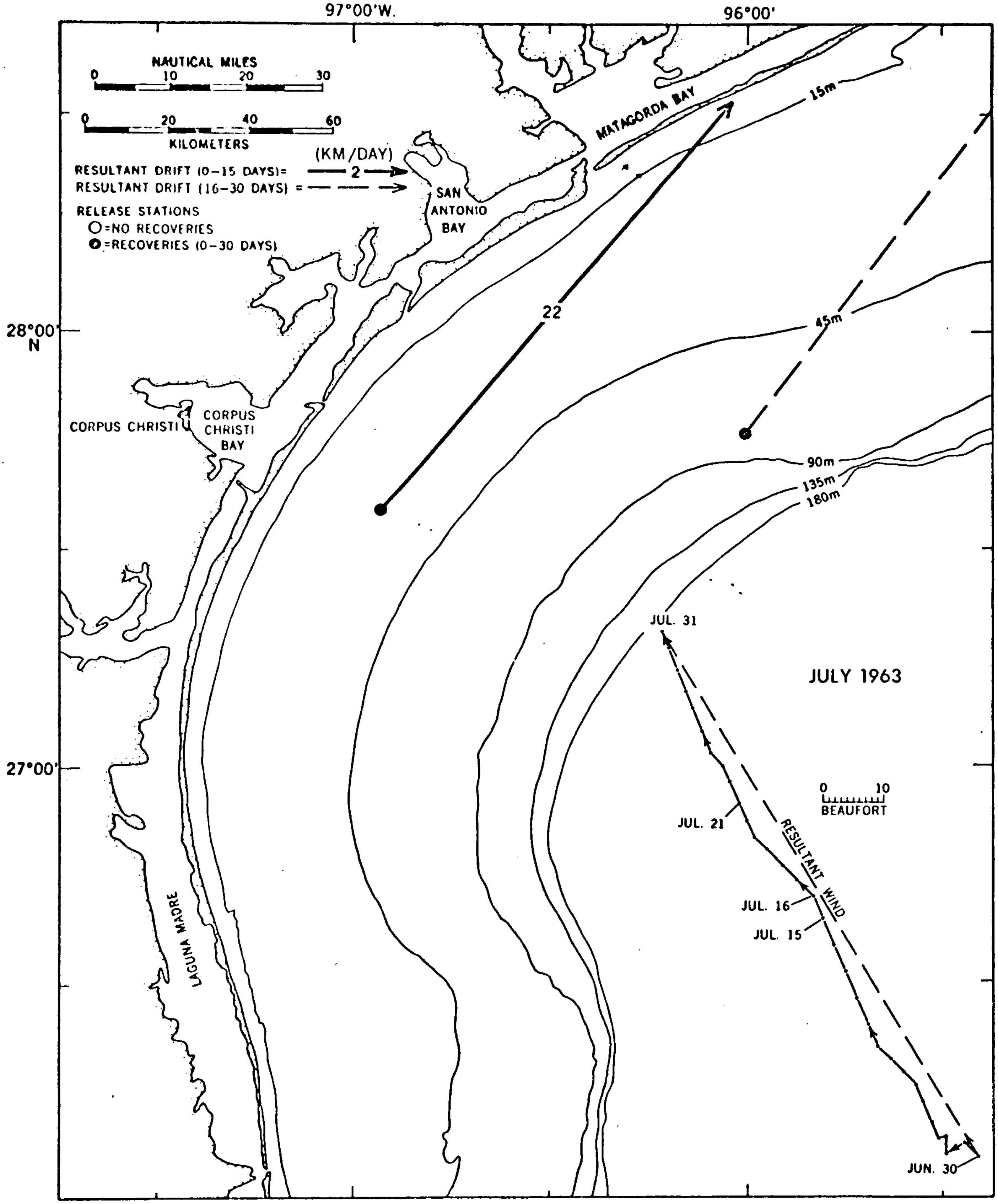


Figure 112. Surface circulation deduced from recoveries of drift bottles released on Cruise 7-63, July 15-16, 1963.

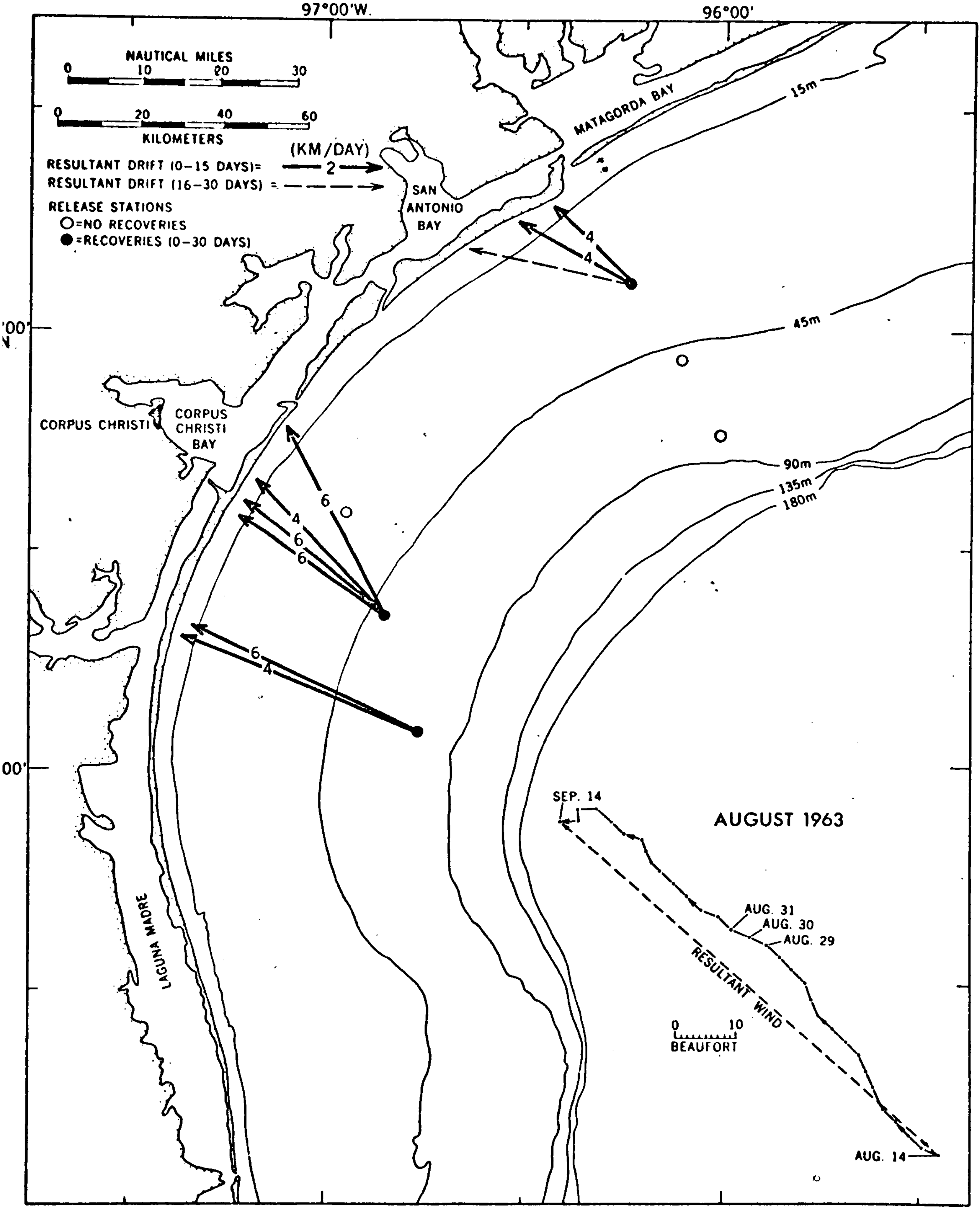


Figure 113. Surface circulation deduced from recoveries of drift bottles released on Cruise 8-63, August 29-30, 1963.

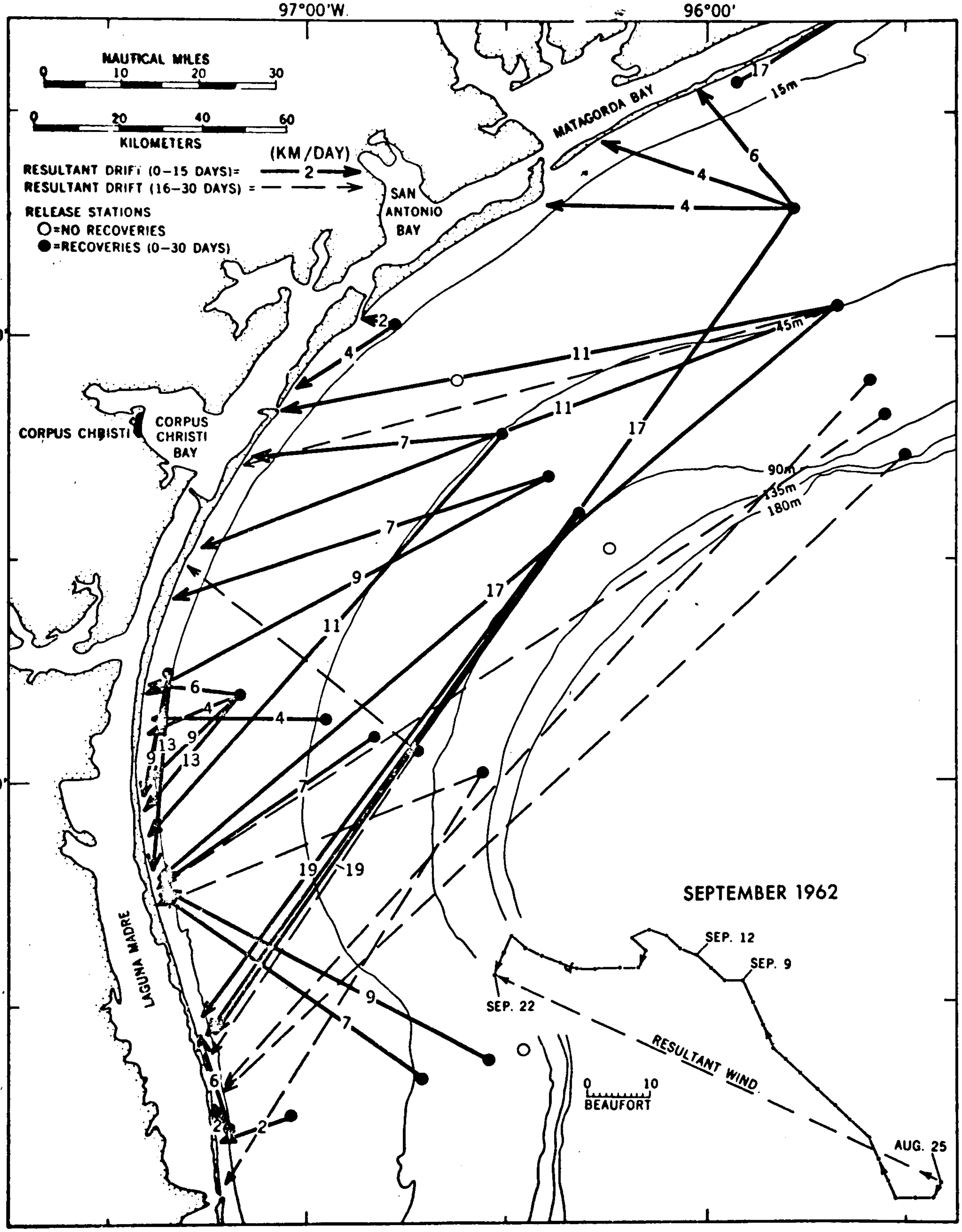


Figure 114. Surface circulation deduced from recoveries of drift bottles released on Cruise 7-62, September 9-12, 1962.

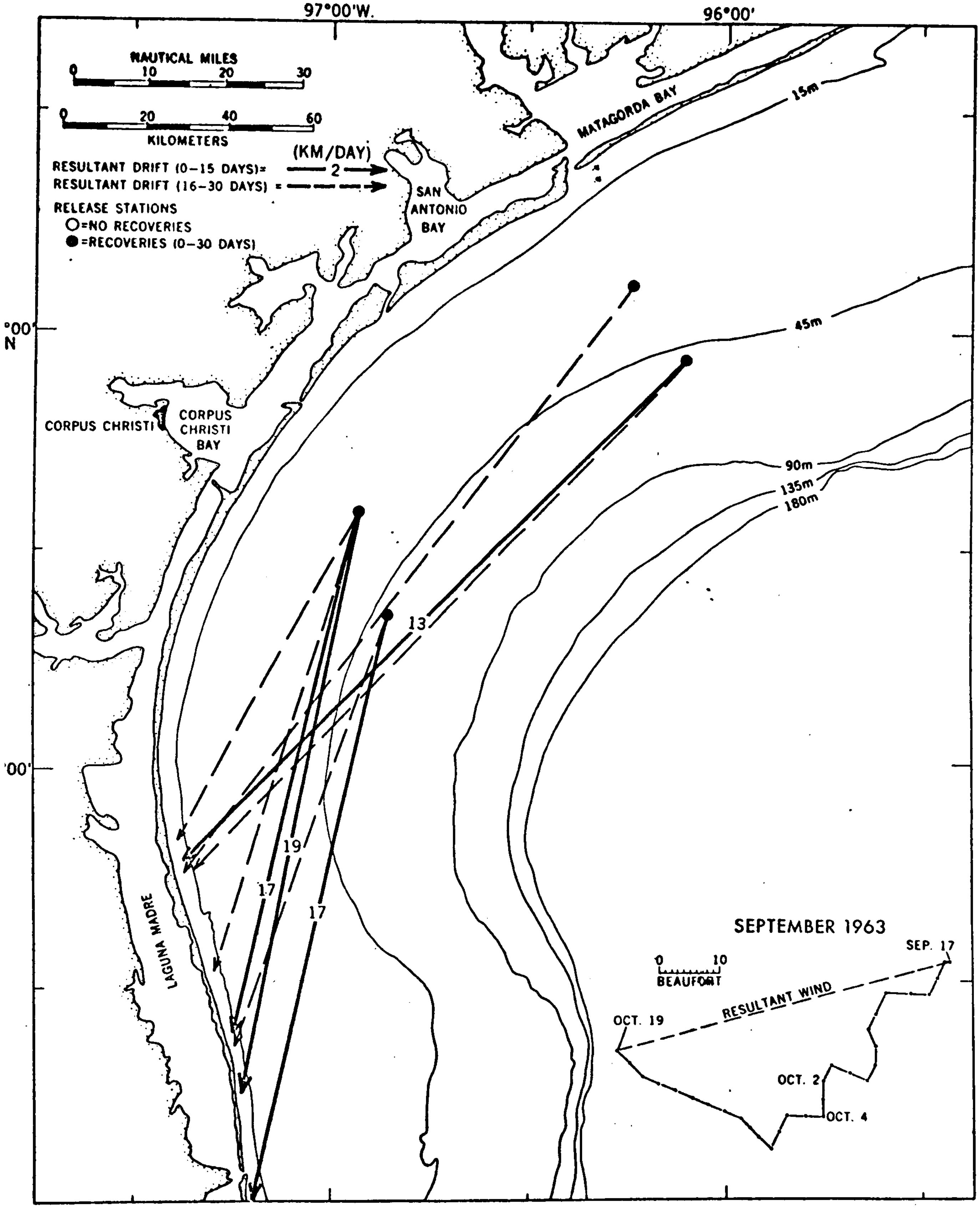


Figure 115. Surface circulation deduced from recoveries of drift bottles released on Cruise 9-63, October 2-4, 1963.

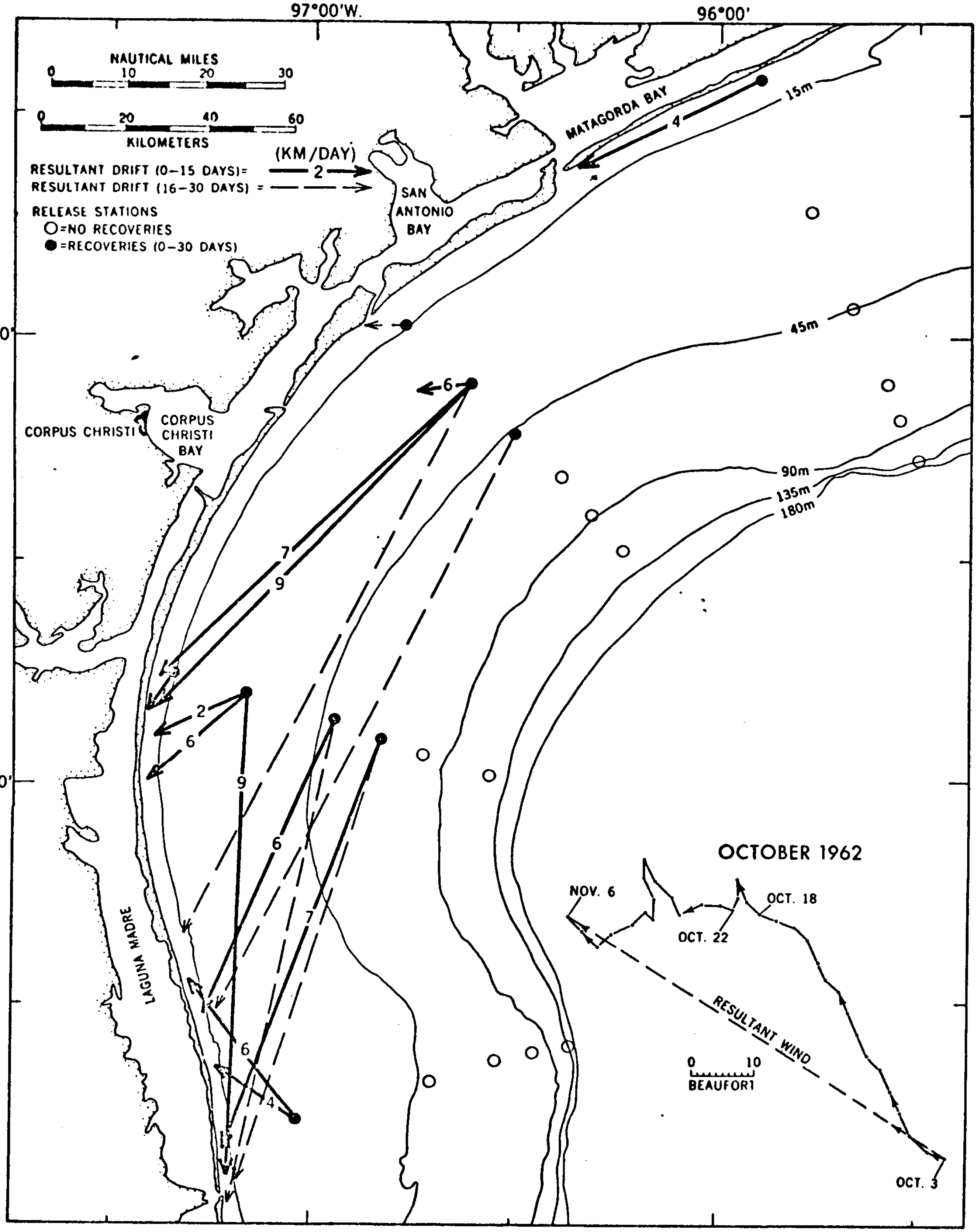


Figure 116. Surface circulation deduced from recoveries of drift bottles released on Cruise 8-62, October 18-22, 1962.

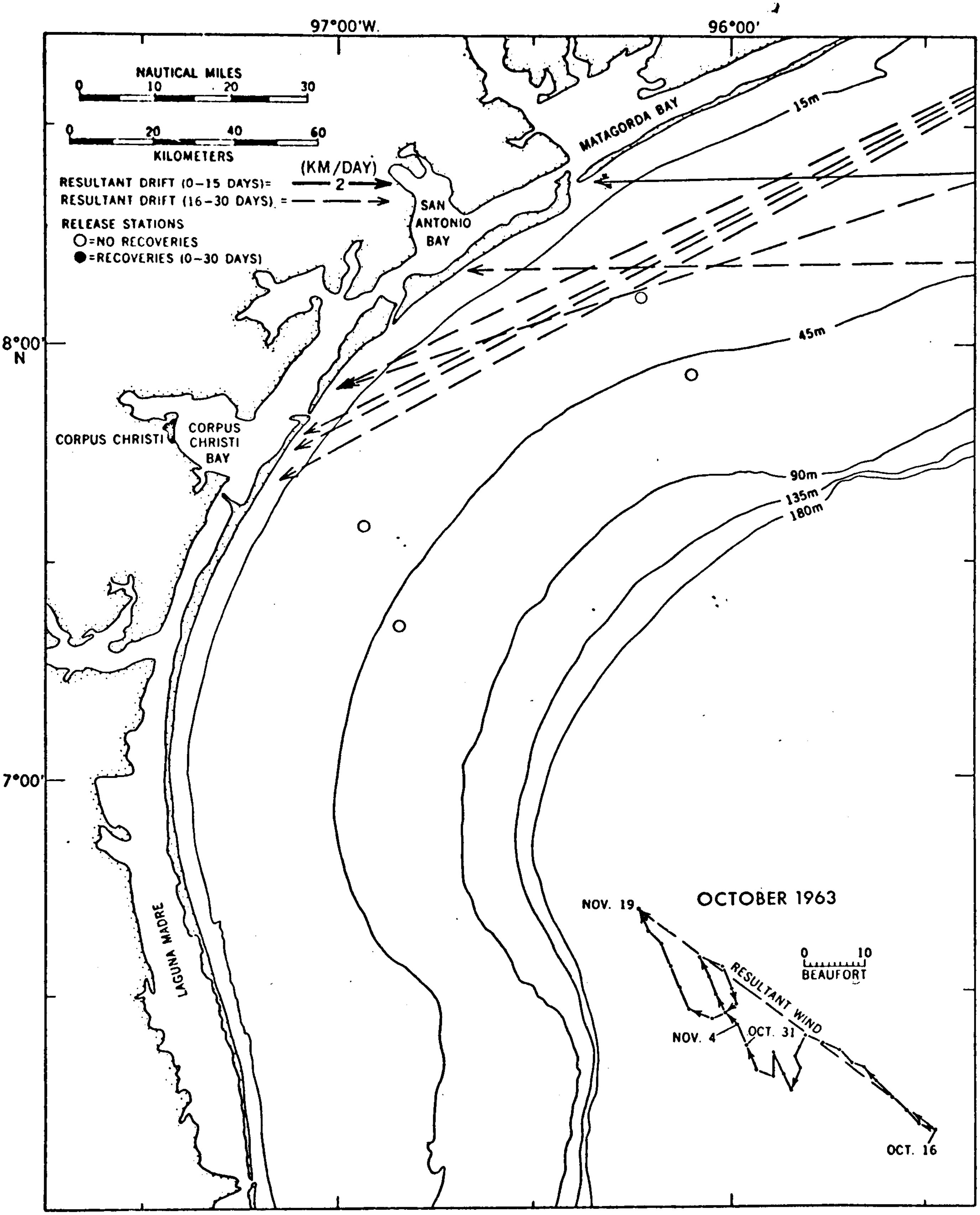


Figure 117. Surface circulation deduced from recoveries of drift bottles released on Cruise 10-63, October 31-November 4, 1963.

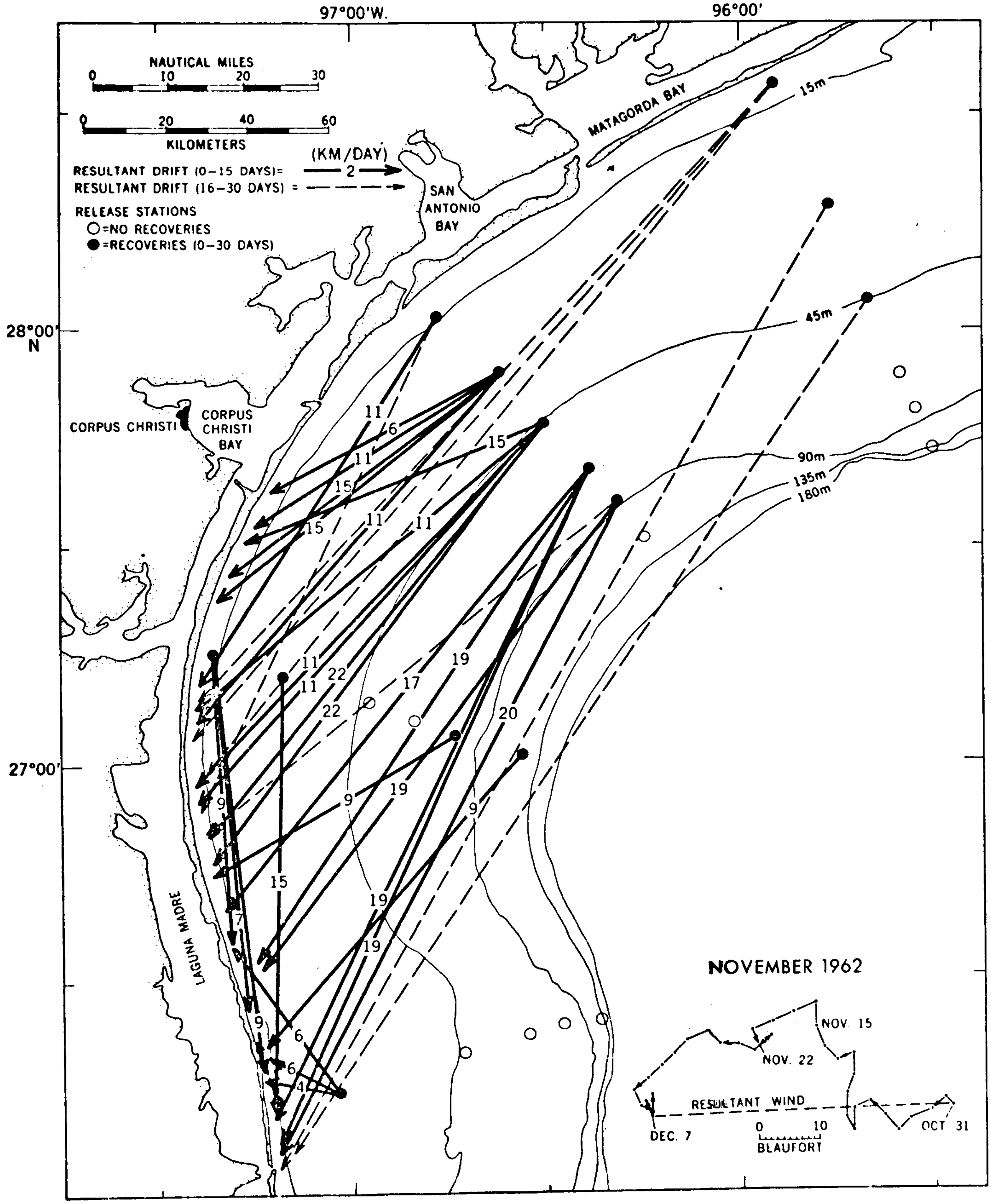


Figure 118. Surface circulation deduced from recoveries of drift bottles released on Cruise 9-62, November 15-22, 1962.

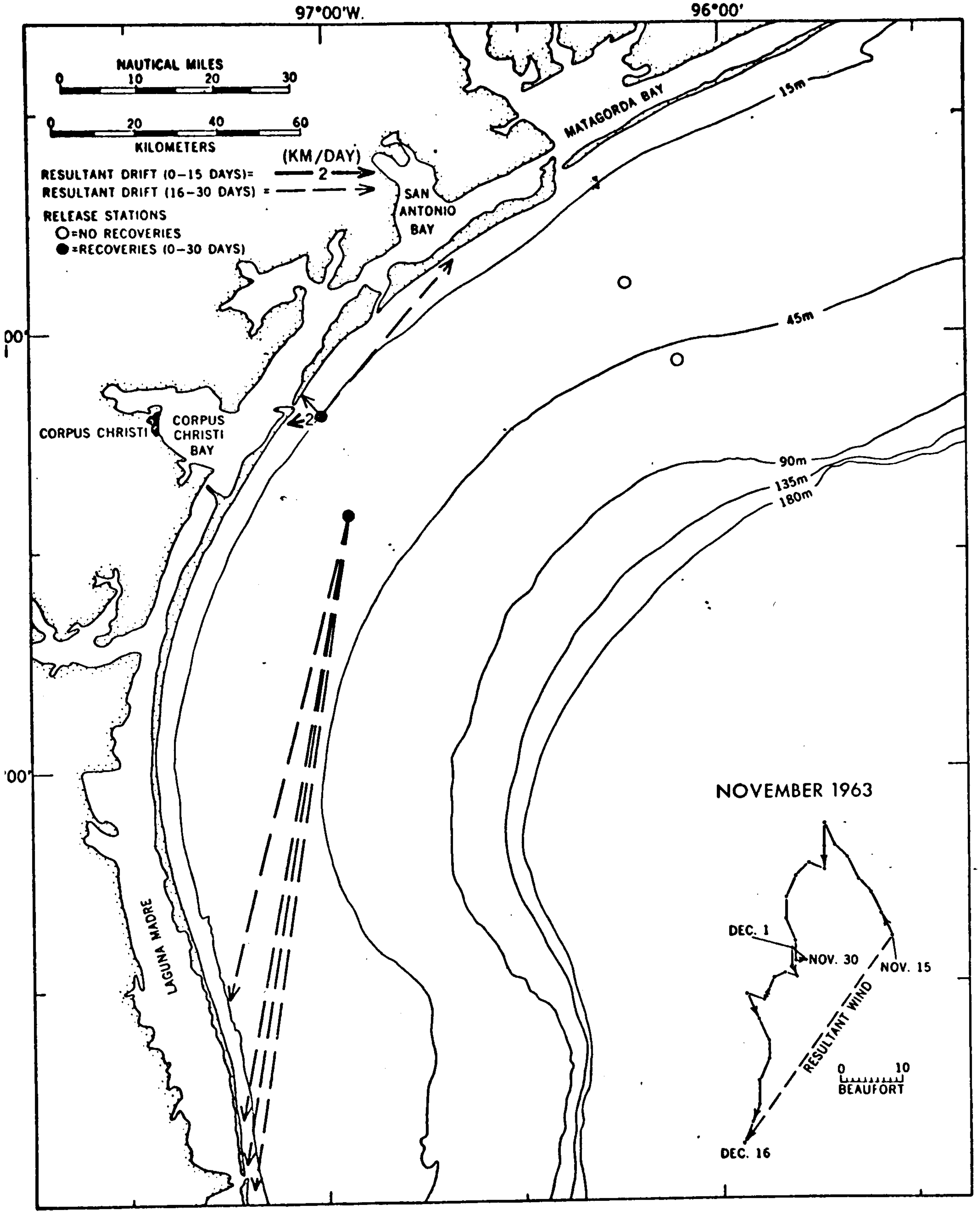


Figure 119. Surface circulation deduced from recoveries of drift bottles released on Cruise 11-63, November 30-December 1, 1963.

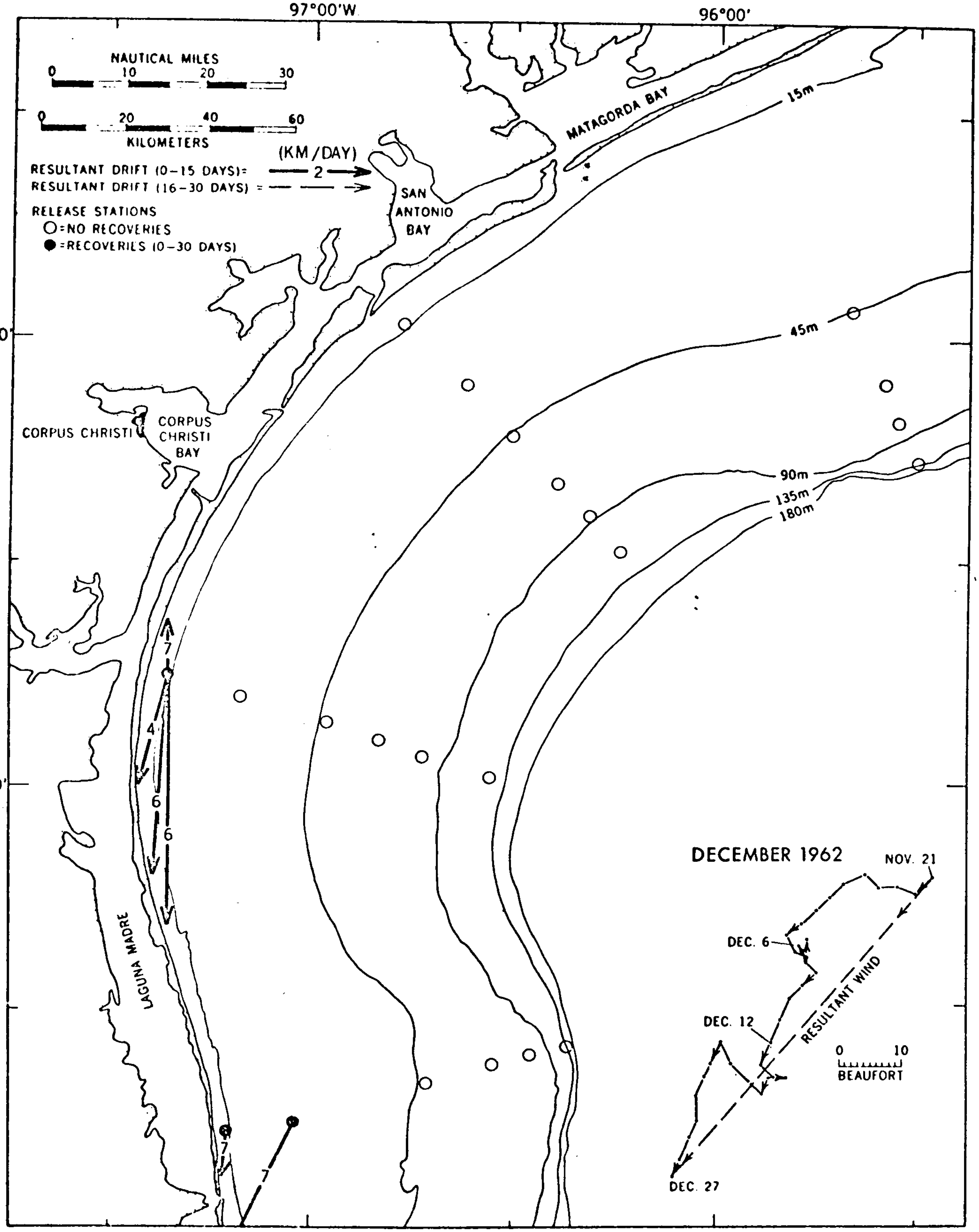


Figure 120. Surface circulation deduced from recoveries of drift bottles released on Cruise 10-62, December 6-12, 1962.

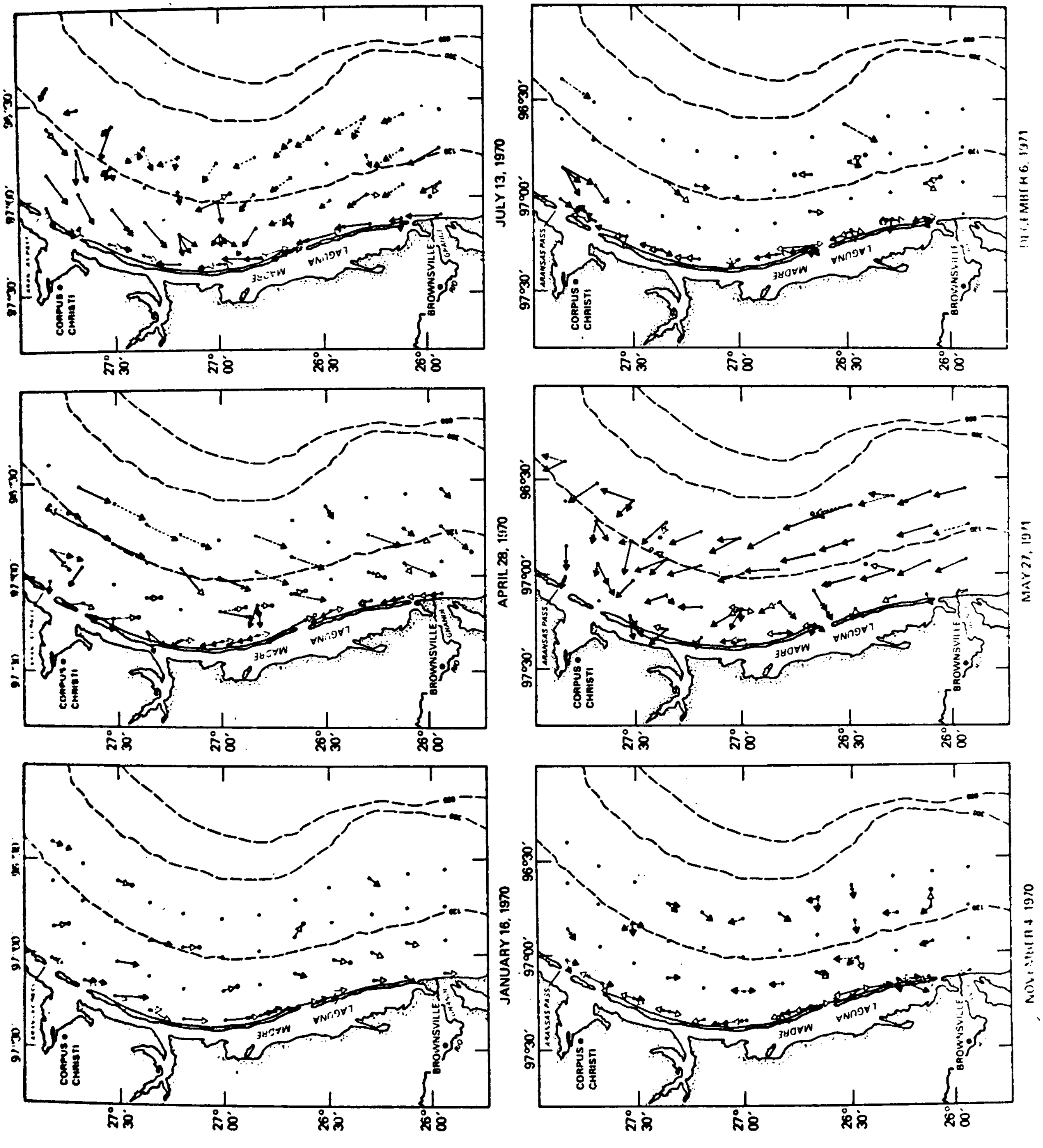


Figure 121. Drifter results of seasonal studies along the South Texas coast (after Hunter, Hill, and Garrison, 1974).

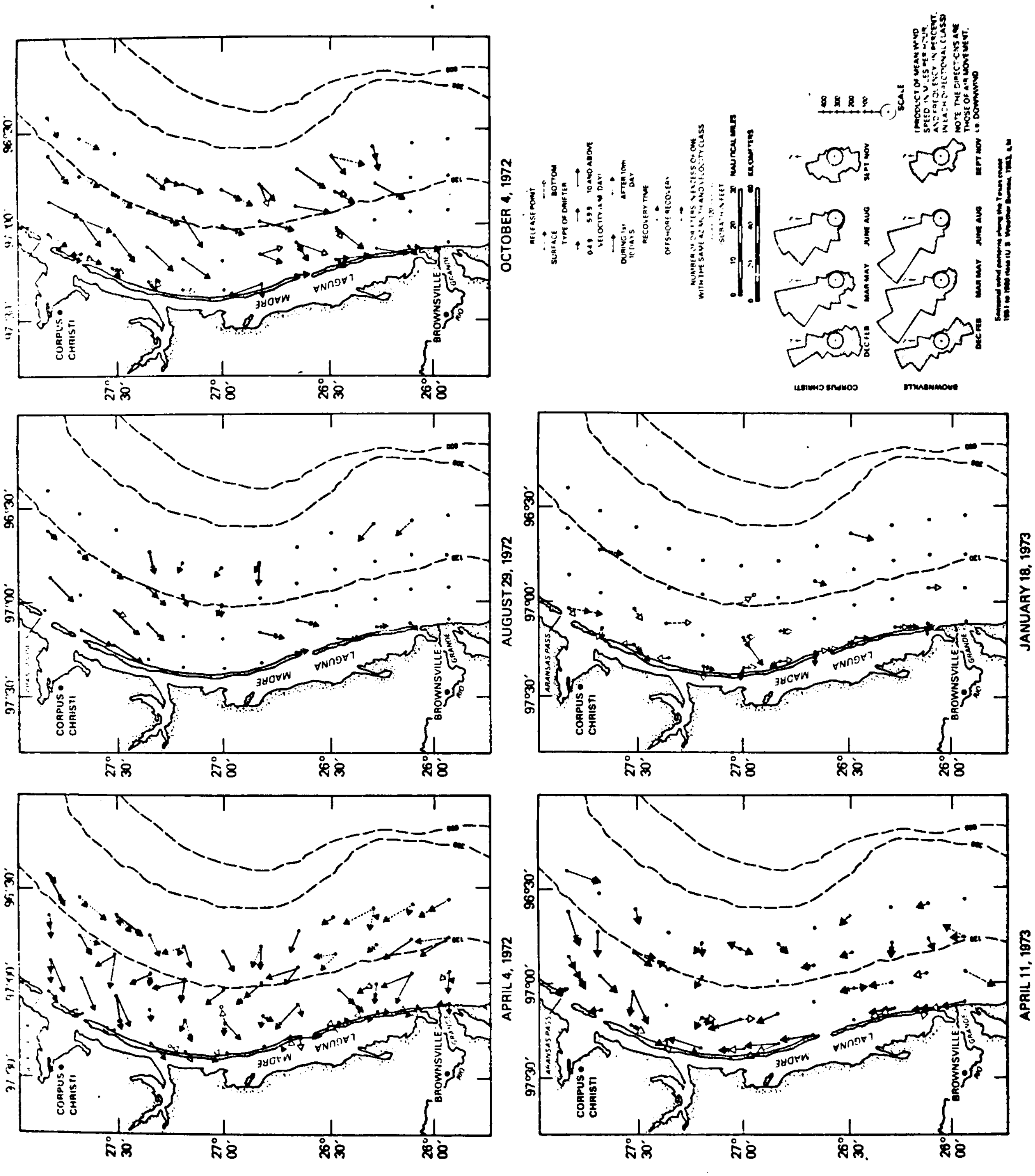
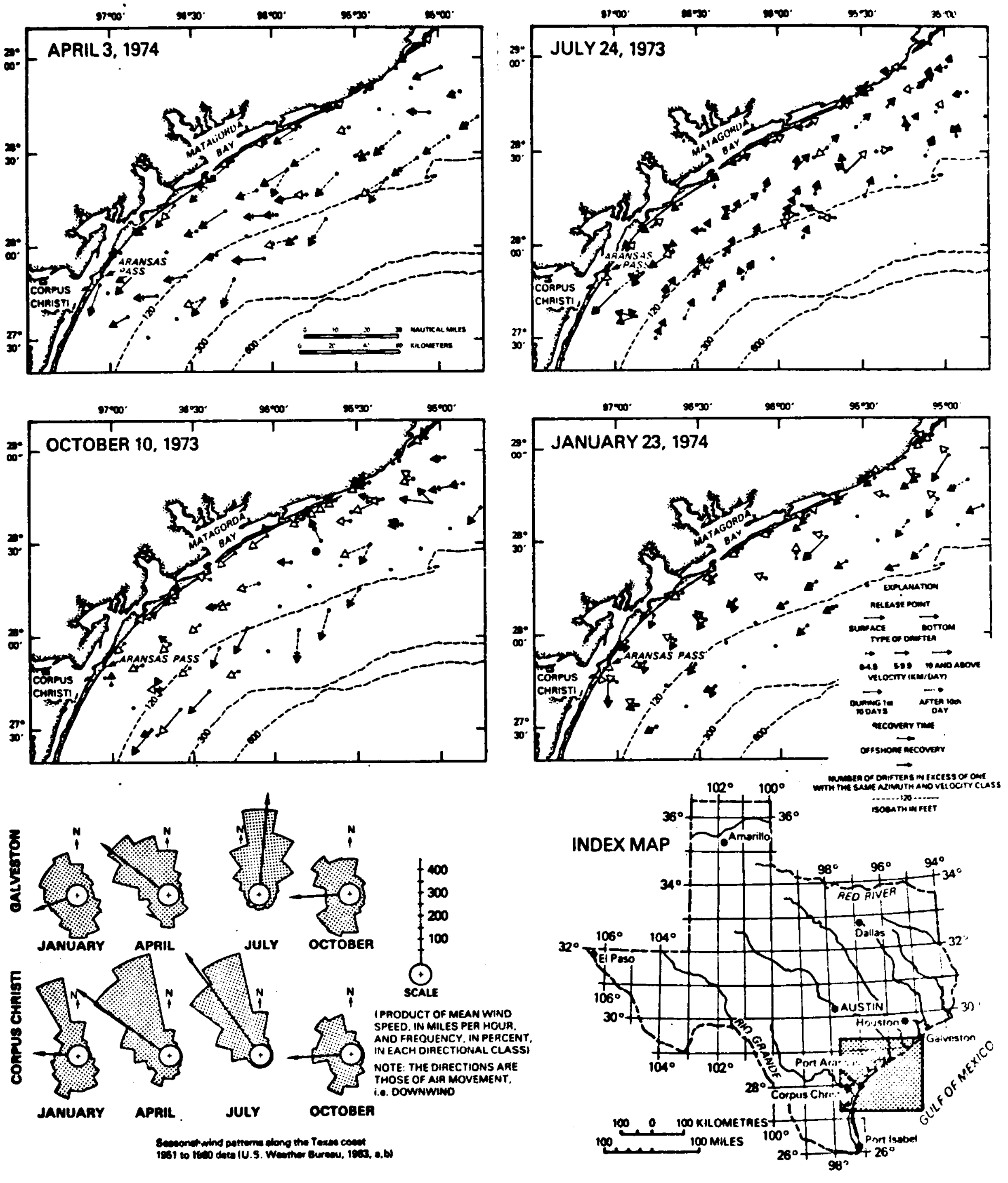


Figure 122. Drifter results of seasonal studies along the South Texas coast (after Hunter, Hill, and Garrison, 1974).



Seasonal wind patterns along the Texas coast
1951 to 1960 data (U.S. Weather Bureau, 1963, a,b)

Figure 123. Drifter results of seasonal studies along the north central Texas coast (after Hill, Garrison, and Hunter, 1975).

