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LITTORAL DRIFT ESTIMATES ALONG THE COASTLINE OF FLORIDA

by T. L. Walton, Jr.

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I. INTRODUCTION

Littoral drift, or longshore sand transport, is perhaps the most important quantity required in the design of coastal engineering projects such as harbors, beach nourishment projects, sand bypassing systems at inlets, and groin fields. Unfortunately, the magnitude and direction of littoral drift movements along Florida's shoreline are very elusive quantities due to the complex dependency of sand movement on wave climate at the shoreline.

Presently many of the estimated values of littoral drift along Florida's shores have been derived through a combination of volumetric surveys at inlet jetties, shoaling rates at inlets, and guess work. In many places these values have been extended to other locations without regard to the effects of the changing orientation of the shore into wave climate. In many other locations, no values exist at all.

The best estimates of littoral drift are those estimates of net littoral drift, made by volumetric surveys of accretion fillets updrift or erosion quantities downdrift of inlet jetties which extend out beyond the zone of active sand movement. Such values are practically non-existant in Florida. The few estimates of magnitudes and directions of littoral drift that do exist, are, as noted, values of net littoral drift, and do not in any way help to define the total sand movement in the updrift and downdrift direction parallel to the shoreline, but, only give the difference between these two values.

For classification of the many littoral drift terms contained in this report, the following definitions are given:

Total littoral drift = the total movement of sand in a given direction past a plane perpendicular to the shoreline. (The sign convention to be used is positive to the right when looking offshore, and negative to the left when looking offshore).

Net littoral drift = the difference between the total updrift and total downdrift movements of sand (The sign convention to be used is positive to the right when looking offshore, and negative to the left when looking offshore).

Gross littoral drift = the sum of the total updrift and total downdrift movements of sand (not directional). This quantity represents the total amount of sand moved past a plane perpendicular to the beach.

These definitions are represented in Figure 1.

To predict values of littoral drift, a knowledge of the wave climate at the site of interest is essential.

One reason for the uncertainty in the littoral drift climate around Florida is a lack of knowledge of wave climate at the shoreline, the causative agent for most of the sand movement on the beaches.

To date, little wave climate information exists along Florida's shoreline. Only 5 wave gages (operated by the Coastal Engineering Research Center) exist along the coastline of Florida and gather data on wave height and wave period. Unfortunately, though, these gages do not incorporate a device for obtaining wave direction and therefore lack the most important piece of information for calculation of littoral drift (i.e. wave direction).

Presently, the only extensive source for wave climate having wave heights, periods, and directions along Florida's shoreline consists of wave observations taken by trained personnel aboard merchant marine and Navy vessels