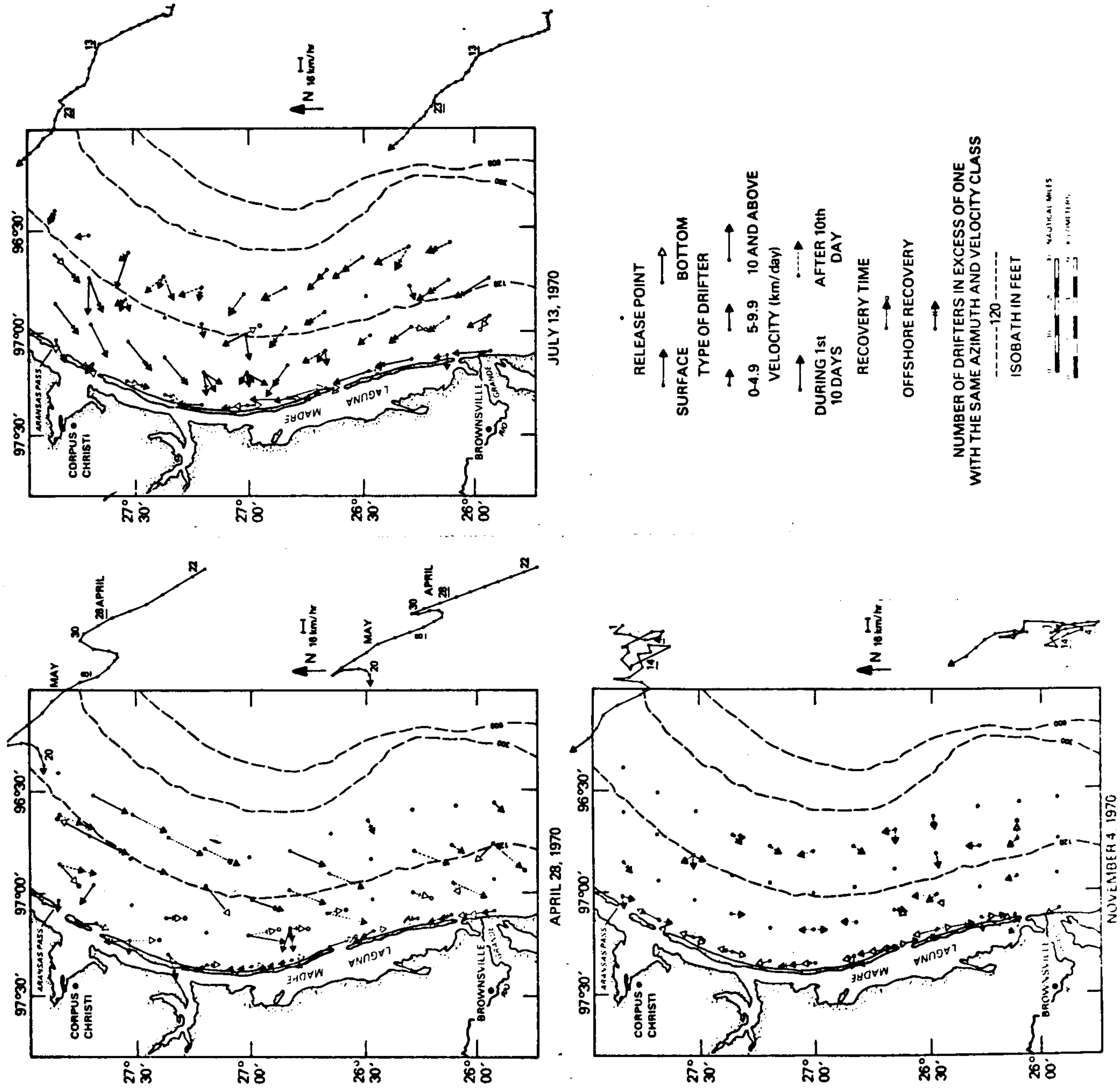
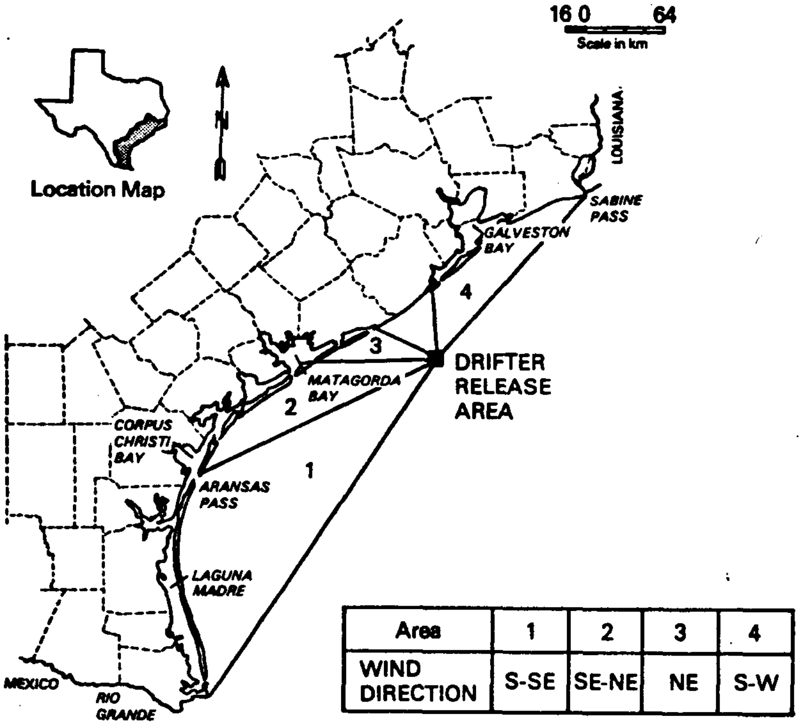


Figure 124. Drifter results with daily wind vectors from Brownsville and Corpus Christi for the South Texas coast.



Area	1	2	3	4
WIND DIRECTION	S-SE	SE-NE	NE	S-W

Figure 125. Drifter release area and recovery areas for the SEADOCK program.

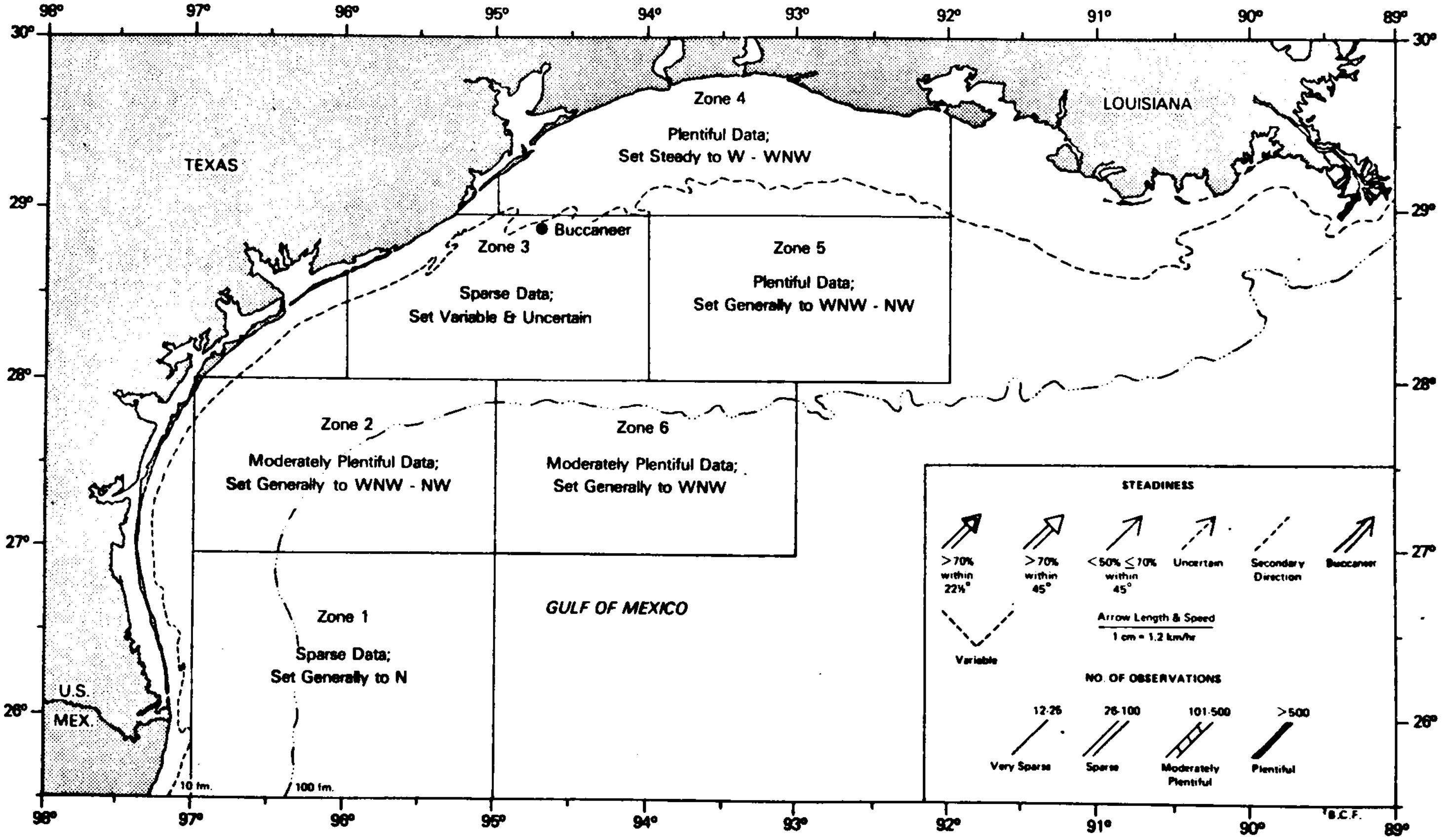


FIGURE 126. OBSERVATION ZONES AND LOCATION OF BUCCANEER STATION WITH DATA AMOUNT AND GENERAL CURRENT CHARACTERISTICS.

JANUARY

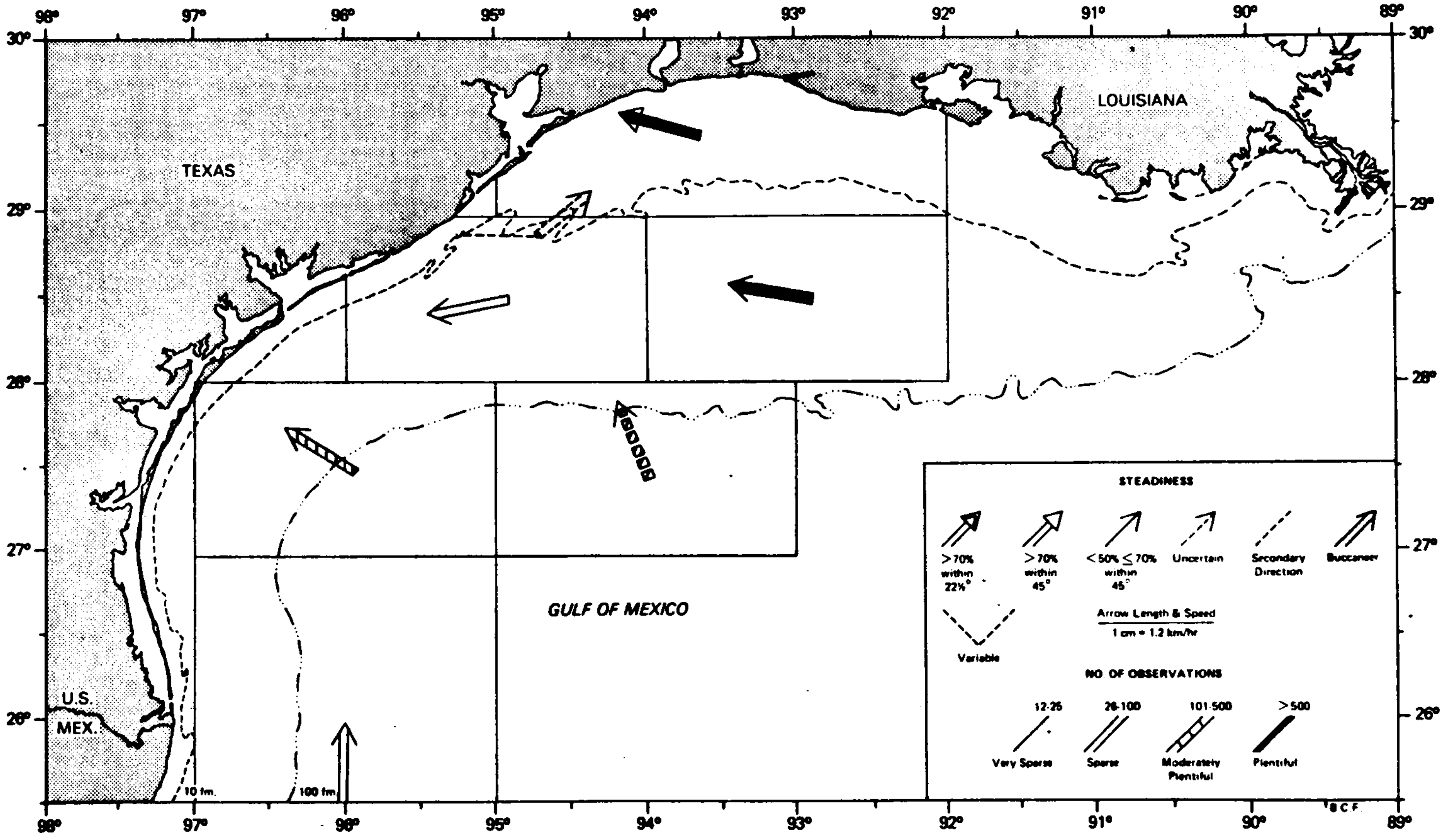


FIGURE 127. SHIP DRIFT AND BUCCANEER SET.

FEBRUARY

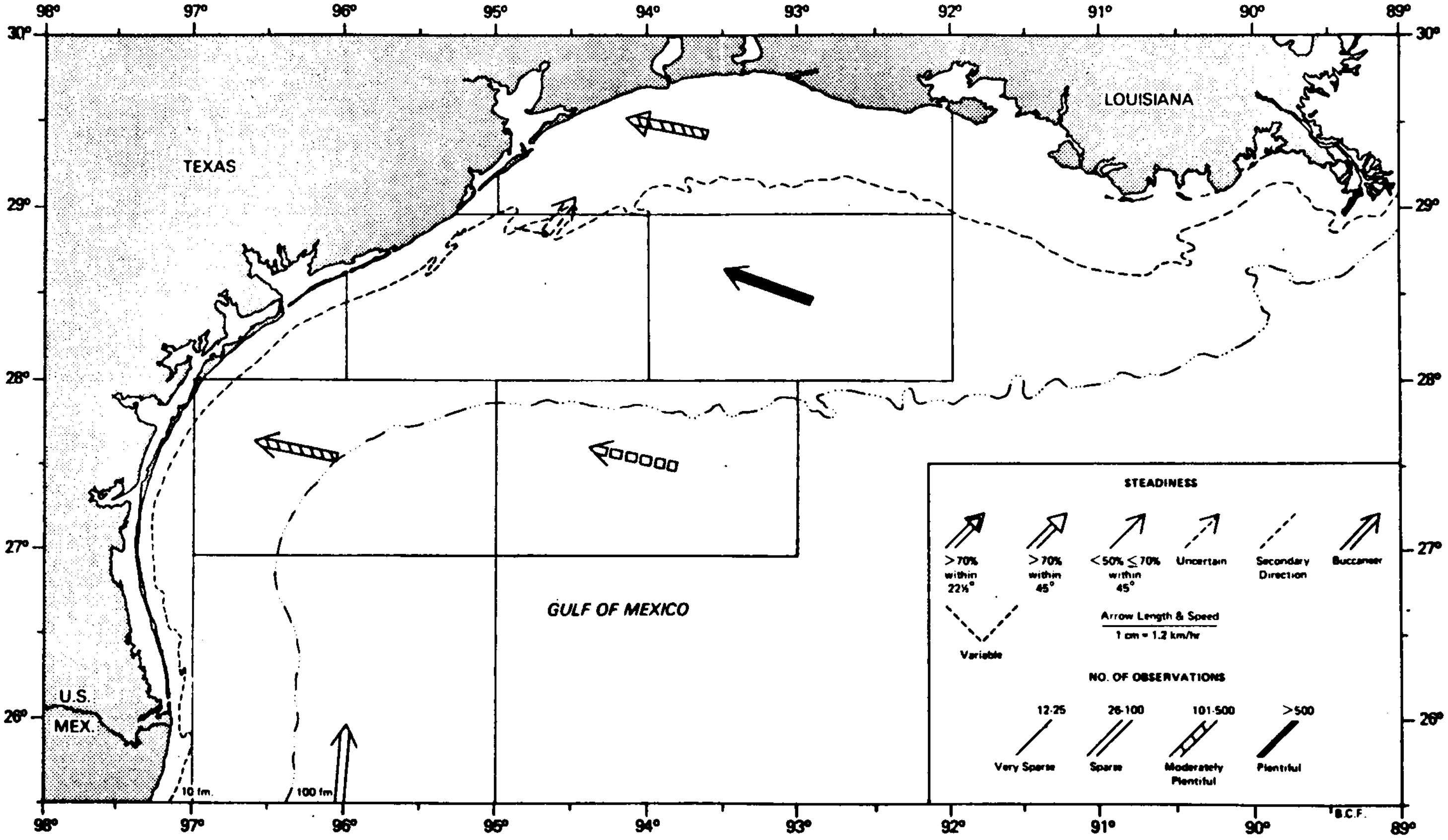


FIGURE 128. SHIP DRIFT AND BUCCANEER SET.

MARCH

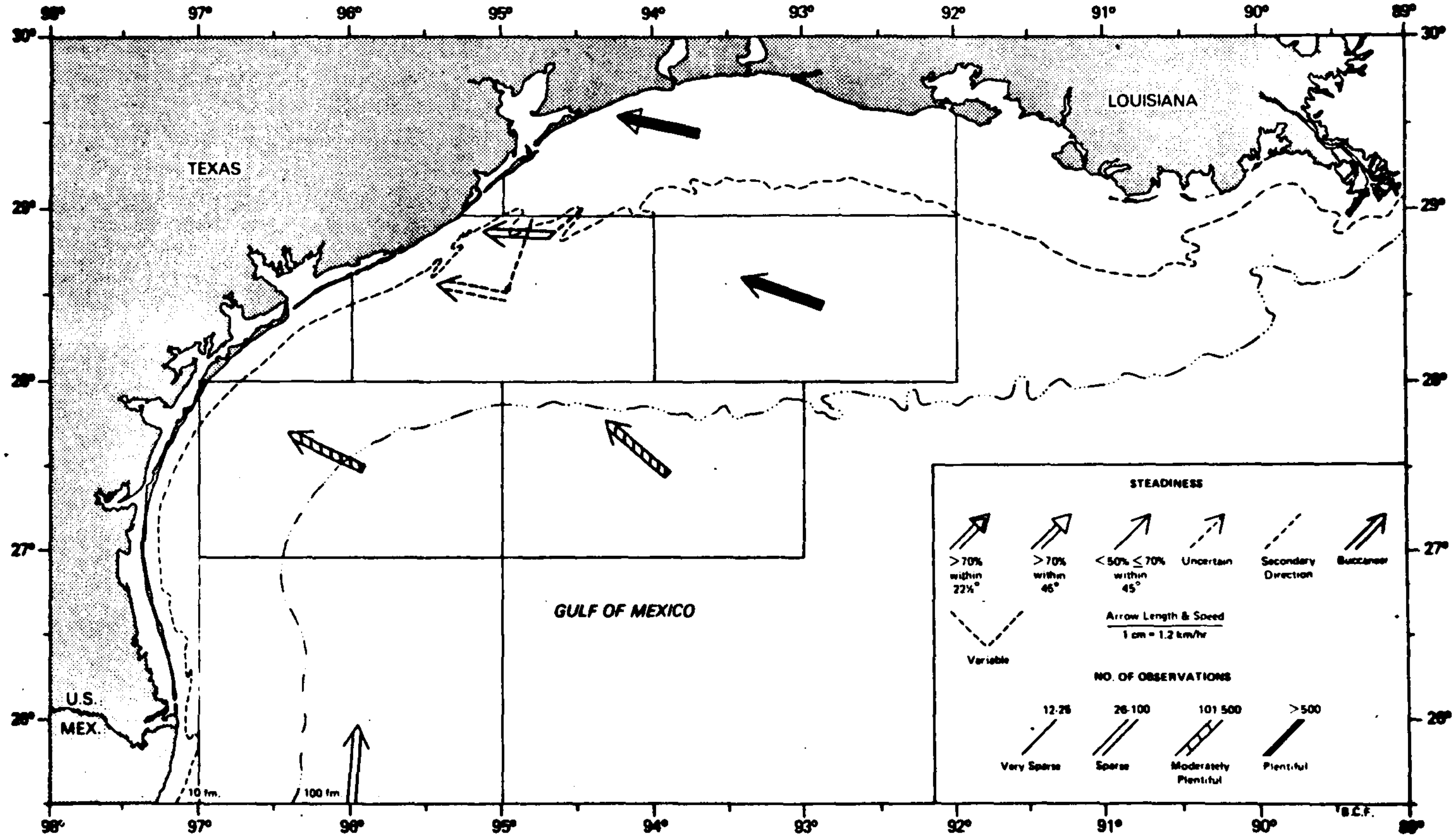


FIGURE 129. SHIP DRIFT AND BUCCANEER SET.

APRIL

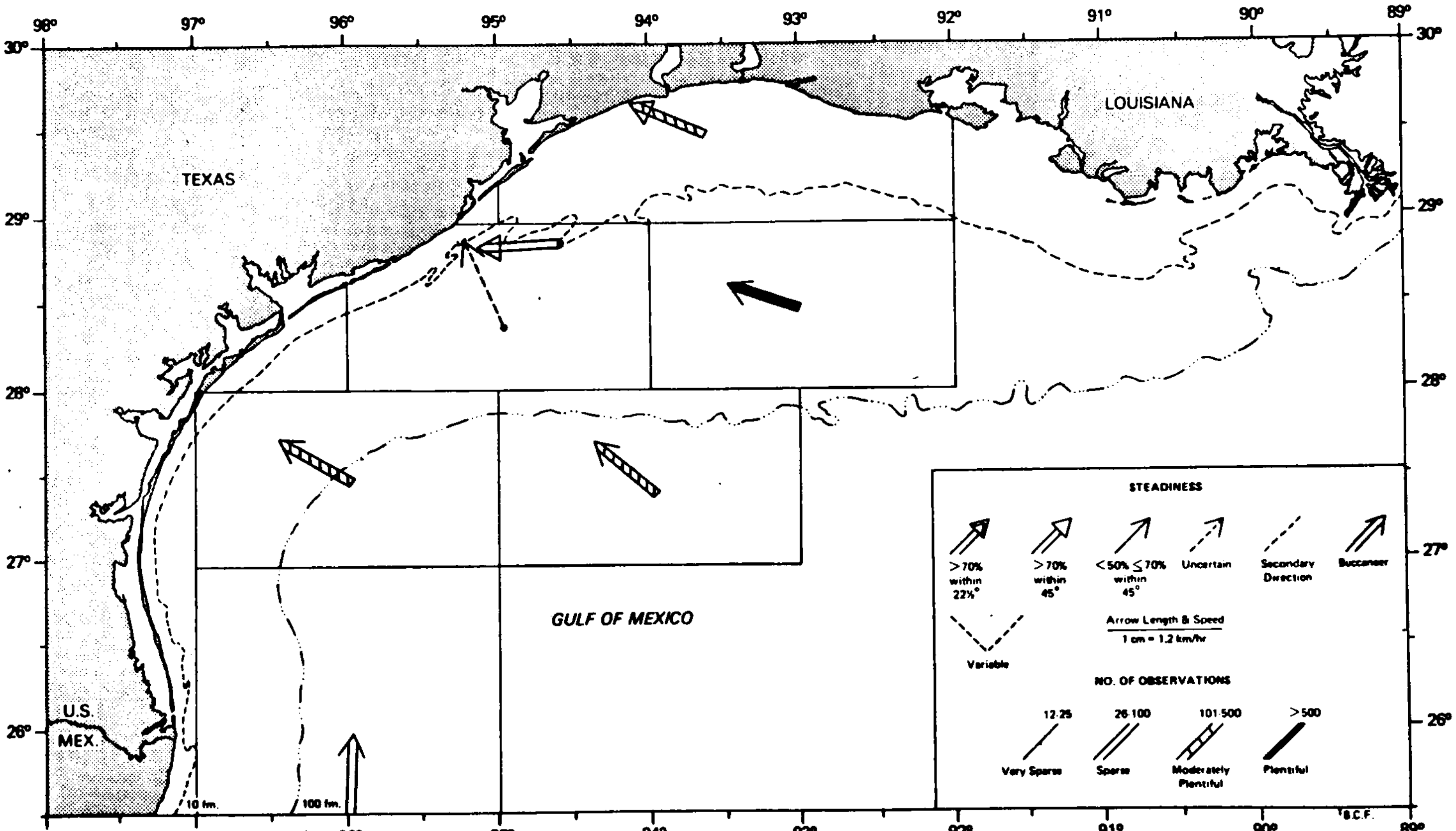


FIGURE 130. SHIP DRIFT AND BUCCANEER SET.

MAY

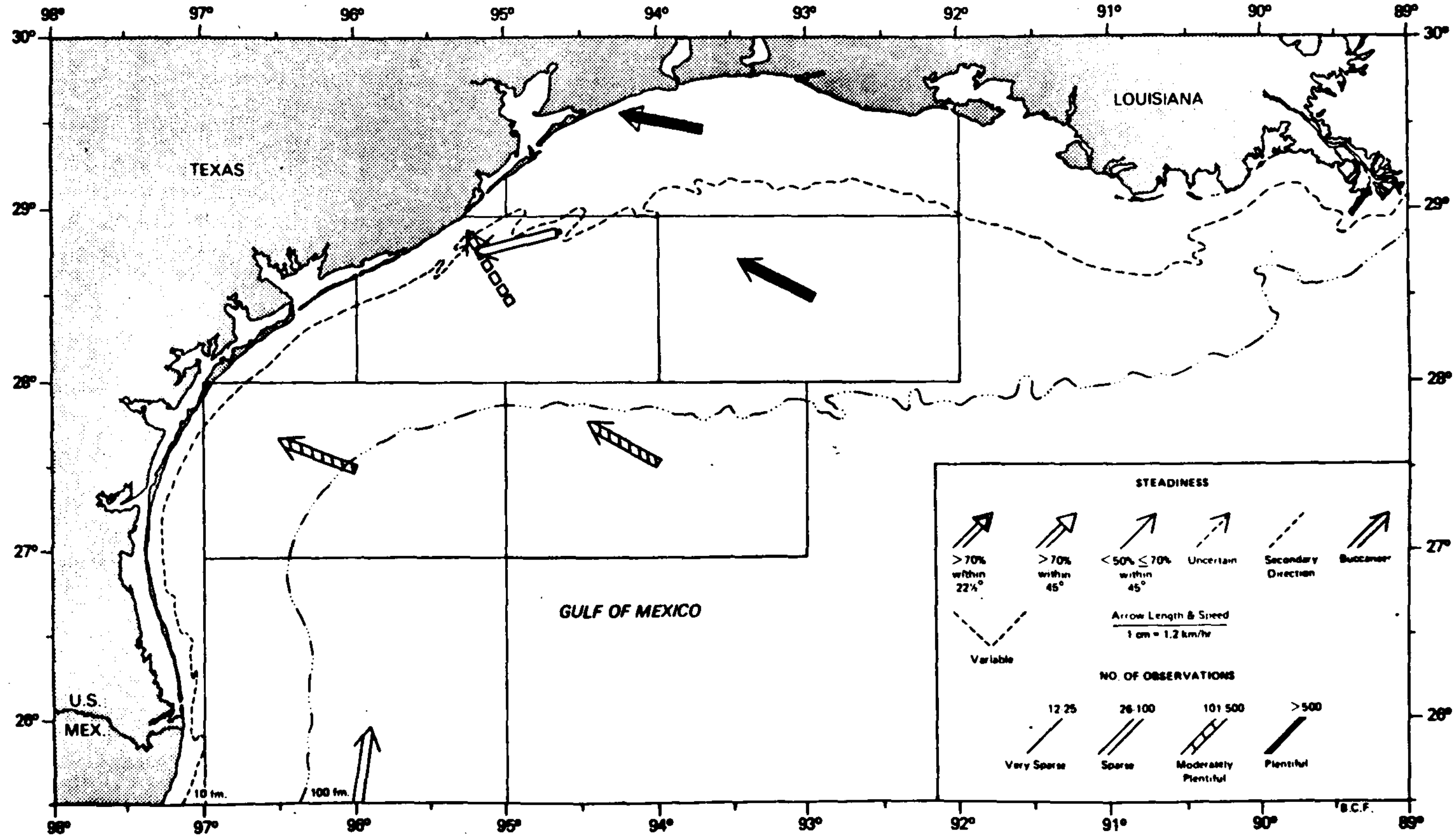


FIGURE 131. SHIP DRIFT AND BUCCANEER SET.

JUNE

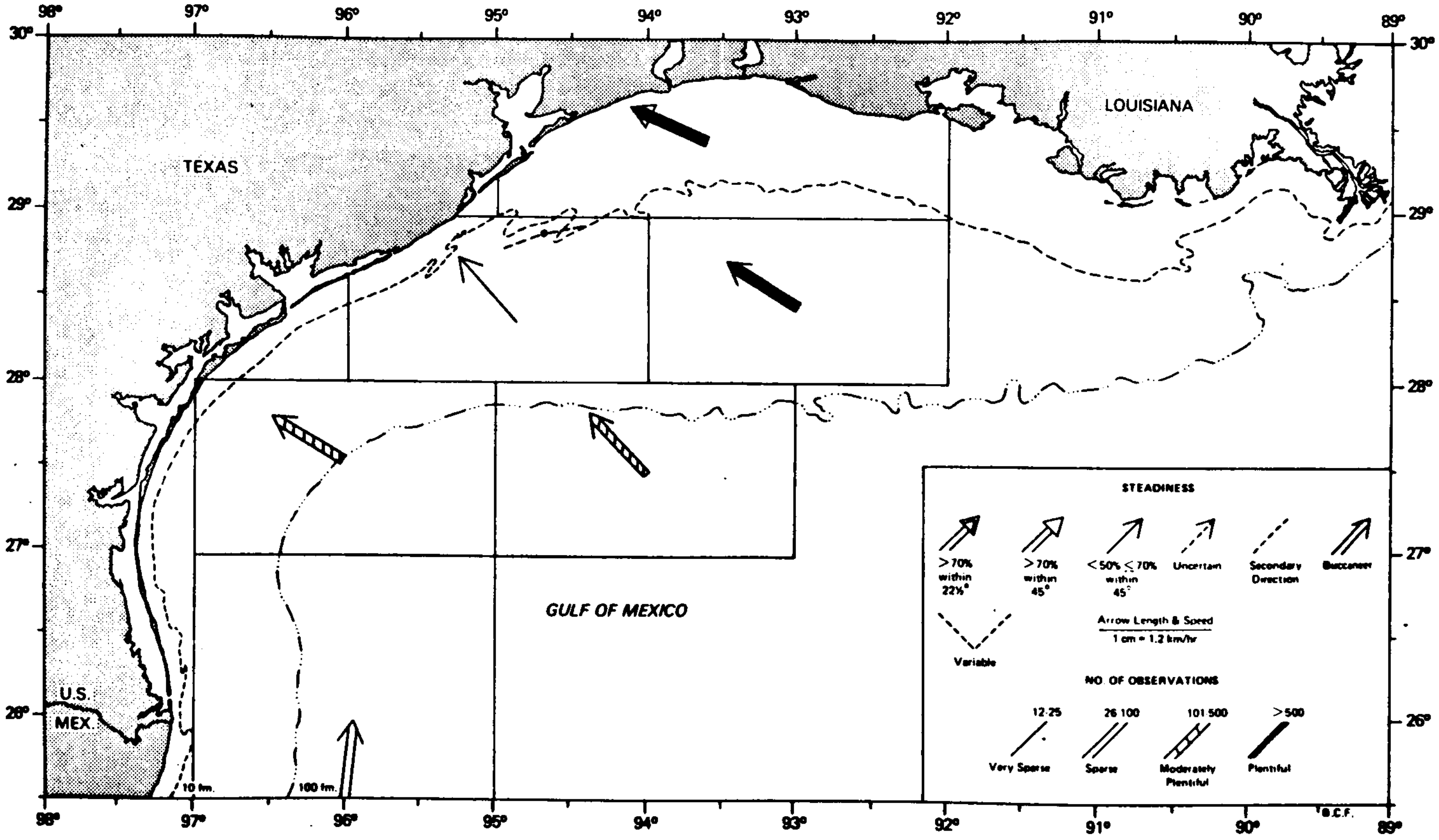


FIGURE 132. SHIP DRIFT AND BUCCANEER SET.

JULY

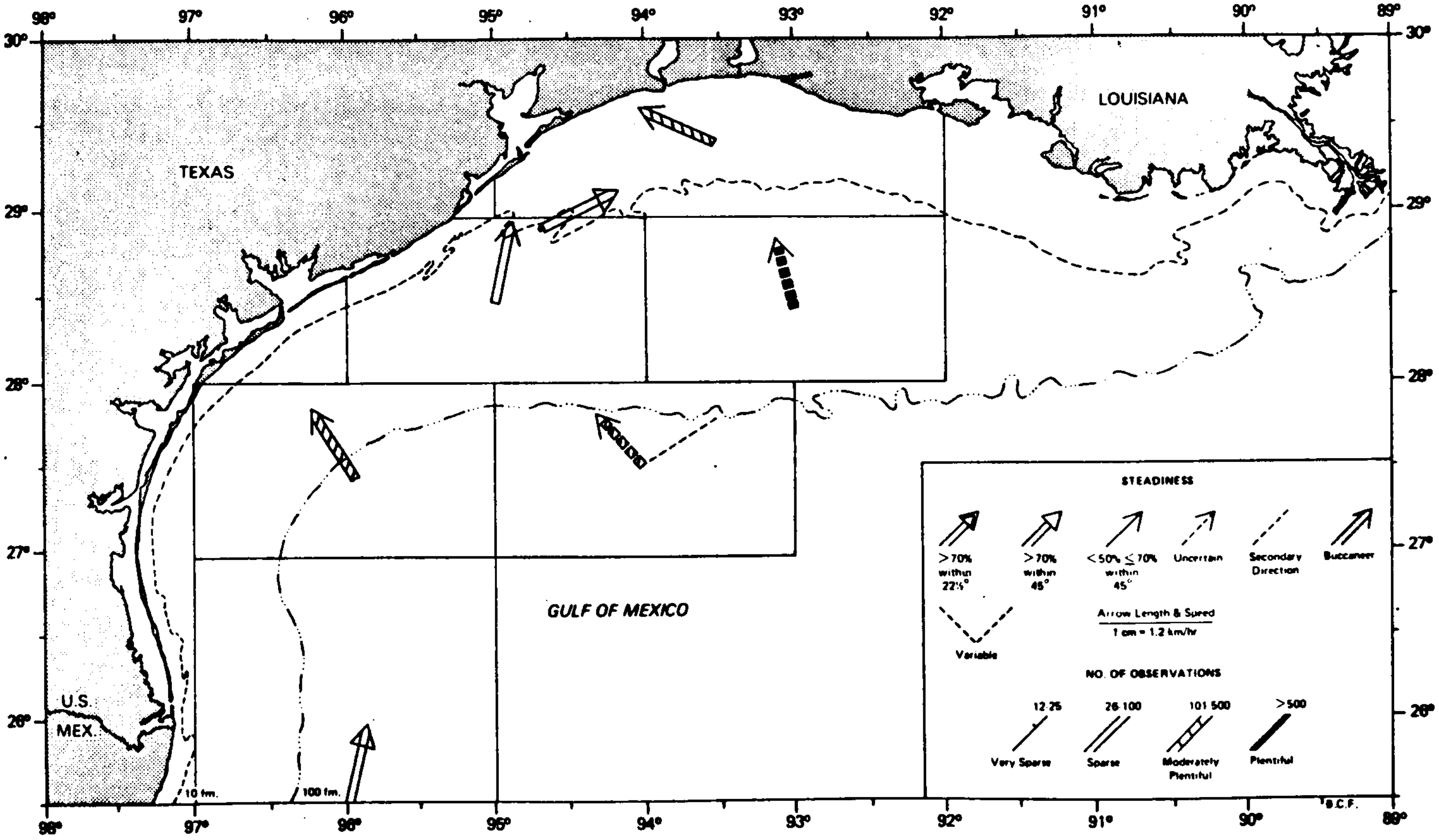


FIGURE 133. SHIP DRIFT AND BUCCANEER SET.

AUGUST

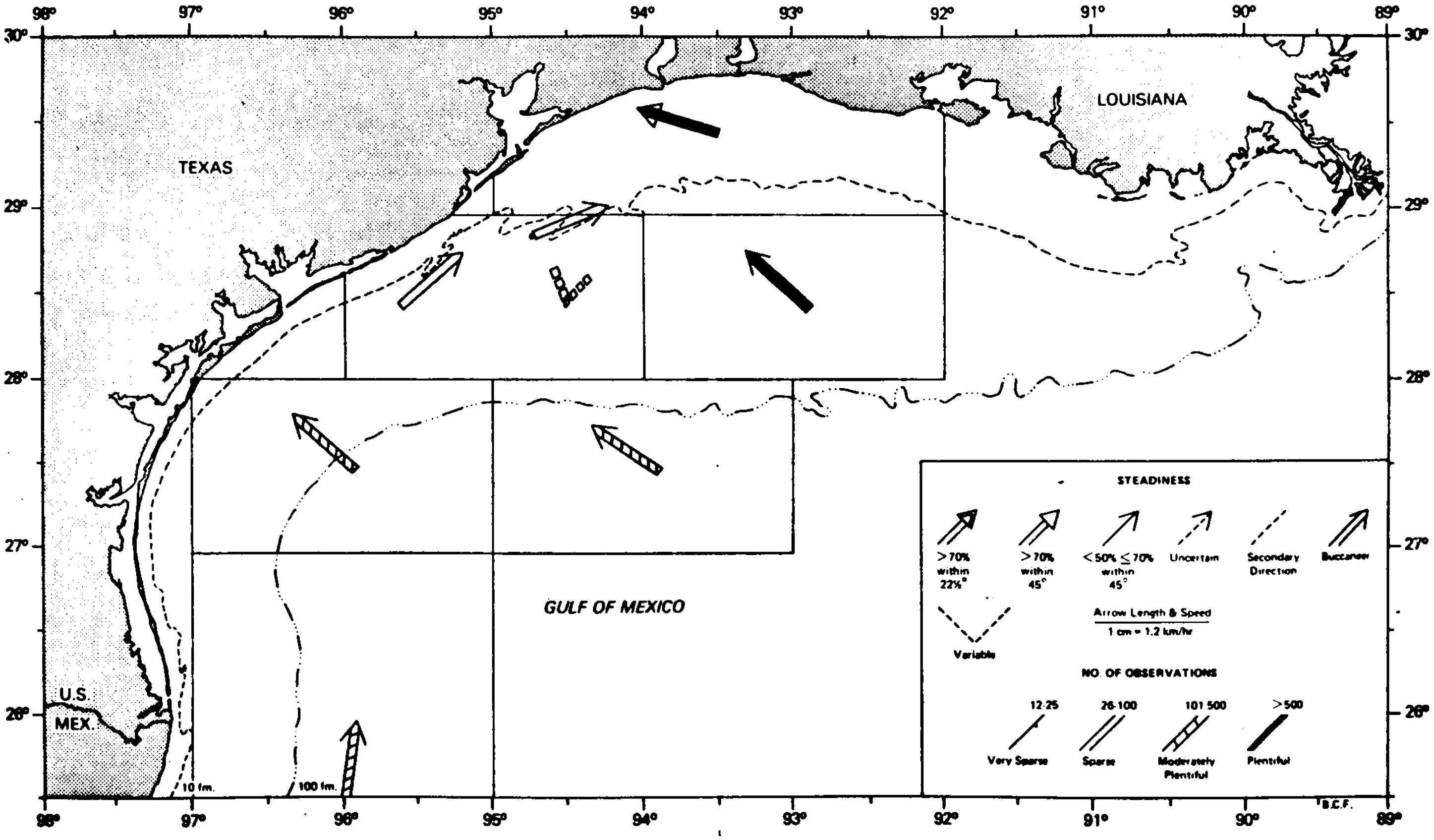


FIGURE 134. SHIP DRIFT AND BUCCANEER SET.

SEPTEMBER

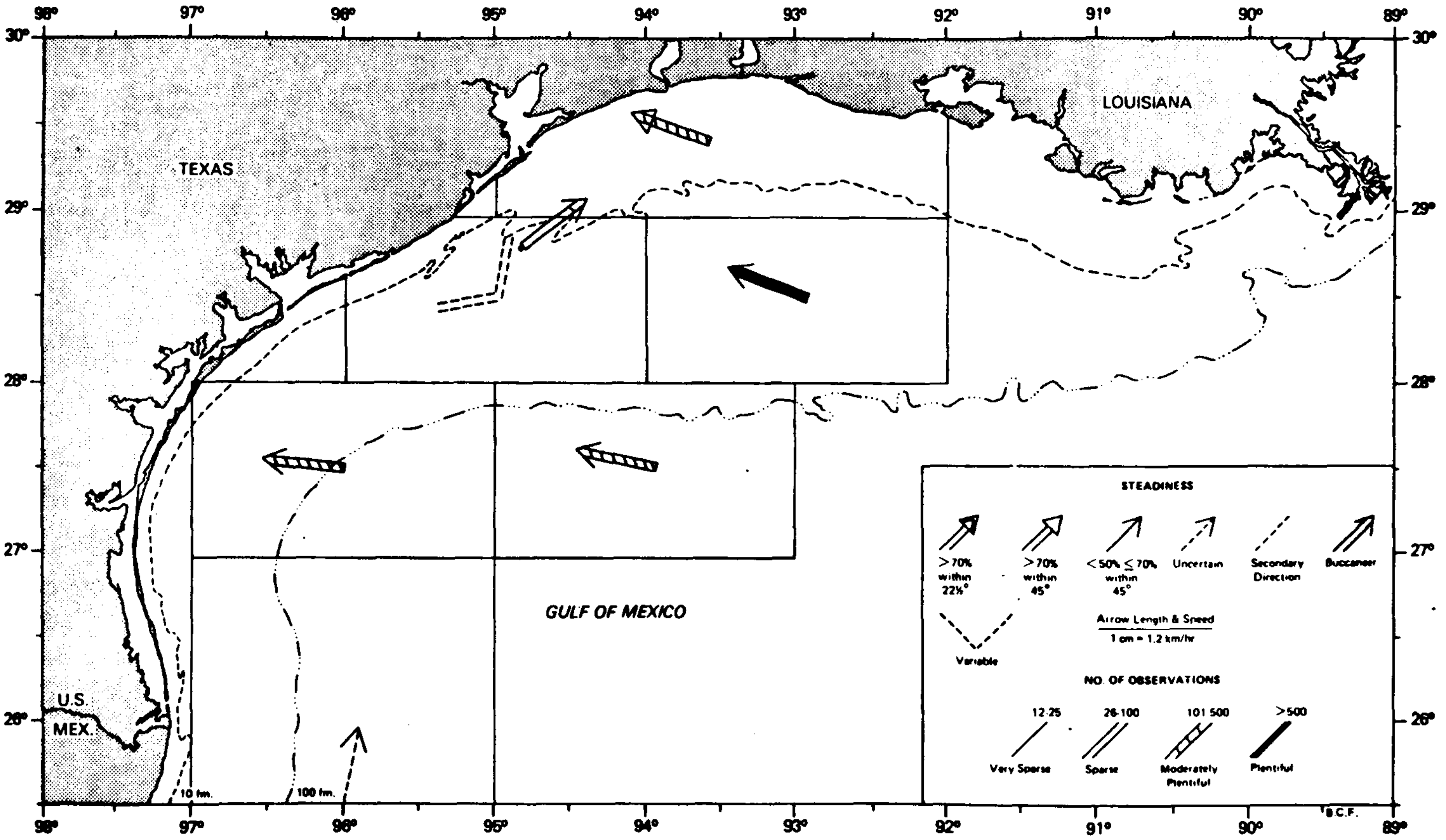


FIGURE 135. SHIP DRIFT AND BUCCANEER SET.

OCTOBER

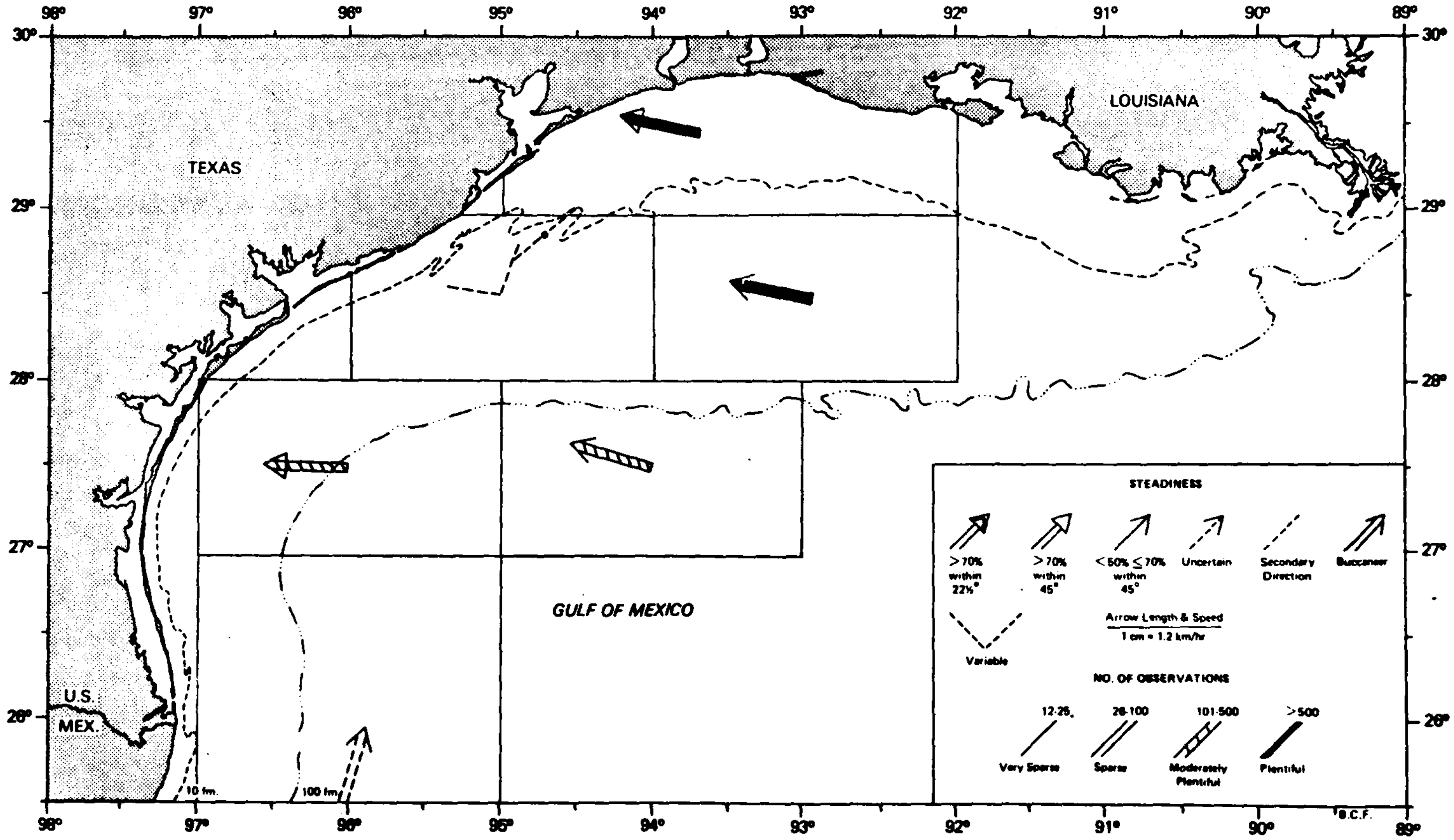


FIGURE 136. SHIP DRIFT AND BUCCANEER SET.

NOVEMBER

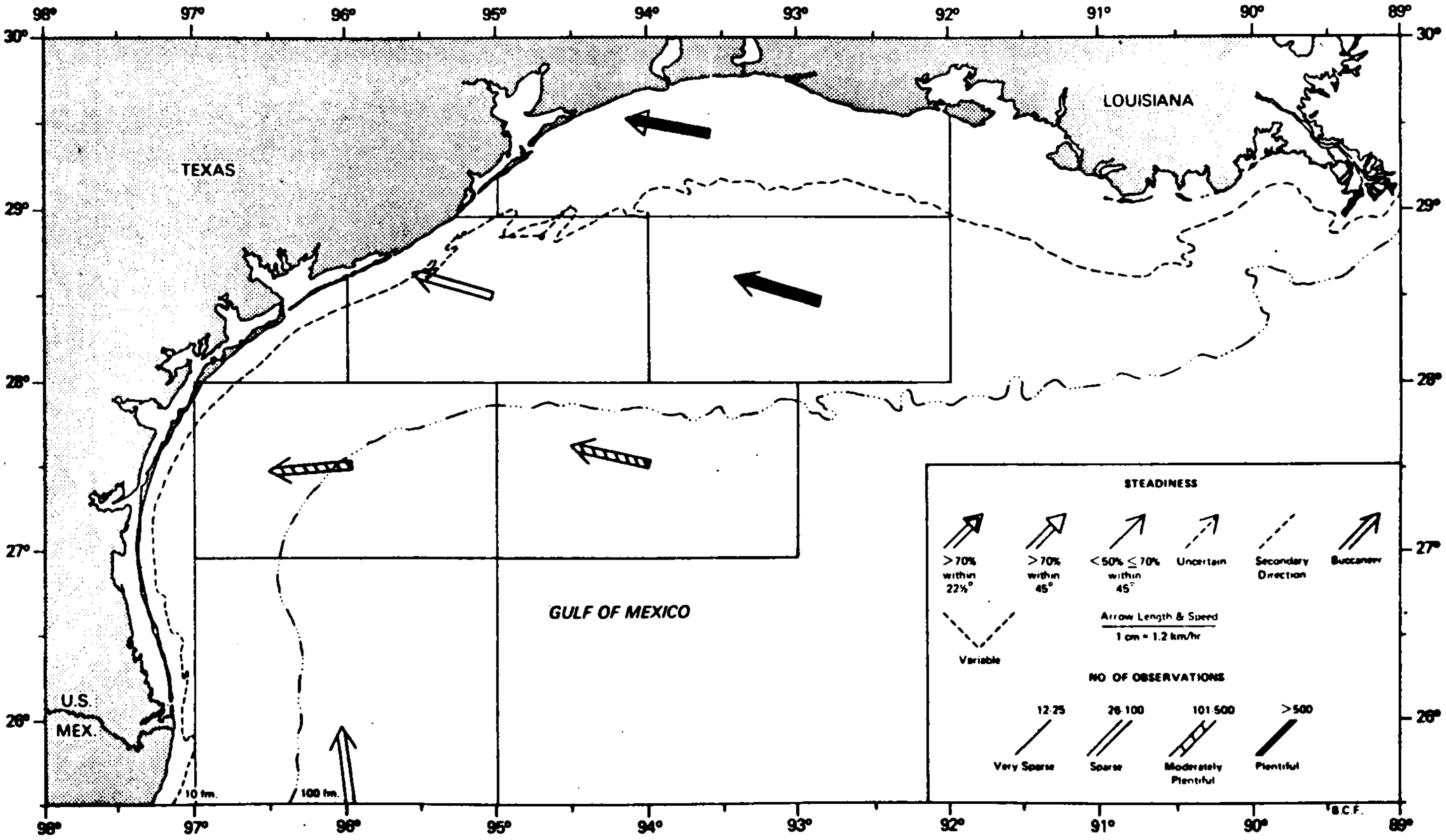


FIGURE 137. SHIP DRIFT AND BUCCANEER SET.

DECEMBER

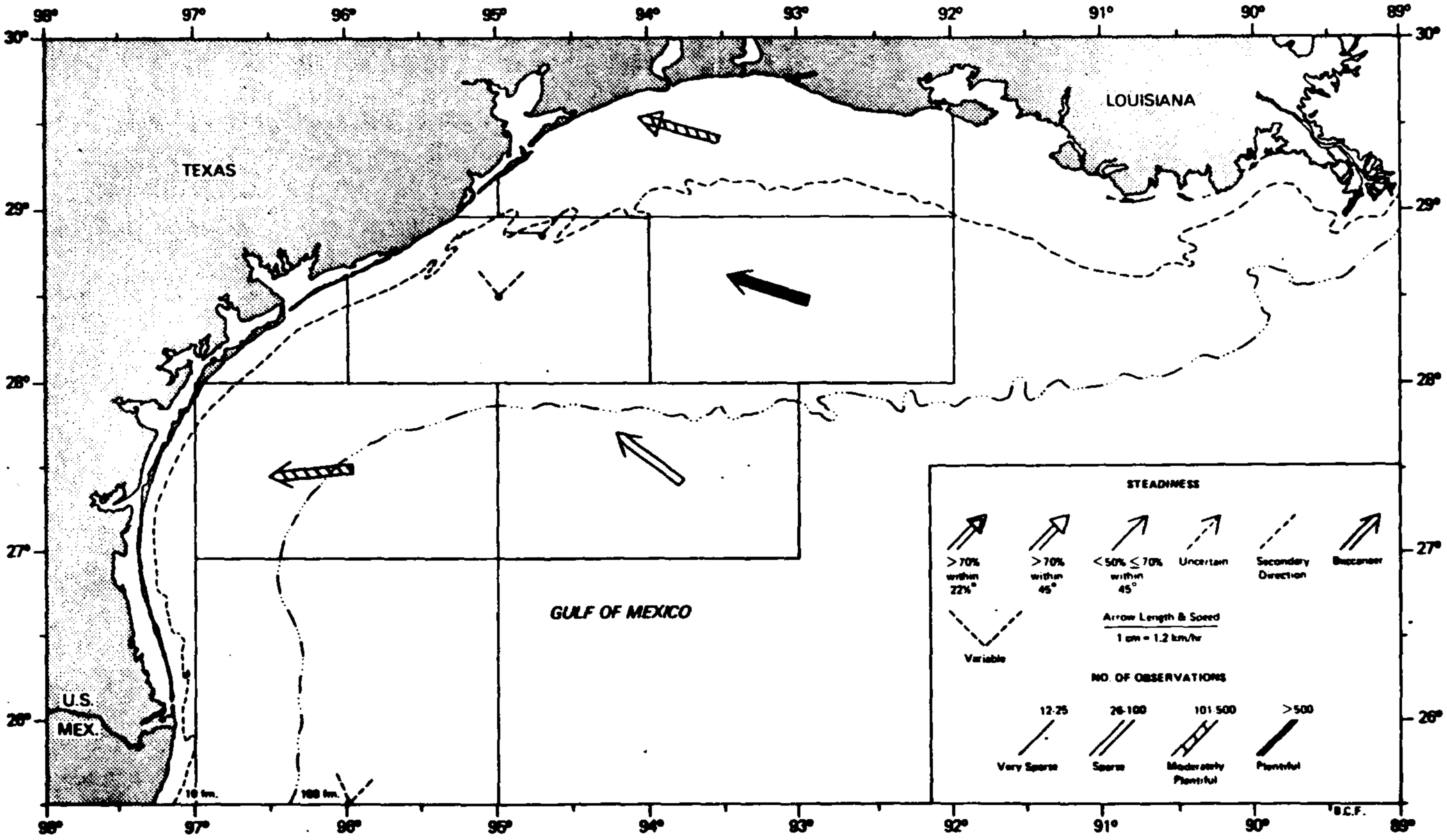


FIGURE 138. SHIP DRIFT AND BUCCANEER SET.

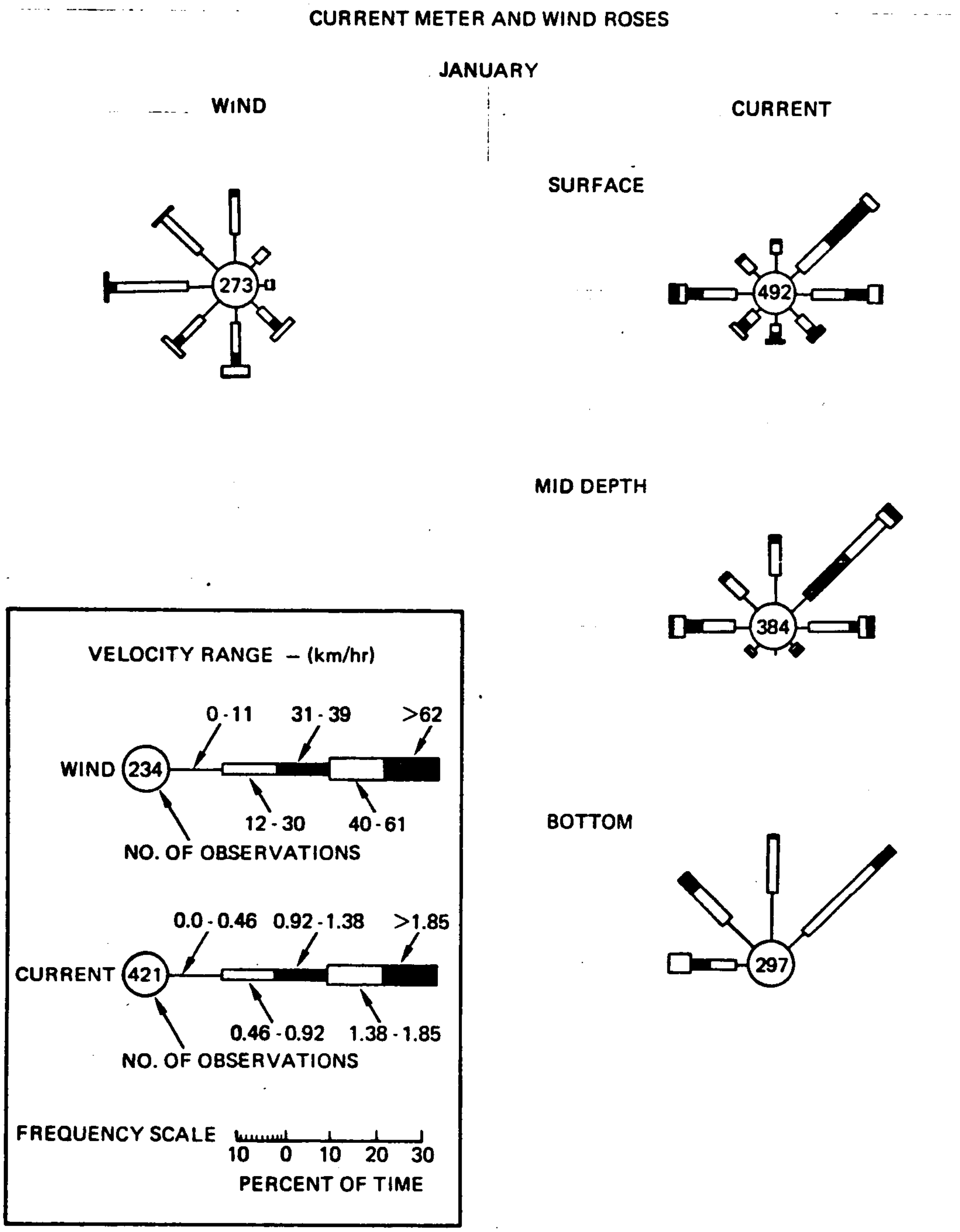


Figure 139. Currents and wind for January.

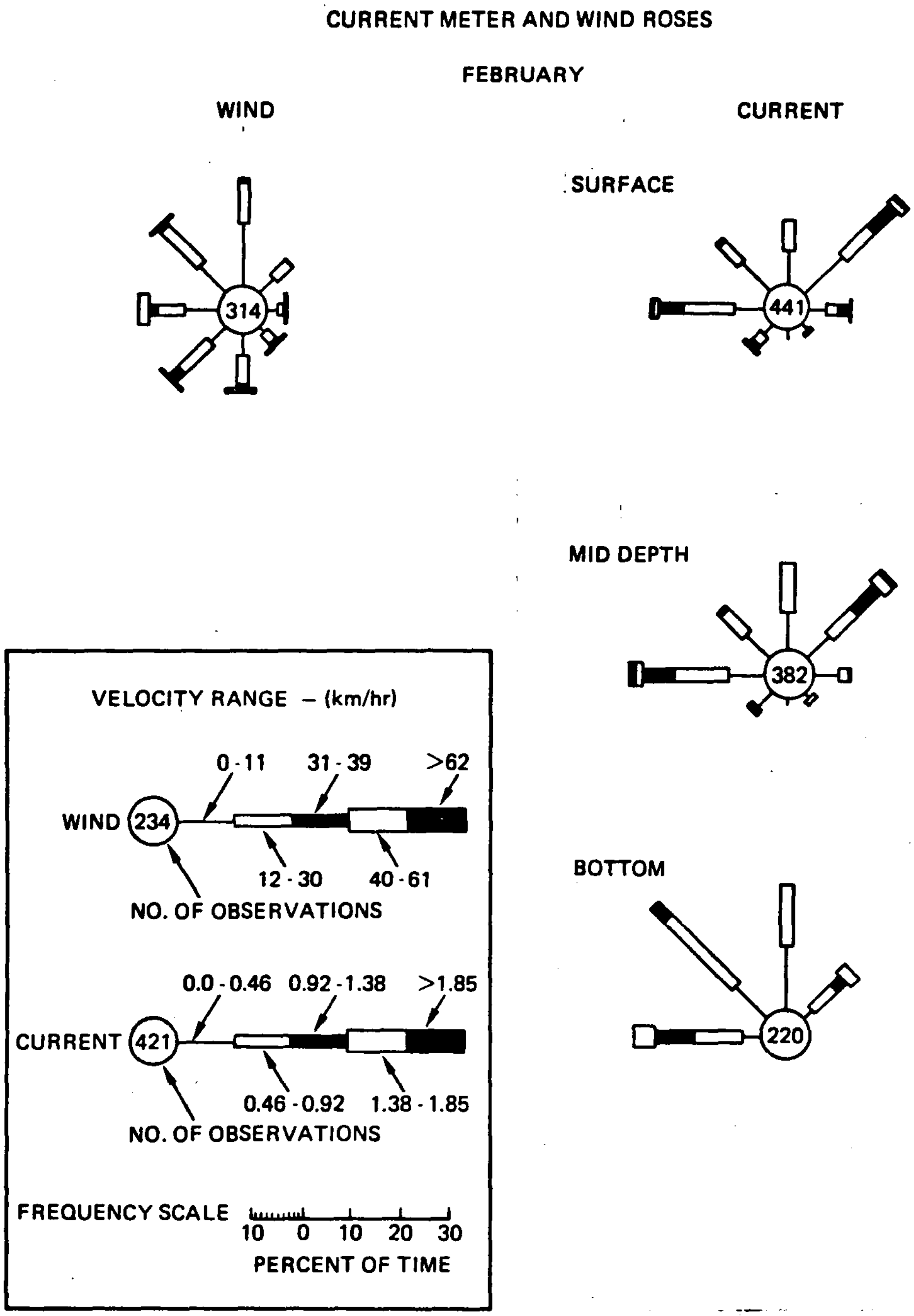


Figure 140. Currents and wind for February.

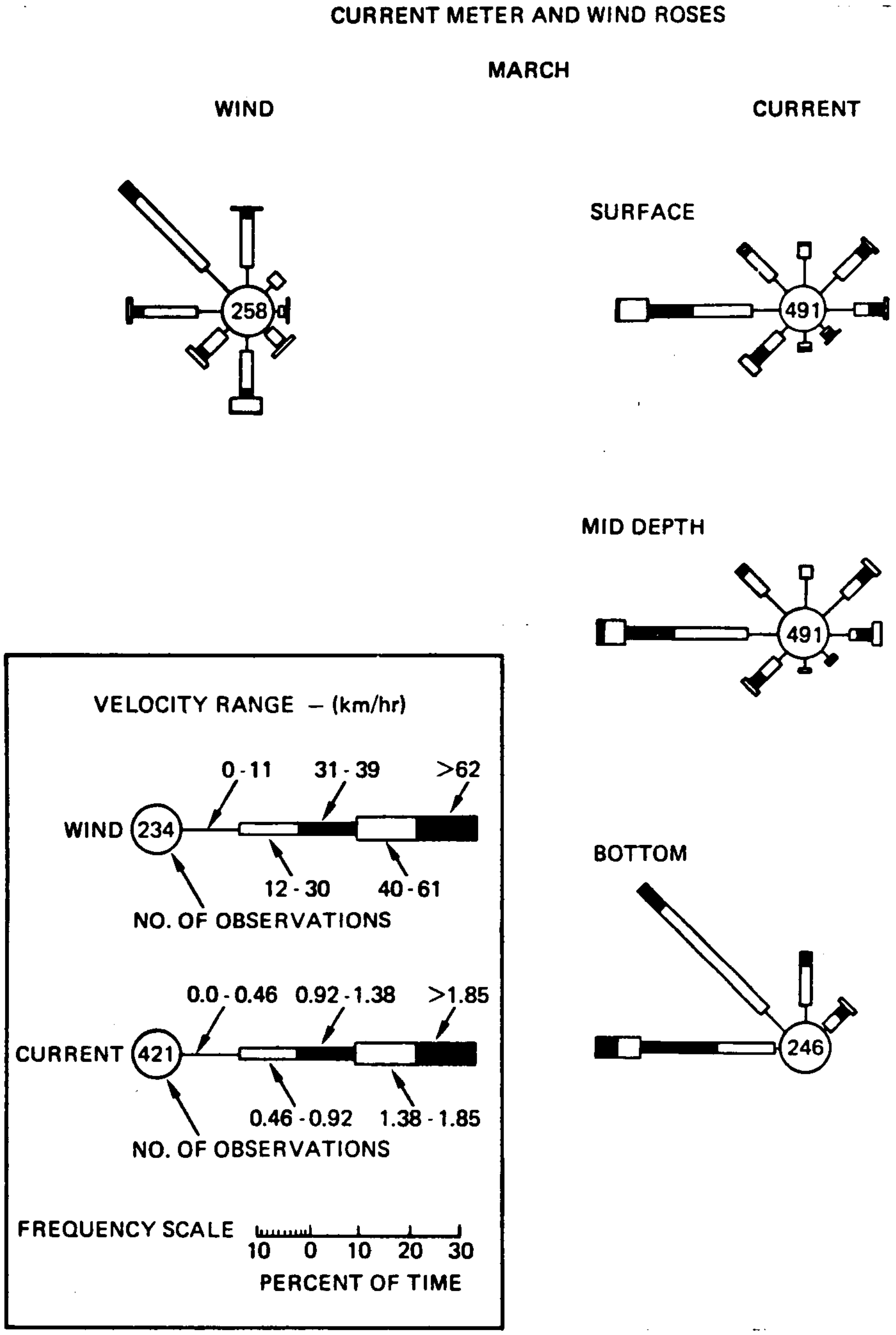


Figure 141. Currents and wind for March.

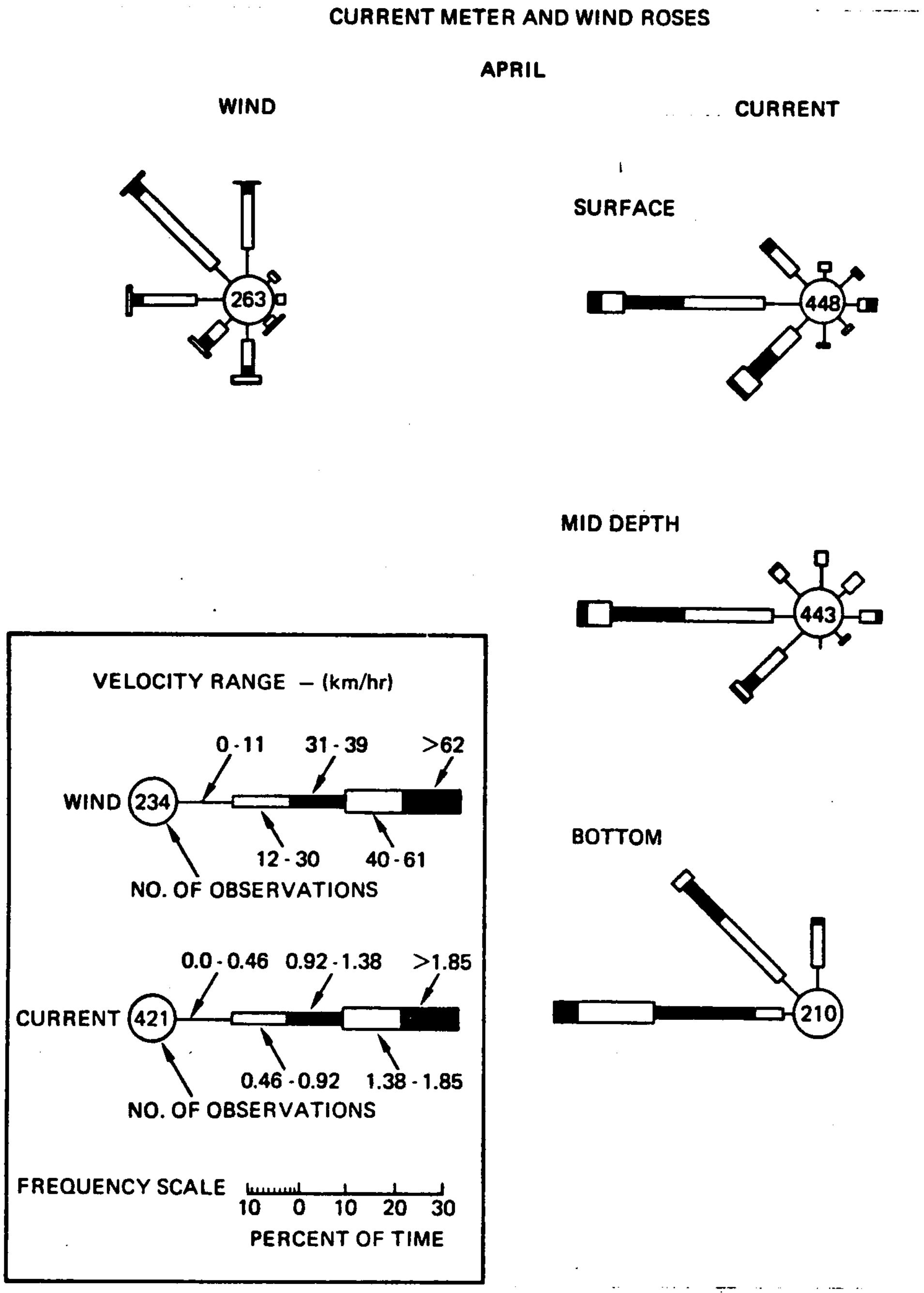


Figure 142. Currents and wind for April.

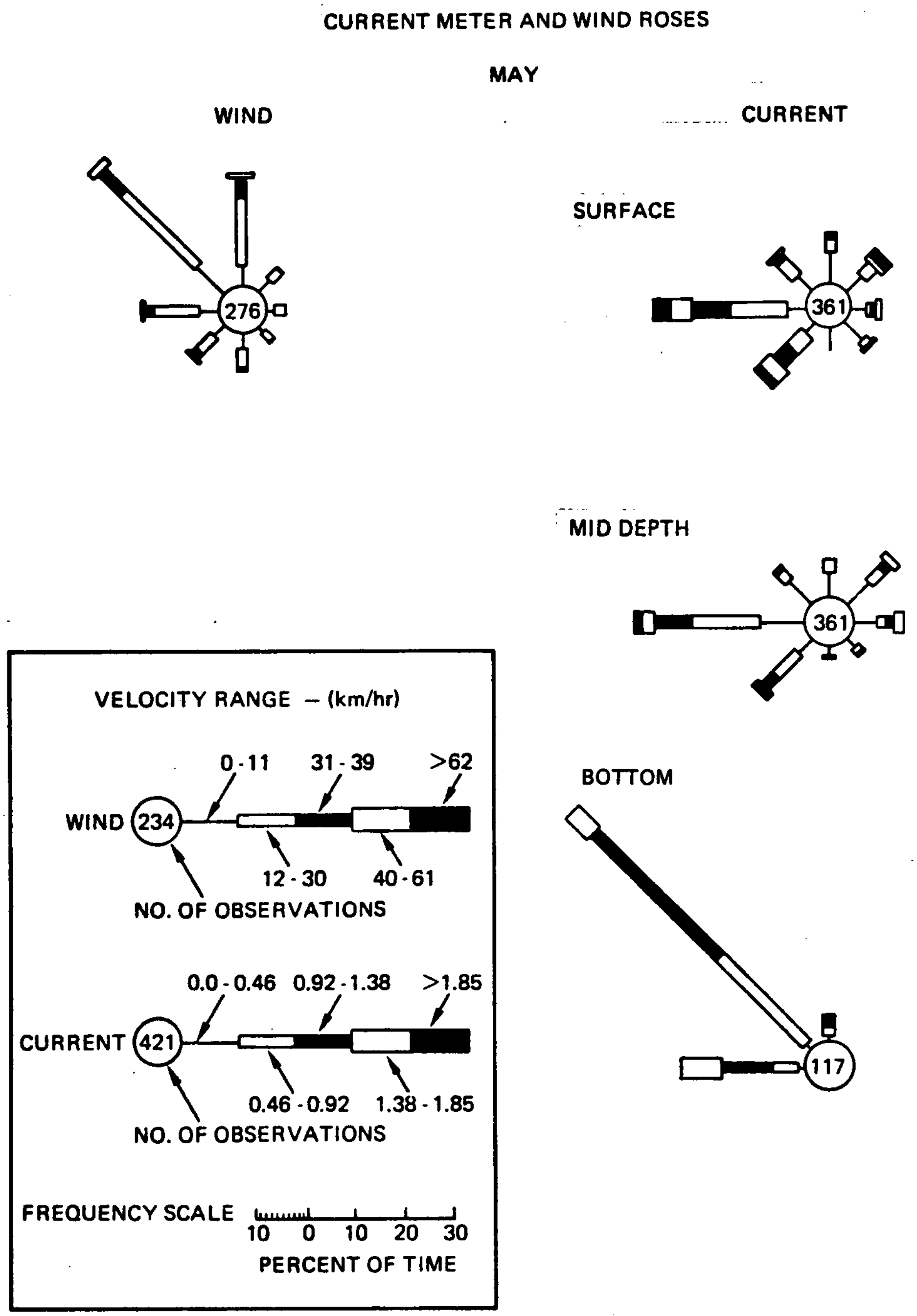


Figure 143. Currents and wind for May.

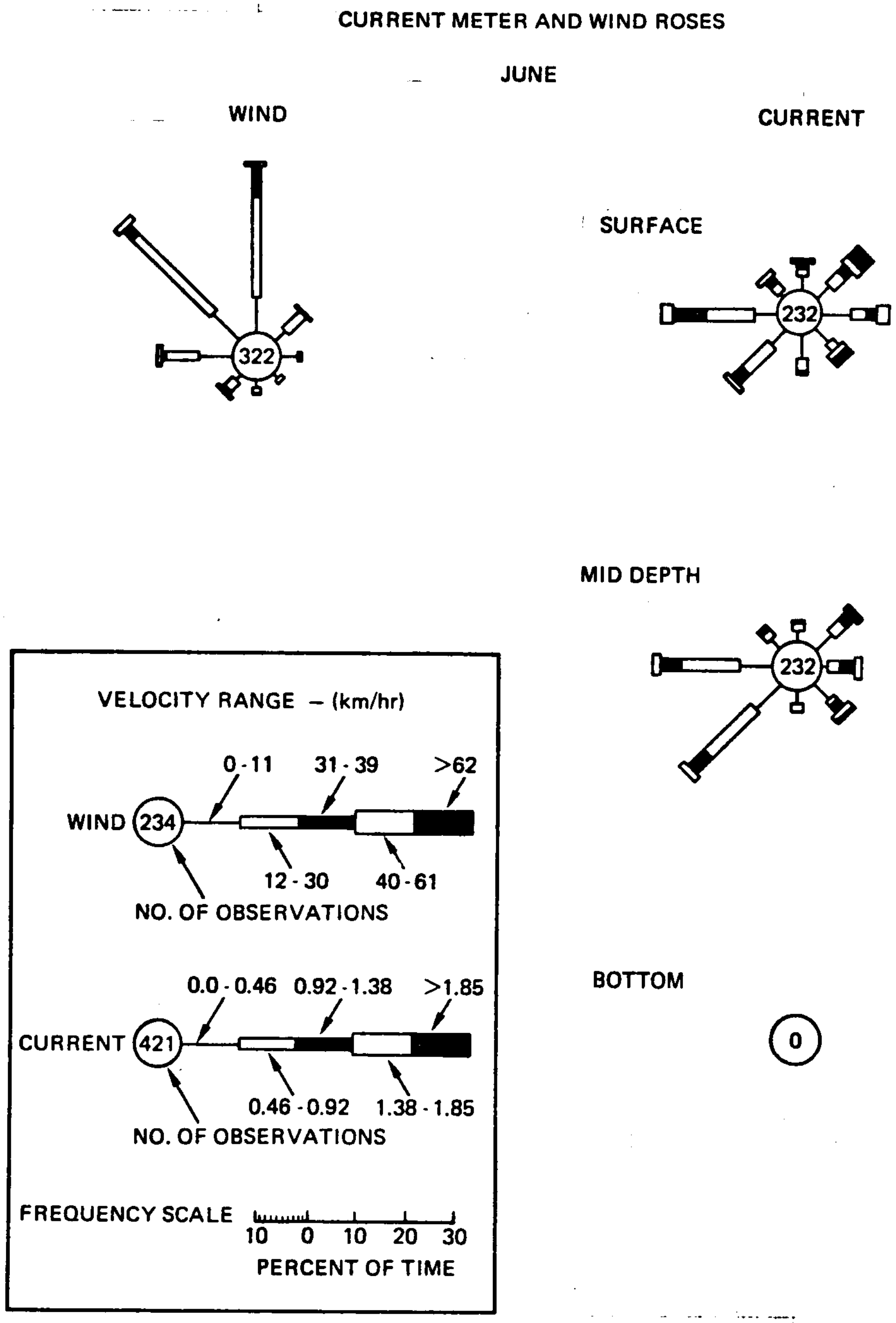


Figure 144. Currents and wind for June.

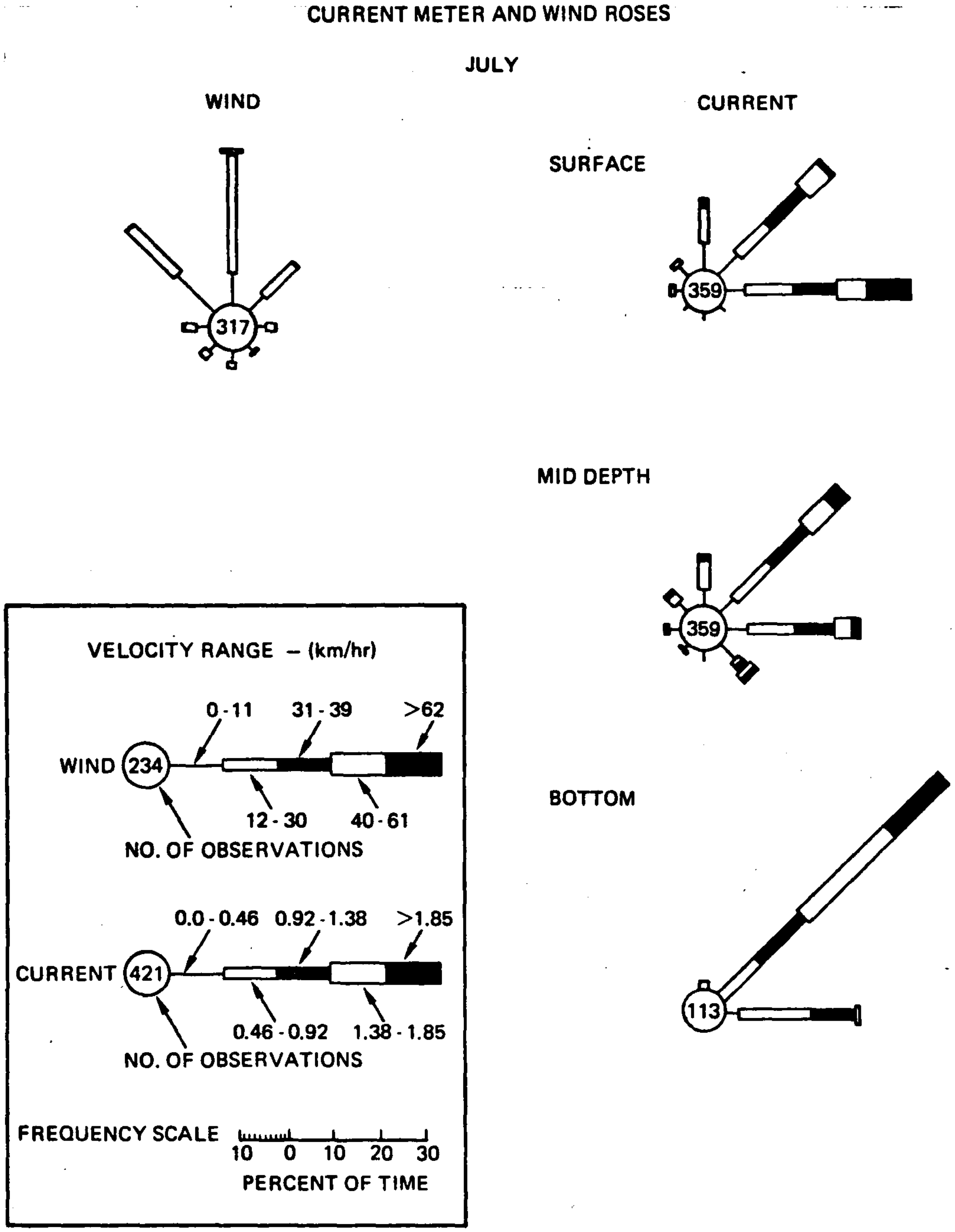


Figure 145. Currents and wind for July.

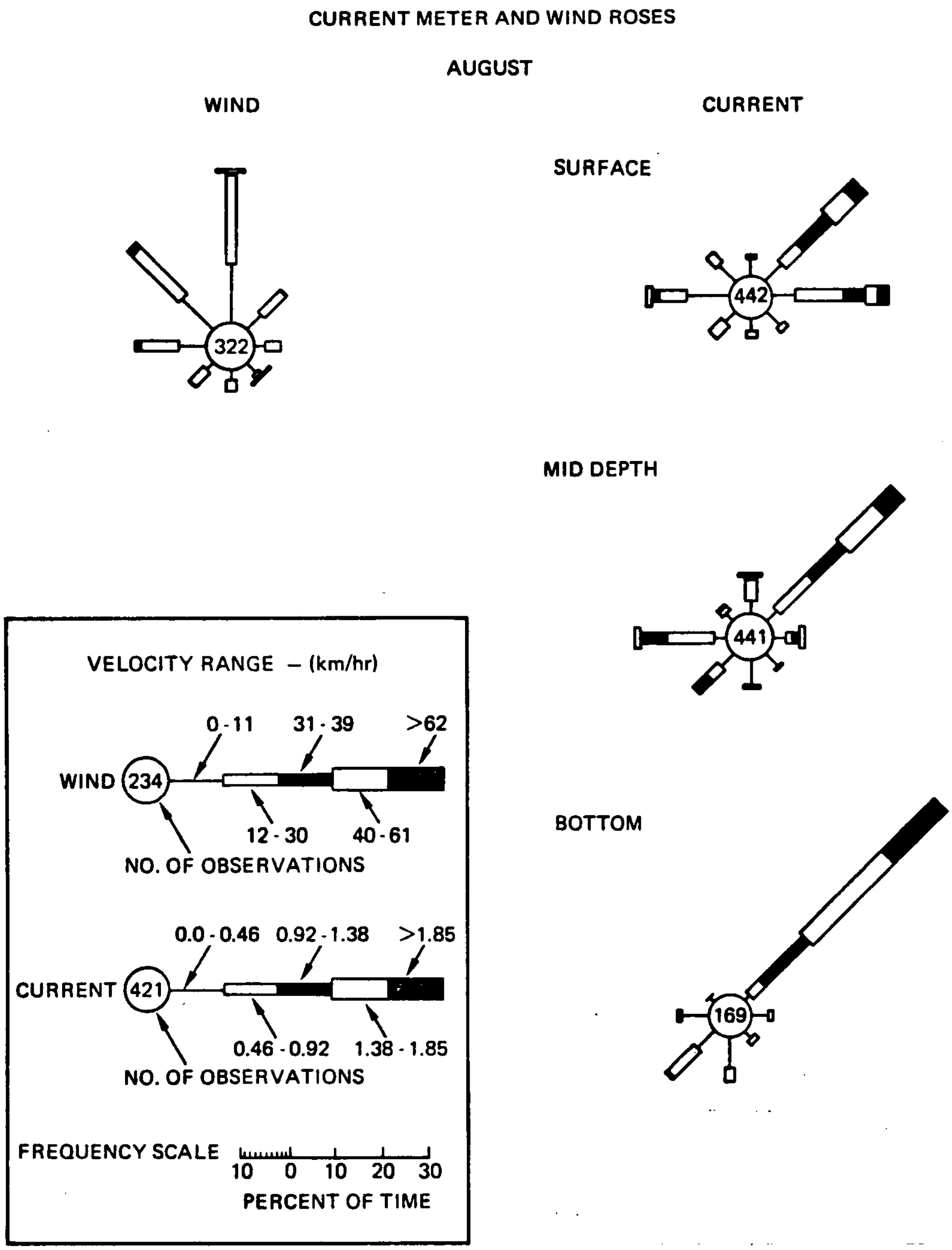


Figure 146. Currents and wind for August.

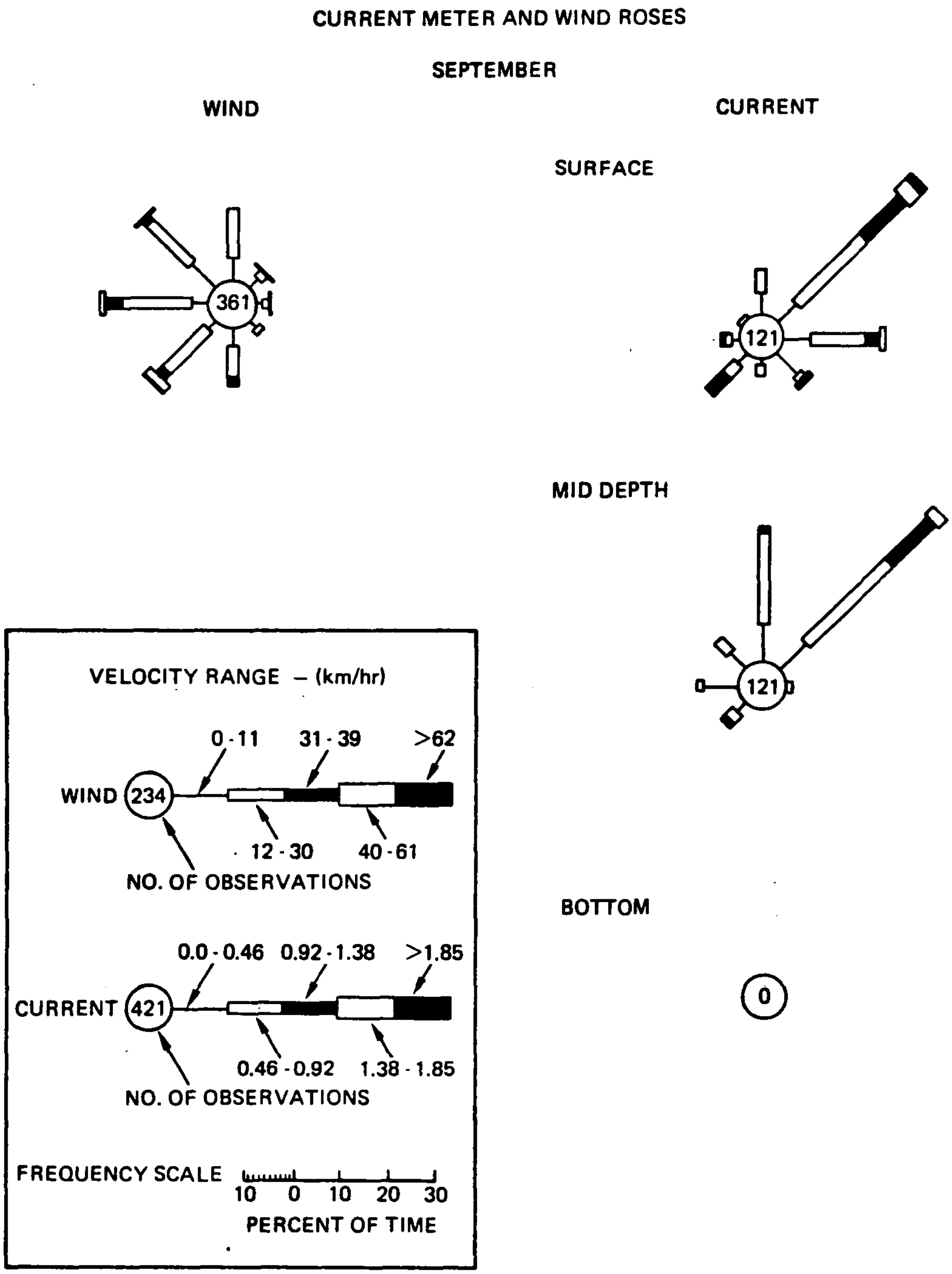


Figure 147. Currents and wind for September.

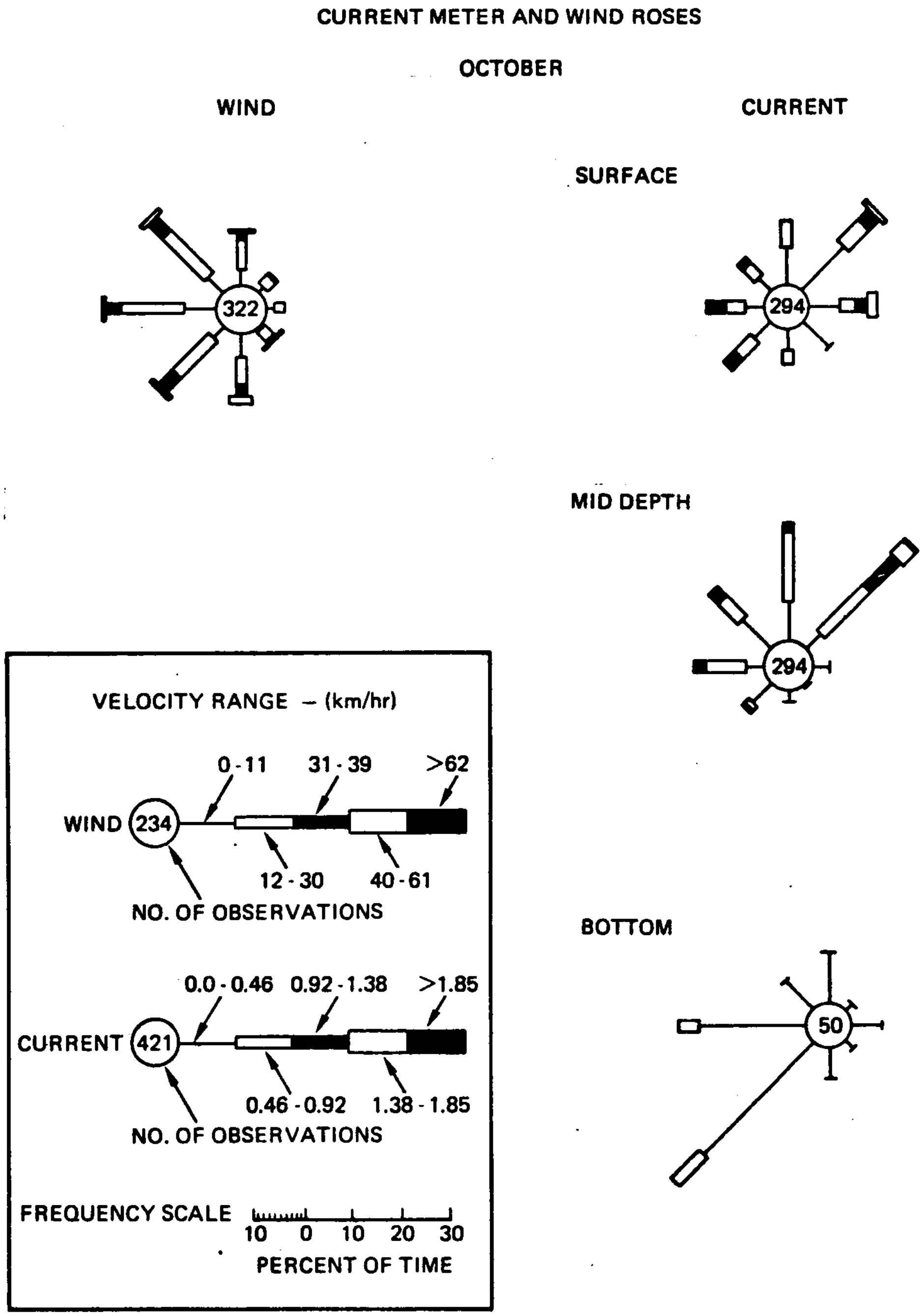


Figure 148. Currents and wind for October.

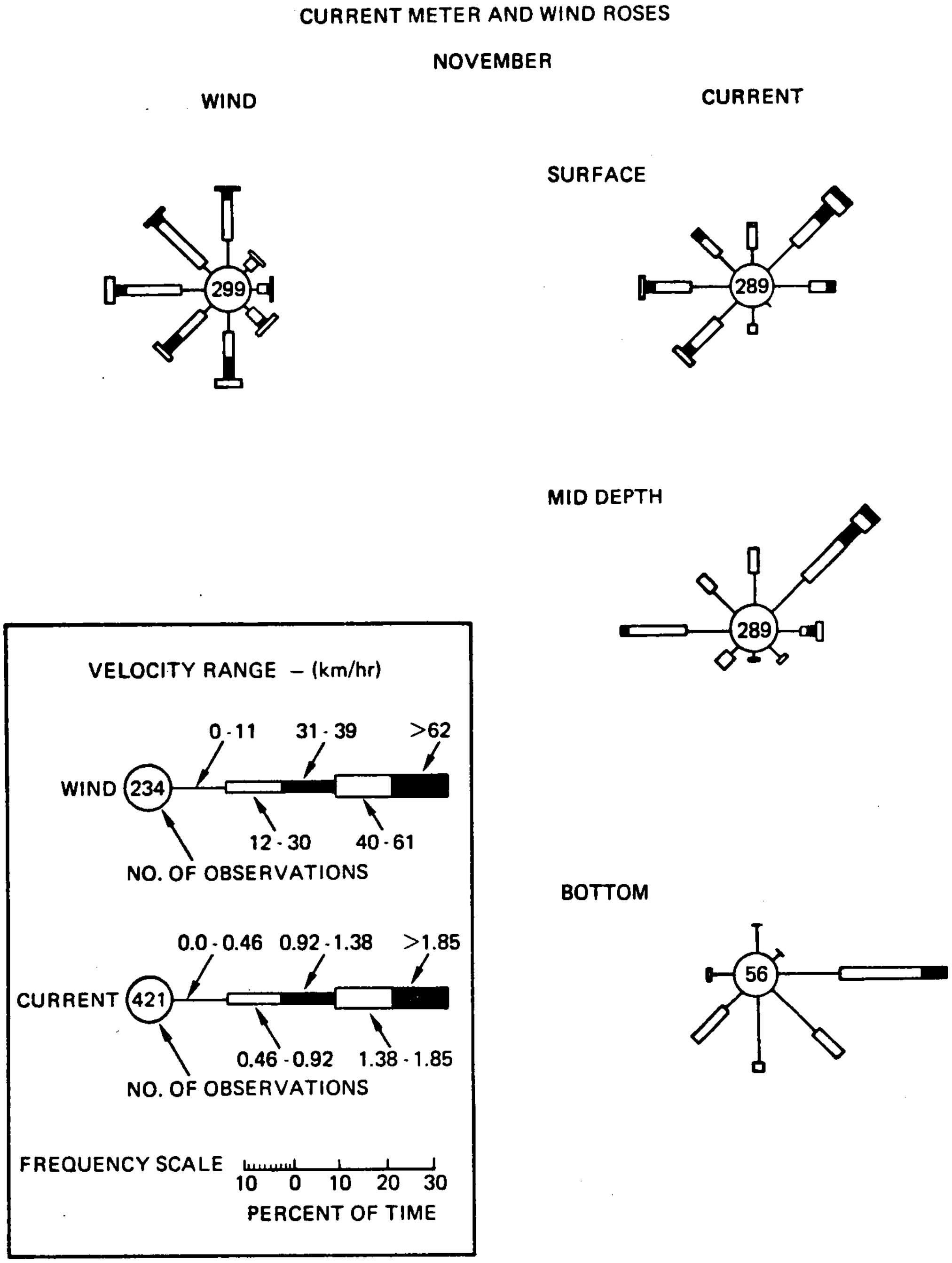


Figure 149. Currents and wind for November.