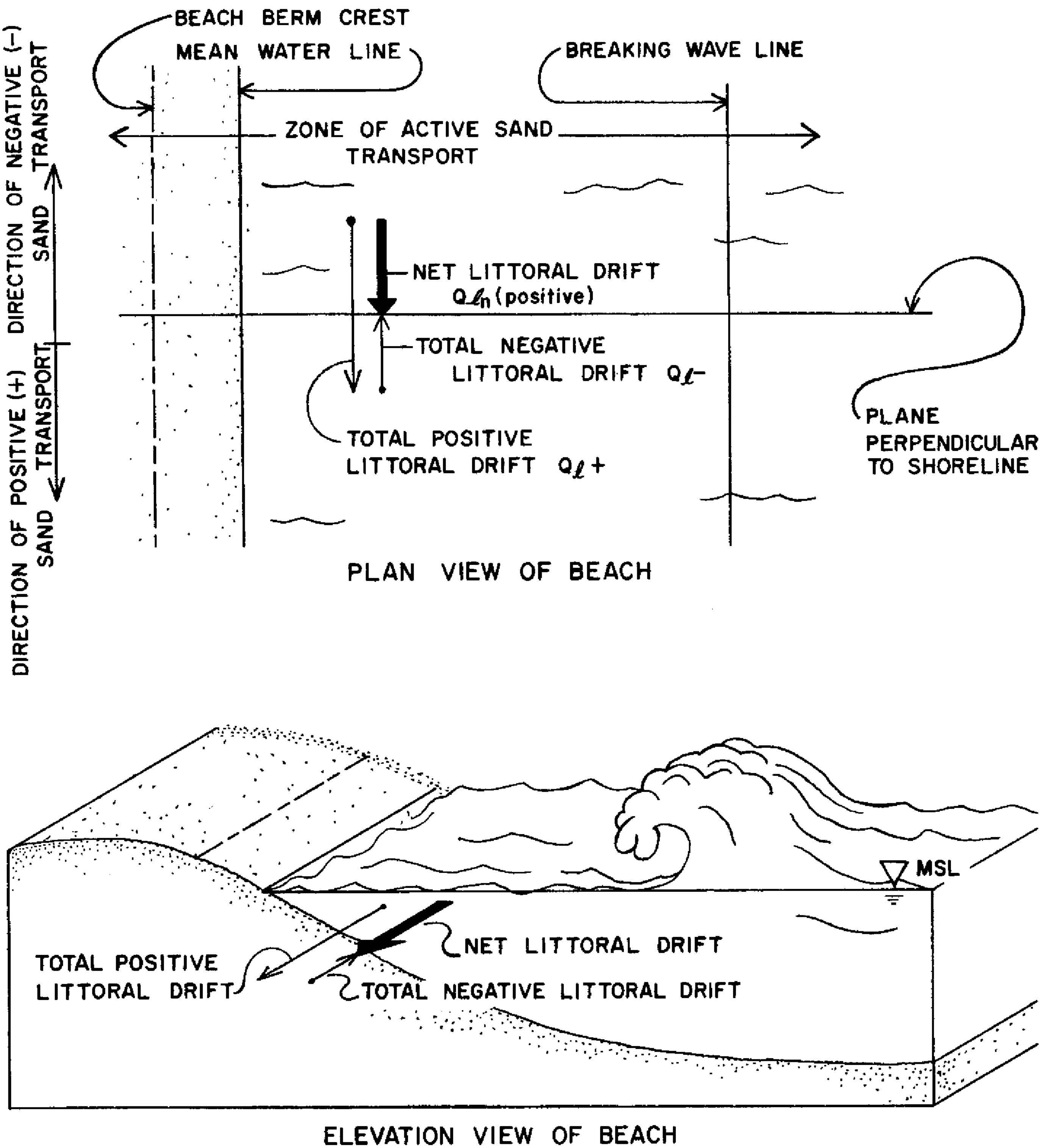


FIGURE 1. DEFINITION OF LITTORAL DRIFT QUANTITIES

in a data collection program of the Environmental Data Service Section of NOAA (formerly ESSA). Reference (1) discusses the means by which the personnel aboard ships have been directed to make these observations.

These wave observations are then organized into data blocks (Marsden Squares) depending on the latitude-longitude location of the wave observation. This data is available to users in Reference (2).

The data presented in Reference (2) provides a source for making littoral drift computations along the coast line of Florida on a monthly and annual basis.

Previous work (see Reference (3)) has summarized such computations for the coast of Florida on an annual basis and discusses extensively the assumptions inherent in the data source and the computational detail. Results of the calculations of littoral drift on an annually averaged basis were presented in Reference (3) in the form of "littoral drift roses". The interpretation and many uses of these roses are discussed in References (3) and (4).

The present report is an extension of the work in Reference (3), and provides littoral drift roses computed on a monthly averaged basis for possible use in feeder beach design and groin system design where a knowledge of seasonal sand movement is important, and in design of jetties where a knowledge of the monthly buildup of sand adjacent to the structure is of beneficial use in planning the construction phase of the project.

The remainder of this report is divided into the sections discussed below. Sections II and III reiterate the more important aspects of the data source and the computational scheme used in the calculations. Both sections present only a brief summary of an extensive discussion presented in Reference (3). For further details interested persons should consult that reference. Section IV presents an example of the littoral drift computational results, with a geomorphological interpretation of a section of coastline using the results. Additionally, heuristic comparisons of monthly littoral drift rates are presented where such comparisons can be made. Section V is a summary of the results from this study with implications for use of the data. Additionally, along with the monthly littoral drift roses, the annually averaged littoral drift roses from Reference (3) have been included with new scales superimposed for ease of interpolating results. Minor variations in the annually averaged littoral drift roses given in this report and those given in Reference (3) may occur due to the larger geographic coverage assigned to the drift roses in this report. These minor variations are not significant though in light of other assumptions in the calculations, as will be discussed.

II. DATA SOURCE: ASSUMPTIONS AND INHERENT LIMITATIONS

As already noted, this report deals with the computation of littoral drift using visual wave observations taken by trained personnel aboard ships. As noted in Reference (3) and reiterated here, this data source has limitations, the most important of which are noted as follows:

(1) Normally, ships are routed out of heavy seas or detained in port until a storm passes, thus the data source has no or little record of extreme waves (i.e. such as occurring during the height of a hurricane) which are undoubtedly very important in determining the magnitude and direction of littoral drift an area experiences. Extreme storm activity is especially important in low energy areas where the average wave climate has little influence on shoreline processes, therefore results of the present study should be used with more caution in low energy zones having large frequency of occurrences for tropical or extratropical storms.