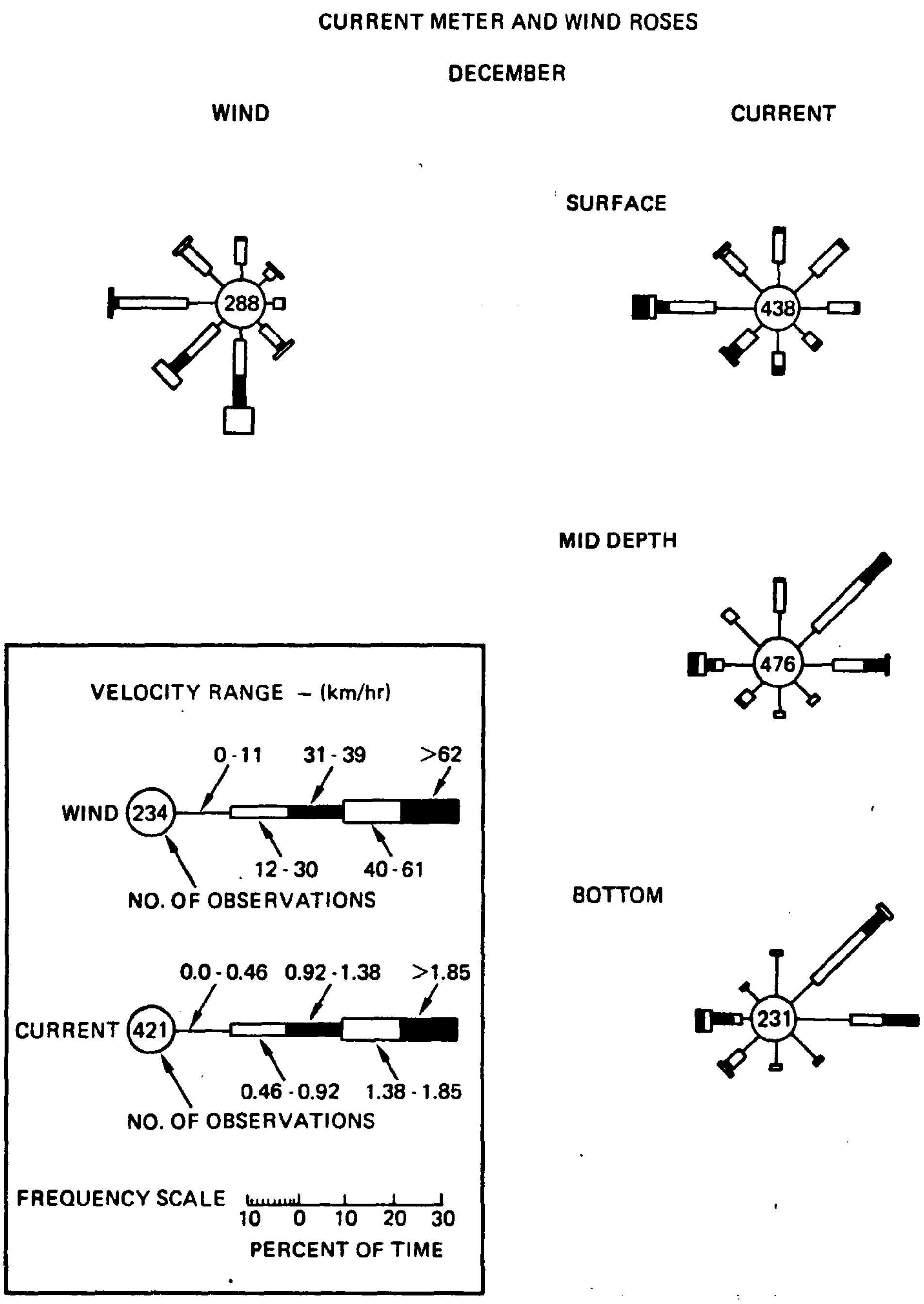


Figure 150. Currents and wind for December.

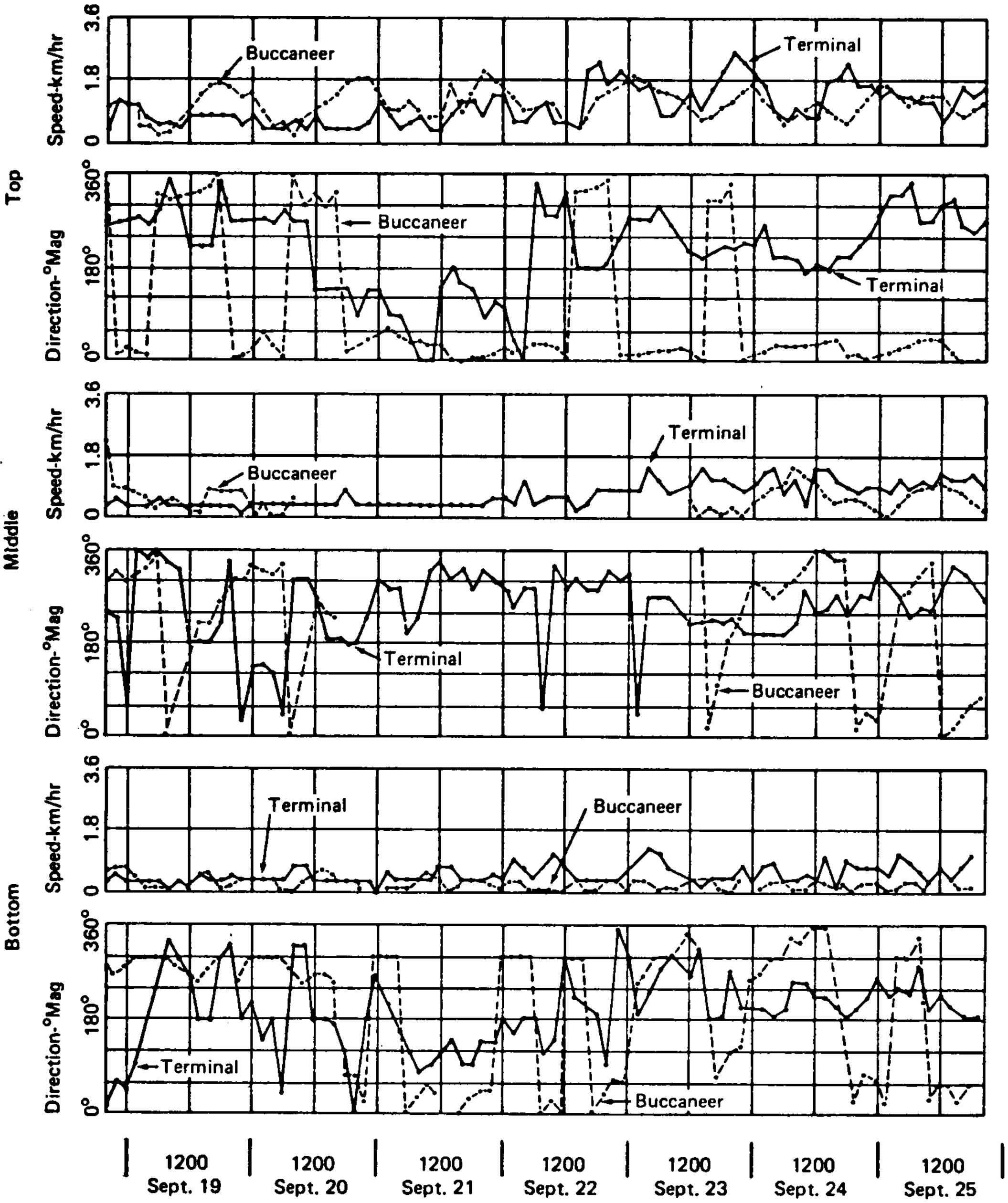


FIGURE 151. CURRENTS FOR SEPTEMBER 7-DAY STUDY.

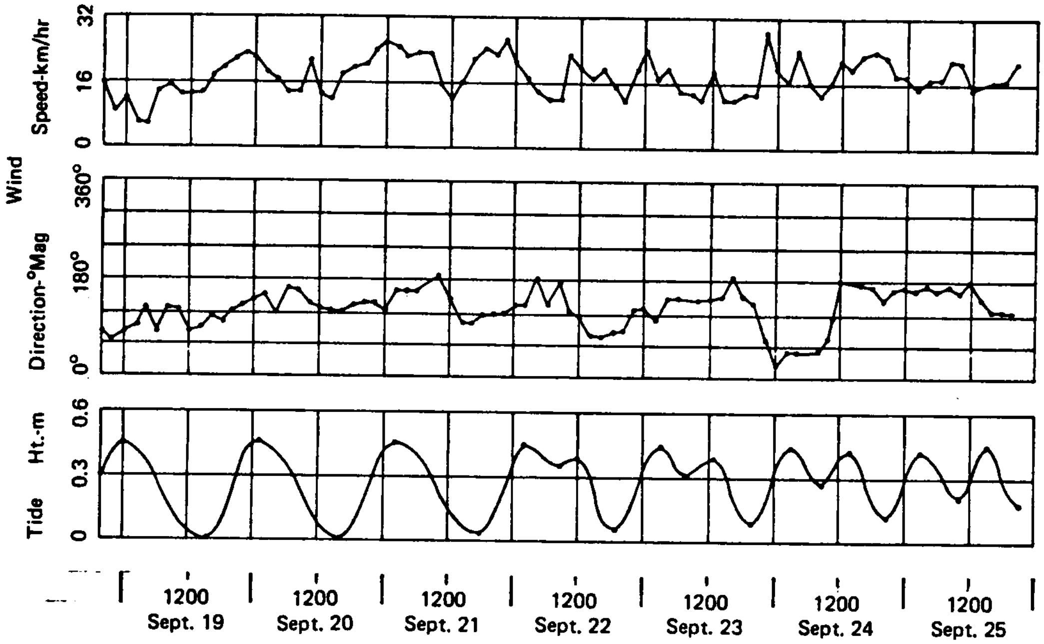


FIGURE 152. WIND AND TIDES FOR SEPTEMBER 7-DAY CURRENT STUDY.

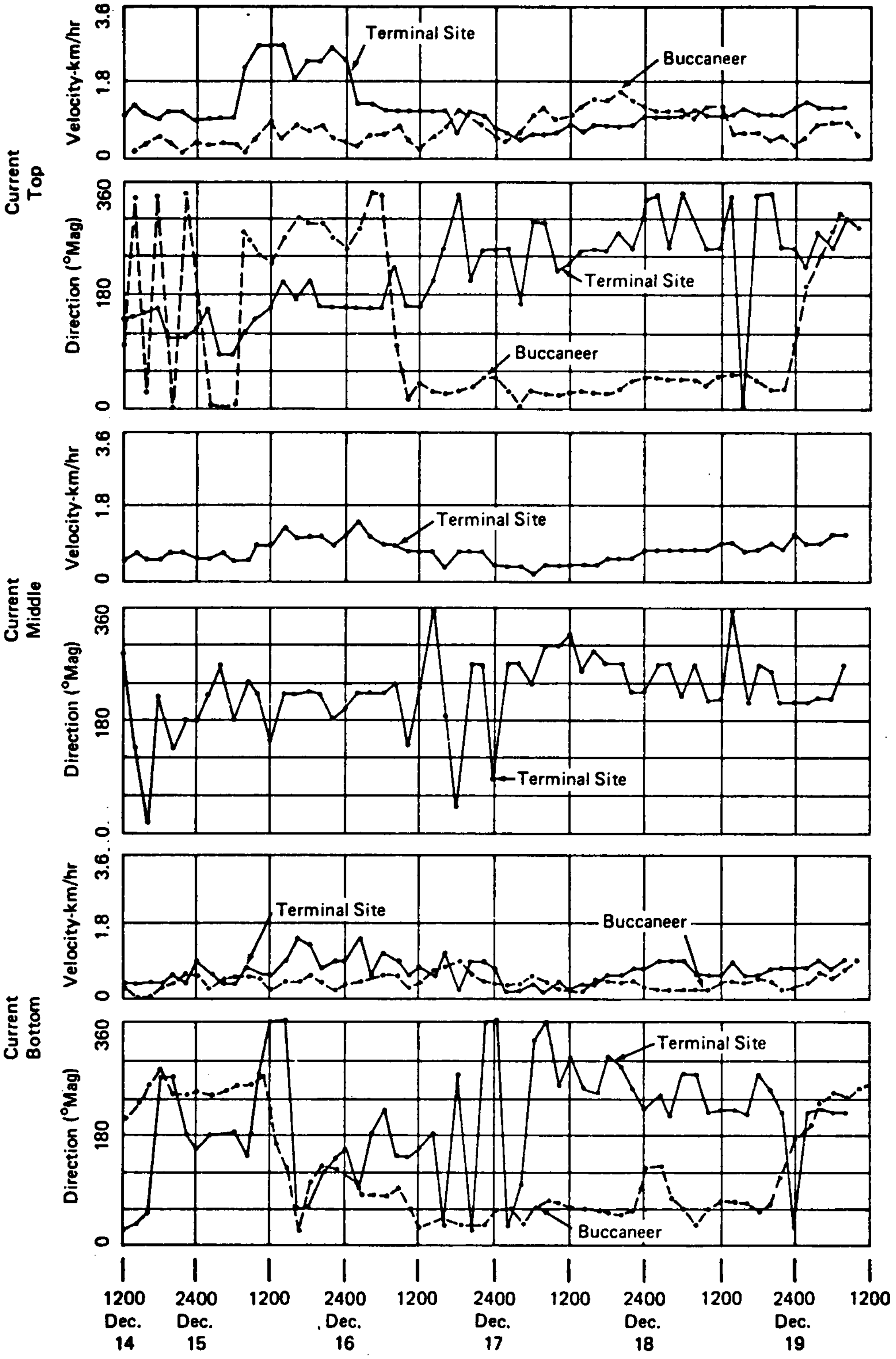


FIGURE 153. CURRENTS FOR DECEMBER 5-DAY STUDY.

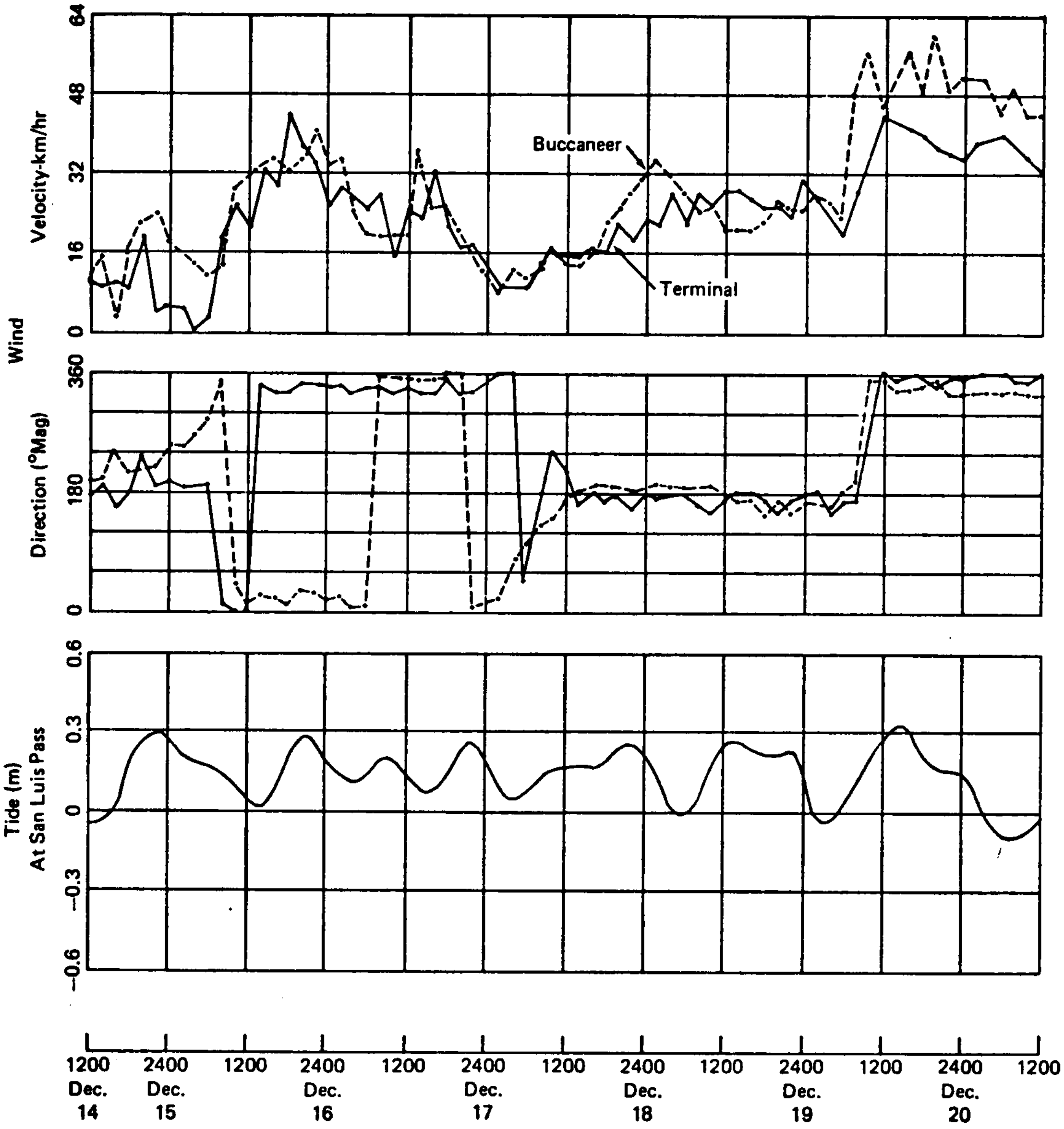


FIGURE 154. WINDS AND TIDES FOR DECEMBER 6-DAY CURRENT STUDY.

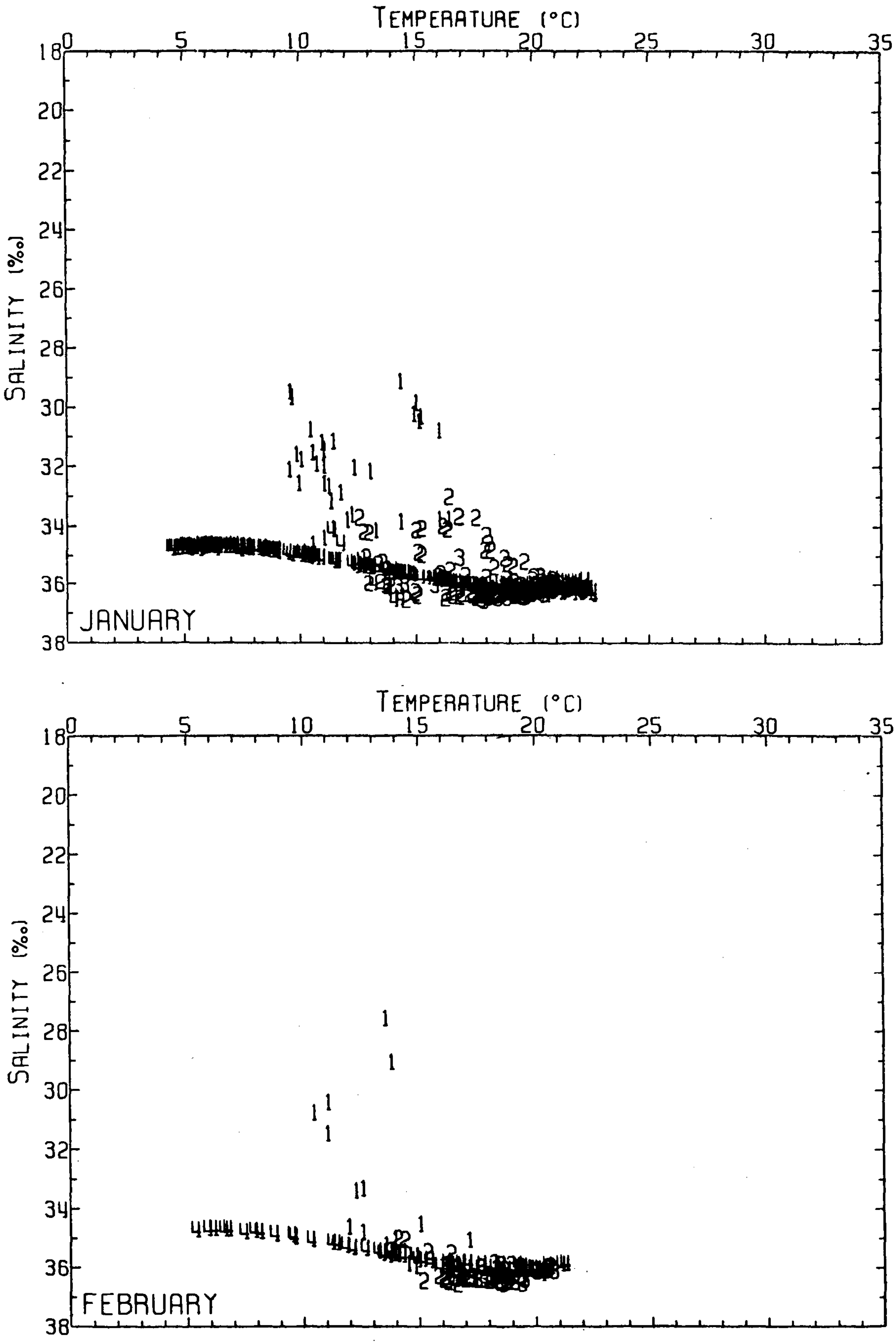


Figure 155. Thermohaline indices for January and February

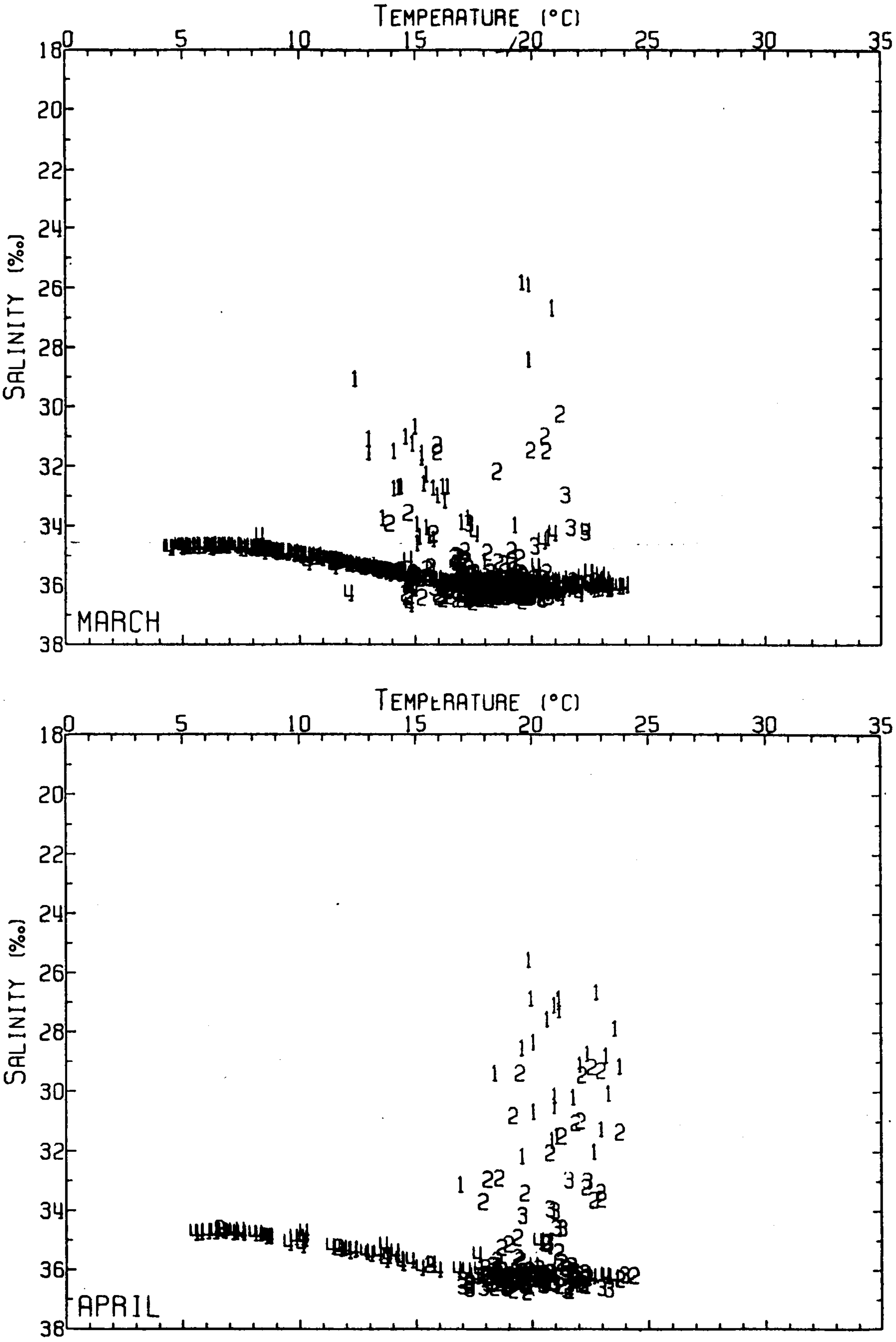


Figure 156. Thermohaline indices for March and April

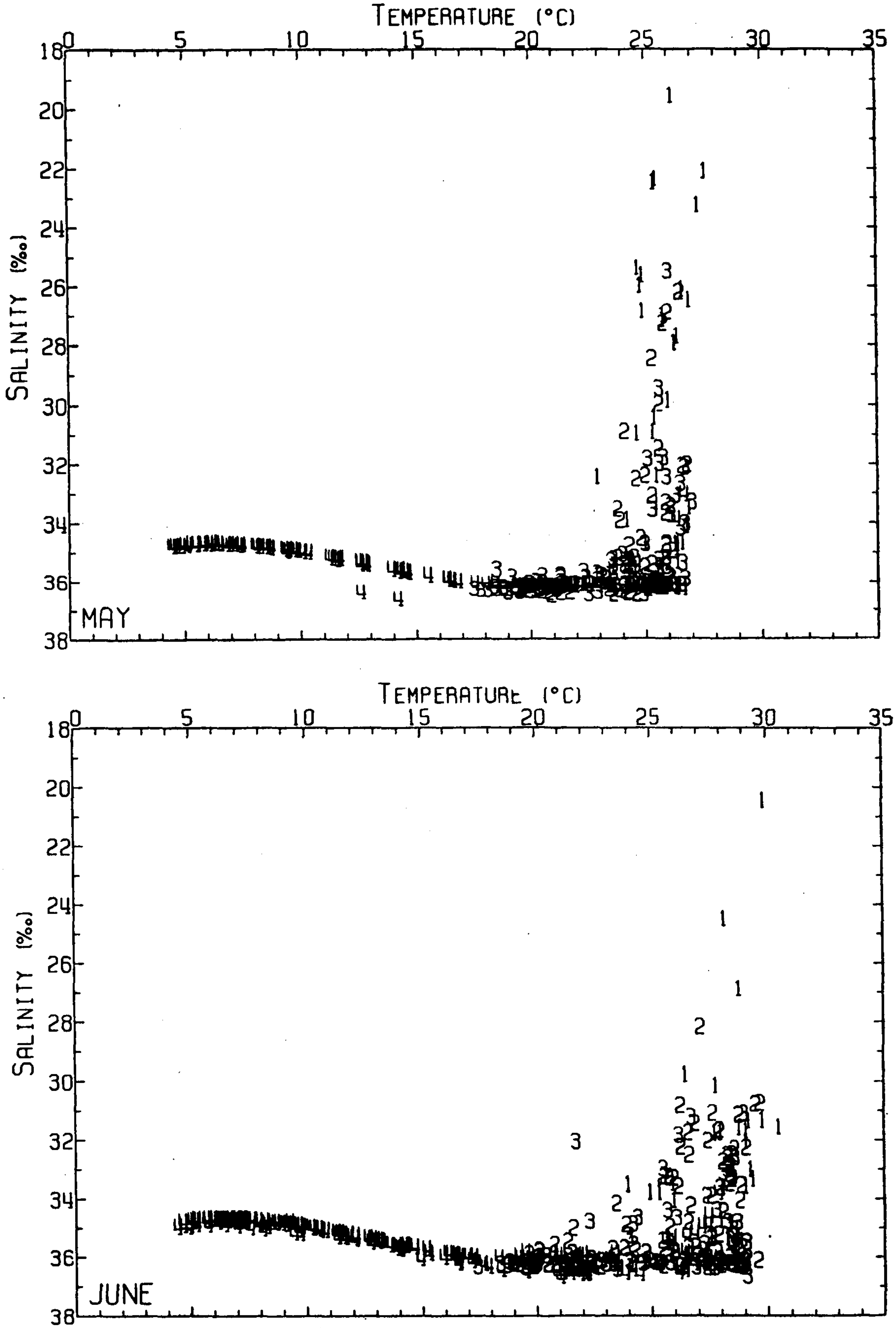
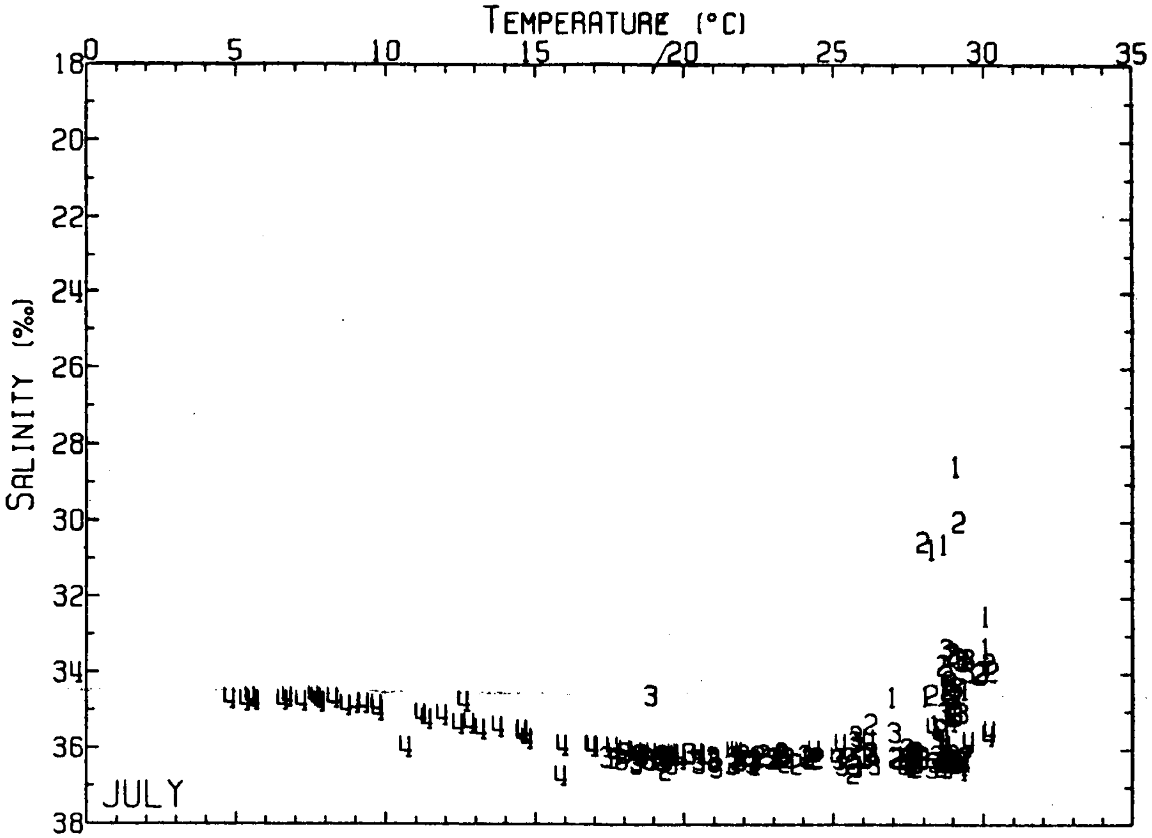


Figure 157. Thermohaline indices for May and June



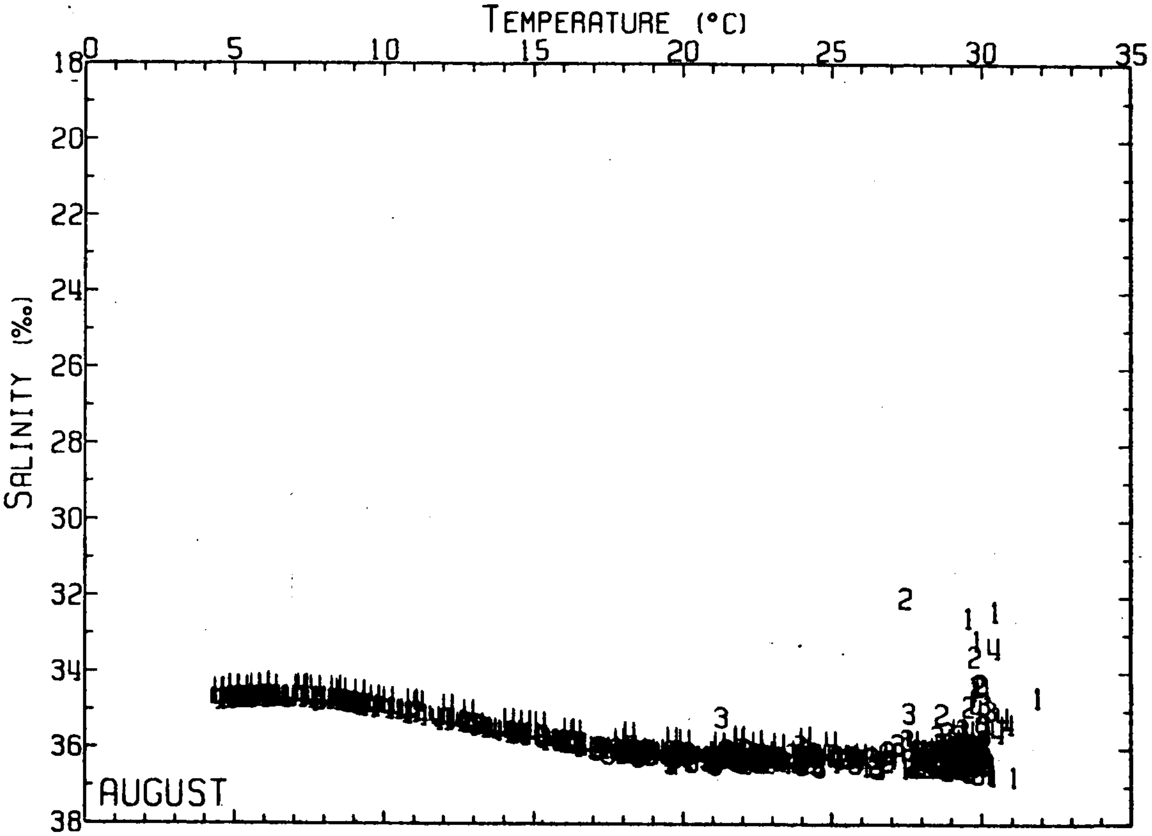
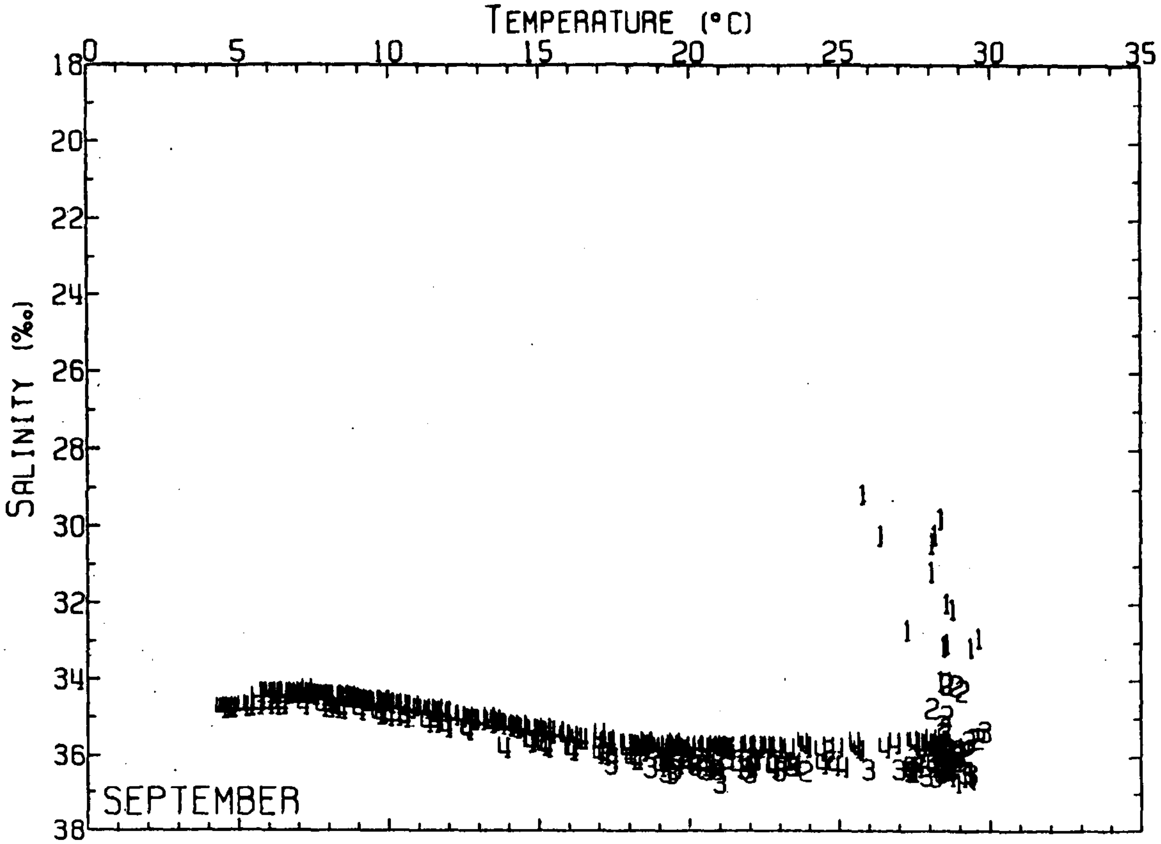


Figure 158. Thermohaline indices for July and August



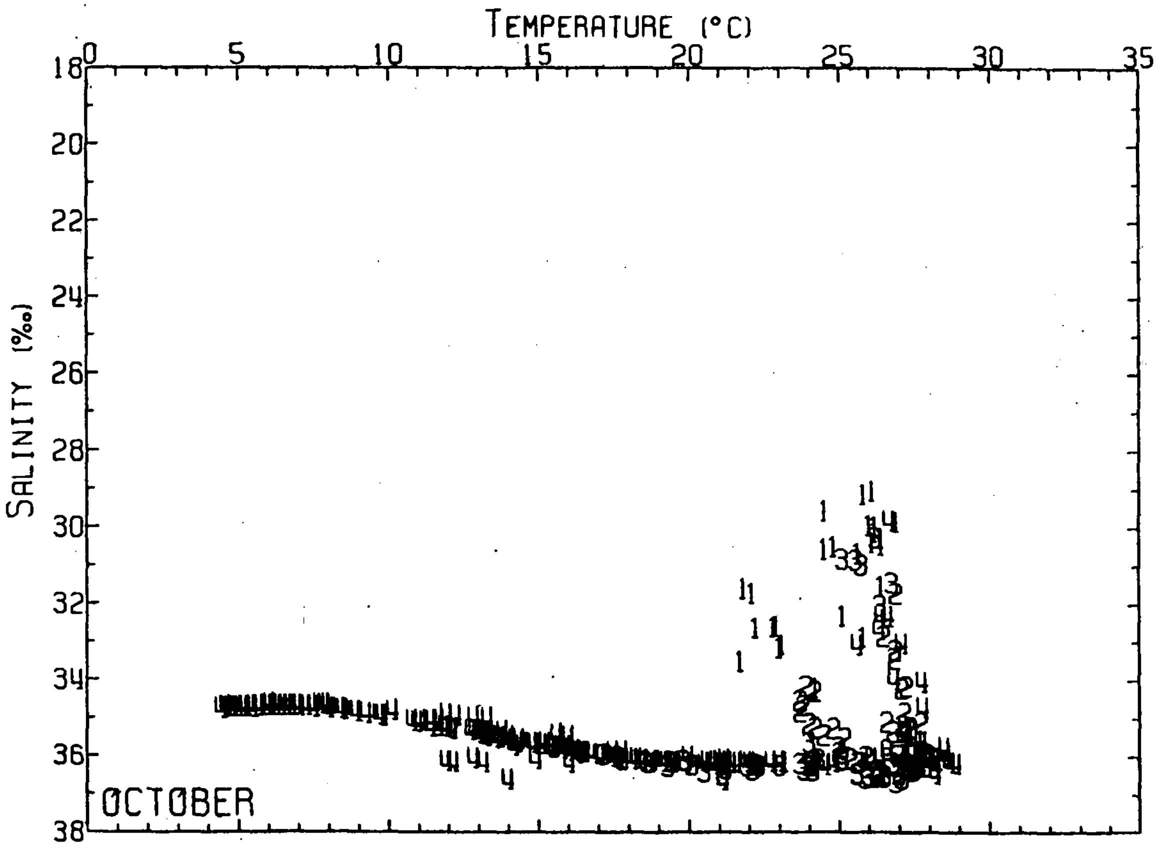
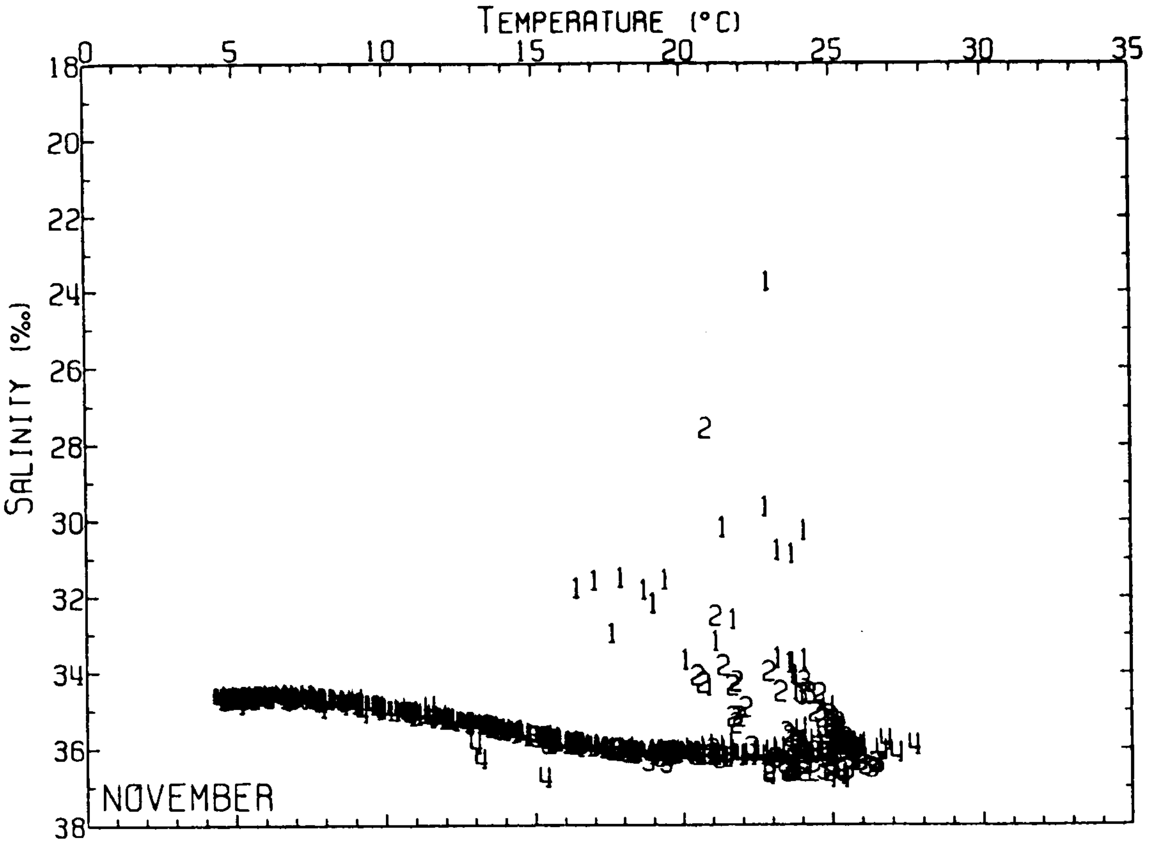


Figure 159. Thermohaline indices for September and October



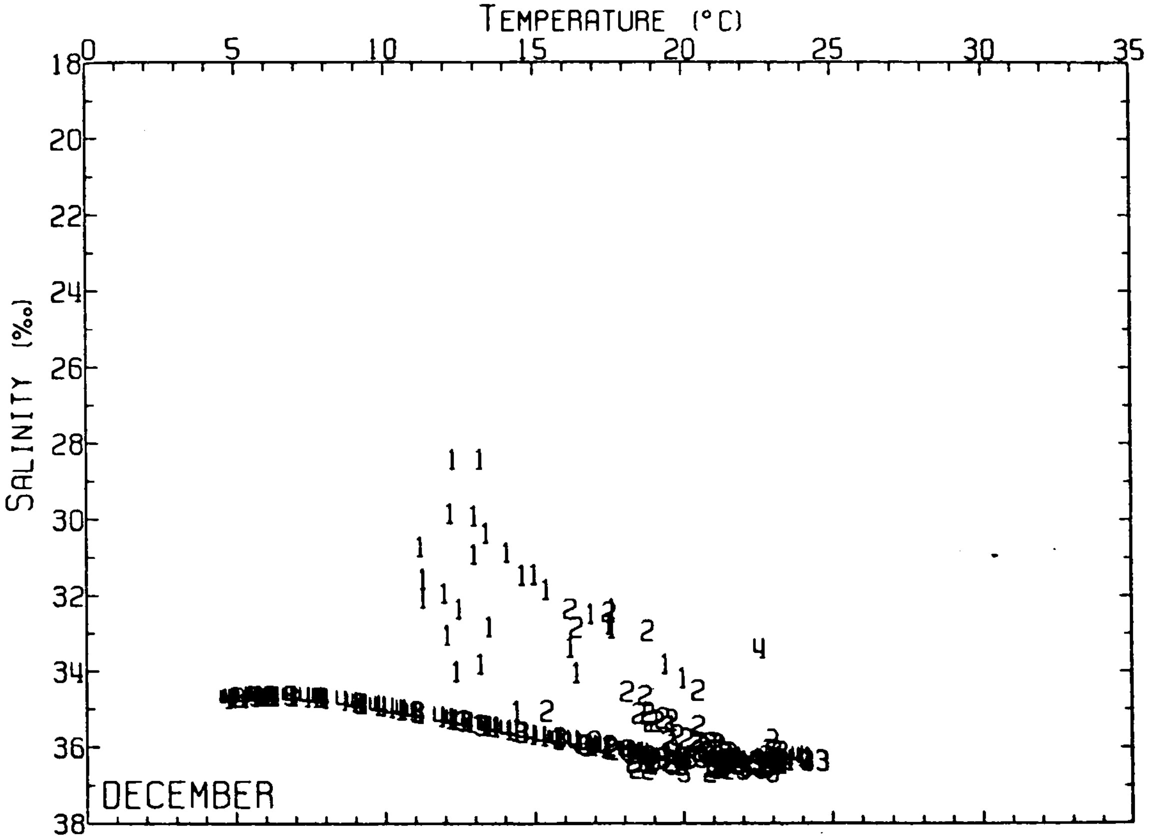


Figure 160. Thermohaline indices for November and December

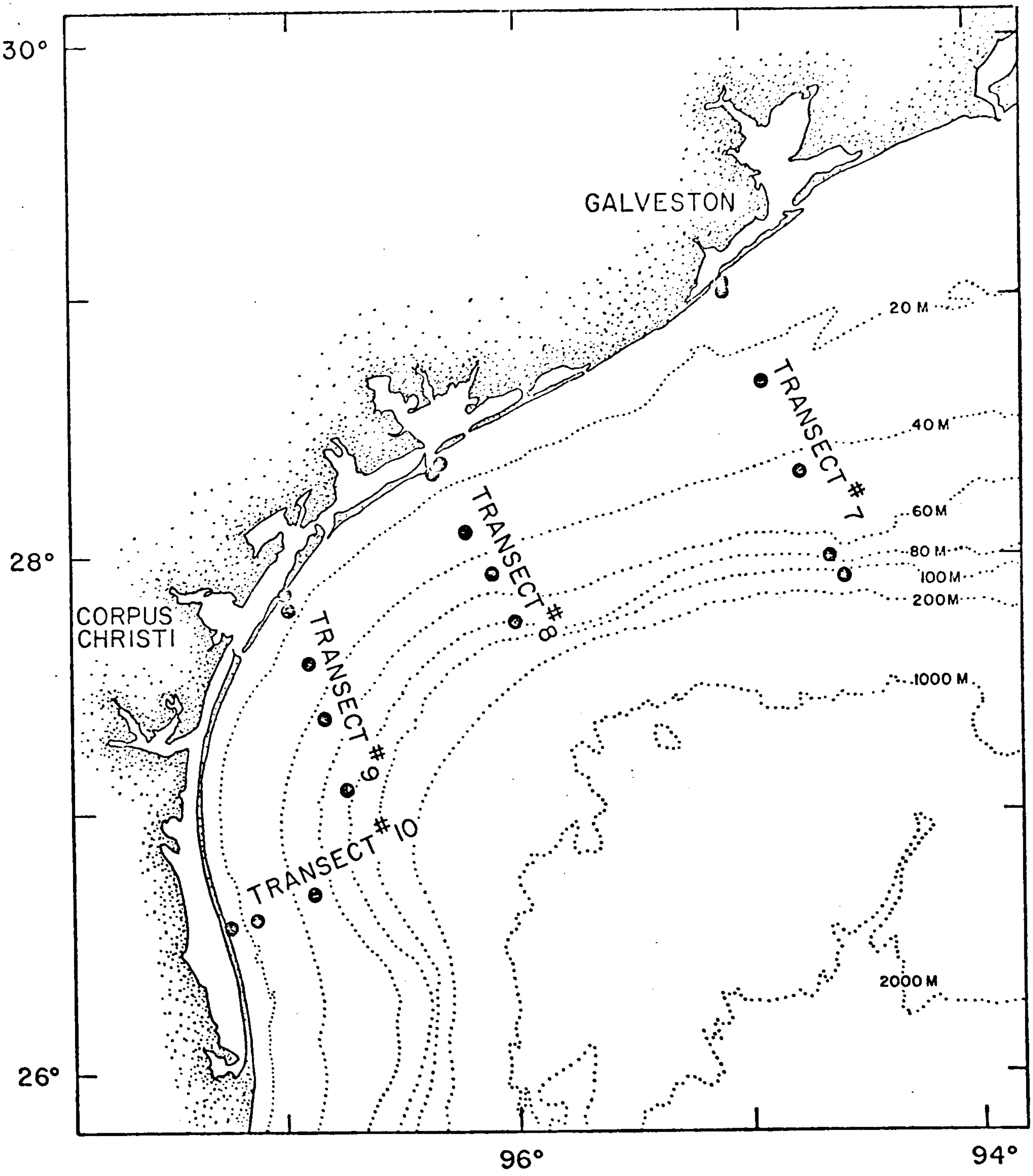


Figure 161. Station locations for monthly surveys of GUS III, 1963-1965.

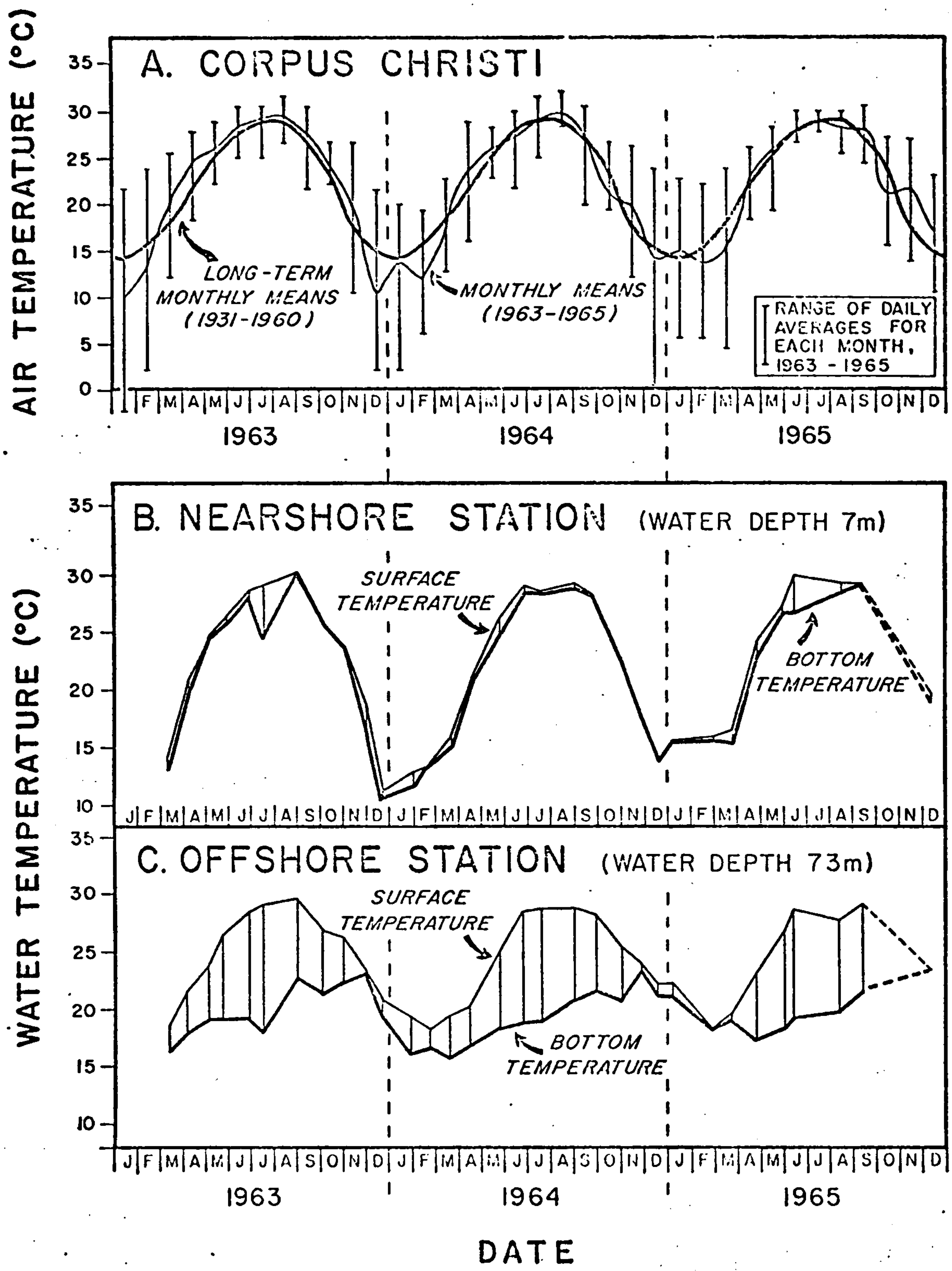


Figure 162. Air and water temperature cycles, 1963-1965
a) Air temperature, Corpus Christi (from Local Climatological Data, National Weather Service)
b) & C) GUS III water temperatures off Pass Cavallo (transect 8)

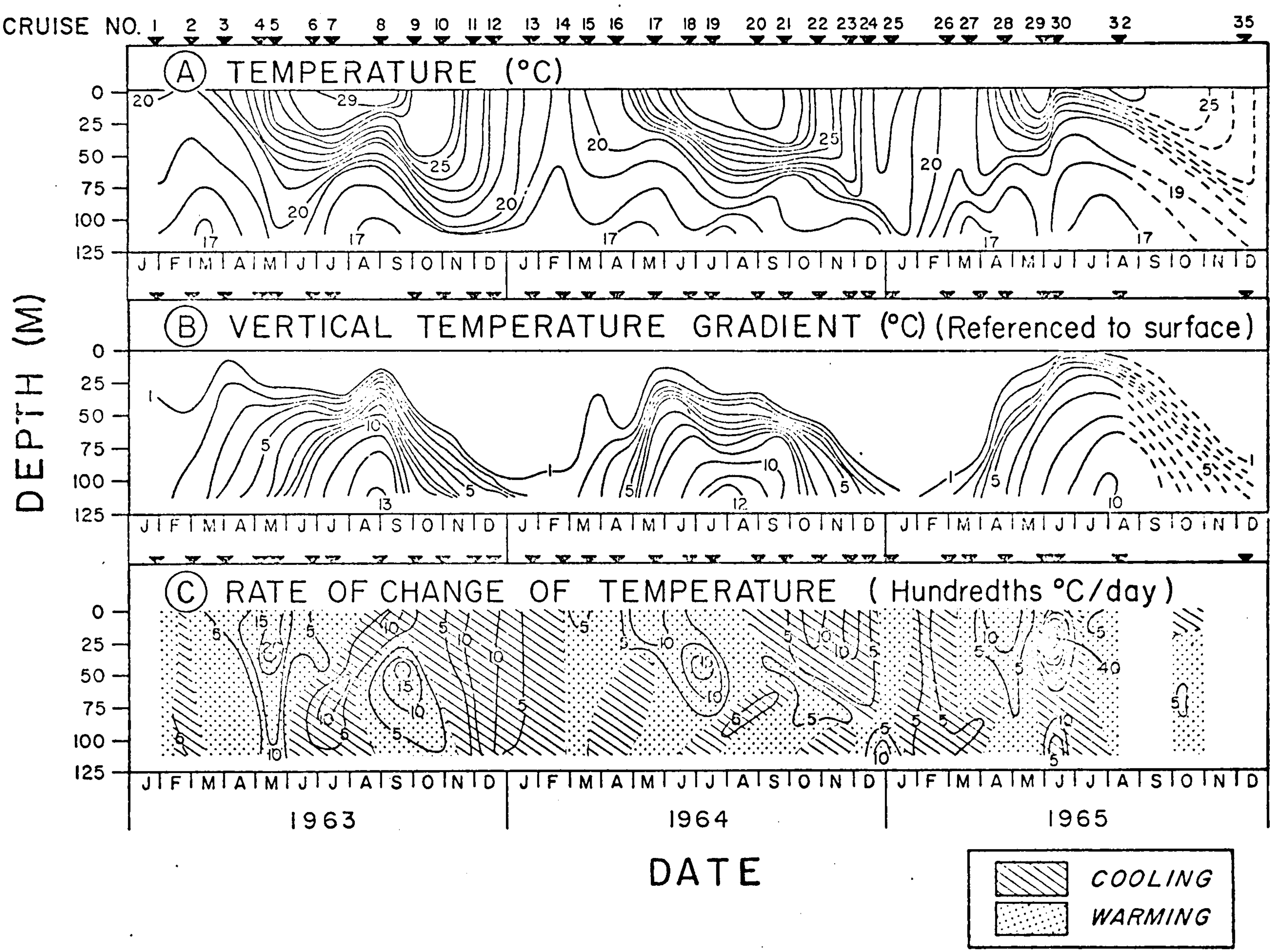


Figure 163. Thermal structure over outer continental shelf south of Galveston - GUS III cruises, 1963-1965.

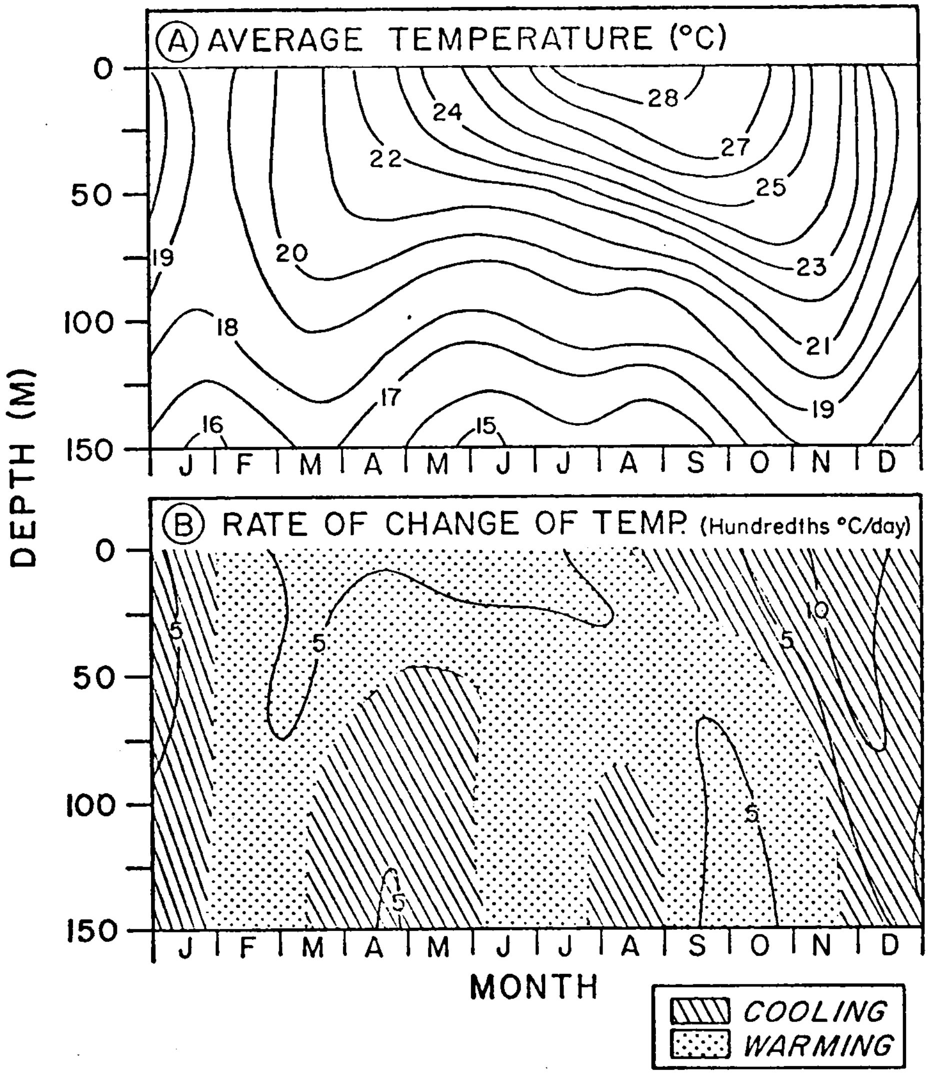


Figure 164. Average thermal structure at 27°N, 96°W -derived from Robinson (1973)..

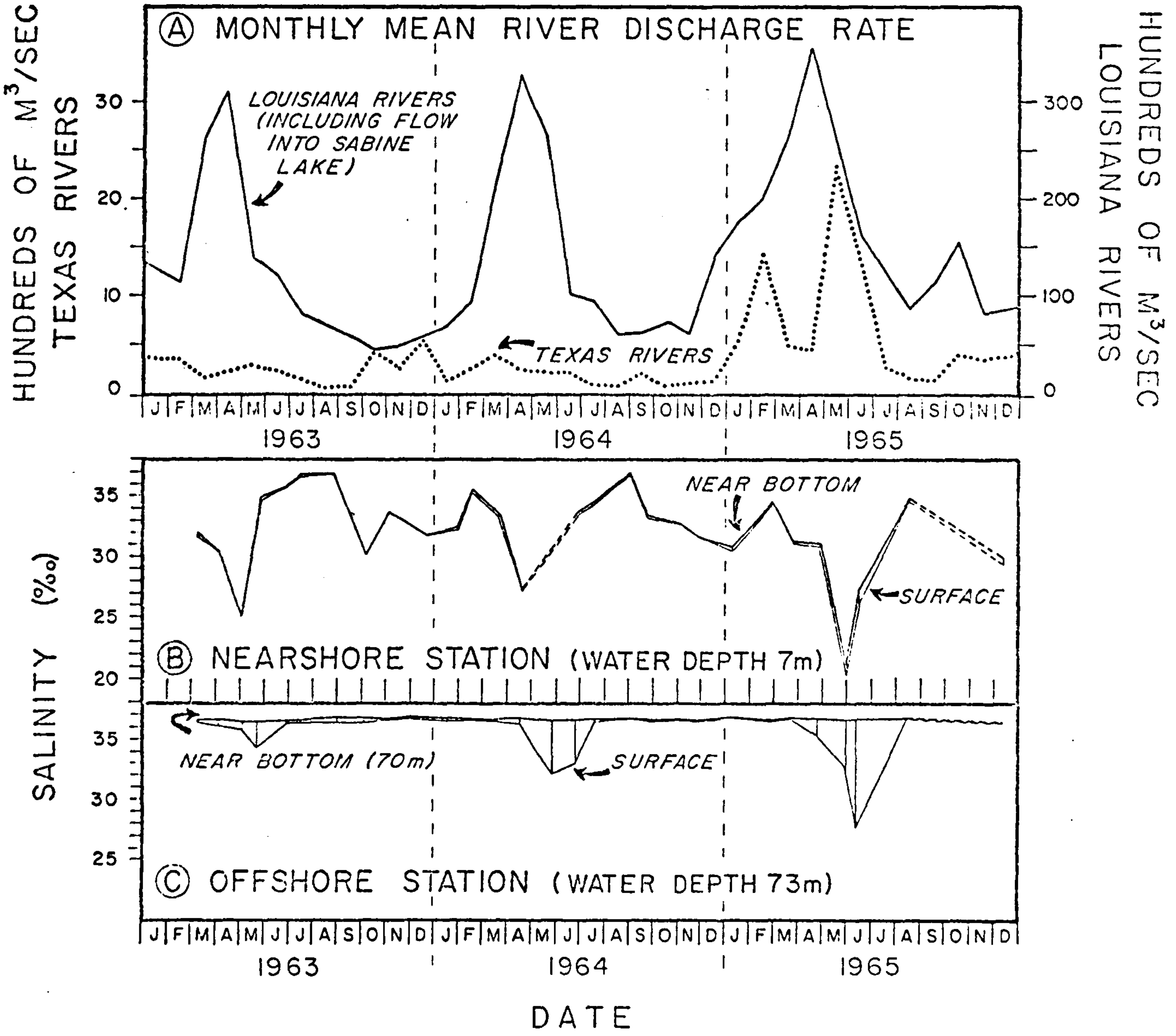


Figure 165. River discharge and salinity cycle, 1963-1965
a. Discharge from rivers of northwestern Gulf (from U.S. Geol. Survey)
b.& c. GUS III salinities off Pass Cavallo (transect 8)

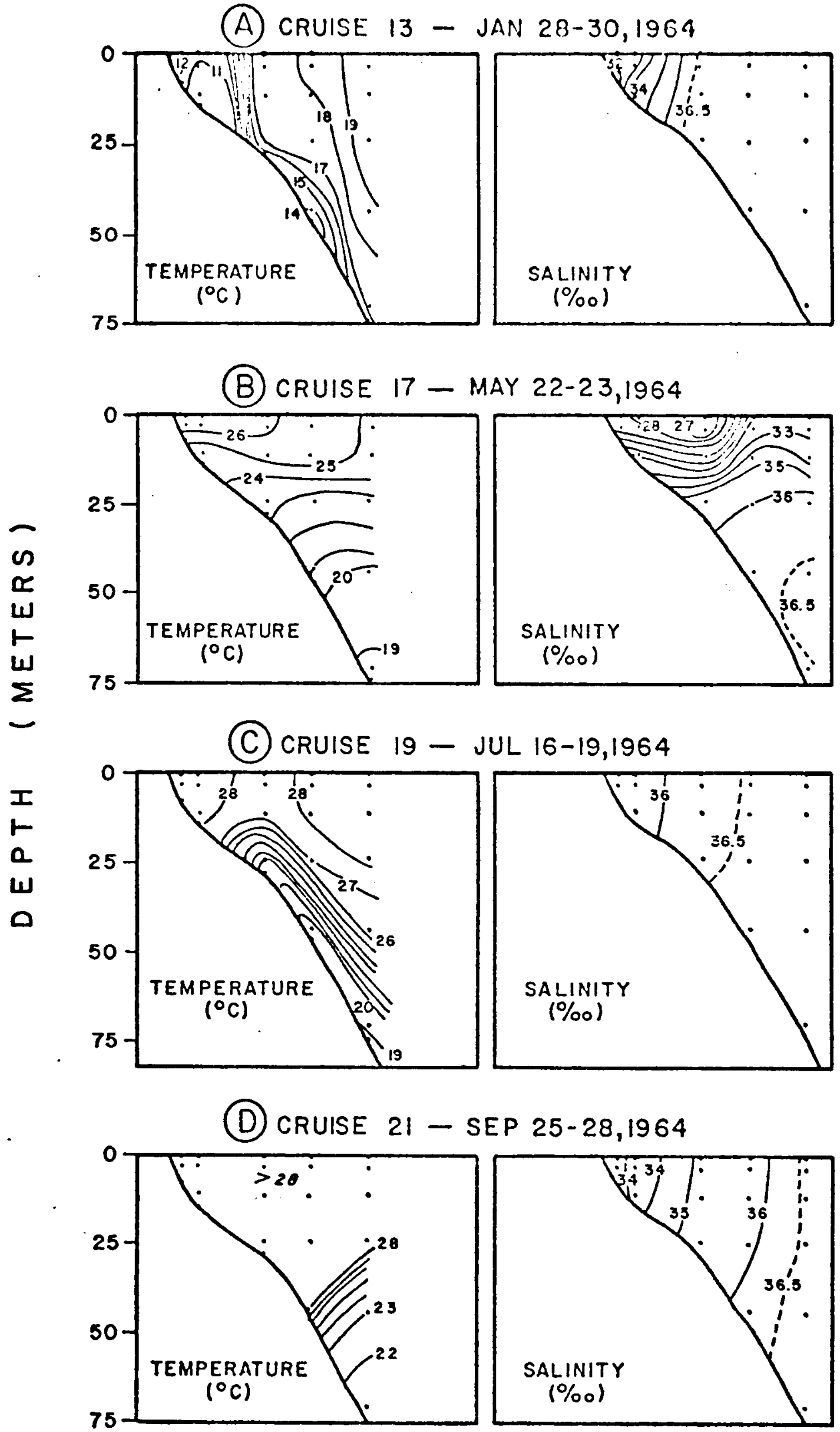


Figure 166. Seasonal temperature and salinity structure during 1964 off Pass Cavallo (transect 8) from GUS III cruises.

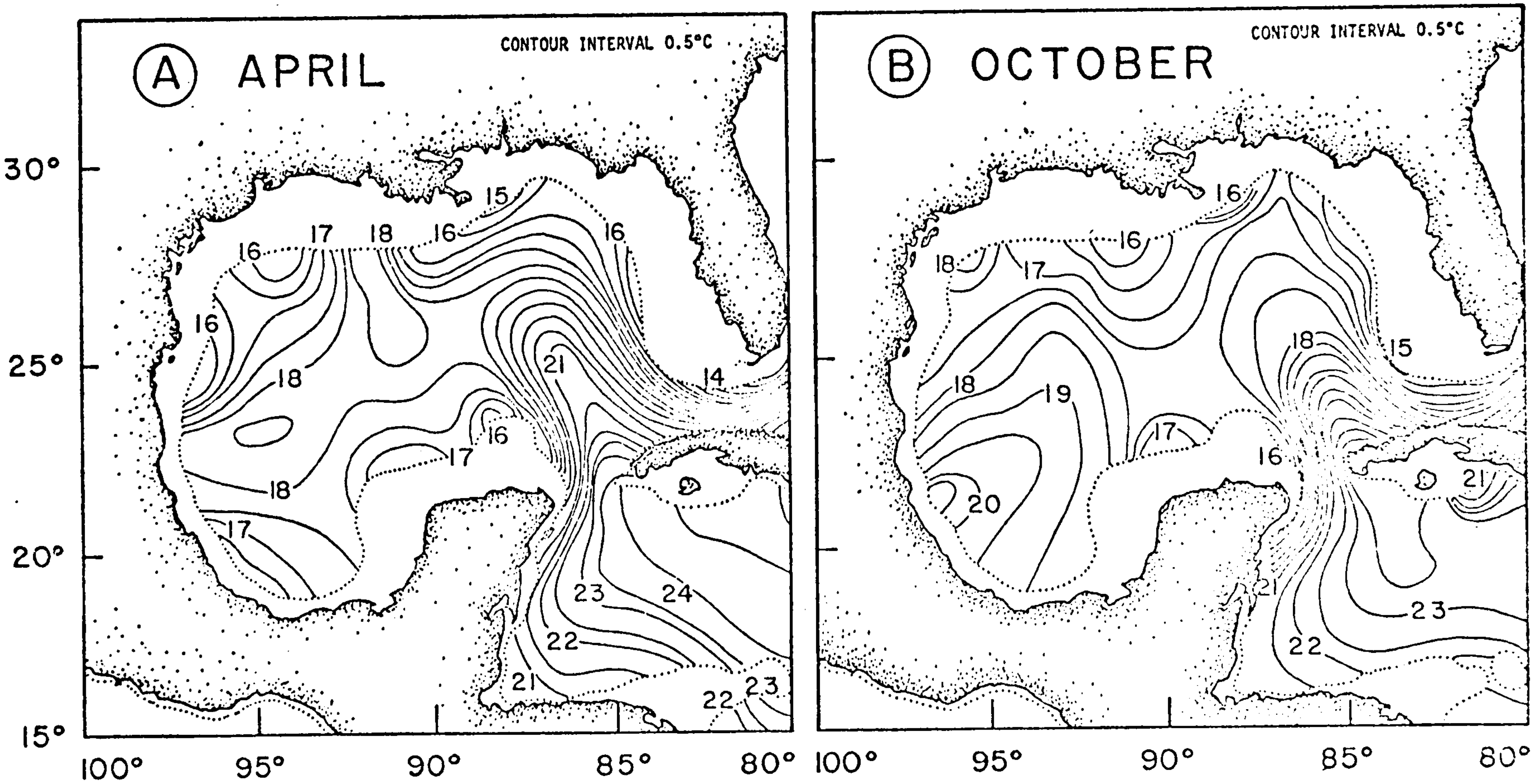


Figure 167. Monthly mean temperature (°C) at 150 m from Robinson (1973, figs. 27 & 69).

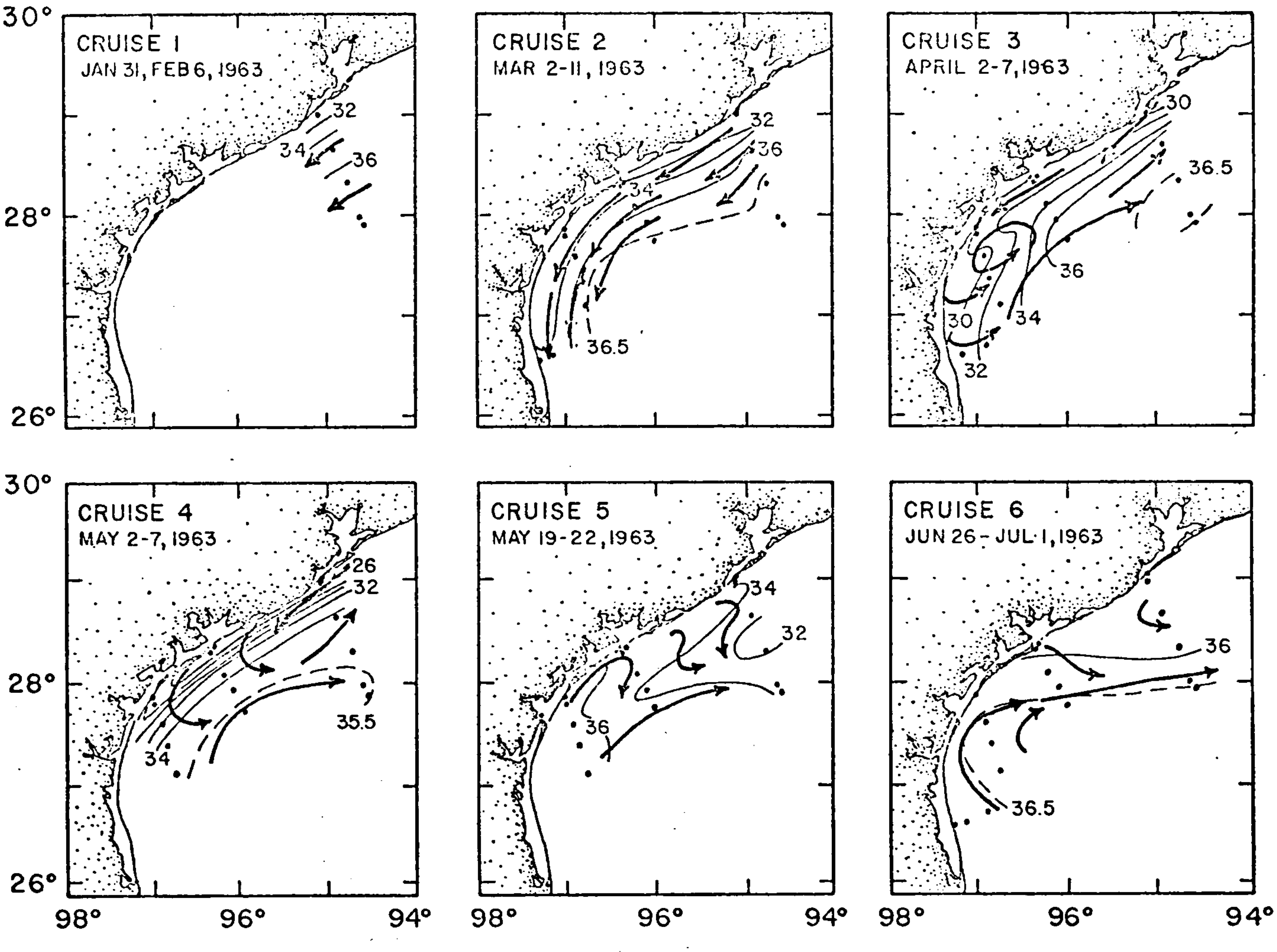


Figure 168a. Shelf water circulation and surface salinity (°/₀₀) GUS III cruises (1963-1965).

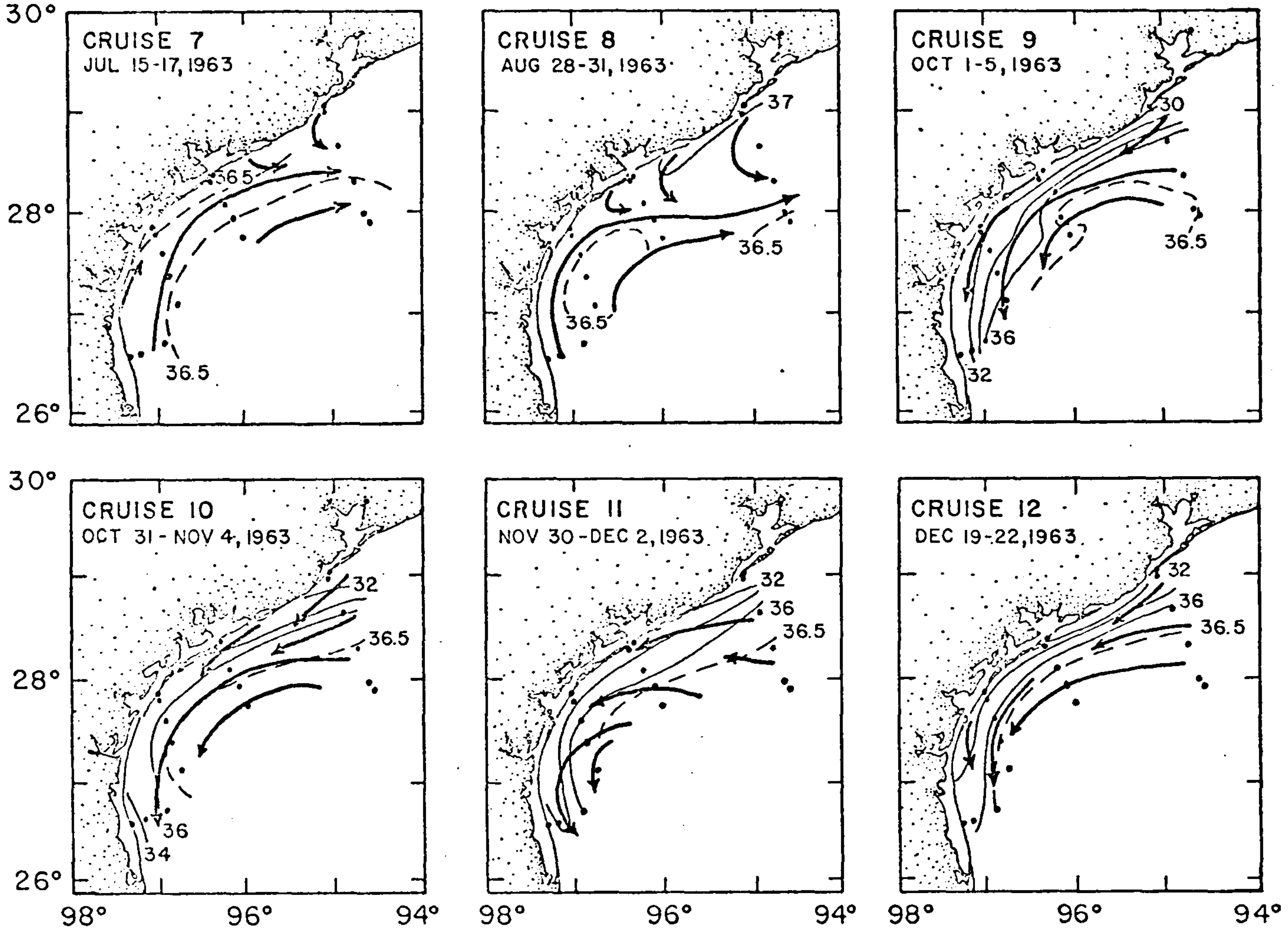


Figure 168b. Shelf water circulation and surface salinity (°/₀₀) GUS III cruises (1963-1965).

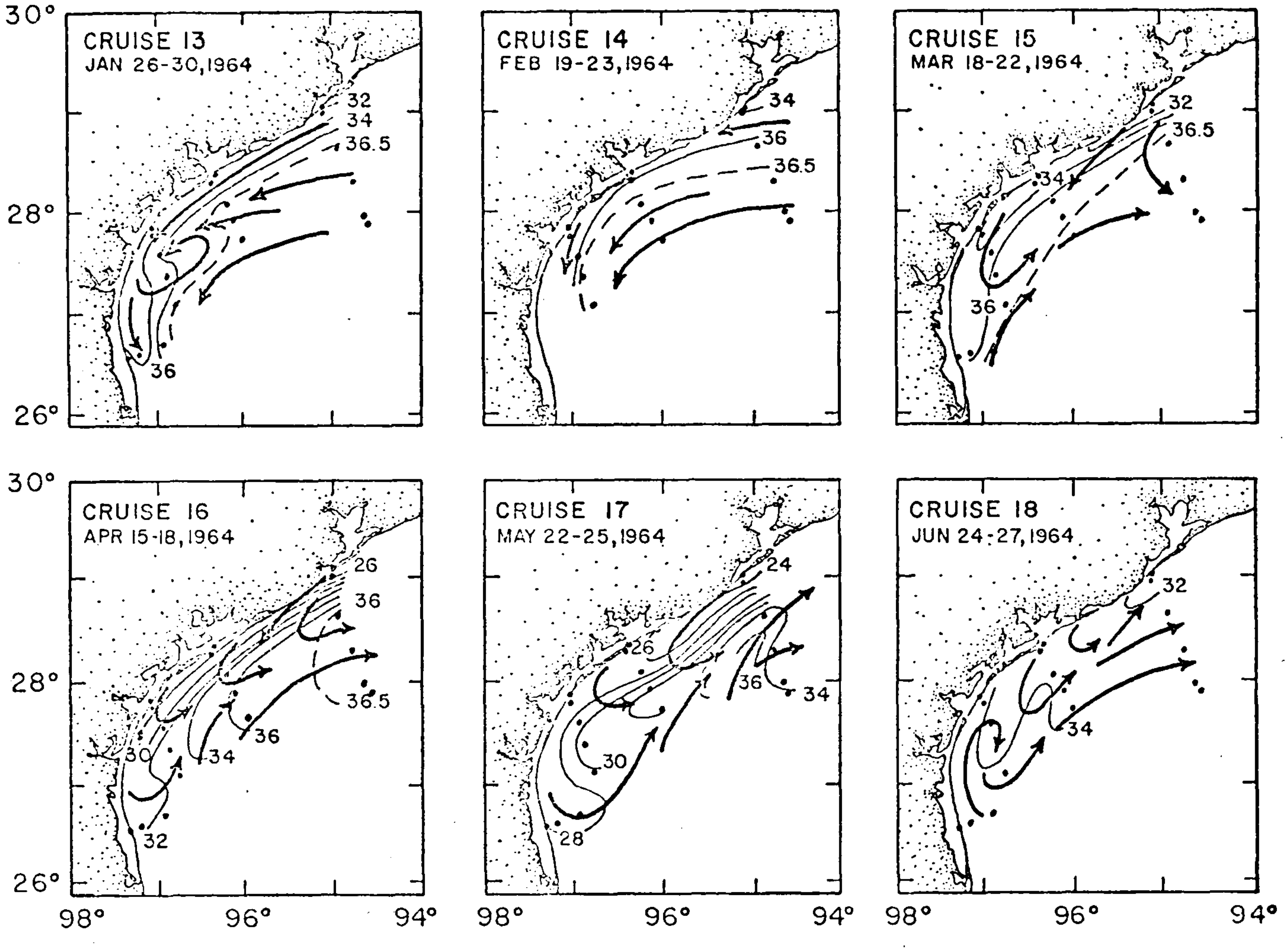


Figure 168c. Shelf water circulation and surface salinity (°/oo) GUS III cruises (1963-1965).

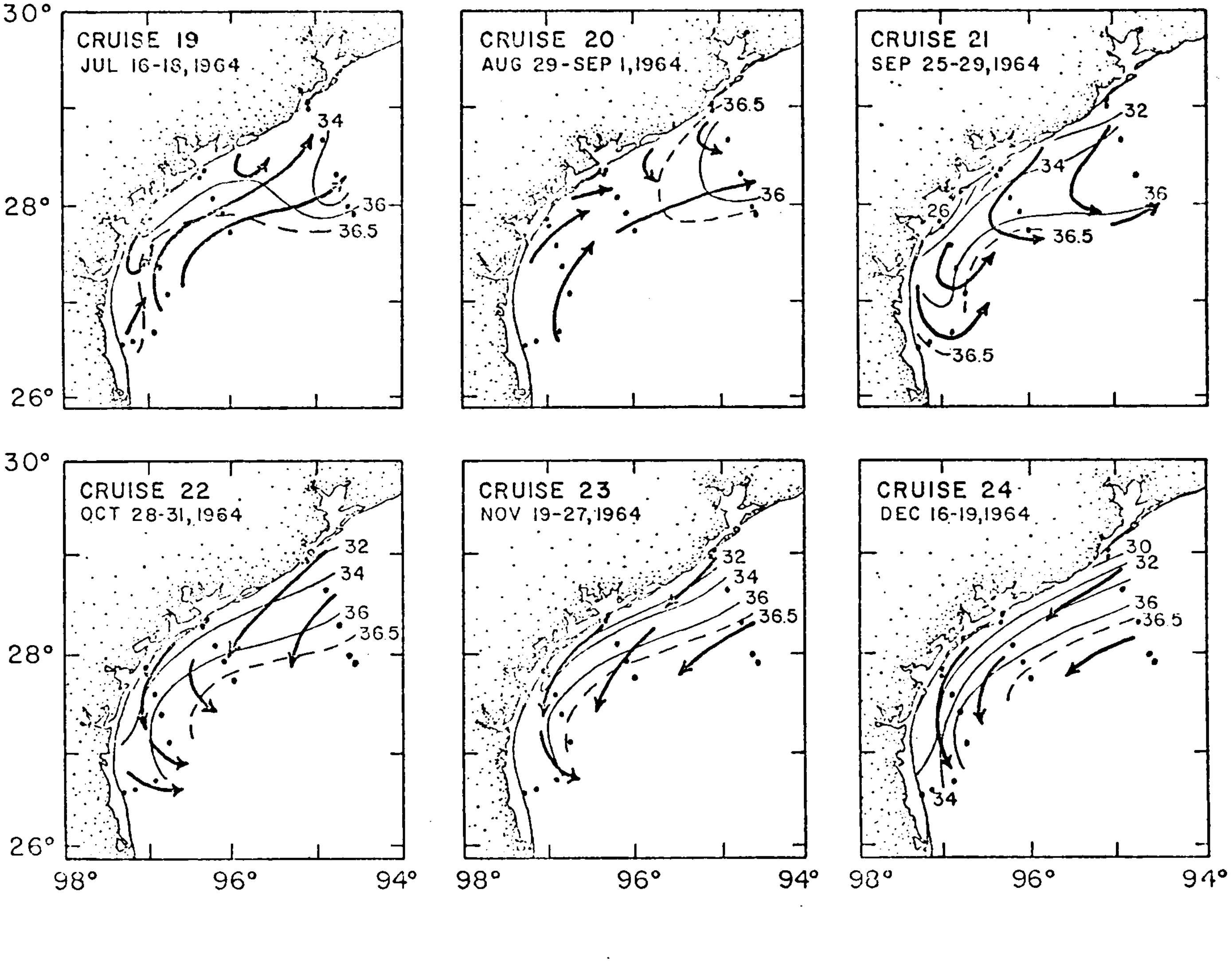


Figure 168d. Shelf water circulation and surface salinity (°/₀₀) GUS III cruises (1963-1965).

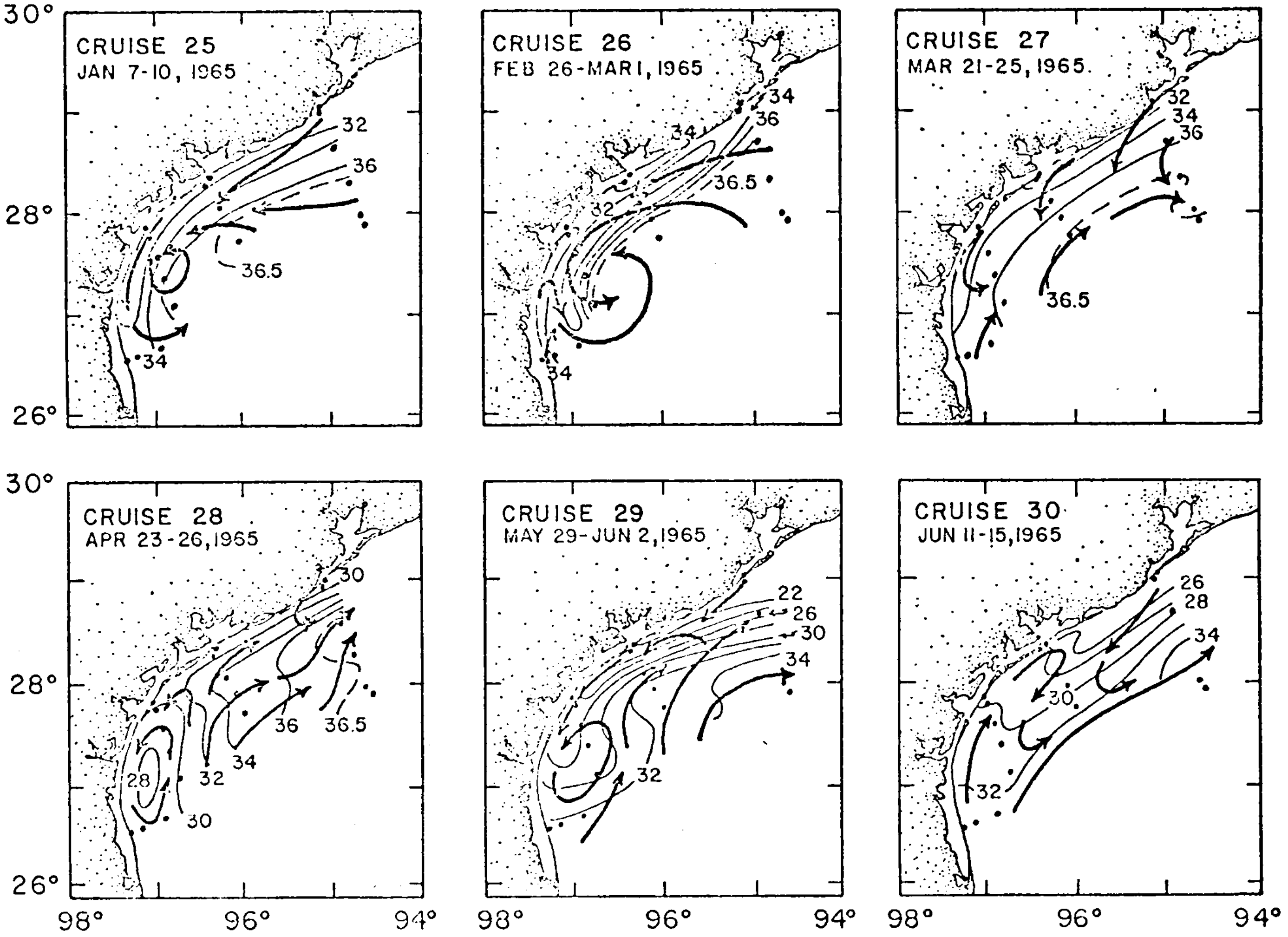


Figure 168e. Shelf water circulation and surface salinity (°/₀₀) GUS III cruises (1963-1965).