(2) Past studies have shown that wave observers aboard vessels tend to classify the direction of waves primarily along the four cardinal (N, E, S, W), and secondarily along the four intercardinal (NE, SE, SW, NW) points of a compass. As wave direction is the most important parameter in determining the magnitude and direction of littoral drift, this bias is a significant consideration.

Assumptions made to use this data source in the present computational scheme are noted as follows:

(1) The direction of sea waves and swell are considered to be coincident with the wind direction

(2) Propagation of waves is undirectional at any specific time

(3) There is zero energy dissipation to the atmosphere by waves and swells as they travel from the point of observation to the coastline

(4) An observed wave height and period are exclusive; i.e., the sea is considered to consist totally of one wave height and period during a given observation (i.e. monochromatic waves rather than a spectrum)

(5) All observations are assumed deep water waves; that is, the water depth is greater than or equal to 2.56 times the wave period squared ($h = 2.56\ T^2$)

(6) Due to the nature of human observations, the wave height is considered to be significant height (average of the highest 1/3 of all waves present)

An extensive discussion of these assumptions can be found in Reference (3).

III. COMPUTATIONAL SCHEME: ASSUMPTIONS AND INHERENT LIMITATIONS

The basic equation used for the computation of littoral drift is as follows:

$$Q_\ell = C \frac{\gamma}{8} H_o^2 C_{go} \cos \alpha_o \sin \alpha_b K_f^2 \cdot \frac{24 \cdot (3600)}{10^6} \qquad (1)$$

where Q_ℓ = littoral drift rate (in cubic yards per day)

C = a constant correlation coefficient = 125 in the present study

γ = specific weight of seawater = 64 lbs./ft.^{3}

H_o = deep water wave height (in feet)

C_{go} = deep water wave group velocity (in feet/sec.)

α_o = deep water angle of wave approach to shoreline, i.e. angle between wave crest and shoreline

α_b = the angle the breaking wave makes with the shoreline

K_f = a friction coefficient defined in Reference (3)

An extensive development of this equation can be found in Appendix I of Reference (3).

One of the inherent difficulties in littoral drift computations lies in the relative uncertainty of the correlation coefficient C in Equation (1) correlating littoral drift with longshore energy flux. In Reference (5), the value of C = 125 was noted to define the relationship of predicted littoral drift from calculated longshore energy flux within an order of magnitude. Further studies, Reference (6), show that the linear relationship appears considerably better than an order of magnitude relationship. Reference (7) based on results of tracer studies made by Komar (Reference (6)) has re-defined the constant such that the new value of C would be 1.88 times the previous value, or C_{new} = 235. In view of the scatter of existing field data (see Reference (7), Figure 4-37) and the uncertainities inherent in tracer movement studies, it it believed by the author that a great deal of uncertainty still remains in this correlation constant, and that further field data is needed correlating littoral drift (by accretion at structures which provide barriers to the longshore movement of sand) with the longshore energy flux present. Until such data becomes available, it is felt that the correlation coefficient of Reference (5), C = 125, is reasonable for computing littoral drift. Since the relationship is linear in this coefficient, the results of the present study can always be adjusted based on existing good estimates of littoral drift (i.e. "calibrated"), and/or possibly readjusted when more data points for the longshore energy flux vs. littoral drift correlation become available in the future.

An extensive discussion of the additional assumptions within the program used to compute littoral drift can be found in Reference (3). The most important of these assumptions which should be noted when using the results of these littoral drift calculations are as follows:

(1) Sediment transport (or littoral drift) is dependent on wave action rather than some other physical phenomena (i.e. tidal currents, wind action on the beach and wind driven littoral currents)

(2) Linear theory is valid for the wave transformation process and the wave energy present in the wave system;

(3) Bottom topography is composed of relatively straight and parallel bottom contours;

(4) No drastic changes in the bottom profile are encountered in the shallow areas seaward of the breaker line up to the beach;

(5) Adequate sources of sand are available for transport.

(6) Waves can approach the shoreline from a 180° segment; i.e. no sheltering effects of nearby capes, promitories, or possible coastal structures (jetties, etc.)

(7) The friction factor used in the program is 0.01

With regard to item (1), this assumption is the basis of the littoral drift equation used to compute the sediment transport rates in this report. In areas near the tips of barrier islands or near inlets where the influence of tidal flow is felt along the shoreline, a good portion of the sediment transport may be taking place due to a combination of wave action placing the sand into suspension and the tidal currents moving the sand in the nearshore zone. This model would not be expected to give valid results in those areas.

Item (2) refers to the mathematical formulation of the problem and its relation to physical reality. This assumption is reasonably good up to the region of breaking waves where it departs drastically from the physical situation. As the existing correlation between sand transport and longshore energy flux has values of longshore energy flux calculated by linear wave theory, the continued use of linear wave theory is justified.