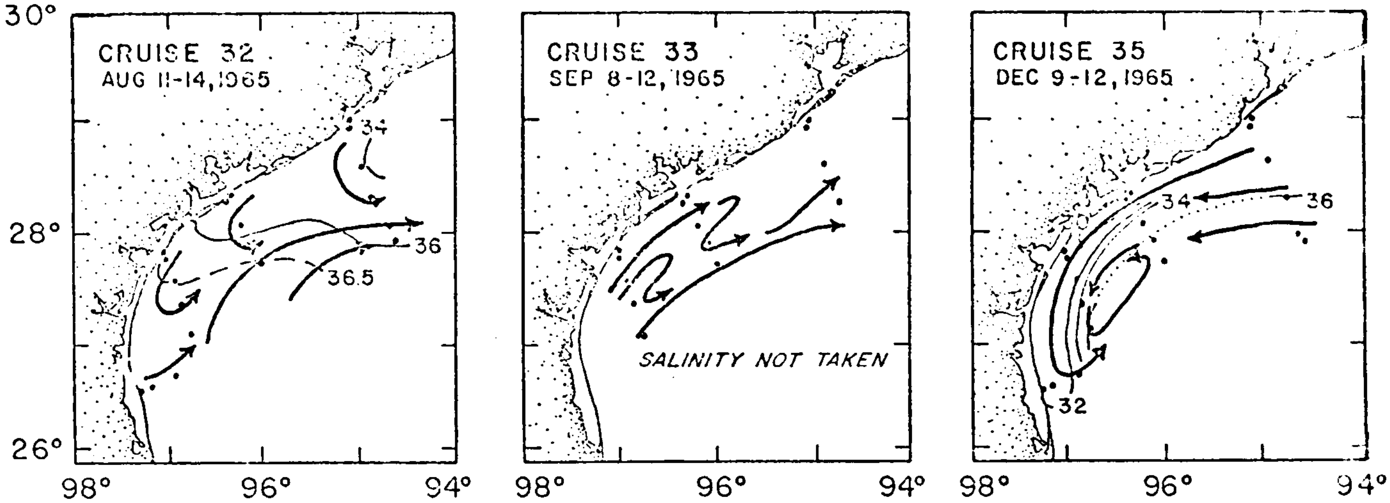


Figure 168f. Shelf water circulation and surface salinity (°/oo) GUS III cruises (1963-1965).

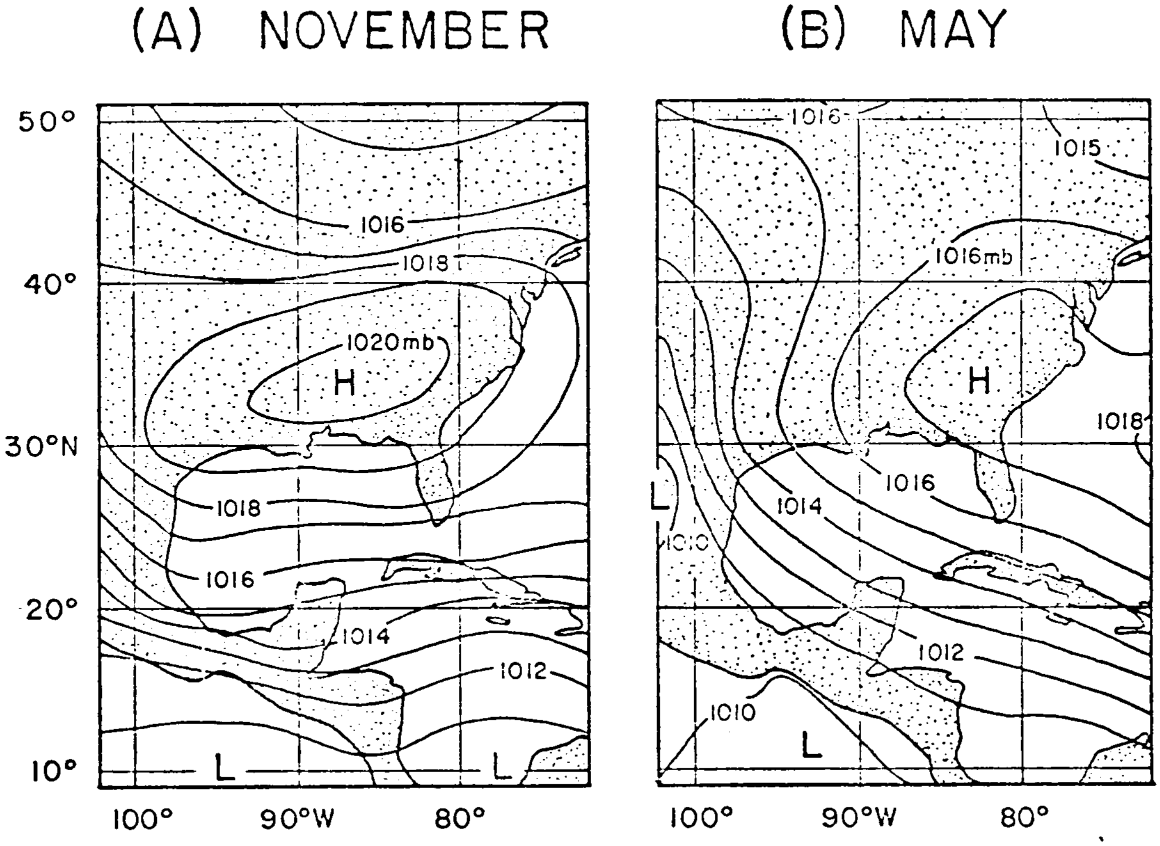


Figure 169. Monthly mean surface atmospheric pressure (mb) from Pacific Environmental Group results, based on FNWC long-term (1946-1969) means.

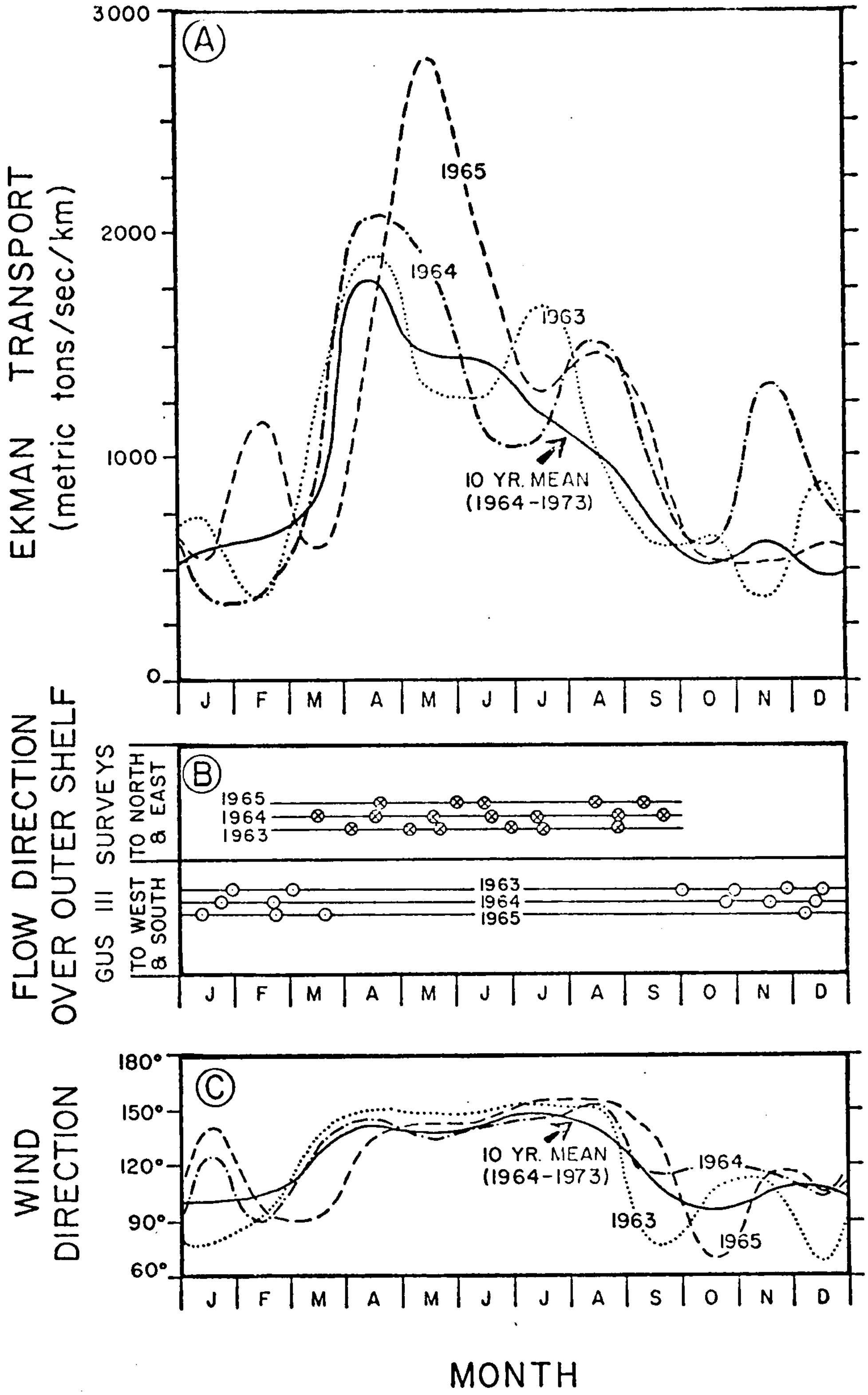


Figure 170. Shelf water flow and wind dynamics (1963-1965)
a. Magnitude of monthly mean Ekman transport at 27°N, 96°W
b. Direction of flow over outer continental shelf from GUS III surveys
c. Monthly mean wind direction at 27°N, 96°W
(a & c from Pacific Environmental Group results, based on FNWC data)

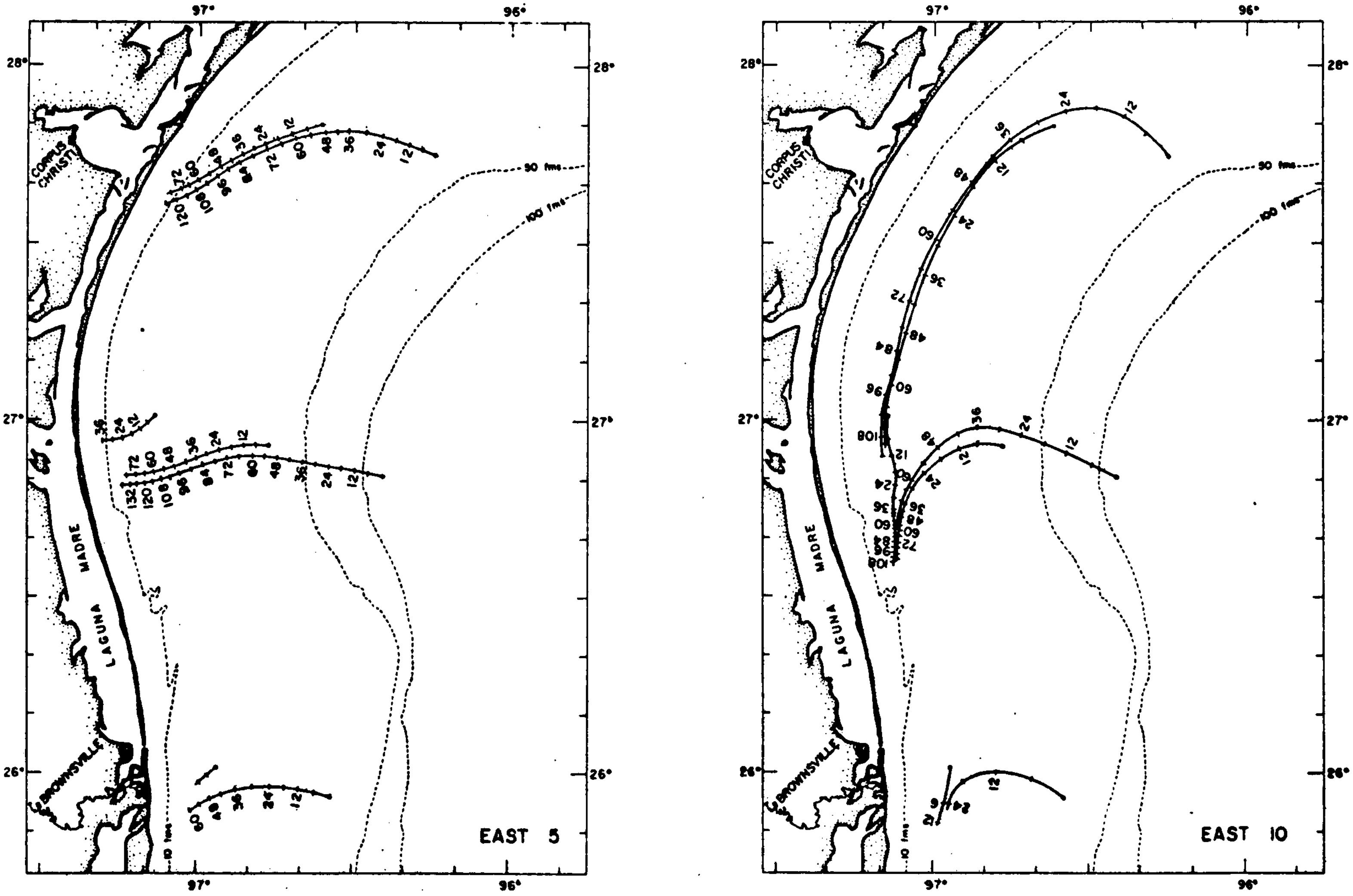


Figure 171. Centroid trajectories for east winds of 5 and 10 m/s. Time in hours.

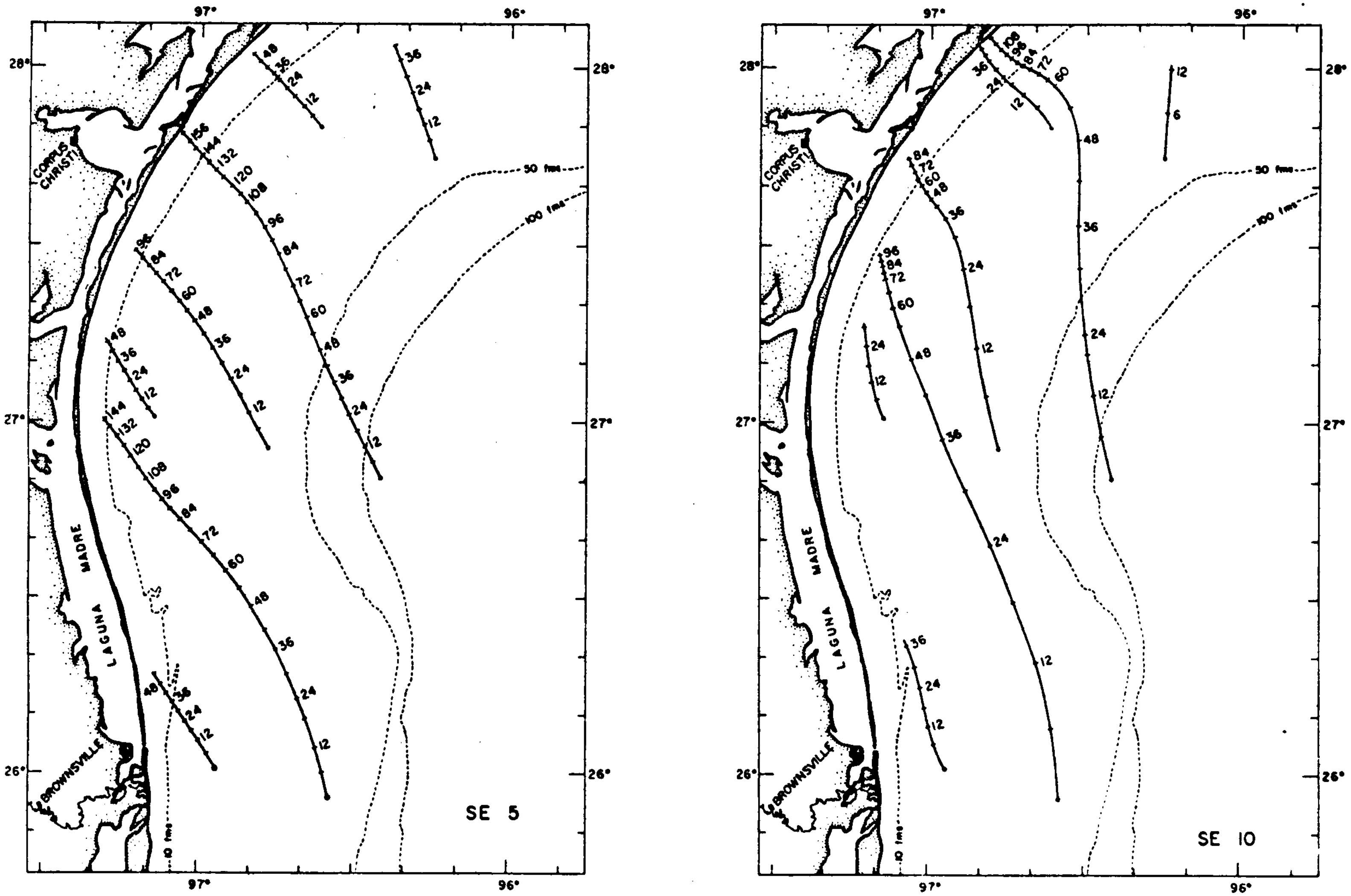


Figure 172. Centroid trajectories for southeast winds of 5 and 10 m/s. Time in hours.

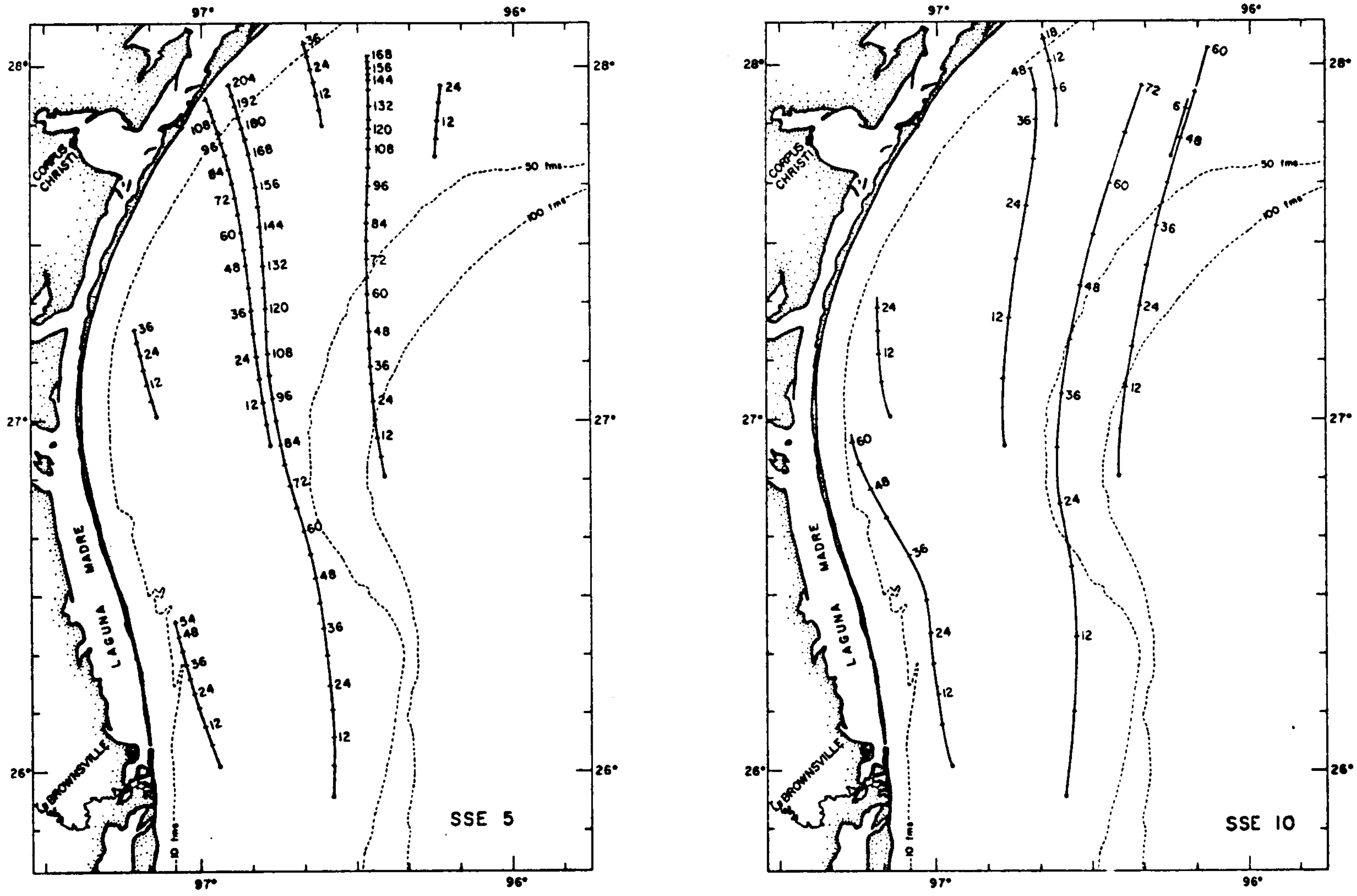


Figure 173. Centroid trajectories for south-southeast winds of 5 and 10 m/s. Time in hours.

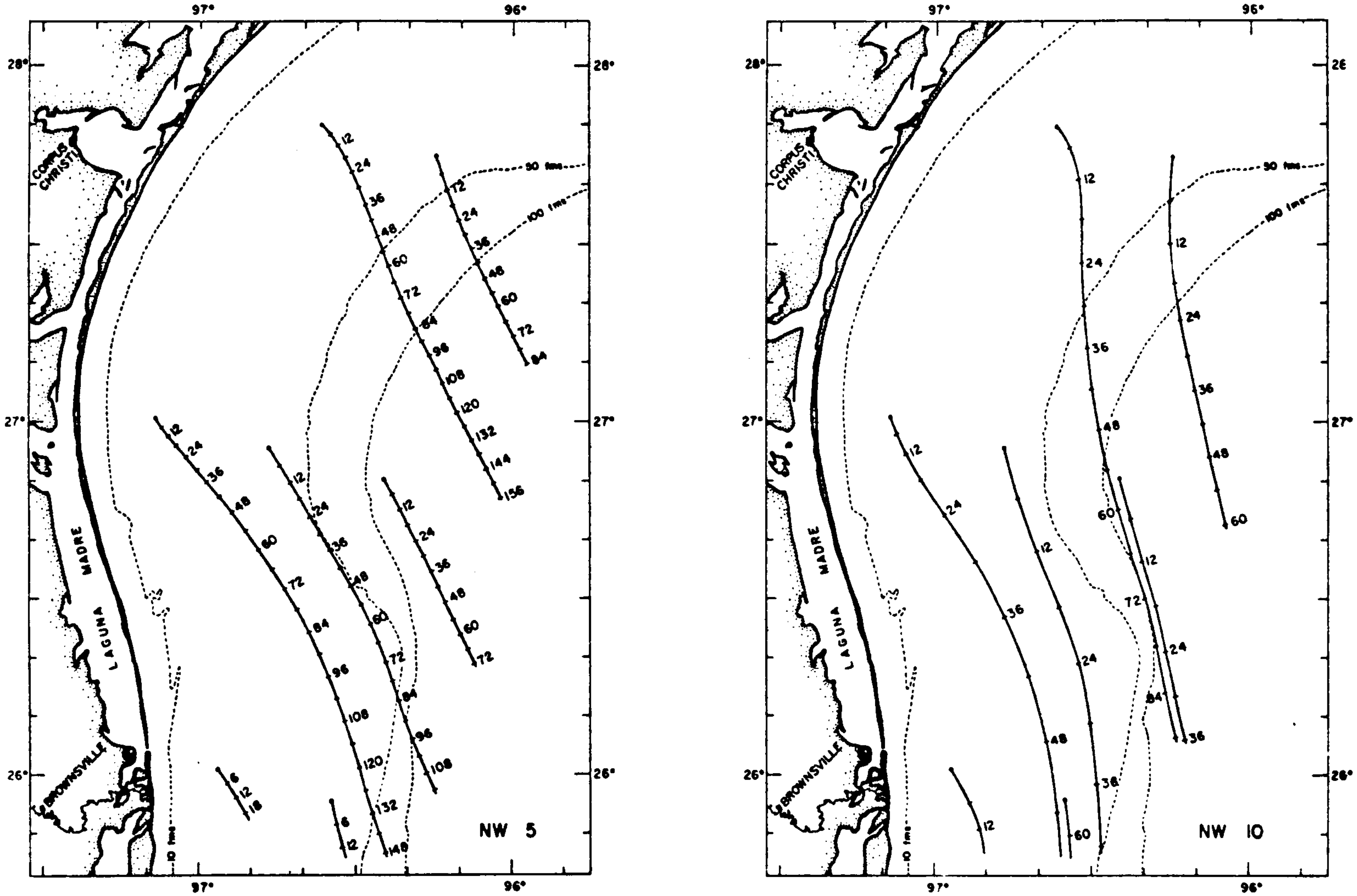


Figure 174. Centroid trajectories for northwest winds of 5 and 10 m/s. Time in hours.

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APPENDIX

Table 1. Temperature (°C) and salinity (°/oo) values by station, cruise, and depth made along transect 7 from 1963-1965.

STATION: W-55
DEPTH: 7.3 M
LATITUDE: 29°03' N
LONGITUDE: 95°06' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	11	3	1963	14.7	14.8						14.8	31.47	31.43					
3	2	4	1963	22.2	22.2						20.4	28.97	28.97					
4	7	5	1963	25.2	25.3						24.0	22.68	23.23					
5	19	5	1963	26.7	26.6						23.2	33.68	34.82					
6	1	7	1963	29.0	28.9						28.8	34.90	34.81					
7	17	7	1963	28.7	28.7						28.4	36.15	36.17					
8	28	8	1963	31.1	31.1						31.1	37.06	36.97					
9	1	10	1963	25.9	25.9						25.9	29.29	29.26					
10	31	10	1963	24.6	24.6						24.6	30.74	30.67					
11	30	11	1963	16.2	00.0						00.0	31.99	32.10					
12	19	12	1963	11.8	11.8						11.6	32.18	32.09					
13	26	1	1964	9.9	9.7						9.4	32.01	31.83					
14	19	2	1964	12.4	12.4						12.2	33.55	33.72					
15	22	3	1964	15.1	15.0						14.6	31.78	31.93					
16	15	4	1964	19.7	19.6						19.4	25.81	25.76					
17	22	5	1964	27.1	27.1						26.2	23.47	23.49					
18	24	6	1964	29.6	29.6						25.8	31.58	31.59					
19	16	7	1964	28.5	28.5						28.5	34.52	34.79					
20	29	8	1964	29.6	29.6						29.6	36.64	36.62					
21	25	9	1964	28.0	28.0						28.0	30.45	30.41					
22	28	10	1964	21.9	21.9						21.9	31.96	32.02					
23	19	11	1964	23.5	23.5						23.5	31.10	31.05					
24	19	12	1964	12.1	12.1						12.1	28.66	28.61					
25	10	1	1965	15.4	15.4						16.0	30.45	30.41					
26	26	2	1965	13.8	14.2						14.2	32.78	33.13					
27	20	3	1965	14.7	14.7						14.5	30.16	30.12					
28	23	4	1965	23.9	23.9						23.8	28.96	29.01					
29	2	6	1965	27.3	27.3						26.4	21.06	20.96					
30	15	6	1965	29.3	28.8						25.9	24.70	25.68					
32	11	8	1965	29.0	28.9						28.7	34.84	35.07					
33	8	9	1965	29.8	29.7						29.6	00.00	00.00					
35	9	12	1965	17.3	17.2						17.1	00.00	00.00					

Table 1. (Continued)

STATION: W-1
DEPTH: 13.7 M
LATITUDE: 29°01' N
LONGITUDE: 95°05' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
1	6	2	1963	10.3	10.3	10.9					10.8	31.00	31.00	31.70				
2	2	3	1963	12.8	12.8	12.8					12.8	31.31	31.40	31.31				
3	3	4	1963	21.9	22.0	19.4					19.2	29.34	29.40	32.40				
4	7	5	1963	25.2	25.3	24.0					23.9	00.00	32.62	34.11				
5	20	5	1963	25.6	26.1	23.2					23.0	34.32	34.92	35.81				
6	1	7	1963	28.9	28.9	28.6					28.1	34.69	34.69	35.26				
7	17	7	1963	29.3	29.3	29.3					29.3	36.53	36.38	36.61				
8	28	8	1963	30.4	30.2	30.1					30.1	00.00	36.94	36.92				
9	2	10	1963	26.0	26.1	26.2					26.1	30.22	30.36	30.68				
10	31	10	1963	24.3	24.4	24.9					25.1	30.81	30.76	32.56				
11	30	11	1963	17.4	17.4	17.5					17.6	33.20	33.13	33.35				
12	19	12	1963	12.3	12.3	12.3					12.3	32.59	32.52	32.54				
13	26	1	1964	9.8	9.8	9.8					9.9	32.79	32.87	34.01				
14	19	2	1964	12.4	12.4	12.4					12.4	35.02	34.91	34.97				
15	22	3	1964	15.1	15.1	14.9					14.9	31.93	32.08	34.80				
16	15	4	1964	19.4	19.4	19.3					19.2	28.78	28.88	29.31				
17	22	5	1964	26.4	26.4	26.3					25.8	26.34	26.40	27.05				
18	25	6	1964	29.0	28.6	25.8					25.0	31.61	31.83	34.29				
19	16	7	1964	27.9	27.9	26.8					26.5	34.84	34.82	34.87				
20	29	8	1964	29.3	29.3	29.3					29.2	36.37	36.37	36.33				
21	25	9	1964	27.9	27.9	27.9					27.9	31.40	31.33	31.49				
22	28	10	1964	22.0	22.0	22.0					22.1	32.86	32.88	32.89				
23	19	11	1964	23.9	23.0	23.0					23.0	31.00	30.98	30.99				
24	19	12	1964	12.8	12.8	13.2					13.3	30.15	30.12	30.61				
25	10	1	1965	15.4	15.4	15.5					16.3	30.51	30.52	33.79				
26	26	2	1965	13.7	14.0	14.7					14.7	33.37	33.68	35.55				
27	21	3	1965	14.8	14.8	14.9					14.9	32.47	32.39	32.40				
28	23	4	1965	23.4	23.3	23.2					23.0	29.97	29.96	30.02				
29	2	6	1965	27.1	27.1	26.7					26.6	21.16	21.12	31.94				
30	15	6	1965	29.3	28.7	25.6					25.5	24.51	26.59	34.81				
32	11	8	1965	29.0	29.0	28.6					28.5	34.87	35.28	35.32				
33	9	9	1965	29.6	29.5	29.4					29.4	00.00	00.00	00.00				
35	9	12	1965	18.9	18.9	18.9					18.9	00.00	00.00	00.00				

Table 1. (Continued)

STATION: W-2
DEPTH: 27.5 M
LATITUDE: 28°40' N
LONGITUDE: 94°56' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
1	31	1	1963	13.4	13.2	12.7	13.4				13.4	35.45	35.50	35.30	35.78			
2	3	3	1963	14.2	13.7	13.5	13.8				13.8	35.73	35.73	35.68	35.98			
3	3	4	1963	20.1	19.7	19.3	18.5				18.5	36.17	36.23	36.46	36.24			
4	7	5	1963	23.7	24.1	24.2	23.6				23.3	34.13	34.97	35.24	35.37			
5	20	5	1963	26.4	26.4	25.7	23.1				22.8	32.29	32.24	33.53	36.08			
6	26	6	1963	28.7	28.6	28.6	26.1				26.0	34.45	34.93	34.91	35.58			
7	17	7	1963	29.2	29.2	29.2	28.8				24.7	36.44	36.44	36.38	36.37			
8	31	8	1963	29.9	29.8	29.7	29.6				28.6	36.62	36.89	36.57	36.64			
9	2	10	1963	27.5	27.5	27.5	27.5				27.4	36.33	36.37	36.36	36.32			
10	31	10	1963	25.7	25.7	25.7	25.6				25.6	36.24	36.28	36.30	36.27			
11	30	11	1963	20.8	20.8	20.8	20.8				20.7	36.24	36.17	36.21	36.19			
12	19	12	1963	17.3	17.3	17.3	17.3				17.2	36.21	36.39	36.31	36.61			
13	26	1	1964	14.8	14.8	14.8	14.4				13.8	36.53	36.64	36.66	36.77			
14	23	2	1964	13.7	13.6	13.6	13.7				13.8	36.31	36.19	36.21	36.24			
15	18	3	1964	17.3	17.3	17.1	16.8				16.8	36.81	36.68	36.70	36.70			
16	15	4	1964	18.6	18.6	18.6	18.6				18.4	36.56	36.53	36.68	36.57			
17	22	5	1964	25.2	25.2	25.2	24.3				24.1	36.15	36.14	36.20	36.29			
18	25	6	1964	28.3	28.2	28.1	26.4				24.8	32.74	32.65	32.85	35.05			
19	16	7	1964	28.5	28.5	28.6	23.1				23.1	34.02	34.00	34.84	36.34			
20	29	8	1964	29.4	29.4	29.4	29.1				29.1	35.12	35.10	35.55	36.12			
21	29	9	1964	27.9	27.9	28.0	28.3				28.3	34.97	00.00	35.01	35.42			
22	28	10	1964	23.5	23.5	23.4	23.4				23.3	35.06	35.07	35.04	35.09			
23	27	11	1964	21.7	21.7	21.6	21.5				21.5	35.41	35.56	35.45	35.40			
24	16	12	1964	18.3	18.3	18.3	18.2				18.3	35.36	35.33	35.40	00.00			
25	7	1	1965	16.3	16.3	16.4	16.6				16.6	34.50	34.50	34.99	35.33			
26	26	2	1965	16.5	16.5	16.5	16.5				16.5	36.62	36.62	36.58	36.59			
27	21	3	1965	15.9	15.9	15.8	15.8				15.7	36.00	35.95	35.91	35.98			
28	23	4	1965	22.4	22.3	22.2	21.6				21.6	36.59	36.57	36.59	36.46			
29	2	6	1965	27.1	27.1	25.5	25.0				25.0	22.68	22.58	35.09	35.68			
30	11	6	1965	29.7	28.9	26.5	26.0				25.8	30.89	31.50	34.66	36.36			
32	11	8	1965	29.2	29.1	29.2	28.3				28.3	34.02	34.84	35.04	35.02			
33	9	9	1965	29.3	29.3	29.2	29.1				29.2	00.00	00.00	00.00	00.00			
35	9	12	1965	21.2	21.2	21.2	21.2				21.1	00.00	00.00	00.00	00.00			

able 1. (Continued)

TATION: W-3
EPTH: 45.8 M
ATITUDE: 28°18' N
ONGITUDE: 94°46' W

ruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
1	31	1	1963	18.7	18.6	18.2	17.7	17.1			15.9	36.32	36.37	36.54	36.60	36.56		
2	3	3	1963	18.2	18.1	18.1	17.9	17.2			17.4	36.55	36.55	36.60	36.56	36.57		
3	3	4	1963	21.9	21.9	21.7	19.5	19.0			18.9	36.71	36.61	36.54	36.59	36.61		
4	7	5	1963	24.3	24.2	24.1	22.2	19.7			19.6	35.40	35.32	35.54	36.30	36.56		
5	20	5	1963	26.6	26.6	25.7	23.2	20.6			20.2	32.24	32.39	34.91	36.50	36.63		
6	26	6	1963	28.7	28.4	28.3	25.0	21.2			21.1	35.88	35.86	35.98	36.39	36.39		
7	17	7	1963	29.1	29.1	29.1	29.1	22.3			20.2	36.56	36.48	36.58	36.57	36.42		
8	31	8	1963	30.0	30.0	29.9	29.6	23.5			23.5	36.60	36.60	36.52	36.57	36.38		
9	2	10	1963	27.5	27.5	27.5	27.5	27.5			27.4	36.40	36.49	36.51	36.42	36.50		
10	31	10	1963	26.2	26.2	26.2	26.2	26.2			26.1	36.68	36.64	36.67	36.63	36.62		
11	30	11	1963	22.7	22.7	22.7	22.7	22.7			22.7	36.84	36.73	36.68	36.72	36.79		
12	19	12	1963	20.7	20.7	20.7	20.6	20.6			20.6	36.88	36.84	36.80	36.80	36.81		
13	26	1	1964	16.7	16.7	16.7	16.6	16.1			16.1	36.55	36.79	36.59	36.64	36.71		
14	23	2	1964	16.5	16.5	16.4	16.4	16.3			16.3	36.79	36.76	36.73	36.65	00.00		
15	18	3	1964	18.2	18.2	18.1	17.6	16.0			16.0	36.72	36.70	36.74	36.68	36.70		
16	15	4	1964	19.5	19.5	19.4	18.7	18.2			18.2	36.68	36.68	36.61	36.76	36.83		
17	22	5	1964	25.9	25.8	25.7	23.9	21.1			20.6	33.65	33.62	33.90	36.57	36.62		
18	25	6	1964	28.1	28.1	27.9	26.5	21.1			20.5	32.76	32.72	32.97	34.46	36.49		
19	16	7	1964	28.7	28.7	28.7	28.4	22.9			20.4	33.76	33.35	33.80	35.72	36.47		
20	29	8	1964	29.8	29.8	29.7	29.4	24.3			22.5	34.54	34.50	34.50	36.31	36.43		
21	29	9	1964	28.3	28.3	28.2	28.3	27.3			27.0	35.91	35.84	35.88	35.96	36.26		
22	28	10	1964	24.8	24.8	24.8	24.8	24.8			24.8	36.15	36.11	36.39	36.32	36.46		
23	27	11	1964	23.2	23.2	23.2	23.1	23.1			23.1	36.58	36.65	36.57	36.56	36.55		
24	16	12	1964	20.8	20.8	20.8	20.8	20.8			20.8	36.65	36.58	36.62	36.61	36.61		
25	7	1	1965	20.6	20.6	20.5	20.4	20.4			20.4	36.69	36.64	36.70	36.71	36.86		
26	26	2	1965	18.7	18.7	18.6	18.6	18.5			18.5	36.76	36.69	36.92	36.73	36.73		
27	21	3	1965	17.3	17.3	17.2	17.2	17.2			17.2	36.58	36.47	36.52	36.59	36.59		
28	23	4	1965	22.5	22.5	22.4	19.7	17.6			17.6	36.37	36.32	36.53	36.51	36.58		
32	11	8	1965	29.3	29.3	29.3	28.0	21.3			20.9	34.57	34.70	35.05	36.53	36.53		
33	9	9	1965	29.3	29.3	29.3	29.3	23.5			23.4	00.00	00.00	00.00	00.00	00.00		
35	9	12	1965	21.8	21.8	21.8	21.7	21.7			21.7	36.00	35.97	35.97	36.00	36.04		

Table 1. (Continued)

STATION: W-54
DEPTH: 73.2 M
LATITUDE: 28°00' N
LONGITUDE: 94°38' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
1	32	1	1963	19.[illegible]	19.1	18.8	18.4	18.2	17.3		17.2	36.49	36.43	36.41	36.54	36.53	36.57	
2	3	3	1963	18.6	18.6	18.5	18.3	17.5	17.4		17.2	36.57	36.51	36.55	36.49	36.54	36.57	
3	3	4	1963	21.6	21.6	21.5	20.0	19.3	18.4		18.1	36.55	36.57	36.61	36.53	36.58	36.50	
4	6	5	1963	24.2	24.1	23.9	23.3	20.5	18.8		18.4	35.71	35.71	35.63	35.52	36.37	36.63	
5	20	5	1963	26.3	26.2	25.7	25.3	20.8	19.3		18.6	32.90	32.93	35.40	36.24	36.41	36.51	
6	26	6	1963	28.6	28.6	28.6	28.3	23.8	19.7		19.6	36.46	36.49	36.46	00.00	36.35	36.49	
7	17	7	1963	28.8	28.7	28.6	27.8	22.8	19.1		19.1	36.59	36.46	36.50	36.49	36.48	36.42	
8	31	8	1963	29.7	29.7	29.6	25.6	21.9	18.3		18.2	36.89	36.90	36.43	36.63	36.31	36.33	
9	2	10	1963	27.3	27.3	27.3	27.3	27.3	23.5		21.4	36.59	36.61	36.54	36.58	36.57	36.43	
10	31	10	1963	26.3	26.3	26.3	26.2	26.2	26.1		22.7	36.76	36.63	36.74	36.75	36.69	36.63	
11	30	11	1963	23.3	23.3	23.3	23.3	23.3	23.3		21.4	36.84	36.85	36.83	36.82	36.76	36.61	
12	19	12	1963	21.1	21.1	21.1	21.0	20.9	20.7		20.7	36.77	36.71	36.71	36.70	36.77	36.76	
13	26	1	1964	18.3	18.3	18.2	18.2	18.2	17.4		17.3	36.60	36.72	36.64	36.62	36.77	36.62	
14	23	2	1964	18.2	18.2	18.2	18.1	17.9	17.1		17.0	36.75	36.65	36.54	36.49	36.70	00.00	
15	18	3	1964	19.5	19.5	19.5	19.4	19.3	17.5		17.5	36.59	36.59	36.58	36.58	36.54	36.51	
16	15	4	1964	20.7	20.7	20.6	19.2	18.4	16.8		16.8	36.65	36.62	36.61	36.45	36.66	36.58	
17	22	5	1964	26.1	26.1	26.0	23.9	19.1	17.9		17.9	33.30	33.29	34.34	36.35	36.37	36.54	
18	25	6	1964	28.1	28.1	27.9	27.6	21.6	18.6		18.6	33.26	33.27	33.35	34.62	36.51	36.40	
19	16	7	1964	28.7	28.7	28.7	28.4	25.1	20.3		17.5	35.05	35.04	36.02	36.55	36.66	36.62	
20	30	8	1964	29.6	29.6	29.4	29.2	24.4	20.1		19.9	36.16	36.05	36.63	36.64	36.72	36.60	
21	26	9	1964	28.2	28.2	28.1	28.1	20.7	20.3		20.2	35.97	35.90	35.89	36.20	36.60	36.60	
22	28	10	1964	25.4	25.4	25.4	25.3	25.4	21.9		21.9	36.68	36.59	36.62	36.62	36.65	36.60	
23	27	11	1964	23.4	23.4	23.4	23.3	23.3	23.2		23.1	36.80	36.70	36.65	36.66	36.68	36.65	
24	16	12	1964	21.7	21.7	21.7	21.7	21.7	21.7		21.7	36.67	36.66	36.66	36.69	36.68	36.67	
25	7	1	1965	22.1	22.1	22.1	22.0	21.9	21.2		21.1	36.82	36.78	36.80	36.81	36.78	36.76	
26	26	2	1965	19.6	19.6	19.4	19.4	19.4	19.3		19.3	36.78	36.69	36.70	36.72	36.68	36.67	
27	21	3	1965	17.7	17.7	17.7	17.7	17.7	17.1		17.1	36.32	36.30	36.31	36.26	36.28	36.32	
28	23	4	1965	22.5	22.5	22.4	22.3	19.7	17.8		17.7	36.56	36.68	36.66	36.51	36.76	36.51	
29	2	6	1965	26.6	26.6	26.4	24.7	20.6	18.8		18.8	35.58	35.57	35.64	36.54	36.65	36.63	
30	12	6	1965	26.5	26.5	24.7	20.6	19.3	18.9		18.9	35.23	35.45	35.92	36.06	36.58	36.61	
32	11	8	1965	26.7	26.4	24.8	20.8	19.3	19.0		19.0	34.64	35.08	35.19	36.53	36.61	36.69	
35	9	12	1965	23.4	23.4	23.3	23.2	23.2	23.1		23.1	00.00	00.00	00.00	00.00	00.00	00.00	

Table 1. (Continued)

STATION: W-6
DEPTH: 109.8 M
LATITUDE: 27°55' N
LONGITUDE: 94°36' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
1	31	1	1963	20.3	20.1	19.8	19.6	19.1	19.0	00.0	00.0	36.40	36.42	36.51	36.49	36.45	36.52	36.56
2	3	3	1963	19.7	19.7	19.6	19.5	18.9	18.3	17.1	17.1	36.65	36.57	36.62	36.53	36.56	36.57	36.58
3	3	4	1963	21.7	21.6	20.4	19.8	19.2	18.7	17.5	17.3	36.50	36.44	36.61	36.49	36.54	36.52	36.42
4	6	5	1963	24.1	24.1	24.0	23.4	20.9	19.3	18.8	18.8	35.47	35.34	35.45	35.44	36.41	36.58	36.49
5	20	5	1963	26.8	26.4	26.3	26.1	23.6	20.9	20.2	19.9	33.50	35.58	36.00	36.33	36.53	36.51	36.50
6	23	6	1963	28.9	28.8	28.7	28.4	24.5	20.9	18.8	18.7	36.88	36.48	36.58	36.54	36.41	36.49	36.46
7	16	7	1963	29.1	29.1	28.8	28.7	25.9	18.4	17.8	17.8	36.53	36.36	36.51	36.52	36.47	36.40	36.35
8	31	8	1963	29.9	29.8	29.7	25.6	21.7	18.6	16.9	16.9	36.43	36.39	36.42	36.45	36.41	36.28	36.30
9	2	10	1963	26.8	26.8	26.7	26.7	26.6	22.1	17.6	17.6	36.50	36.48	36.38	36.39	36.41	36.49	36.34
10	31	10	1963	26.3	26.2	26.2	26.1	26.1	23.9	19.9	17.9	36.79	36.62	36.71	36.75	36.67	36.63	36.47
11	30	11	1963	23.5	23.5	23.5	23.4	23.4	23.3	19.2	19.1	36.83	36.73	36.78	36.79	36.75	36.72	36.59
12	19	12	1963	21.6	21.5	21.4	21.3	21.3	21.2	20.3	17.1	36.70	36.70	36.55	36.71	36.78	36.69	36.34
13	26	1	1964	19.4	19.4	19.4	19.3	19.3	19.0	17.8	17.6	36.66	36.62	36.66	36.67	36.62	36.62	36.55
14	23	2	1964	18.6	18.6	18.6	18.6	18.5	17.9	17.4	17.4	36.74	36.63	36.65	36.65	36.61	36.70	00.00
15	18	3	1964	20.3	20.2	19.8	19.4	19.3	18.9	17.8	17.7	36.72	36.68	36.59	36.65	36.64	36.56	36.43
16	15	4	1964	20.8	20.8	20.7	20.4	20.3	18.8	17.1	00.0	36.68	36.65	36.66	36.65	36.74	36.69	36.86
17	22	5	1964	25.8	25.7	25.7	23.9	19.7	18.2	17.6	16.8	25.72	34.60	34.74	36.28	36.26	36.41	36.54
18	25	6	1964	28.3	28.3	28.3	27.1	21.8	19.0	18.2	17.4	33.51	33.47	32.91	35.77	36.47	36.49	36.46
19	16	7	1964	28.6	28.6	28.6	28.3	25.6	20.8	17.4	16.5	36.39	36.38	36.36	36.39	36.71	36.57	36.50
20	30	8	1964	29.5	29.5	29.5	29.3	26.3	20.8	18.3	17.9	36.64	36.61	36.63	36.63	36.74	36.63	36.46
21	28	9	1964	28.7	28.8	28.7	28.7	28.0	19.3	19.0	18.9	36.18	36.34	36.62	36.64	36.78	36.60	36.66
22	29	10	1964	25.7	25.7	25.7	25.7	25.6	21.0	19.1	18.8	36.82	36.81	36.80	36.91	36.88	36.57	36.51
23	27	11	1964	23.5	23.5	23.5	23.4	23.4	23.3	18.6	18.3	36.74	36.71	36.72	36.76	36.80	36.77	36.56
24	16	12	1964	21.8	21.8	21.8	21.8	21.8	21.8	18.8	18.7	36.82	36.66	36.75	36.67	36.68	36.66	36.57
25	7	1	1965	22.1	22.2	22.2	22.1	21.9	21.5	21.1	20.8	36.81	36.78	36.80	36.81	36.78	36.76	36.76
26	27	2	1965	19.6	19.7	19.7	19.6	19.3	19.2	18.3	17.8	36.76	36.72	36.79	36.69	36.70	36.73	36.68
27	21	3	1965	19.8	19.8	19.8	19.7	19.7	19.7	16.9	16.9	36.83	36.60	36.67	36.68	36.70	36.67	36.39
28	23	4	1965	23.3	23.3	23.1	22.5	21.1	18.2	17.4	17.4	36.68	36.47	36.68	36.66	36.78	36.43	36.42
29	1	6	1965	26.8	26.8	26.7	24.9	21.1	18.9	18.8	18.8	35.49	35.52	35.46	36.38	36.62	36.59	36.57
30	12	6	1965	25.6	24.9	22.2	20.3	18.8	17.9	17.2	17.1	35.00	35.05	35.33	36.57	36.24	34.82	36.53
32	11	8	1965	26.6	26.6	25.3	20.8	19.4	17.4	16.7	16.7	35.49	36.03	36.67	35.73	36.52	36.60	36.50
35	9	12	1965	23.5	23.5	23.5	23.5	23.5	23.5	19.8	19.6	00.00	00.00	00.00	00.00	00.00	00.00	00.00

Table 2. Temperature (^{o}C) and salinity ($^{o}/oo$) values by station, cruise, and depth made along transect 8 from 1963-1965.