Assumption (3) is necessary for the simple application of Snell's Law of Refraction used in this model and does not require a monotonic decrease in depth toward shore, but only the aforementioned relationship of straight and parallel contours. In areas of relatively complex offshore topography, this assumption would not be valid and therefore local deviations in longshore energy flux would exist. Over areas of generally smooth topography in depths shoreward of 50 feet this assumption is usually very good.

Assumption (4) is necessary due to the use of offshore wave conditions for the computation of longshore energy rather than nearshore conditions. Thus, rock or coral reef might cause a large dissipation or reflection of energy before the wave reaches the computed breaker zone, which would not be apparent in the equation of E_a formulated above. Obviously an offshore breakwater (submerged or above water) would also violate assumption (4) and therefore results of the computations could not be used shoreward of such a structure.

An additional assumption inherent in the formula for calculating littoral drift is Item (5), the availability of sand to be moved. This is dependent on the geologic processes acting in the area, and the natural or man-made conditions present. Along much of the shoreline bordering the Gulf of Mexico there is a lack of sand (i.e. the Apalachee Bay area), predominantly in areas having extremely low wave energy, and in areas which are drained by rivers containing mostly silt and organics rather than coarse alluvial materials. Rivers, inlets, jetties, groins, seawalls, prominent headlands, and submarine ridges and valleys can also cause a lack of sand in an area downdrift of the barrier. Additionally it goes without saying that if an area has no sand to begin with, then no sand can be moved no matter how much energy is present.

Assumption (6) considers that the shoreline is question can receive waves generated in a 180° arc in an offshore direction. Thus sheltered areas such as exist in the near vicinity of inlets with offshore bars, capes, jetties, or other promotories should not be considered when applying the present data.

The choice of f = .01, Assumption (7), was based on laboratory test results for wave energy dissipation on a sandy bottom, Reference (8). No field data exists (to the knowledge of the author) on which to base the friction factor in areas of a coast with a sandy and rocky bottom. Field data in areas with fine silt and mud bottoms have shown considerably higher friction factors, on the order of f = .04 - .08, Reference (9).

IV. RESULTS AND EXAMPLES

Results of the computations are presented in the form of littoral drift roses. The littoral drift roses can be used to predict littoral drift at locations along the open coastline of Florida where no limitations are imposed by the "idealized" beach assumptions of the program.

In addition to their use for predicting littoral drift, the "roses" have utility in other uses such as numerical modeling of beach fills or in shoreline geomorphologic trends, see References (3) and (4). An example of how to use the littoral drift rose was presented in Reference (3). It is worthwhile to consider more examples of the use of littoral drift roses, with an evaluation of there applicability and use in reinforcing geomorphologic trends.

EXAMPLE ON THE PANHANDLE COAST OF FLORIDA

The first area to be considered is the Panhandle coast of Florida from Cape San Blas, Florida, westward to the Alabama - Florida boarder, and is shown in Figure 2. This stretch of coast fits the idealized beach assumptions contained in the littoral drift roses very well over most of the area. In the nearshore zone the underwater topographic contours are relatively straight and parallel to the coast, and the total 100 odd miles of the shoreline is broken by only four inlets (St. Andrews Bay Entrance, East Pass, Pensacola Harbor entrance, and Perido Pass,) and one bay entrance (St. Joseph Bay). The absence of inlets with the anomalous effects they impose on the normal shoreline trends are lacking in most of this area.

In the vicinity of Perido Pass, (far enough away from the inlet proper as not to be influenced by it), an azmuth of a normal to the shoreline has