STATION: W-56
DEPTH: 7.3 M
LATITUDE: 28°23' N
LONGITUDE: 96°20' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	8	3	1963	13.9	13.8						13.1	31.72	31.92					
3	7	4	1963	20.8	20.8						20.2	30.38	30.40					
4	3	5	1963	24.5	24.5						24.5	25.61	25.61					
5	22	5	1963	26.4	26.2						26.0	34.87	34.94					
6	27	6	1963	28.7	28.7						28.3	35.70	35.67					
7	16	7	1963	29.2	29.2						24.7	36.80	36.71					
8	28	8	1963	30.2	30.2						30.2	36.88	36.87					
9	5	10	1963	25.8	25.8						25.7	30.17	30.17					
10	4	11	1963	23.0	23.0						22.9	33.84	33.78					
11	1	12	1963	16.7	16.7						18.8	32.74	32.79					
12	20	12	1963	11.1	11.1						10.8	31.81	31.80					
13	30	1	1964	12.2	12.9						11.9	32.29	32.42					
14	19	2	1964	13.4	13.4						13.4	35.44	35.46					
15	21	3	1964	16.1	16.0						15.5	33.37	33.32					
16	18	4	1964	21.0	21.0						21.1	27.12	27.21					
17	25	5	1964	26.7	26.2						25.0	00.00	00.00					
18	27	6	1964	29.2	29.1						28.6	33.57	33.49					
19	19	7	1964	28.6	28.6						28.5	34.53	34.44					
20	1	9	1964	29.3	29.3						29.0	36.85	36.83					
21	25	9	1964	28.3	28.3						28.3	33.35	33.21					
22	31	10	1964	22.7	22.7						22.7	32.83	32.76					
23	26	11	1964	17.7	17.7						17.7	31.73	31.68					
24	18	12	1964	13.9	13.9						13.9	31.12	31.09					
25	10	1	1965	15.7	15.7						15.7	30.56	30.52					
26	1	3	1965	15.9	15.9						15.8	34.53	34.52					
27	25	3	1965	16.5	16.4						15.7	31.10	31.17					
28	26	4	1965	24.4	24.2						23.2	30.81	31.00					
29	29	5	1965	26.8	27.0						27.1	20.15	20.71					
30	14	6	1965	30.0	29.3						26.8	26.21	27.33					
32	14	8	1965	29.3	29.2						28.6	34.78	34.74					
33	12	9	1965	29.3	29.2						29.2	00.00	00.00					
35	12	12	1965	19.1	19.2						19.5	28.93	29.36					

ble 2. (Continued)

ATION: W-13
PTH: 13.7 M
TITUDE: 28°19' N
NGITUDE: 96°21' W

uise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	8	3	1963	14.1	14.1	12.8					12.8	00.00	32.92	31.75				
3	7	4	1963	20.8	20.8	20.8					19.8	30.71	30.71	00.00				
4	3	5	1963	24.7	24.7	24.7					24.7	25.85	25.88	25.91				
5	22	5	1963	26.2	26.1	23.4					23.1	35.52	35.42	35.72				
7	16	7	1963	29.2	29.2	25.0					24.3	36.67	00.00	00.00				
8	28	8	1963	30.3	30.3	30.3					30.3	37.03	36.93	36.92				
9	5	10	1963	25.9	25.8	26.0					26.3	30.63	30.57	31.71				
10	4	11	1963	23.4	23.4	23.3					23.3	33.97	33.94	33.72				
11	1	12	1963	17.4	17.4	19.2					19.3	32.61	32.47	34.05				
12	20	12	1963	13.3	13.3	13.3					13.2	33.06	33.55	33.50				
13	30	1	1964	11.1	11.0	10.9					10.9	32.88	32.84	32.82				
14	19	2	1964	13.8	13.8	13.8					13.8	35.73	35.67	35.69				
15	21	3	1964	16.2	16.0	15.6					15.6	32.88	32.89	32.94				
16	18	4	1964	20.8	20.5	19.9					19.1	27.34	27.81	30.92				
17	25	5	1964	00.0	00.0	00.0					00.0	27.17	28.94	31.89				
18	27	6	1964	28.9	28.8	27.9					27.9	33.83	33.80	33.85				
19	19	7	1964	28.2	28.2	28.1					28.1	35.59	35.62	35.58				
20	1	9	1964	29.0	29.0	29.0					29.0	36.78	36.77	36.73				
21	25	9	1964	28.4	28.3	28.3					28.3	33.28	33.26	33.29				
22	31	10	1964	22.6	22.6	22.6					22.6	32.85	32.82	32.81				
23	26	11	1964	18.5	18.5	18.8					20.4	32.05	32.16	32.40				
24	18	12	1964	14.4	14.4	14.4					14.4	31.71	31.73	31.77				
25	10	1	1965	15.6	15.6	15.6					15.7	30.53	30.48	30.81				
26	1	3	1965	16.2	16.2	16.2					16.3	34.19	34.56	00.00				
27	24	3	1965	16.7	16.5	15.6					15.6	31.78	31.87	32.25				
28	25	4	1965	24.7	24.3	23.6					23.6	30.98	30.97	31.11				
29	29	5	1965	27.0	27.0	26.3					25.5	22.32	22.40	29.40				
30	14	6	1965	30.6	28.0	25.1					25.1	28.08	29.19	33.88				
32	14	8	1965	29.2	29.1	28.9					28.8	34.82	34.86	35.10				
33	12	9	1965	29.2	29.2	29.2					29.1	00.00	00.00	00.00				
35	12	12	1965	19.0	19.0	20.2					20.3	28.73	30.44	32.74				

Table 2. (Continued)

STATION: W-14
DEPTH: 27.5 M
LATITUDE: 28°07' N
LONGITUDE: 96°13'30" W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	8	3	1963	15.6	14.3	14.1	14.7				15.1	00.00	35.70	35.56	35.80			
3	4	4	1963	19.5	19.5	19.2	19.7				19.8	33.64	33.81	35.13	36.27			
4	2	5	1963	23.6	23.6	23.6	23.6				23.5	33.75	33.84	33.82	34.67			
5	21	5	1963	26.0	26.0	25.4	22.2				20.2	35.15	35.10	35.47	36.07			
6	27	6	1963	27.8	27.7	27.7	24.7				24.7	36.38	36.38	36.40	36.32			
7	16	7	1963	27.8	27.7	27.7	23.9				21.7	36.44	36.45	36.54	36.41			
8	30	8	1963	29.3	29.3	29.3	23.9				22.3	37.04	36.68	36.66	36.61			
9	3	10	1963	27.5	27.5	27.5	27.5				27.5	36.11	36.04	36.24	36.40			
10	1	11	1963	25.6	25.6	25.6	25.6				25.5	36.44	36.32	36.37	36.32			
11	1	12	1963	19.4	19.4	19.6	20.4				20.3	35.54	35.65	35.94	36.14			
12	20	12	1963	18.6	18.6	18.6	18.2				17.9	36.79	36.69	36.71	36.78			
13	28	1	1964	17.4	17.4	17.4	17.3				15.9	36.69	36.63	36.59	36.62			
14	19	2	1964	16.1	16.1	16.0	15.9				15.9	36.74	36.78	36.70	36.65			
15	22	3	1964	16.8	16.8	16.8	16.8				16.8	36.22	36.18	36.20	36.29			
16	16	4	1964	18.8	18.8	18.5	18.2				18.2	35.36	35.46	35.46	36.06			
17	23	5	1964	26.3	26.2	25.4	23.6				23.2	26.42	26.48	30.21	35.40			
18	26	6	1964	28.3	28.3	28.2	24.0				23.9	33.57	33.35	33.45	35.79			
19	17	7	1964	27.5	27.5	27.4	21.8				21.8	36.37	36.39	36.33	36.40			
20	30	8	1964	29.3	28.8	28.6	28.1				28.0	36.76	36.69	36.70	36.71			
21	28	9	1964	28.4	28.4	28.4	28.3				28.3	35.17	35.16	35.22	35.31			
22	29	10	1964	24.0	24.0	24.1	24.3				24.3	35.48	35.52	35.55	35.68			
23	26	11	1964	21.6	21.6	21.6	21.6				22.5	35.57	35.49	00.00	35.50			
24	17	12	1964	18.6	18.6	18.6	18.5				18.3	35.34	35.31	35.33	35.24			
25	8	1	1965	16.9	00.0	00.0	00.0				17.4	34.79	34.79	34.80	35.00			
26	27	2	1965	14.7	00.0	00.0	0.00				17.4	31.78	31.53	35.13	36.54			
27	22	3	1965	15.7	00.0	00.0	00.0				15.7	35.38	35.34	35.41	35.45			
28	24	4	1965	22.0	00.0	00.0	00.0				20.5	35.08	35.05	35.27	35.50			
29	29	5	1965	26.1	00.0	00.0	00.0				24.3	31.73	31.20	35.05	26.36			
30	13	6	1965	29.1	00.0	00.0	00.0				24.6	27.80	28.03	29.94	35.41			
32	12	8	1965	28.7	00.0	00.0	00.0				27.1	35.60	35.63	35.56	31.35			
33	11	9	1965	29.3	29.2	29.1	28.9				28.9	00.00	00.00	00.00	00.00			
35	10	12	1965	21.3	21.3	21.3	21.2				21.2	34.92	34.87	34.81	34.79			

Table 2. (Continued)

STATION: W-15
DEPTH: 45.8 M
LATITUDE: 27°57' N
LONGITUDE: 96°07' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	8	3	1963	16.9	16.9	16.9	15.0	15.6			15.7	36.35	36.22	36.27	36.01	36.28		
3	4	4	1963	22.1	22.1	22.1	21.4	19.1			19.1	36.34	36.36	36.30	36.37	36.44		
4	2	5	1963	23.8	23.8	23.8	21.1	20.3			20.2	35.30	35.21	35.02	36.06	36.02		
5	21	5	1963	26.5	26.4	25.9	22.8	20.0			19.6	32.34	32.49	33.96	35.97	36.55		
6	27	6	1963	28.8	28.6	28.5	24.4	22.2			22.2	36.35	36.37	36.42	36.45	36.42		
7	16	7	1963	28.5	28.5	28.5	28.3	23.3			20.5	36.58	36.53	36.51	36.41	36.47		
8	30	8	1963	28.7	28.6	28.2	25.4	23.1			23.1	36.30	37.04	36.32	36.50	36.54		
9	3	10	1963	27.2	27.2	27.1	27.0	26.9			27.0	36.62	36.50	36.57	36.55	36.54		
10	1	11	1963	26.2	26.2	26.2	26.2	26.2			26.1	36.59	36.63	36.60	36.70	36.72		
11	1	12	1963	22.7	22.7	22.7	22.7	22.7			22.6	36.71	36.68	36.62	36.65	36.69		
12	20	12	1963	20.9	20.9	20.8	20.8	19.8			19.6	36.80	36.69	36.70	36.75	36.88		
13	28	1	1964	18.2	18.2	17.9	17.2	14.3			14.0	36.55	36.56	36.60	36.60	36.27		
14	19	2	1964	17.0	17.0	17.0	16.9	16.4			16.4	36.59	36.75	36.55	36.65	36.63		
15	19	3	1964	16.9	16.9	16.9	16.9	16.9			16.9	36.53	36.40	36.39	36.41	36.59		
16	16	4	1964	19.4	19.4	19.2	18.7	17.9			17.9	34.39	36.11	36.51	36.73	36.70		
17	23	5	1964	25.6	25.4	25.4	22.7	21.1			21.0	31.99	32.20	34.53	35.94	36.20		
18	26	6	1964	28.2	28.1	28.1	25.9	20.7			19.9	33.46	33.44	33.57	34.88	36.50		
19	17	7	1964	28.2	28.2	28.2	27.3	19.4			19.4	36.58	36.50	36.62	36.50	36.65		
20	30	8	1964	29.2	29.0	28.7	28.5	26.2			25.2	36.70	36.60	36.59	36.62	36.46		
21	28	9	1964	28.3	28.3	28.3	28.3	28.2			27.9	35.62	35.60	35.68	35.87	36.27		
22	29	10	1964	24.9	24.9	24.9	24.9	24.9			24.9	36.33	36.33	36.31	36.32	36.33		
23	26	11	1964	22.9	22.9	22.9	22.9	22.9			22.9	36.50	36.50	36.48	36.57	36.48		
24	17	12	1964	20.6	20.6	20.5	20.6	20.4			20.3	36.42	36.57	36.42	36.48	36.51		
25	8	1	1965	20.8	20.8	20.7	20.4	20.3			20.0	36.67	36.63	00.00	36.55	36.51		
26	27	2	1965	18.7	18.7	18.6	18.6	18.6			18.6	36.67	36.64	36.80	36.67	36.68		
27	22	3	1965	17.7	17.7	17.6	17.6	17.6			17.6	36.66	36.09	36.04	36.10	36.13		
28	24	4	1965	23.3	23.2	22.5	21.5	18.9			18.8	35.00	34.80	35.79	36.41	36.33		
29	1	6	1965	26.6	26.6	26.3	25.5	22.3			20.1	33.51	35.31	34.41	35.31	36.62		
30	12	6	1965	30.0	28.2	27.0	26.1	23.8			20.7	30.72	31.03	32.53	35.67	36.59		
32	12	8	1965	28.5	28.5	28.4	28.3	21.3			21.2	36.17	36.19	36.04	36.06	36.59		
33	11	9	1965	29.3	29.3	29.3	29.2	23.8			23.7	00.00	00.00	00.00	00.00	00.00		
35	10	12	1965	22.6	22.6	22.6	22.6	22.6			22.6	00.00	00.00	00.00	00.00	00.00		

Table 2. (Continued)

STATION: W-57
DEPTH: 73.2 M
LATITUDE: 27°46' N
LONGITUDE: 96°00' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	10
2	8	3	1963	18.6	18.6	18.6	18.5	17.9	17.3		16.4	36.61	36.51	36.48	36.42	36.55	36.50	
3	4	4	1963	21.6	21.3	21.2	20.6	19.8	18.1		18.1	36.27	36.20	36.28	36.29	36.35	36.63	
4	2	5	1963	23.9	23.9	23.9	23.9	21.1	19.6		19.3	35.87	35.87	35.86	35.82	36.31	36.38	
5	21	5	1963	26.5	26.3	25.7	23.4	20.7	19.3		19.3	34.25	34.38	34.98	35.90	36.36	36.42	
6	26	6	1963	28.6	28.5	28.3	25.6	22.2	19.8		19.6	36.50	36.42	36.52	36.42	36.30	36.44	
7	16	7	1963	29.1	29.1	29.0	28.9	22.7	20.0		18.2	36.54	36.48	36.52	36.59	36.48	36.35	
8	30	8	1963	29.4	29.4	29.4	29.7	26.4	23.7		22.8	36.84	36.37	36.70	36.51	36.76	36.56	
9	2	10	1963	26.9	26.8	26.8	26.7	26.7	21.7		21.5	36.82	36.47	36.42	36.49	00.00	36.48	
10	1	11	1963	26.3	26.3	26.3	26.2	26.2	26.1		22.5	36.59	36.63	36.60	36.73	36.64	36.73	
11	30	11	1963	23.3	23.3	23.3	23.3	23.3	23.3		23.2	36.80	36.76	36.77	36.82	36.76	36.73	
12	20	12	1963	20.8	20.8	20.8	20.8	20.8	19.7		19.6	36.66	36.56	36.75	36.76	36.70	36.71	
13	28	1	1964	19.5	19.5	19.4	19.3	18.9	17.2		16.4	36.64	36.66	36.61	36.64	36.51	36.51	
14	20	2	1964	18.3	18.3	18.2	17.9	17.0	16.9		16.9	36.71	36.64	36.63	36.56	36.57	36.71	
15	19	3	1964	19.5	19.5	19.5	19.4	18.5	16.0		15.8	36.58	36.57	36.59	36.55	36.50	36.57	
16	16	4	1964	20.3	20.3	20.2	18.8	18.1	17.1		16.9	36.45	36.29	36.30	36.41	36.68	36.75	
17	23	5	1964	24.9	24.9	25.1	22.7	19.4	18.8		18.4	32.05	32.60	33.78	36.16	36.52	36.49	
18	25	6	1964	28.4	28.4	28.2	23.8	21.2	19.3		18.9	32.85	33.00	33.18	35.49	36.57	36.54	
19	17	7	1964	28.6	28.6	28.6	28.1	26.2	19.0		19.0	36.74	36.72	36.67	36.74	36.64	36.52	
20	30	8	1964	28.8	28.7	28.7	28.6	24.3	20.9		20.9	36.70	36.66	36.71	36.70	36.65	36.66	
21	28	9	1964	28.3	28.3	28.3	28.3	22.8	21.6		21.6	36.51	36.50	36.52	36.51	36.62	36.58	
22	29	10	1964	25.4	25.4	25.4	25.4	25.4	23.6		20.8	36.72	36.68	36.71	36.69	36.70	36.59	
23	26	11	1964	23.9	23.9	23.9	23.9	23.9	23.5		23.5	36.64	36.51	36.58	36.48	36.52	36.48	
24	17	12	1964	22.2	22.2	22.2	22.2	22.2	21.4		21.4	36.65	36.58	36.66	36.53	36.57	36.58	
25	7	1	1965	22.3	22.3	22.2	22.2	22.1	21.8		21.3	36.82	36.79	36.80	36.78	36.80	36.72	
26	27	2	1965	18.4	18.4	18.4	18.4	18.4	18.4		18.4	36.59	36.60	36.53	36.58	36.60	36.63	
27	22	3	1965	19.6	19.6	19.6	19.5	19.4	19.3		19.3	36.69	36.68	36.67	36.80	36.71	36.77	
28	24	4	1965	23.3	23.3	22.7	20.9	19.1	17.5		17.5	35.45	35.41	35.42	36.66	36.52	36.49	
29	1	6	1965	26.6	26.6	26.1	23.3	20.6	19.7		18.5	32.78	32.74	33.61	36.48	36.61	36.63	
30	12	6	1965	28.6	26.7	25.1	22.9	19.9	19.5		19.6	31.85	32.09	27.43	34.99	36.65	36.39	
32	12	8	1965	27.7	27.7	27.2	23.9	21.8	19.9		19.9	36.61	36.66	36.69	36.61	36.72	36.60	
33	11	9	1965	29.0	28.9	28.9	26.7	22.8	21.6		21.6	00.00	00.00	00.00	00.00	00.00	00.00	
35	10	12	1965	23.2	23.2	23.2	23.2	23.2	23.2		23.3	00.00	00.00	00.00	00.00	00.00	00.00	

Table 3. Temperature (°C) and salinity (°/oo) values by station, cruise, and depth made along transect 9 from 1963-1965.

STATION: W-59
DEPTH: 7.3 M
LATITUDE: 27°51' N
LONGITUDE: 97°01' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	9	3	1963	15.3	15.3						15.0	32.49	32.53					
3	6	4	1963	23.6	23.6						22.7	29.41	29.30					
4	5	5	1963	25.6	25.6						25.2	27.20	27.20					
5	22	5	1963	24.8	24.4						24.7	36.29	36.23					
6	27	6	1963	29.0	29.0						28.9	36.47	36.50					
7	16	7	1963	26.2	25.0						28.0	37.02	37.31					
8	28	8	1963	30.1	30.1						29.6	36.89	36.89					
9	3	10	1963	26.2	26.2						26.7	30.52	30.40					
10	3	11	1963	23.6	23.6						23.6	34.31	34.30					
11	1	12	1963	17.3	17.3						15.9	32.99	32.98					
12	21	12	1963	11.9	11.8						11.8	33.30	33.30					
13	30	1	1964	11.6	11.6						11.6	33.12	33.12					
14	20	2	1964	13.8	13.8						13.8	35.31	35.41					
15	20	3	1964	17.2	17.1						15.6	34.14	34.15					
16	18	4	1964	21.0	21.0						19.7	27.22	27.31					
17	25	5	1964	00.0	00.0						00.0	25.54	25.60					
18	27	6	1964	28.3	28.2						28.3	00.00	35.10					
19	18	7	1964	28.5	28.4						28.2	36.04	36.02					
20	1	9	1964	29.2	29.2						29.2	36.76	36.76					
21	29	9	1964	28.5	28.5						28.6	34.29	34.35					
22	31	10	1964	22.9	22.9						22.7	33.31	33.30					
23	20	11	1964	23.5	23.5						23.5	34.26	34.24					
24	18	12	1964	12.8	12.8						12.8	31.15	31.12					
25	9	1	1965	17.0	17.0						16.9	30.89	30.90					
26	1	3	1965	16.0	16.0						16.5	34.00	34.08					
27	23	3	1965	16.4	16.1						15.3	33.36	33.36					
28	24	4	1965	23.3	23.2						22.7	30.28	30.25					
29	30	5	1965	26.5	26.5						26.4	26.77	26.77					
30	14	6	1965	28.5	28.5						27.2	28.95	28.98					
32	12	8	1965	28.8	28.7						28.6	36.62	36.61					
33	12	9	1965	29.4	29.4						29.3	00.00	00.00					
35	10	12	1965	19.3	19.2						19.1	30.81	30.44					

Table 3. (Continued)

STATION: W-24
DEPTH: 13.7 M
LATITUDE: 27°48' N
LONGITUDE: 97°00' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	9	3	1963	14.2	13.9	13.4					13.4	32.90	32.96	33.95				
3	6	4	1963	21.6	21.6	20.9					20.6	30.43	30.48	31.73				
4	3	5	1963	24.6	24.6	24.6					24.6	26.21	27.48	28.15				
5	22	5	1963	25.2	25.0	22.7					22.6	36.40	36.22	35.99				
6	27	6	1963	28.8	28.8	28.8					28.7	36.48	36.52	36.58				
7	16	7	1963	25.9	25.9	22.8					22.8	36.37	36.39	37.96				
8	28	8	1963	29.3	29.3	28.9					28.8	36.54	36.57	36.60				
9	3	10	1963	26.0	26.1	26.7					25.5	30.35	30.79	30.09				
10	3	11	1963	23.8	23.7	23.6					23.6	34.82	34.65	34.68				
11	1	12	1963	17.4	17.4	19.4					15.5	00.00	33.12	35.68				
12	21	12	1963	13.0	13.0	13.0					13.0	34.04	34.20	34.15				
13	30	1	1964	11.2	11.2	11.2					11.3	33.39	33.38	33.35				
14	20	2	1964	14.2	14.2	14.2					14.2	35.68	35.67	35.66				
15	20	3	1964	17.1	16.8	15.6					15.6	33.96	34.08	34.67				
16	18	4	1964	21.0	21.0	19.9					19.6	27.48	27.84	28.58				
17	25	5	1964	26.7	26.6	26.6					26.5	26.69	26.66	26.78				
18	27	6	1964	27.8	27.8	28.1					28.6	34.98	34.95	35.59				
19	18	7	1964	28.4	28.4	28.4					28.3	35.96	36.07	35.93				
20	1	9	1964	28.6	28.6	28.6					28.3	36.75	36.71	36.72				
21	25	9	1964	28.2	28.2	28.2					28.3	34.27	34.20	34.42				
22	31	10	1964	22.8	22.8	22.7					22.6	33.39	33.44	33.38				
23	20	11	1964	23.9	23.9	23.9					23.9	33.89	33.91	33.88				
24	18	12	1964	14.8	14.7	14.7					14.7	31.68	31.64	31.65				
25	9	1	1965	16.4	16.4	15.7					15.7	30.33	31.20	32.59				
26	1	3	1965	16.7	16.6	16.5					16.5	34.52	34.53	34.90				
27	23	3	1965	16.1	15.6	15.1					15.0	33.59	33.58	33.58				
28	24	4	1965	24.3	23.5	22.7					22.7	29.07	30.48	31.47				
29	30	5	1965	26.8	26.8	26.7					26.7	26.32	26.32	26.33				
30	14	6	1965	28.6	28.6	27.0					26.3	30.15	30.23	32.23				
32	12	8	1965	28.7	28.6	28.4					28.4	36.50	36.38	36.34				
33	12	9	1965	29.4	29.4	29.3					29.3	00.00	00.00	00.00				
35	10	12	1965	19.5	19.5	19.4					19.4	30.66	30.68	30.86				

Table 3. (Continued)

STATION: W-23
DEPTH: 27.5 M
LATITUDE: 27°35'30" N
LONGITUDE: 96°55' W

Cruise	Day	Month	Year	Temperatures (°C) Depth (M) 0	3	11	24	43	70	107	B	Salinity (o/oo) Depth (M) 0	3	11	24	43	70	107
2	9	3	1963	15.6	15.6	15.6	15.3				15.3	34.49	34.71	35.79	35.66			
3	4	4	1963	22.4	22.3	20.4	18.3				17.7	29.42	29.52	35.34	35.90			
4	5	5	1963	24.8	24.8	24.4	23.9				22.9	32.63	32.73	32.73	31.12			
5	21	5	1963	25.8	25.4	24.4	19.4				19.3	36.02	36.05	36.15	36.36			
6	27	6	1963	27.8	27.8	23.9	23.8				23.8	36.52	36.49	36.40	36.49			
7	16	7	1963	27.6	27.5	27.4	23.1				23.1	36.46	36.43	36.40	36.42			
8	30	8	1963	29.1	29.1	29.0	22.4				22.3	36.52	36.90	36.47	36.60			
9	5	10	1963	26.3	26.7	26.9	27.0				27.0	33.09	33.45	34.45	34.80			
10	1	11	1963	25.5	25.5	25.5	25.5				25.4	36.18	00.00	00.00	00.00			
11	2	12	1963	21.2	21.2	21.2	21.2				21.3	36.39	36.29	36.32	36.38			
12	21	12	1963	16.8	16.8	16.8	16.8				16.6	36.10	36.19	36.14	36.10			
13	30	1	1964	16.0	16.0	16.0	15.8				15.4	36.00	35.97	35.95	35.94			
14	20	2	1964	15.2	15.2	15.1	15.2				15.2	35.70	35.76	35.74	35.75			
15	19	3	1964	16.8	16.8	16.8	16.8				16.8	35.60	35.74	36.16	36.21			
16	16	4	1964	19.3	19.3	19.0	17.7				17.5	29.63	29.64	31.05	33.93			
17	24	5	1964	25.3	25.3	25.4	25.0				24.4	00.00	00.00	00.00	00.00			
18	26	6	1964	27.8	27.7	27.4	25.6				25.0	33.86	33.83	34.13	35.19			
19	17	7	1964	27.6	27.6	27.2	21.6				21.5	36.68	36.64	36.62	36.51			
20	31	8	1964	28.4	28.4	28.3	28.1				27.2	36.72	36.68	36.67	36.71			
21	26	9	1964	28.7	28.4	28.5	28.4				28.5	34.38	34.34	35.48	35.42			
22	29	10	1964	23.7	23.6	23.5	00.0				00.0	34.40	34.38	34.78	35.04			
23	24	11	1964	21.9	21.9	21.9	21.9				21.9	35.15	35.11	35.13	35.15			
24	17	12	1964	17.3	17.9	18.5	18.7				18.8	32.70	34.78	34.88	35.57			
25	8	1	1965	16.9	16.9	19.8	20.5				20.3	34.15	34.01	35.38	36.32			
26	28	2	1965	15.3	15.3	16.7	17.8				17.6	31.77	31.72	35.78	36.40			
27	22	3	1965	16.0	16.0	16.0	15.9				15.9	35.39	35.32	35.27	35.32			
28	24	4	1965	24.0	23.2	20.3	19.9				19.8	00.00	00.00	00.00	00.00			
29	30	5	1965	26.6	26.6	26.5	25.6				25.2	00.00	35.27	29.65	31.52			
30	13	6	1965	27.5	27.5	27.5	25.7				24.1	30.85	30.86	31.33	34.20			
32	13	8	1965	28.4	28.4	28.3	28.2				28.2	36.52	36.48	36.56	36.61			
33	12	9	1965	29.3	29.2	28.7	28.6				28.6	00.00	00.00	00.00	00.00			
35	11	12	1965	20.2	20.5	21.2	21.3				21.2	31.89	31.82	33.91	34.00			

able 3. (Continued)

TATION: W-22
EPTH: 45.8 M
ATITUDE: 27°21' N
ONGITUDE: 96°50' W

ruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	9	3	1963	16.9	16.9	17.0	16.9	14.5			14.5	36.39	36.44	36.42	36.46	36.19		
3	4	4	1963	23.6	22.8	21.1	20.2	19.6			19.5	31.61	33.85	35.97	36.35	36.43		
4	6	5	1963	24.6	24.5	24.1	21.1	20.3			19.7	34.74	33.88	35.60	35.98	36.25		
5	21	5	1963	26.3	25.7	25.4	20.9	19.4			19.4	36.31	36.32	36.39	36.38	36.40		
6	27	6	1963	27.2	26.2	26.0	22.6	19.8			19.7	36.57	36.34	36.51	36.53	36.43		
7	15	7	1963	27.2	27.1	26.9	24.1	20.8			20.7	36.48	36.51	36.45	36.48	36.49		
8	30	8	1963	28.8	28.8	26.7	24.2	21.7			21.7	36.42	36.28	36.32	36.35	36.57		
9	4	10	1963	26.9	27.0	27.1	27.6	27.2			26.8	35.42	35.26	35.51	36.12	36.32		
10	4	11	1963	25.7	25.7	25.7	25.6	25.6			25.6	36.54	36.47	36.52	36.52	36.50		
11	2	12	1963	22.6	22.6	22.6	22.6	22.6			22.5	36.50	36.59	36.45	36.54	36.56		
12	21	12	1963	18.7	18.7	18.5	18.1	17.4			17.1	36.60	36.59	36.59	36.62	36.30		
13	29	1	1964	16.3	16.3	16.3	18.1	16.2			16.1	35.74	35.74	35.39	36.63	36.39		
14	20	2	1964	17.3	17.3	17.3	17.3	17.3			17.2	36.62	36.59	36.55	36.63	36.56		
15	19	3	1964	18.4	18.2	17.8	17.4	17.3			17.3	36.39	36.38	36.30	36.35	36.27		
16	16	4	1964	17.9	18.4	19.2	18.2	17.7			17.7	33.18	33.13	35.80	36.45	36.41		
17	24	5	1964	25.4	25.4	25.4	23.9	21.7			20.5	31.70	31.90	33.58	35.63	36.30		
18	26	6	1964	28.2	28.2	27.9	25.8	20.3			19.0	33.73	33.71	34.66	36.00	36.46		
19	17	7	1964	27.5	27.5	27.4	22.2	19.2			19.2	36.72	36.66	36.81	36.64	36.79		
20	31	8	1964	28.7	28.7	28.5	28.3	27.7			22.8	36.78	36.69	36.63	36.70	36.62		
21	26	9	1964	28.4	28.3	28.2	28.1	27.3			25.2	36.32	36.32	36.61	36.66	36.62		
22	29	10	1964	25.4	25.4	25.4	25.2	25.1			25.2	36.40	36.18	36.29	36.31	36.32		
23	24	11	1964	23.5	23.5	23.5	23.5	23.5			23.5	36.18	36.18	36.15	36.18	36.18		
24	17	12	1964	20.2	20.2	20.1	19.9	20.5			20.2	36.12	36.12	36.04	36.03	36.26		
25	8	1	1965	20.8	20.8	20.7	20.7	21.0			21.0	36.28	36.21	36.23	36.32	36.61		
26	28	2	1965	16.5	16.5	16.7	17.9	18.1			18.0	34.43	34.36	36.27	35.80	36.40		
27	22	3	1965	17.7	17.7	17.6	17.4	17.8			17.8	35.86	35.92	35.88	35.82	36.06		
28	24	4	1965	24.9	24.7	22.0	18.1	17.6			17.6	00.00	00.00	00.00	00.00	00.00		
29	30	5	1965	26.5	26.5	26.4	25.3	23.1			22.8	29.85	29.93	30.30	34.92	36.54		
30	13	6	1965	27.9	27.9	27.7	25.5	22.3			20.9	30.57	30.58	30.93	35.00	36.50		
32	13	8	1965	28.2	28.1	28.0	27.9	24.2			22.3	36.63	36.62	36.57	36.59	36.69		
33	11	9	1965	30.1	30.1	29.9	29.5	22.6			22.6	00.00	00.00	00.00	00.00	00.00		
35	11	12	1965	21.7	21.8	21.8	22.8	23.5			23.5	34.22	34.23	34.25	34.99	35.57		

able 3. (Continued)

TATION: W-58
EPTH: 73.2 M
ATITUDE: 27°06' N
NGITUDE: 96°45' W

uise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	9	3	1963	18.1	17.8	17.8	17.8	17.8	16.6		16.5	36.41	36.31	36.27	36.27	36.38	36.45	
3	5	4	1963	22.2	21.4	20.5	19.4	17.9	17.9		17.9	33.24	33.20	35.30	36.27	36.41	36.37	
4	6	5	1963	23.9	18.3	18.2	21.2	19.7	18.6		18.5	35.87	35.79	36.14	36.25	36.27	36.42	
5	22	5	1963	26.5	26.4	25.9	25.0	20.1	19.1		18.8	36.12	00.00	36.04	36.13	36.23	36.45	
6	28	6	1963	28.4	28.3	28.2	23.1	21.7	19.4		19.4	36.51	36.46	36.44	36.46	36.59	36.40	
7	15	7	1963	27.6	27.6	27.6	25.9	21.5	19.1		18.8	36.58	36.44	36.50	36.42	36.44	36.57	
8	29	8	1963	28.5	28.4	28.0	22.6	21.6	19.6		19.6	36.28	36.32	36.34	36.42	36.50	36.40	
9	4	10	1963	27.3	27.3	27.3	27.3	27.1	26.1		24.3	36.47	36.55	36.44	36.47	36.55	36.60	
10	4	11	1963	25.9	25.9	25.9	25.9	25.8	25.8		22.7	36.67	36.68	36.62	36.66	36.64	36.75	
11	2	12	1963	23.1	23.1	23.1	23.0	22.9	22.7		22.9	36.38	36.39	36.45	36.38	36.34	36.32	
12	22	12	1963	21.7	21.7	21.7	21.7	21.6	19.1		18.9	36.64	36.64	36.64	36.68	36.61	36.54	
13	29	1	1964	19.1	19.1	19.0	18.2	17.4	15.6		14.8	36.54	36.69	36.58	36.50	36.48	36.28	
14	20	2	1964	19.3	19.2	19.2	19.1	17.8	16.6		16.6	36.66	36.58	36.60	36.56	36.48	36.41	
15	19	3	1964	19.0	18.7	18.2	17.7	17.1	17.3		17.3	36.41	36.42	36.39	36.38	36.40	36.52	
16	17	4	1964	20.8	20.6	19.2	18.7	17.9	17.8		17.8	34.24	34.18	36.49	36.46	36.47	36.90	
17	24	5	1964	25.4	25.4	25.7	22.8	20.0	18.3		18.1	29.68	29.95	32.66	35.98	36.21	36.49	
18	26	6	1964	28.3	28.1	27.4	22.6	19.6	18.5		18.5	35.28	35.03	35.60	36.36	36.41	36.51	
19	18	7	1964	28.4	28.4	28.3	27.6	22.1	18.2		18.2	36.71	36.78	36.64	36.60	36.62	36.55	
20	31	8	1964	29.0	28.9	28.9	28.6	23.8	20.6		20.6	36.73	36.66	36.65	36.69	36.64	36.55	
21	26	9	1964	28.4	28.4	28.4	28.4	27.2	21.8		21.8	36.52	36.49	36.40	36.66	36.65	36.68	
22	30	10	1964	25.5	25.5	25.5	25.6	26.0	25.8		25.8	00.00	00.00	36.41	36.52	36.80	36.75	
23	24	11	1964	23.8	23.8	23.8	23.8	23.8	23.8		23.8	36.62	36.55	36.56	36.49	36.57	36.55	
24	17	12	1964	20.9	20.9	20.7	20.7	20.7	20.7		20.7	36.14	36.15	36.13	36.22	36.21	36.27	
25	8	1	1965	20.7	20.7	20.6	20.6	20.5	20.1		20.0	36.09	36.10	36.13	36.11	36.40	36.42	
26	28	2	1965	19.5	19.5	19.4	19.4	19.4	17.5		17.6	36.58	36.49	36.56	36.51	36.36	35.40	
27	22	3	1965	19.4	19.4	19.3	19.2	19.2	19.2		19.2	36.43	36.41	36.40	36.47	36.48	36.59	
28	24	4	1965	24.6	24.4	18.1	17.2	16.8	17.2		17.2	29.52	29.90	33.27	35.97	36.39	36.47	
29	30	5	1965	27.1	27.1	26.4	21.8	20.0	18.9		18.8	28.68	28.68	29.42	36.04	36.48	36.47	
30	13	6	1965	27.5	26.9	25.0	21.9	19.2	18.9		18.9	31.81	31.80	32.04	34.98	36.48	36.48	
32	13	8	1965	27.6	27.5	26.6	23.6	22.1	19.4		19.4	36.53	36.50	36.50	36.62	36.64	36.56	
33	11	9	1965	30.1	30.1	30.1	27.9	22.7	00.0		22.4	00.00	00.00	00.00	00.00	00.00	00.00	
35	11	12	1965	23.6	23.6	23.7	23.7	23.7	23.7		23.7	36.15	36.13	36.15	36.42	36.13	36.11	

Table 4. Temperature (°C) and salinity (°/oo) values by station, cruise, and depth made along transect 10 from 1963-1965.

TATION: W-60
PTH: 7.3 M
ATITUDE: 26°34' N
NGITUDE: 97°16' W

ruise	Day	Month	Year	Temperatures (°C)								Salinity (°/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	9	3	1963	15.3	14.9						14.9	34.27	34.15					
6	28	6	1963	26.3	26.3						24.0	36.41	36.32					
7	15	7	1963	25.1	23.9						22.8	36.49	36.44					
8	29	8	1963	27.6	27.6						24.9	36.47	36.62					
9	4	10	1963	26.2	26.2						26.3	31.77	32.13					
10	3	11	1963	23.5	23.5						23.5	33.95	33.81					
11	2	12	1963	19.8	19.8						19.7	34.42	34.62					
12	22	12	1963	12.2	12.2						12.2	34.25	34.35					
13	30	1	1964	14.2	14.2						14.2	34.08	34.05					
15	20	3	1964	17.8	17.8						16.8	35.42	35.42					
16	17	4	1964	20.7	20.7						20.4	31.86	31.80					
17	24	5	1964	26.1	26.1						24.7	28.16	28.15					
18	27	6	1964	27.4	27.4						27.4	35.49	35.45					
19	18	7	1964	27.1	27.1						26.9	36.40	36.46					
20	31	8	1964	27.3	26.0						24.6	36.73	36.70					
21	26	9	1964	28.8	28.8						28.8	00.00	36.93					
22	30	10	1964	24.0	24.0						24.0	34.45	34.43					
23	24	11	1964	19.9	19.9						19.9	33.88	33.85					
24	18	12	1964	15.2	15.2						15.2	32.09	32.05					
25	9	1	1965	16.9	16.9						16.1	32.67	32.66					
26	28	2	1965	17.2	17.2						17.5	34.90	35.00					
27	23	3	1965	16.7	16.7						16.2	34.32	34.39					
28	25	4	1965	24.0	24.0						23.3	29.72	29.72					
29	31	5	1965	26.2	26.2						26.2	33.20	33.21					
30	14	6	1965	27.2	27.2						27.0	34.21	34.37					
32	14	8	1965	28.0	28.0						27.9	36.65	36.62					
35	11	12	1965	20.1	20.1						20.0	31.76	31.73					

Table 4. (Continued)

STATION: W-61
DEPTH: 22.9 M
LATITUDE: 26°36' N
LONGITUDE: 97°08' W

Cruise	Day	Month	Year	Temperatures (°C)								Salinity (o/oo)						
				Depth (M)								Depth (M)						
				0	3	11	24	43	70	107	B	0	3	11	24	43	70	107
2	10	3	1963	14.5	14.5	13.7					15.1	33.78	33.73	34.13				
3	5	4	1963	21.9	21.8	21.7					18.3	31.23	31.22	31.29				
6	28	6	1963	27.2	27.2	22.1					21.8	36.39	36.42	36.40				
7	15	7	1963	25.5	25.3	23.3					22.2	36.90	00.00	00.00				
8	29	8	1963	28.2	28.0	26.7					23.6	36.61	36.52	36.56				
9	4	10	1963	26.7	26.7	26.8					28.1	31.95	31.96	32.29				
10	4	11	1963	24.4	24.4	24.4					24.3	34.80	34.63	34.72				
11	2	12	1963	18.6	18.7	20.3					20.6	33.17	33.11	34.75				
12	22	12	1963	15.2	15.2	15.2					15.0	35.29	35.31	35.25				
13	29	1	1964	12.4	12.3	12.3					12.2	33.96	33.91	33.91				
15	20	3	1964	17.1	16.6	16.5					16.4	36.72	35.41	35.53				
16	17	4	1964	19.8	19.8	19.7					19.5	00.00	00.00	00.00				
17	24	5	1964	25.6	25.5	25.1					22.9	27.49	27.42	28.69				
18	27	6	1964	26.7	26.4	24.1					23.9	35.88	35.90	35.98				
19	18	7	1964	25.4	25.4	24.3					23.2	36.47	36.49	36.45				
20	31	8	1964	28.3	27.5	26.3					23.4	36.69	36.66	36.65				
21	26	9	1964	00.0	00.0	00.0					00.0	36.48	36.42	36.50				
22	30	10	1964	24.0	24.0	23.9					23.9	34.53	34.55	34.50				
23	24	11	1964	21.6	21.6	21.6					21.7	34.46	34.42	34.50				
24	17	12	1964	16.0	16.0	16.2					16.7	32.59	32.59	33.09				
25	9	1	1965	16.8	16.7	16.4					17.4	32.48	32.45	33.35				
26	28	2	1965	15.5	15.5	16.1					16.2	33.09	33.15	34.59				
27	23	3	1965	16.7	16.6	16.6					16.6	34.65	34.63	34.81				
28	25	4	1965	23.8	23.8	23.5					18.7	29.29	29.22	29.79				
29	31	5	1965	26.1	26.0	26.0					25.0	33.18	33.18	33.27				
30	14	6	1965	27.9	27.9	26.3					25.7	32.71	32.73	33.81				
32	14	8	1965	27.7	27.6	27.5					27.3	36.50	36.63	36.58				
35	11	12	1965	20.0	19.9	20.4					21.4	31.55	31.53	31.53				

Table 4. (Continued)

STATION: W-62
DEPTH: 45.8 M
LATITUDE: 26°41' N
LONGITUDE: 96°53' W

Cruise	Day	Month	Year	Temperatures (°C) Depth (M) 0	3	11	24	43	70	107	B	Salinity (o/oo) Depth (M) 0	3	11	24	43	70	107
2	10	3	1963	18.2	18.1	18.1	16.8	16.6			16.6	36.09	36.43	36.41	36.41	36.38		
3	5	4	1963	00.0	00.0	00.0	00.0	00.0			00.0	33.39	33.41	36.26	35.96	36.52		
6	28	6	1963	27.3	27.2	26.4	21.4	19.8			19.8	36.45	00.00	00.00	00.00	36.30		
7	15	7	1963	27.0	27.0	26.9	24.0	20.8			20.4	36.48	36.47	36.37	36.48	36.45		
8	29	8	1963	29.3	29.2	29.1	24.1	21.4			21.3	36.67	36.63	36.64	36.43	36.33		
9	4	10	1963	27.9	27.9	27.9	27.9	27.6			25.6	36.27	36.35	36.41	36.46	36.48		
10	4	11	1963	25.6	25.6	25.7	25.7	25.7			25.7	36.34	36.32	36.36	36.33	36.52		
11	2	12	1963	22.8	22.8	22.8	22.8	22.8			23.6	36.05	36.05	35.94	35.86	36.13		
12	22	12	1963	19.8	19.8	19.3	18.7	18.6			18.4	36.69	36.62	36.60	36.66	36.63		
13	29	1	1964	16.7	16.7	16.7	16.8	16.4			16.4	36.24	36.27	36.24	36.31	36.62		
15	20	3	1964	14.6	14.5	14.4	14.3	00.0			13.2	36.56	36.49	36.48	36.49	36.49		
16	17	4	1964	20.6	20.6	19.3	20.3	17.9			17.9	32.30	32.23	35.88	36.71	36.50		
17	24	5	1964	25.8	25.7	25.1	22.9	20.3			19.7	27.12	26.91	33.32	36.00	36.57		
18	26	6	1964	27.7	27.7	27.4	22.2	20.3			20.2	35.46	35.59	35.53	36.32	36.48		
19	18	7	1964	27.4	27.3	23.6	21.5	19.1			19.1	36.58	36.55	36.62	36.61	36.54		
20	31	8	1964	27.9	27.7	27.6	24.4	21.9			21.9	36.70	36.71	36.71	36.63	36.63		
21	26	9	1964	28.8	28.8	28.8	28.8	28.9			28.9	36.15	36.18	36.32	36.16	36.30		
22	30	10	1964	24.6	24.7	24.7	24.8	25.0			25.0	35.50	35.72	36.05	35.99	35.76		
23	24	11	1964	23.4	23.4	23.4	23.6	23.6			23.7	35.92	35.87	35.80	36.09	35.93		
24	17	12	1964	20.3	20.2	20.3	21.0	21.1			21.1	35.68	35.77	35.89	36.17	36.22		
25	9	1	1965	18.2	18.2	17.6	19.5	20.0			20.0	34.27	34.26	34.90	35.96	36.12		
26	28	2	1965	15.5	15.5	16.4	18.2	18.0			17.9	32.19	32.15	34.88	36.03	32.71		
27	23	3	1965	16.9	16.9	16.8	17.6	17.8			17.8	35.08	35.07	35.16	35.61	35.86		
28	25	4	1965	24.4	24.3	21.5	18.2	17.9			17.8	28.47	28.42	32.51	36.09	32.02		
29	31	5	1965	26.5	26.4	26.0	24.2	23.0			23.0	33.06	33.03	33.96	35.12	36.22		
30	13	6	1965	27.9	27.8	26.6	24.1	22.5			22.3	33.02	34.37	35.33	36.10	36.50		
32	13	8	1965	28.2	27.9	27.9	26.5	23.7			23.6	36.50	36.49	36.48	36.53	36.67		
35	11	12	1965	20.4	20.4	22.6	23.3	00.0			23.2	32.61	32.12	34.74	35.17	35.63		

Table 5. Drift bottle release and recoveries by cruise, station, and date in the south Texas OCS study area in 1962.