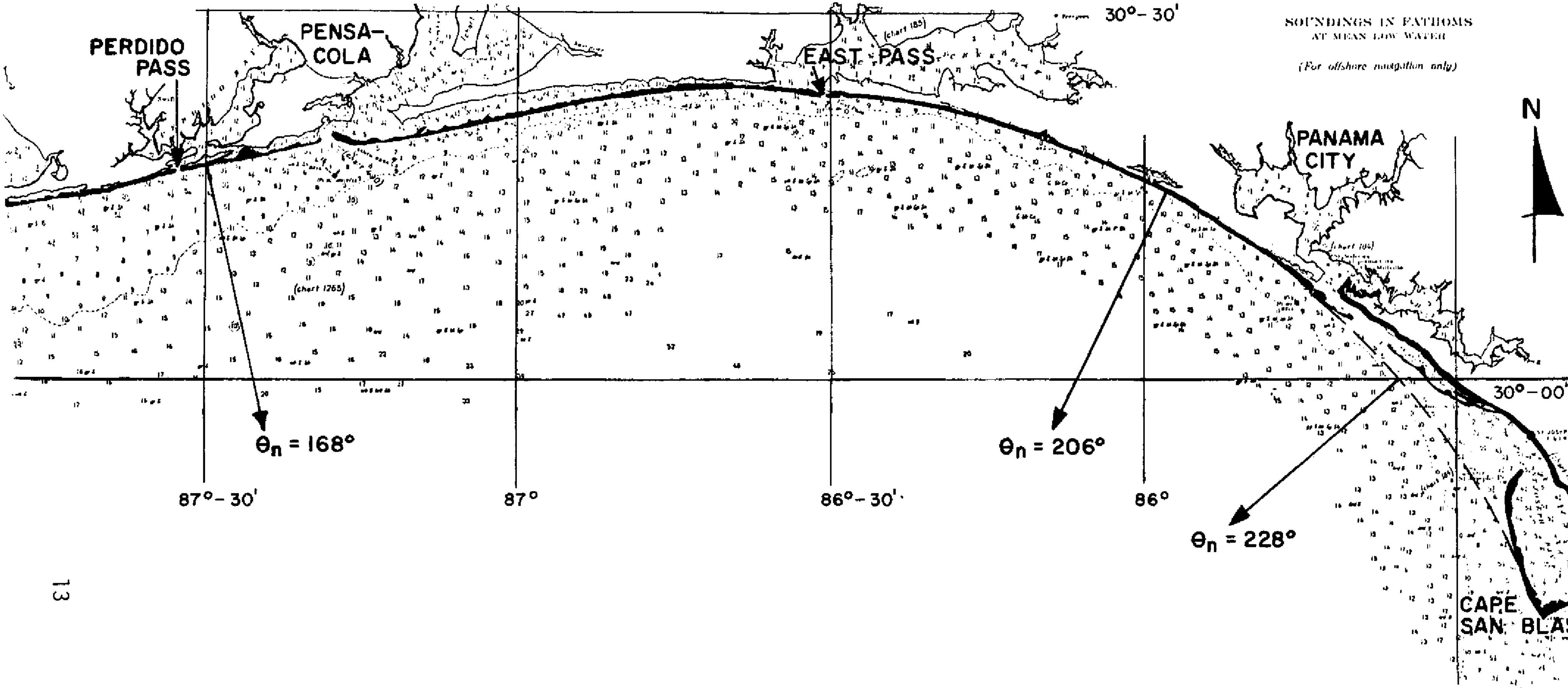


FIGURE 2. PANHANDLE COAST OF FLORIDA

an angle θ_n = 168°, see Figure 2. Figure A-299, Appendix A, is the annually averaged total littoral drift rose for this area. Entering the drift rose with this azmuth angle (i.e. θ_n = 168°, the following littoral drift rates can be obtained):

Annually Averaged Total Positive Littoral Drift (drift to the right when looking offshore - i.e. westward drift) = 1110 cubic yards per day

= 405,150 cubic yards per year (westward)

Annually Averaged Total Negative Littoral Drift (drift to the left when looking offshore - i.e. eastward drift) = 340 cubic yards per day

= 124,000 cubic yards per year (eastward)

Annually Averaged Net Littoral Drift

= total positive drift - total negative drift

= 1110 - 240 = 770 cubic yards per day

= 281,050 cubic yards per year (westward)

An estimate of littoral drift at Perido Pass based on hydrographic surveys of 1934, 1948, and 1953 was presented in Reference (10) and is summarized in Appendix B. The net littoral drift in that study was estimated to be on the order of 200,000 cubic yards per year to the West.

If we accept that this estimate from Reference (10) is correct for this location, then a "calibrated" littoral drift rose can be constructed by scaling the calculated littoral drift rose presented in Figure A-299, Appendix A by a factor equal to 0.71 (i.e. 200,000 / 281,050 = actual drift rate / calculated drift rate). A "calibrated" littoral drift rose for the location (i.e. scaled down) along with the calculated littoral drift rose is presented in Figure 3. The best interpretation of a deviation in the calculated values in littoral drift rate from the true littoral drift rate

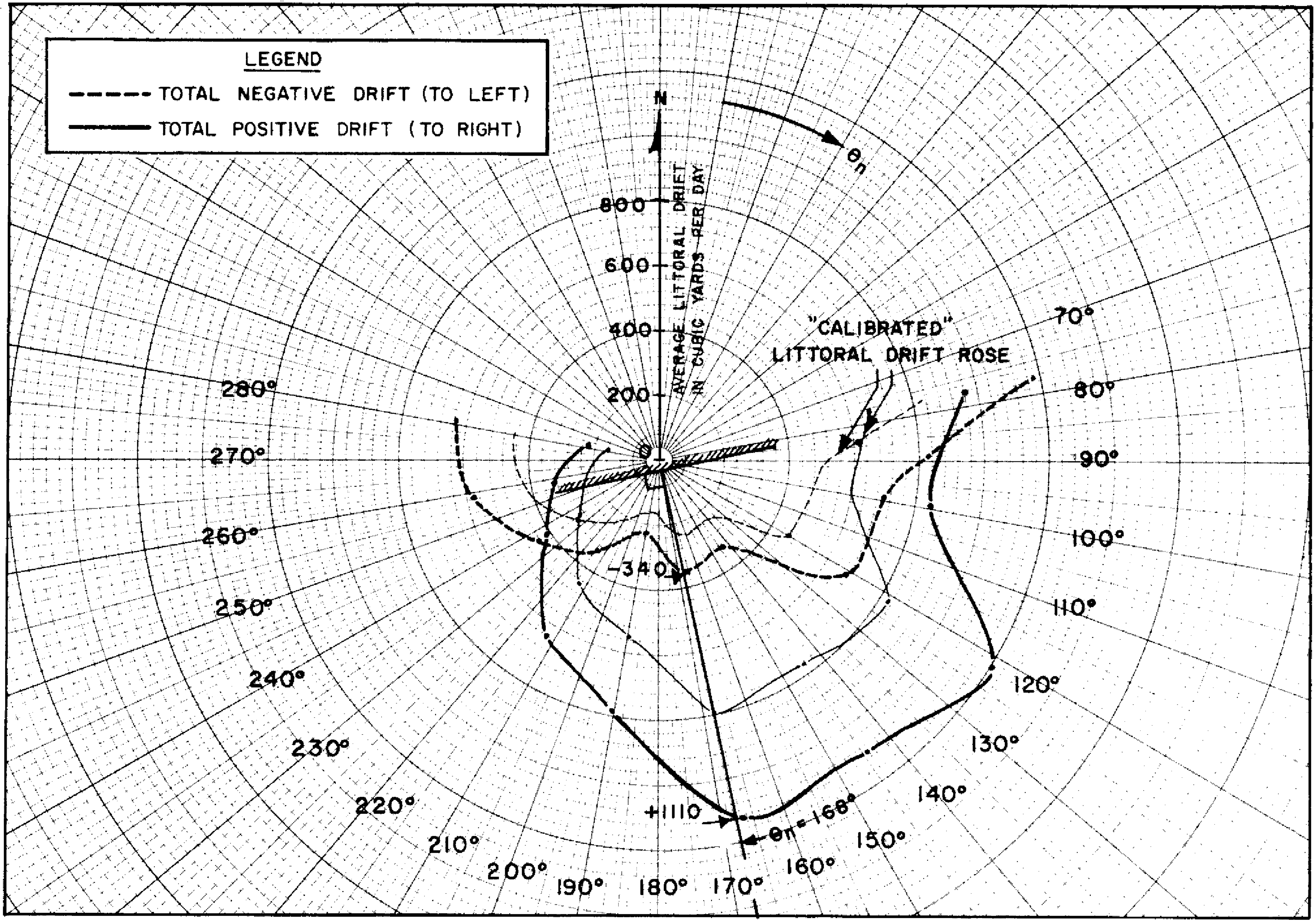


FIGURE 3. ANNUALLY AVERAGED TOTAL LITTORAL DRIFT ROSE AND "CALIBRATED" TOTAL LITTORAL DRIFT ROSE FOR THE COASTAL SECTOR - PERDIDO PASS TO PENSACOLA ENTRANCE CHANNEL, FLORIDA

(in this case true littoral drift rate cannot be stated with certainty but is believed to be close to the value estimated in Reference (10) and summarized in Appendix B) is that: (1) frictional effects of the damping of wave energy have not been totally accounted for in the present computations due to uncertainty in the friction factor used, and (2) uncertainty exists in the longshore energy flux versus littoral drift correlation constant C. Until further research progress is made in obtaining a better knowledge of the friction factor (and wave energy dissipating mechanisms in general), and a better defined correlation coefficient in the longshore energy flux versus littoral drift relationship, the present method of computing littoral drift rates cannot be considered as anything but a gross estimate to the true littoral drift rates. As such, the littoral drift rates presented in this report should be calibrated on reliable available field data where it exists.

Since the estimate of drift provided in Reference (10) and summarized in Appendix B appears to be the only reasonable estimate of littoral drift on this section of coast, all the calculated values of littoral drift for the Panhandle section of Florida (in Appendix A) should be scaled according to a "calibration" factor based on this estimate of drift.