CRUISE #: 1-62

INCLUSIVE DATES: 2/24-2/27

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W- 7	27°44'	95°30'	2-27-62	12	NONE			
W- 8	27°39'	95°32'	2-27-62	12	NONE			
W- 9	27°54'	95°35'	2-27-62	12	NONE			
W-10	28°04'	95°40'	2-27-62	12	NONE			
W-11	28°17'	95°46'	2-27-62	12	NONE			
W-13	28°02'	96°46'	2-26-62	12	NONE			
W-14	27°54'	96°37'	2-26-62	12	NONE			
W-15	27°47'	96°30'	2-26-62	12	00138	26°55.5'	96°57.5'	6
W-16	27°41'	96°23'	2-26-62	12	NONE			
W-17	27°37'	96°20'	2-26-62	12	NONE			
W-18	27°32'	96°14'	2-26-62	12	NONE			
W-19	27°01'	96°32'	2-26-62	12	NONE			
W-20	27°04'	96°42'	2-25-62	12	NONE			
W-21	27°06'	96°48'	2-25-62	12	NONE			
W-22	27°08'	96°56'	2-25-62	12	NONE			
W-23	27°12'	97°08'	2-26-62	12	00363	26°17'	97°11'	8
W-24	27°15'	97°19'	2-26-62	12	00347	27°21'	97°20'	5
					00350	27°28.5'	97°15.5'	1
					00345	27°29'	97°15'	1
					00356	27°29'	97°15'	14
					00346	27°38'	97°11.5'	13
					00354	27°28'	97°16.5'	17
					00348	27°28'	97°16.5'	16
					00352	27°27'	97°17'	19
					00355	27°27'	97°17'	18
W-25	26°14'	97°08'	2-24-62	12	00270	26°12.5'	97°10.5'	3
					00269	26°14.5'	97°11'	1
					00271	26°14.5'	97°11'	1
					00274	26°14.5'	97°11'	1
					00276	26°14.5'	97°11'	1

Table 5. (Continued)

CRUISE #: 1-62

INCLUSIVE DATES: 2/24-2/27

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-25	26°14'	97°08'	2-24-62	12	00277	27°14.5'	97°11'	1
					00278	27°14.5'	97°11'	1
					00279	27°14.5'	97°11'	1
					00280	27°14.5'	97°11'	1
					00272	27°14.5'	97°11'	1
W-26	26°15'	97°00'	2-24-62	12	NONE			
W-27	26°21'	96°41'	2-24-62	12	NONE			
W-28	26°24'	96°31'	2-24-62	12	NONE			
W-29	26°25'	96°26'	2-25-62	12	NONE			
W-30	26°26'	96°21'	2-25-62	12	NONE			
CRUISE #: 2-62								
INCLUSIVE DATES: 3/22-3/27								
W- 7	27°44'	94°30'	3-22-62	12	00672	28°12'	96°40'	24
W- 8	27°49'	95°32'	3-22-62	12	NONE			
W- 9	27°54'	95°35'	3-22-62	12	00650	27°07'	97°22'	12
W-10	28°04'	94°40'	3-22-62	12	00534	26°33.5'	97°33.5'	15
					00542	26°43.5'	97°20'	24
W-11	28°17'	95°46'	3-23-62	12	00546	26°31'	97°15.5	28
W-12	28°34'	95°55'	3-23-62	12	00567	27°51'	97°02.5'	11
					00565	27°51'	97°02'	11
					00569	27°52'	97°02'	11
					00559	27°09'	97°22'	12
					00566	27°36'	97°57.5'	6
W-13	28°02'	96°46'	3-23-62	12	00576	26°33.5'	97°16.5'	14
W-14	27°54'	96°37'	3-23-62	12	NONE			
W-15	27°47'	96°30'	3-25-62	12	NONE			

Table 5. (Continued)

CRUISE #: 2-62

INCLUSIVE DATES: 3/22-3/27

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-16	27°41'	96°23'	3-25-62	12	NONE			
W-17	27°37'	96°20'	3-25-62	12	00623	27°19.5'	97°20'	27
W-18	27°32'	96°14'	3-25-62	12	NONE			
W-19	27°01'	96°32'	3-26-62	4	00642	26°43.5'	97°20'	20
					00643	27°36'	97°12.5'	26
W-20	27°04'	96°42'	3-26-62	9	NONE			
W-21	27°06'	96°48'	3-26-62	12	00416	26°29'	97°14.5'	19
					00414	27°17.5'	97°11.5'	13
W-22	27°08'	96°56'	3-27-62	12	NONE			
W-23	27°12'	97°08'	3-27-62	12	NONE			
W-24	27°15'	97°19'	3-27-62	12	00528	27°25.5'	97°18'	1
					01364	27°23'	97°18.5'	1
					00525	27°35.5'	97°13.0'	2
					00530	27°20.5'	97°19.5'	1
					01368	27°20.5'	97°19.5'	1
					01367	27°32.5'	97°14.5'	4
					01363	27°32.5'	97°14.5'	4
					00526	27°26.5'	97°17.0'	5
					00527	27°26.5'	97°17.0'	5
					00529	27°31.5'	97°15'	19
W-25	26°14'	97°08'	3-27-62	12	00518	27°09'	97°22'	8
					00520	27°09'	97°22'	8
					00522	27°09'	97°22'	8
					00524	27°09'	97°22'	8
W-26	26°15'	97°00'	3-27-62	12	00501	26°09'	97°10'	9
					00507	26°09'	97°10'	9
					00509	26°09'	97°10'	9
					00504	26°15'	97°11'	19
					00511	26°11'	97°10'	27
W-27	26°21'	96°41'	3-26-62	9	00708	25°56'	97°08.5'	12
					00710	26°03'	97°09'	19
					00706	26°15'	97°11'	20

Table 5. (Continued)

CRUISE #: 2-62

INCLUSIVE DATES: 3/22-3/27

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-28	26°24'	96°31'	3-26-62	12	00720	26°06'	97°10'	20
W-29	26°25'	96°26'	3-26-62	12	00438	26°43.5'	97°20'	20
					00442	25°55'	97°08'	20
W-30	26°26'	96°21'	3-26-62	12	00430	26°06'	97°06'	15
					00435	26°05'	97°09.5	21
					00427	26°32.5'	97°14.5'	27

CRUISE #: 3-62

INCLUSIVE DATES: 4/19-4/26

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W- 7	27°44'	94°30'	4-19-62	12	NONE			
W- 8	27°49'	95°32'	4-20-62	12	02455	27°36'	96°54'	16
					02456	27°39'	97°11'	30
					02462	27°13'	97°22'	30
W- 9	27°54'	95°35'	4-20-62	12	02474	28°04'	96°50.5'	15
					02464	27°13'	97°22'	30
W-10	28°04'	95°40'	4-20-62	12	02480	27°03'	97°23'	30
W-11	28°17'	95°46'	4-20-62	12	02344	27°49'	97°04'	21
W-12	28°34'	95°55'	4-20-62	11	NONE			
W-13	28°02'	96°46'	4-20-62	12	02742	28°47'	95°34.5'	25
W-14	27°54'	96°37'	4-26-62	12	02057	27°03'	97°23'	24
					02719	27°45'	97°07'	30
					02728	27°16'	97°21'	30
W-15	27°47'	96°30'	4-26-62	12	02702	27°13'	97°22'	24
					02710	27°16'	97°21'	30
W-16	27°41'	96°23'	4-26-62	12	02690	28°02'	96°53'	10
					02698	27°39'	97°11'	10
					02694	27°52'	97°02'	14

Table 5. (Continued)

CRUISE #: 3-62

INCLUSIVE DATES: 4/19-4/26

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-17	27°37'	96°20'	4-26-62	12	02686	27°27.5'	97°17.5'	27
					02688	27°46'	97°06'	29
					02696	27°16'	97°21'	30
W-18	27°32'	96°14'	4-26-62	12	02265	28°24'	96°22'	30
					02676	29°32'	94°26'	30
W-19	27°01'	96°32'	4-24-62	12	02418	26°19'	97°11.5'	19
W-20	27°04'	96°42'	4-24-62	12	02414	27°13'	97°22'	26
W-21	27°06'	96°48'	4-24-62	12	02399	27°51'	97°03'	19
W-22	27°08'	96°56'	4-24-62	12	NONE			
W-23	27°12'	97°08'	4-24-62	12	02760	27°26'	97°17.5'	5
					02764	27°27'	97°17'	5
					02772	27°13'	97°22'	5
					02765	27°27'	97°17'	12
					02766	27°28'	97°17'	15
					02767	27°27'	97°17.5'	15
					02768	27°32'	97°15'	16
					02749	27°36'	97°12.5'	18
					02761	27°13'	97°22'	26
W-24	27°15'	97°19'	4-24-62	12	02752	27°16'	97°21'	18
W-25	26°14'	97°08'	4-25-62	12	02268	26°19'	97°12'	3
					02271	26°26'	97°14'	3
					02272	26°21'	97°12.5'	3
					02273	26°23'	97°13'	3
					02274	26°26'	97°14'	3
					02278	26°31'	97°15.5'	3
					02280	26°21'	97°12.5'	3
W-26	26°15'	97°00'	4-24-62	11	02261	27°13'	97°22'	26
W-27	26°21'	96°41'	4-25-62	12	02244	27°37'	97°12.5'	25
W-28	26°24'	96°31'	4-25-62	12	NONE			
W-29	26°25'	96°26'	4-24-62	12	02444	29°27'	94°38.5	21
W-30	26°26'	96°21'	4-25-62	12	NONE			

Table 5. (Continued)

CRUISE #: 4-62

INCLUSIVE DATES: 5/20-5/22

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W- 7	27°44'	95°30'	5-20-62	12	NONE			
W- 8	27°49'	95°32'	5-20-62	12	NONE			
W- 9	27°54'	95°35'	5-20-62	12	NONE			
W-10	28°04'	95°40'	5-20-62	12	NONE			
W-11	28°17'	95°46'	5-20-62	12	NONE			
W-12	28°34'	95°55'	5-21-62	12	NONE			
W-13	28°02'	96°46'	5-21-62	12	NONE			
W-24	27°15'	97°19'	5-22-62	12	01423	27°16'	97°21'	3
					03041	27°23'	97°19'	3
					03043	27°16'	97°21'	3
					01422	27°16'	97°21'	4
					03040	27°16'	97°21'	4
					03042	27°16'	97°21'	4
					03044	27°16'	97°21'	4
					03045	27°16'	97°21'	4
					03046	27°16'	97°21'	4
					03047	27°16'	97°21'	4
					03048	27°16'	97°21'	4
					03049	27°16'	97°21'	5

CRUISE #: 5-62

INCLUSIVE DATES: 6/19-6/23

STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W- 7	27°44'	95°30'	6-19-62	12	01505	28°44'	95°41.5'	20
W- 8	27°49'	95°32'	6-20-62	12	01516	28°40'	95°48'	18
W- 9	27°54'	95°35'	6-20-62	12	01535	28°51.5'	95°26.5'	15
					01531	28°46'	95°36.5'	16
W-10	28°04'	95°40'	6-20-62	12	01538	28°08.5'	95°02.0'	14
					01642	29°11'	94°58'	13

Table 5. (Continued)

CRUISE #: 5-62

INCLUSIVE DATES: 6/19-6/23

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-11	28°17'	95°46'	6-20-62	12	01648	28°54'	95°17'	7
					01652	28°57'	95°17'	8
					01650	28°57'	95°17.5'	8
					01658	28°49'	95°30.5'	15
W-12	28°34'	95°55'	6-20-62	12	01659	28°55'	95°21'	18
					01666	28°39'	95°51'	7
W-13	28°02'	96°46'	6-21-62	12		NONE		
W-14	27°54'	96°37'	6-21-62	12	01684	28°03'	96°52'	16
W-15	27°47'	96°30'	6-21-62	11		NONE		
W-16	27°41'	96°23'	6-21-62	10	03376	28°04'	96°50.5'	16
W-17	27°37'	96°20'	6-21-62	12		NONE		
W-18	27°32'	96°14'	6-22-62	12		NONE		
W-19	27°01'	96°32'	6-22-62	8		NONE		
W-20	27°04'	96°42'	6-22-62	12	01585	28°04'	96°50.5'	15
					01587	28°50.5'	97°04.0'	16
					01582	27°36.5'	97°12.5'	10
					01583	28°01.0'	97°03.0'	21
W-21	27°06'	96°48'	6-22-62	12		NONE		
W-22	27°08'	96°56'	6-22-62	12	01560	27°35'	97°13'	7
					01557	27°35'	97°13'	10
W-23	27°12'	97°08'	6-22-62	12	01554	27°44'	97°07.5'	8
					01549	27°31.5'	97°15'	6
					01545	27°32.5'	97°14.5'	12
					01548	27°44'	97°07.5'	7
W-24	27°15'	97°19'	6-22-62	12	01544	27°36.5'	97°12.5'	2
					01542	27°38.5'	97°11.5'	4
					01543	27°39'	97°11'	4
					03394	27°35'	97°13'	2
					03396	27°35'	97°13'	2
					03393	27°43'	97°08'	12

Table 5. (Continued)

CRUISE #: 5-62

INCLUSIVE DATES: 6/19-6/23

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-24	27°15'	97°19'	6-22-62	12	03395	27°43'	97°08'	7
					03392	27°35.5'	97°13'	7
					03391	27°50'	97°03.5'	23
					01541	27°45.5'	97°06.5'	6
W-25	26°14'	97°08'	6-23-62	12	03408	26°56'	97°22.5'	17
					03409	26°53.5'	97°22'	29
					03404	26°49.5'	97°21.5'	29
					03402	26°49.5'	97°21.5'	29
					03400	26°54.5'	97°22'	29
					03398	26°53.5'	97°22'	29
					03403	26°52.5'	97°22'	29
W-26	26°15'	97°00'	6-23-62	12	-----NONE-----			
W-27	26°21'	96°41'	6-23-62	12	03428	28°24'	96°22.5'	26
W-28	26°24'	96°31'	6-23-62	12	03436	28°12.5'	96°39'	12
					03440	28°32'	96°07.5'	17
W-29	26°25'	96°26'	6-23-62	12	03453	27°44'	97°07.5'	13

CRUISE #: 6-62

INCLUSIVE DATES: 7/20-7/23

W- 8	27°49'	95°32'	7-23-62	6	-----NONE-----			
W- 9	27°54'	95°35'	7-23-62	6	-----NONE-----			
W-10	28°04'	95°40'	7-23-62	6	-----NONE-----			
W-11	28°17'	95°46'	7-20-62	6	-----NONE-----			
W-13	28°02'	96°46'	7-21-62	6	01922	28°24.5'	96°21'	5
					01724	28°18'	96°28.5'	7
					01708	28°18'	96°28.5'	13

Table 5. (Continued)

CRUISE #: 6-62

INCLUSIVE DATES: 7/20-7/23

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-14	27°54'	96°37'	7-21-62	6	01704	28°38.5'	95°51'	7
					01738	28°29'	96°13.5'	8
					01709	29°18'	94°41.5'	14
					01732	28°49.5'	95°29'	29
					01743	29°46.5'	93°12'	30
W-15	27°47'	96°30'	7-21-62	6	01698	29°12'	94°57'	12
					01718	29°19.5'	94°44.5'	12
W-16	27°41'	96°23'	7-21-62	6	---NONE---			
W-17	27°37'	96°20'	7-21-62	6	---NONE---			
W-18	27°32'	96°14'	7-21-62	6	---NONE---			
W-20	27°04'	96°42'	7-22-62	6	---NONE---			
W-21	27°06'	96°48'	7-22-62	6	01728	29°47'	93°16.5'	22
W-22	27°08'	96°56'	7-22-62	6	01726	28°53'	95°23'	12
					01748	28°49'	95°31'	13
					01932	28°45'	95°38.5'	13
W-23	27°12'	97°08'	7-22-62	6	01940	27°34'	97°13.5'	3
					01944	27°34.5'	97°13.5'	3
					01746	27°49.5'	97°03'	5
					01750	27°49.5'	97°03'	5
					03551	27°35'	97°13'	5
W-24	27°15'	97°19'	7-22-62	6	01966	27°17.5'	97°20.5'	2
					01994	27°17.5'	97°20.5'	2
					01998	27°17.5'	97°20.5'	2
					03541	27°24.5'	97°18.5'	3
W-25	26°14'	97°08'	7-22-62	6	01956	28°04.5'	96°50'	9
					03573	28°44.5'	95°39'	29
W-26	26°15'	97°00'	7-23-62	6	03526	29°16'	94°49.5'	16
					01958	29°46'	93°29.5'	27
					03543	28°52.5'	95°24.5'	28

Table 5. (Continued)

CRUISE #: 6-62

INCLUSIVE DATES: 7/20-7/23

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-27	26°21'	96°41'	7-23-62	6	01972	29°45'	93°37'	29
W-28	26°24'	96°31'	7-23-62	6	----------NONE----------			
W-29	26°25'	96°26'	7-23-62	5	----------NONE----------			
CRUISE #: 7-62								
INCLUSIVE DATES: 9/9-9/12								
W- 7	27°44'	95°30'	9-9-62	10	04658	29°19.5'	97°12'	20
W- 8	27°49'	95°32'	9-9-62	11	04642	26°42'	97°20'	21
					04674	26°42'	97°20'	21
W- 9	27°54'	95°35'	9-9-62	10	04610	26°19.5'	97°12'	20
W-10	28°04'	95°40'	9-9-62	12	04506	26°40'	97°18.5'	13
					04512	27°33'	97°14'	14
					04510	26°39'	97°18.5'	14
					04504	27°51'	97°02.5'	12
					04502	27°43'	97°08.5'	23
W-11	28°17'	95°46'	9-9-62	12	04520	28°28'	96°16'	14
					04514	28°21'	96°24'	15
					04516	28°34'	96°03.5'	7
					04541	26°33'	97°16'	14
W-12	28°34'	95°55'	9-9-62	11	04528	28°57'	95°17.5'	22
					04534	28°57'	95°17.5'	4
					04536	28°57'	95°17.5'	5
					04613	28°58'	95°13'	17
W-13	28°02'	96°46'	9-10-62	11	04538	27°56'	96°58'	7
					04542	28°03'	96°51.5'	13
					04639	27°56'	96°58'	7
					04643	27°56'	96°58'	7
					04653	27°56'	96°58'	7
					04560	28°03'	96°51.5'	12

Table 5. (Continued)

CRUISE #: 7-62

INCLUSIVE DATES: 9/9-9/12

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-14	27°54'	96°37'	9-10-62	12	NONE			
W-15	27°47'	96°30'	9-10-62	12	04574	27°45'	97°07'	8
					04681	26°49.5'	97°21'	13
W-16	27°41'	96°23'	9-10-62	10	04556	27°08'	97°22.5'	12
					04572	27°29.5'	97°16'	13
W-17	27°37'	96°20'	9-10-62	12	04586	26°40'	97°19'	20
					04576	26°42'	97°20'	20
					04554	26°42'	97°20'	20
					04601	26°32'	97°15.5'	8
					04702	26°23.5'	97°13'	8
W-18	27°32'	96°14'	9-10-62	12	NONE			
W-19	27°01'	96°32'	9-11-62	11	04563	26°40'	97°19'	19
					04525	26°06'	97°10'	20
W-20	27°04'	96°42'	9-11-62	11	04744	26°26.5'	97°14'	19
					04551	26°24.5'	97°13'	18
					04553	27°32'	97°14.5'	24
W-21	27°06'	96°48'	9-11-62	11	04270	26°41'	97°19'	11
W-22	27°08'	96°56'	9-11-62	12	04272	26°54'	97°22'	1
W-23	27°12'	97°08'	9-11-62	11	04742	27°05'	97°22.5'	9
					04734	26°58.5'	97°22.5'	4
					04730	27°05'	97°22.5'	9
					04557	27°12.5'	97°22'	4
					04573	26°54'	97°22'	3
W-24	27°15'	97°19'	9-11-62	12	04507	26°47'	97°20.5'	2
					04509	27°03'	97°23'	5
					04543	26°57.5'	97°22.5'	4
					04545	27°03.5'	97°23'	2
					04708	26°53.5'	97°22'	2
					04746	26°43.5'	97°19.5'	2
					04738	26°53.5'	97°22'	2
					04720	27°07'	97°22.5'	22
					04256	27°02.5'	97°22.5'	27
					04593	27°02.5'	97°22.5'	5

Table 5. (Continued)

CRUISE #: 7-62

INCLUSIVE DATES: 9/9-9/12

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-25	26°14'	97°08'	9-12-62	12	04503	26°16'	97°11'	12
					04722	26°34.5'	97°16.5'	7
					04714	26°34.5'	97°16.5'	14
W-26	26°15'	97°00'	9-12-62	12	04304	26°11.5'	97°10.5'	12
					04326	26°13.5'	97°10.5'	1
					04302	26°18.5'	97°11.5'	1
W-27	26°21'	96°41'	9-12-62	12	04332	26°41'	97°19'	10
W-28	26°24'	96°31'	9-12-62	12	04292	26°41'	97°19'	10
W-29	26°25'	96°26'	9-12-62	5	--------------------NONE-------------------------			

CRUISE #: 8-62

INCLUSIVE DATES: 10/18-10/22

W- 7	27°44'	95°30'	10-18-62	12	--------------------NONE-------------------------			
W- 8	27°49'	95°32'	10-18-62	10	--------------------NONE-------------------------			
W- 9	27°54'	95°35'	10-18-62	12	--------------------NONE-------------------------			
W-10	28°04'	95°40'	10-18-62	9	--------------------NONE-------------------------			
W-11	28°17'	95°46'	10-18-62	12	--------------------NONE-------------------------			
W-12	28°34'	95°55'	10-18-62	11	03778	28°24'	96°21.5'	11
					04760	28°29.5'	96°13'	17
W-13	28°02'	96°46'	10-18-62	11	--------------------NONE-------------------------			
W-14	27°54'	96°37'	10-19-62	12	04801	27°51'	96°47'	3
					03808	27°15.5'	97°21'	12
					04984	27°10.5'	97°22'	12
					04992	27°17'	97°21'	12
					03816	26°36'	97°17'	30
W-15	27°47'	96°30'	10-19-62	12	04986	26°21'	97°12.5'	20
W-16	27°41'	96°23'	10-19-62	11	--------------------NONE-------------------------			
W-17	27°37'	96°20'	10-19-62	11	--------------------NONE-------------------------			
W-18	27°32'	96°14'	10-19-62	12	--------------------NONE-------------------------			

Table 5. (Continued)

CRUISE #: 8-62

INCLUSIVE DATES: 10/18-10/22

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-19	27°01'	96°32'	10-19-62	12	NONE			
W-20	27°04'	96°42'	10-20-62	12	NONE			
W-21	27°06'	96°48'	10-20-62	11	04008	26°07'	97°10'	15
					04003	26°02'	97°09.5'	18
					04001	26°02'	97°09.5'	28
W-22	27°08'	96°56'	10-20-62	12	04068	26°22'	97°12.5'	14
					04031	26°02'	97°09.5'	16
W-23	27°12'	97°08'	10-20-62	12	04024	26°59'	97°22.7'	7
					04015	26°05'	97°09.5'	13
					04072	27°05.5'	97°23'	14
W-24	27°15'	97°19'	10-20-62	12	04025	27°11.5'	97°22'	30
W-25	26°14'	97°08'	10-20-62	12	NONE			
W-26	26°15'	97°00'	10-22-62	12	04114	26°21.2'	97°12.5'	5
					04112	26°29'	97°14.5'	12
					04148	26°29'	97°14.5'	12
W-27	26°21'	96°41'	10-22-62	12	NONE			
W-28	26°24'	96°31'	10-22-62	12	NONE			
W-29	26°25'	96°26'	10-22-62	12	NONE			
W-30	26°26'	96°21'	10-22-62	12	NONE			

CRUISE #: 9-62

INCLUSIVE DATES: 11/15-11/22

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W- 7	27°44'	95°30'	11-15-62	12	NONE			
W- 8	27°49'	95°32'	11-16-62	10	NONE			
W- 9	27°54'	95°35'	11-16-62	12	NONE			
W-10	28°04'	95°40'	11-16-62	11	05100	26°00'	97°09'	24
W-11	28°17'	95°46'	11-16-62	12	05493	26°00'	97°09'	24

Table 5. (Continued)

CRUISE #: 9-62

INCLUSIVE DATES: 11/15-11/22

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-12	28°34'	95°55'	11-16-62	11	05114	27°02.5'	97°22.7'	16
					05106	26°57.5'	97°22.5'	16
					05124	27°06'	97°22.5'	19
W-13	28°02'	96°46'	11-17-62	12	03751	27°12'	97°22'	7
					03773	26°47'	97°20.5'	29
W-14	27°54'	96°37'	11-22-62	12	05287	27°33.5'	97°14'	6
					05255	27°32'	97°14.7'	6
					05297	27°30'	97°15.5'	5
					05271	27°30'	97°15.5'	5
					05301	27°37.5'	97°12'	14
					05259	27°27'	97°17.5'	5
					05303	27°29'	97°16.5'	5
					05257	27°27'	97°17'	7
					05249	27°27'	97°17'	7
					05245	27°02.5'	97°23'	11
					05253	27°27.5'	97°17'	6
W-15	27°47'	96°30'	11-22-62	12	05237	26°49.5'	97°21.5'	6
					05243	26°46.5'	97°20.5'	6
					05239	26°47'	97°20.5'	6
					05285	26°44.5'	97°20'	6
					05295	27°29'	97°16.5'	5
					05283	27°28'	97°16.5'	5
					05228	27°28'	97°16.5'	5
					05267	27°05.5'	97°23'	11
					05231	26°54.5'	97°22.3'	11
					05229	26°56.5'	97°22.5'	11

Table 5. (Continued)

CRUISE #: 9-62

INCLUSIVE DATES: 11/15-11/22

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-16	27°41'	96°23'	11-22-62	12	05281	26°29.5'	97°14.7'	8
					05277	26°08'	97°10'	10
					05260	26°11'	97°10.5'	10
					05299	26°33'	97°16'	9
					05218	26°44.5'	97°20'	16
					05216	26°52.5'	97°22'	16
					05263	26°05'	97°10'	9
					05275	26°05'	97°10'	9
					05273	26°05'	97°10'	9
					05220	26°05'	97°10'	10
W-17	27°37'	96°20'	11-22-62	12	05224	26°28'	97°14.5'	8
					05242	26°49.5'	97°21'	16
					05240	26°05'	97°10'	9
					05033	26°03	97°09'	19
					05234	26°47'	97°20.5'	24
					05031	26°05'	97°10'	10
W-18	27°32'	96°14'	11-22-62	10	----------NONE----------			
W-19	27°01'	96°32'	11-17-62	10	04918	26°19.5'	97°12'	13
					04962	26°19.5'	97°12'	14
					04960	26°16.5'	97°11.3'	22
W-20	27°04'	96°42'	11-17-62	11	03783	26°42.5'	97°19.5'	8
W-21	27°06'	96°48'	11-17-62	11	----------NONE----------			
W-22	27°08'	96°56'	11-17-62	12	----------NONE----------			
W-23	27°12'	97°08'	11-17-62	11	04898	26°05'	97°09.5	9
					04894	26°05'	97°09.5'	9
					04888	26°05'	97°09.5'	9
					04886	26°05'	97°09.5'	9
					03789	26°05'	97°09.5'	11
					04920	26°07.5'	97°10'	10

Table 5. (Continued)

CRUISE #: 9-62

INCLUSIVE DATES: 11/15-11/22

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-24	27°15'	97°19'	11-17-62	12	04882	26°31'	97°15.5'	10
					04876	26°33'	97°16'	10
					04878	26°29'	97°14.5'	10
					04902	26°19.5'	97°12'	13
					04900	26°19.5'	97°12'	13
					04880	26°16.5'	97°11.5'	13
W-25	26°14'	97°08'	11-21-62	12	04946	26°33'	97°16'	6
					05087	26°33'	97°16'	6
					05085	26°33'	97°16'	6
					04954	26°21.5'	97°12.5'	6
					05095	26°31.5'	97°15.5'	6
					04964	26°21.5'	97°12.5'	6
					05077	26°31'	97°15.5'	6
					05075	26°31'	97°15.5'	6
					04966	26°29'	97°14.5'	9
					05069	26°24'	97°13'	18
W-26	26°15'	97°00'	11-21-62	12	05278	26°21.5'	97°12.5'	6
					05268	26°21.5'	97°12.5'	6
					05073	26°24.5'	97°13.5'	6
					04906	26°19.5'	97°12'	6
					05071	26°24'	97°13'	6
					05067	26°21'	97°12.5'	6
					04970	26°31'	97°15.5'	6
					04968	26°23.5'	97°13'	9
					05079	26°24'	97°13'	9
					05083	26°19.5'	97°12'	9
					04908	26°30'	97°15'	4
W-27	26°21'	96°41'	11-21-62	12		NONE		
W-28	26°24'	96°31'	11-21-62	12		NONE		
W-29	26°25'	96°26'	11-21-62	11		NONE		
W-30	26°26'	96°21'	11-21-62	12		NONE		

Table 5. (Continued)

CRUISE #: 10-62

INCLUSIVE DATES: 12/6-12/12

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W- 7	27°44'	95°30'	12-12-62	12	NONE			
W- 8	27°49'	95°32'	12-12-62	11	NONE			
W- 9	27°54'	95°35'	12-12-62	11	NONE			
W-10	28°04'	95°40'	12-12-62	5	NONE			
W-13	28°02'	96°46'	12-6-62	12	NONE			
W-14	27°54'	96°37'	12-6-62	12	NONE			
W-15	27°47'	96°30'	12-6-62	12	NONE			
W-16	27°41'	96°23'	12-6-62	12	NONE			
W-17	27°37'	96°20'	12-6-62	11	NONE			
W-18	27°32'	96°14'	12-7-62	12	NONE			
W-19	27°01'	96°32'	12-7-62	12	NONE			
W-20	27°04'	96°42'	12-7-62	12	NONE			
W-21	27°06'	96°48'	12-7-62	11	NONE			
W-22	27°08'	96°56'	12-7-62	12	NONE			
W-23	27°12'	97°08'	12-7-62	11	NONE			
W-24	27°15'	97°19'	12-7-62	12	05980	27°02.5'	97°22.7'	1
					05992	27°27.3'	97°17'	2
					05996	27°17'	97°21'	3
					05988	27°28.5'	97°16.5'	4
					05998	27°28.5'	97°16.5'	4
					06321	26°47'	97°20.5'	9
					06347	26°47'	97°20.5'	9
					06311	26°42'	97°19'	10
					06313	26°47'	97°20.5'	10
					06345	26°42'	97°19'	10
					06315	27°02.5'	97°22.7'	16
W-25	26°14'	97°08'	12-9-62	12	05920	26°12.5'	97°10.5'	1
					05922	26°12.5'	97°10.5'	1
					05928	26°12.5'	97°10.5'	1
					05930	26°12.5'	97°10.5'	1

Table 5. (Continued)

CRUISE #: 10-62

INCLUSIVE DATES: 12/6-12/12

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-25	26°14'	97°08'	12-9-62	12	05932	26°12.5'	97°10.5'	1
					05936	26°12.5'	97°10.5'	1
					05938	26°12.5'	97°10.5'	1
					05940	26°12.5'	97°10.5'	1
					05942	26°12.5'	97°10.5'	1
					05946	26°12.5'	97°10.5'	1
					05948	26°12.5'	97°10.5'	1
W-26	26°15'	97°00'	12-9-62	9	05908	25°25'	97°19'	1
W-27	26°21'	96°41'	12-9-62	10	NONE			
W-28	26°24'	96°31'	12-9-62	12	NONE			
W-29	26°25'	96°26'	12-12-62	11	NONE			
W-30	26°26'	96°21'	12-12-62	12	NONE			

Table 6. Drift bottle releases and recoveries by cruise, station, and date in the south Texas OCS study area in 1963.

CRUISE #: 1-63

INCLUSIVE DATES: 2/1-2/4

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W- 7	27°44'	95°30'	2-2-63	12	05508	27°32'	97°14.5'	18
W- 8	27°49'	95°32'	2-2-63	12	NONE			
W- 9	27°54'	95°35'	2-2-63	11	NONE			
W-10	28°04'	95°40'	2-2-63	11	05740	26°22'	97°12.5'	15
					05742	26°21'	97°12.5'	15
					06995	27°50.5'	97°03.5'	22
					05540	26°19'	97°12'	26
					06989	27°48'	97°07.5'	16
					05515	26°23'	97°13'	15
					05503	26°24'	97°13'	15
					05746	27°37'	97°12'	8
					06991	26°04'	97°10'	29
W-11	28°17'	95°46'	2-4-63	11	06790	26°33.5'	97°16.5'	12
					06800	26°19'	97°12'	12
					06814	26°22'	97°12.5'	12
					06796	26°17'	97°11.5'	12
					06757	26°09'	97°10'	13
					06769	26°18'	97°11.5'	12
					06727	26°14'	97°10.5'	12
					06755	26°16'	97°11'	12
W-12	28°34'	95°55'	2-4-63	12	NONE			
W-13	28°02'	96°46'	2-4-63	11	NONE			
W-14	27°54'	96°37'	2-4-63	11	NONE			
W-18	27°32'	96°14'	2-4-63	11	NONE			

Table 6. (Continued)

CRUISE #: 2-63

INCLUSIVE DATES: 3/8-3/9

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-13	28°19'	96°21'	3-8-63	8	-------------------NONE-------------------------			
W-14	28°06'	96°13'	3-8-63	6	08091	26°03'	97°09'	17
W-15	27°57'	96°07'	3-8-63	8	06740	27°29'	97°16.5'	15
					06750	27°27'	97°17.5'	12
					08097	26°03'	97°09'	16
					08099	26°06'	97°10'	15
					08087	26°05.5'	97°10'	14
W-57	27°46'	96°00'	3-8-63	8	07428	26°15'	97°11'	19
					07925	26°47'	97°20.5'	15
					07941	26°02'	97°09.5'	15
W-58	27°06'	96°45'	3-9-63	7	07430	26°29'	97°14.5'	29
					07446	26°32.5'	97°15'	28
					07378	26°19.5'	97°12'	15
W-22	27°21'	96°50'	3-9-63	8	-------------------NONE-------------------------			
W-23	27°36'	96°55'	3-9-63	8	07877	26°01.5'	97°09.5'	13
					07456	25°08'	97°29'	16
					07420	25°07'	97°29.5'	16
W-24	27°48'	97°00'	3-8-63	8	07376	27°26.5'	97°17.5'	2
					07737	27°32'	97°15'	27
					07739	27°31'	97°15'	13
					07998	27°26.5'	97°17.5'	2
					07996	27°27'	97°17.5'	2
					08006	27°26.5'	97°17.5'	2
					08085	26°00'	97°09'	12
W-61	26°36'	97°08'	3-9-63	8	08088	25°54.5'	97°13.5'	10
W-62	26°41'	96°53'	3-9-63	8	-------------------NONE-------------------------			

Table 6. (Continued)

CRUISE #: 3-63

INCLUSIVE DATES: 4/3-4/6

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-13	28°19'	96°21'	4-6-63	8	08064	28°24'	96°24.5'	24
W-14	28°07'	96°14'	4-4-63	7	06732	28°29.5'	96°13.5'	17
					07879	28°37'	95°55'	22
W-15	27°57'	96°07'	4-3-63	8	06787	28°37'	95°55'	23
W-57	27°46'	96°00'	4-3-63	8	07400	28°37'	95°55'	23
					07406	28°13'	96°38'	28
					07394	28°46'	95°36.5'	26
W-58	27°06'	96°45'	4-4-63	7	05513	28°13'	96°38'	27
					06706	28°13'	96°38'	27
W-23	27°36'	96°55'	4-4-63	8	08075	26°31'	97°15.5'	6
					07707	26°31'	97°15.5'	6
					07408	26°25'	97°13.5'	3
W-22	27°21'	96°50'	4-4-63	8	08089	28°13'	96°38'	27
W-24	27°48'	97°00'	4-6-63	8	07681	27°40.5'	97°10'	2
					07691	27°49.5'	97°03'	5
					07490	27°40'	97°10.5'	2
					07504	27°39.5'	97°10.5'	2
					06703	27°48'	97°04.5'	2
					06779	27°49'	97°03.5'	3
					07486	27°40.5'	97°10'	2
					08080	27°38'	97°11.5'	2
W-61	26°36'	97°08'	4-5-63	8	07416	25°45.5'	97°11'	2
					07931	25°47'	97°11'	2
					07448	25°45.5'	97°11'	2
					07759	25°47'	97°11'	2
W-62	26°41'	96°53'	4-4-63	7	06785	28°05'	96°49'	26
					07424	28°25.5'	96°20'	19
					07372	28°25.5'	96°19.5'	23

Table 6. (Continued)

CRUISE #: 4-63

INCLUSIVE DATES: 5/2-5/5

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-13	28°19'	96°21'	5-2-63	5	07118	28°13'	96°38'	3
					07104	28°13'	96°38'	4
					07141	28°13'	96°38'	3
					07186	28°13'	96°38'	3
					07114	28°13'	96°38'	4
W-14	28°07'	96°14'	5-2-63	7	07102	27°35.5'	97°12.5'	4
					07108	27°40.5'	97°10'	3
					07273	27°29.5'	97°16'	6
					07271	28°40'	95°48'	13
					07194	27°55.5'	96°59.5'	18
					07283	28°13'	96°38'	16
W-15	27°57'	96°07'	5-2-63	8	07122	27°14'	97°21.5'	5
					07204	27°47'	97°05.5'	7
					07206	28°43'	95°42.5'	10
					07216	28°13'	96°38'	8
					07148	27°28'	97°16.5'	5
W-57	27°46'	96°00'	5-2-63	8	07172	28°13'	96°38'	5
					07196	29°16'	94°49'	23
W-58	27°06'	96°45'	5-5-63	7		NONE		
W-22	27°21'	96°50'	5-5-63	8	07784	28°36'	95°58.5'	11
					07782	28°40'	96°17.5'	18
					07778	28°35'	96°12'	17
					07214	28°29.5'	96°13.5'	27
					07218	28°29.5'	96°13.5'	27
					07800	28°29.5'	96°13.5'	27
					07208	29°22.5'	94°44'	19
W-23	27°36'	96°55'	5-5-63	6	07171	28°47.5'	95°33.5'	12
					07163	28°39.5'	95°49'	8
					07143	28°33.5'	96°04'	8
					07306	28°24'	96°21.5'	25

Table 6. (Continued)

CRUISE #: 5-63

INCLUSIVE DATES: 5/20-5/23

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-13	28°19'	96°21'	5-23-63	7	07361	27°59.5'	96°55.5'	10
					07379	28°03.5'	96°51.5'	2
					07383	28°03.5'	96°51.5'	2
					08550	27°53'	97°01.5'	2
					08523	28°03.5'	96°51.5'	2
					08548	27°57'	96°58'	5
W-14	28°07'	96°14'	5-21-63	7	08508	27°59.5'	96°55.5'	12
					08498	27°58.5'	96°56.5'	4
					08516	27°58.5'	96°56.5'	4
					08502	27°58'	96°57.5'	7
W-15	27°57'	96°07'	5-20-63		08556	28°13'	96°38'	14
					08558	28°39'	95°50.5'	11
W-57	27°46'	96°00'	5-20-63	8	07371	28°22.5'	96°24'	10
					06661	28°46'	95°36.5'	12
					06651	28°43.5'	95°41.5'	11
					06657	28°43.5'	95°41.5'	12
					08490	28°41.5'	95°45'	13
					08492	28°41.5'	95°45'	13
					06653	28°37'	95°55'	11
					08494	28°40'	95°48'	11
W-58	27°06'	96°45'	5-21-63	7	08522	28°13'	96°38'	14
					08524	28°13'	96°38'	13
					08512	28°13'	96°38'	21
W-22	27°21'	96°50'	5-21-63	9	07373	28°09'	97°22.5'	6
					07375	27°12'	97°22'	6
					07367	27°35'	97°13'	6
					08510	27°28'	97°17'	6
					08566	27°28'	97°17'	6

Table 6. (Continued)

CRUISE #: 5-63

INCLUSIVE DATES: 5/20-5/23

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-23	27°36'	96°55'	5-21-63	8	05803	27°26.5'	97°17.5'	5
					05805	27°26.5'	97°17.5'	5
					05811	27°26.5'	97°17.5'	5
					07515	27°26.5'	97°17.5'	5
					08500	25°59'	97°09'	5
					08506	27°24'	97°18.5'	4
					08496	27°23.5	97°18.5'	5
					08504	27°23.5'	97°18.5'	5
W-24	27°48'	97°00'	5-22-63	7	07365	27°49'	97°04'	1
					08546	27°39.5'	97°11'	3
					07357	27°48.5'	97°04.5'	3
					08534	27°49'	97°04'	3
					08554	27°48.5'	97°04'	3
					08552	27°49'	97°03.5'	3

CRUISE #: 6-63

INCLUSIVE DATES: 6/26-6/27

W-13	28°19'	96°21'	6-27-63	8	07068	28°21'	96°24'	2
					07553	28°29.5'	96°13.5'	3
					07718	28°21'	96°24'	2
					07722	28°21'	96°24'	1
					08108	28°21'	96°24'	1
					07545	28°39'	96°18.5'	17
					07561	28°39'	96°18.5'	17
W-14	28°07'	96°14'	6-26-63	8	08110	28°38'	95°54.5'	5

Table 6. (Continued)

CRUISE #: 6-63

INCLUSIVE DATES: 6/26-6/27

			RELEASE		RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-15	27°57'	96°07'	6-26-62	8	07740	28°44.5'	95°40'	11
					05801	29°11'	94°58.6'	17
					07094	29°06.5'	95°05.5'	16
					07563	29°10'	95°00'	17
					07559	29°10.5'	94°59.5'	16
					07557	29°09'	95°01'	3
W-57	27°46'	96°00'	6-26-63	8	07097	29°27'	94°37.5'	20
					07207	29°35'	94°17.5'	20
					07305	29°42'	94°00'	21
					07211	29°22'	94°45'	18
W-58	27°06'	96°45'	6-27-63	16	08532	28°52.5'	95°24.5'	16
					07724	28°51.5'	95°26.5'	22
					07714	29°19.5'	94°44.5'	19
					07597	29°09.5'	95°00.5'	22
					07543	29°30.5'	94°29.5'	22
					07091	28°46'	95°36.5'	16
					07790	28°46'	95°36.5'	16
					07774	28°46'	95°36.5'	16
					07599	28°46'	95°36.5'	16
					08514	28°46'	95°36.5'	29
					06170	28°46'	95°36.5'	29
W-22	27°21'	96°50'	6-27-63	8	07712	28°13'	96°38'	8
					08600	28°13'	96°38'	10
					07319	28°13'	96°38'	13
					07297	28°13'	96°38'	13
W-23	27°36'	96°55'	6-27-63	8	07325	28°04'	96°50.5'	8
					07708	28°13'	96°38'	8
					07072	28°13'	96°38'	10
					07734	28°03.5'	96°51'	9
					07088	28°13'	96°38'	16
					07071	28°03.5'	96°51.5'	14
					07331	28°03'	96°52.5'	9

Table 6. (Continued)

CRUISE #: 6-63

INCLUSIVE DATES: 6/26-6/27

RELEASE					RECOVERY			
STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-24	27°48'	97°00'	6-27-63	8	07090	27°58.5'	96°56.5'	2
					07303	27°58.5'	96°56.5'	2
					07329	28°04'	96°50.5'	3
					07732	27°58.5'	96°56.5'	2
					08584	27°58.5'	96°56.5'	2
					07069	28°04'	96°50.5'	2
W-62	26°41'	96°53'	6-27-63	8	07764	28°13'	96°38'	16
					07772	28°13'	96°38'	16
					07537	28°13'	96°38'	16
					07507	28°13'	96°38'	16
					07527	28°13'	96°38'	16
					07752	28°13'	96°38'	16

CRUISE #: 7-63

INCLUSIVE DATES: 7/15-7/16

STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-57	27°46'	96°00'	7-16-63	6	07796	29°16'	94°49'	27
W-23	27°36'	96°55'	7-15-63	6	07728	28°33.5'	96°04'	6
W-62	26°41'	96°53'	7-15-63	6	--------------------NONE--------------------------			

CRUISE #: 8-63

INCLUSIVE DATES: 8/29-8/30

STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-14	28°07'	96°14'	8-30-63	6	08272	28°13'	96°38'	25
					08340	28°17'	96°31.5'	11
					08256	28°19.5'	96°25.5'	10

Table 6. (Continued)

CRUISE #: 8-63

INCLUSIVE DATES: 8/29-8/30

STATION	LATITUDE	LONGITUDE	RELEASE		RECOVERY			
			DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-15	27°57'	96°07'	8-30-63	6	NONE			
W-57	27°46'	96°00'	8-30-63	6	NONE			
W-58	27°06'	96°45'	8-29-63	6	08216	27°21.5'	97°19.5'	15
					08166	27°23'	97°18.5'	13
W-22	27°21'	96°50'	8-29-63	6	08186	27°48.5'	97°04.5'	11
					08178	27°39.5'	97°10.5'	9
					08170	27°37.5'	97°12'	8
					08168	27°47'	97°05.5	12
					08238	27°42.5'	97°09'	12
W-23	27°36'	96°55'	8-29-63	6	NONE			
CRUISE #: 9-63								
INCLUSIVE DATES: 10/2-10/4								
W-14	27°19'	96°39'	10-2-63	11	08201	26°46.5'	97°20.5'	18
W-15	27°57'	96°07'	10-2-63	12	08173	26°44.5'	97°20'	18
					08139	26°45.5'	97°20'	15
					08423	26°46.5'	97°20.5'	18
					08143	26°46.5'	97°20.5'	18
					08167	26°46.5'	97°20.5'	18
W-22	27°21'	96°50'	10-4-63	11	08429	25°54.5'	97°13.5'	9
					08417	26°24'	97°13.5'	16
					08322	26°22'	97°12.5'	17
					08126	25°54.5'	97°13.5'	13
W-23	27°36'	96°55'	10-4-63	12	08268	26°20.5'	97°12'	8
					08388	26°13'	97°11.5'	8
					08115	26°46.5'	97°20.5'	16
					08365	26°33.5'	97°16'	17
					08361	26°31'	97°15.5'	17
					08145	26°30'	97°15'	16
					08219	26°33.5'	97°16'	16
					08421	26°31.5'	97°15.5'	16
					08155	26°46.5'	97°20.5'	16

Table 6. (Continued)

CRUISE #: 10-63

INCLUSIVE DATES: 10/31-11/4

STATION	LATITUDE	LONGITUDE	RELEASE		RECOVERY			
			DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-14	27°19'	96°39'	11-1-63	11		NONE		
W-15	27°57'	96°07'	10-31-63	9		NONE		
W-22	27°21'	96°50'	11-4-63	12		NONE		
W-23	27°36'	96°55'	11-1-63	12		NONE		

CRUISE #: 11-63

INCLUSIVE DATES: 11/30-12/1

STATION	LATITUDE	LONGITUDE	DATE OCCUPIED	TOTAL NUMBER	BOTTLE NUMBER	LATITUDE	LONGITUDE	DAYS OUT
W-14	27°19'	96°39'	11-30-63	12		NONE		
W-15	27°57'	96°07'	11-30-63	11		NONE		
W-23	27°36'	96°55'	12-1-63	12	11797	25°54.5'	97°13.5'	19
					11842	26°04.5'	97°10'	25
					11889	26°27'	97°14.5'	17
					11893	26°09'	97°10'	17
W-24	27°48'	97°00'	12-1-63	12	11865	27°47.5'	97°05'	9
					11813	28°13'	96°38'	26
					11817	28°13'	96°38'	26
					11845	28°13'	96°38'	26
					11864	28°13'	96°38'	26
					11874	28°13'	96°38'	26
					11860	27°52'	97°02'	29

MARCH 3, 1849

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.