Using the monthly averaged total littoral drift roses, diagrams for the net and total littoral drift on a monthly basis in the vicinity of Perdido Pass are presented in Figures 4 and 5. Values of drift in these diagrams are taken from the monthly drift roses for this section of coast presented in Appendix A and scaled down by the 0.71 "calibration" factor to better approximate what appears to be the true littoral drift in this area.

As can be seen in Figures 4 and 5, the net littoral drift in the vicinity of Perdido Pass is always westward, according to this analysis and data source. During the months of July and August there appears to be almost

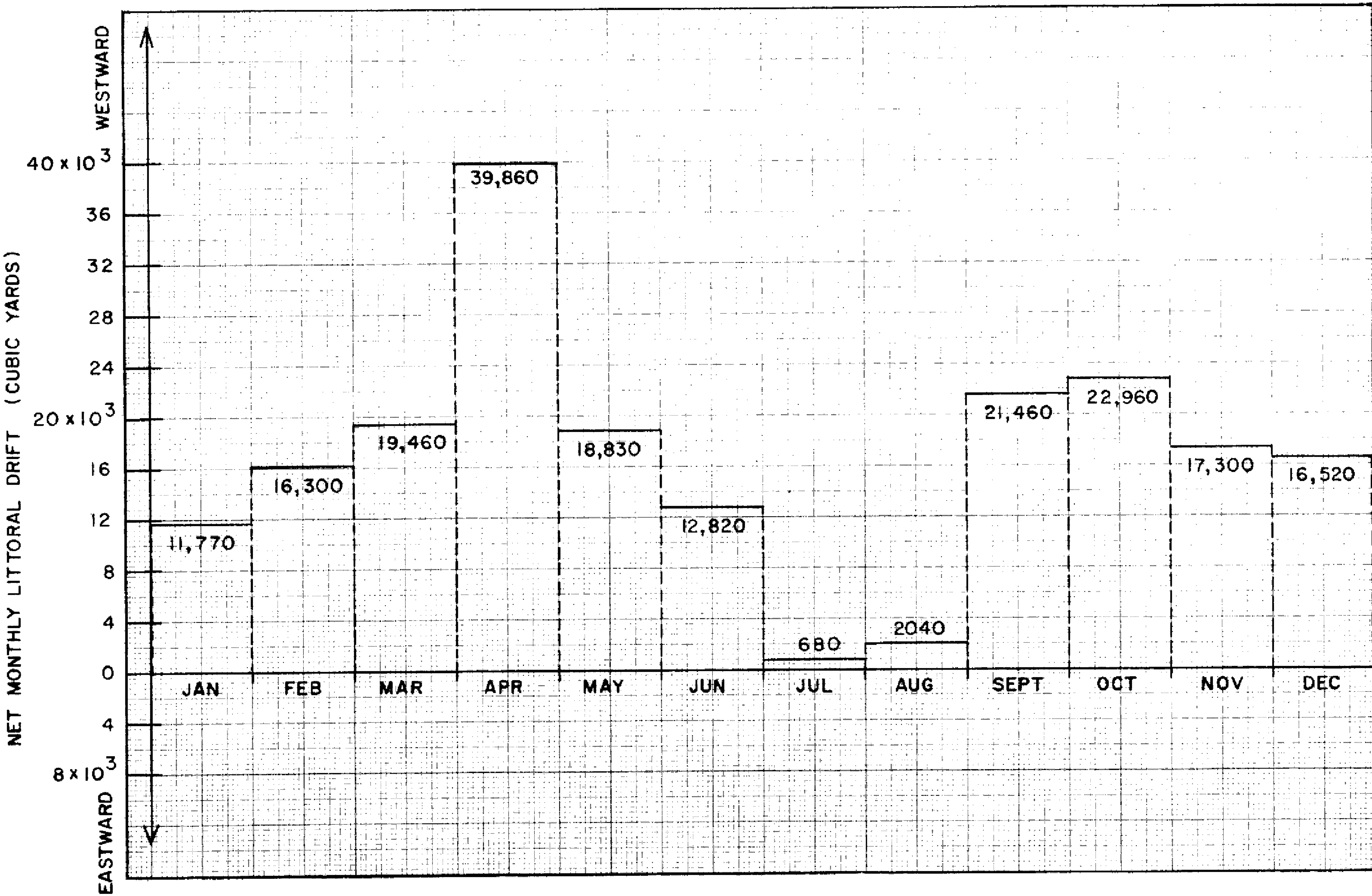


FIGURE 4. NET MONTHLY LITTORAL DRIFT VICINITY PERDIDO PASS AS CALCULATED BY SHIP WAVE OBSERVATION DATA AND "CALIBRATED"

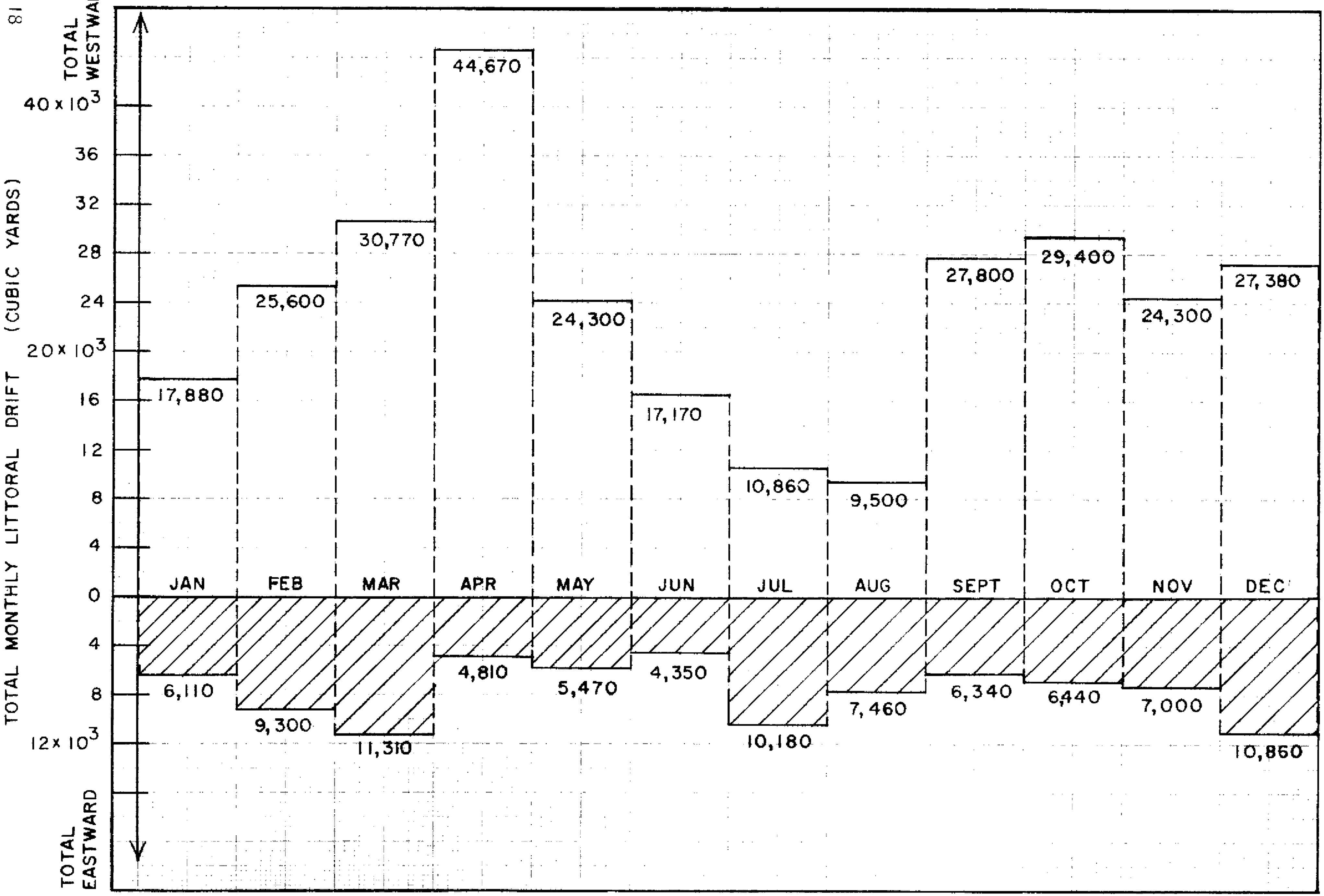


FIGURE 5. TOTAL MONTHLY LITTORAL DRIFT VICINITY PERDIDO PASS AS CALCULATED BY SHIP WAVE OBSERVATION DATA AND "CALIBRATED"

a balanced drift (i.e. no net drift) though.

The total annual littoral drift westward as can be calculated from either the annual drift roses or the monthly drift roses is 289,630* cubic yards per year while the total annual drift eastward is 89,630 cubic yards per year. Therefore, the ratio of westward moving drift to eastward moving drift along this section of coast is on the order of 3 to 1. The gross drift (i.e. the total of both eastward and westward moving drifts which is the potential drift available for the shoaling of a natural inlet in this area) is 289,630 + 89,630 = 379,260 cubic yards per year. The ratio of gross drift to net drift is therefore on the order of 2 to 1.

It appears as though a feeder beach could be located relatively near to the west side of an inlet based on this data since the seasonal movement of sand is always westward. Since the higher values of net westward drift occur in the spring, fall, and winter months though, it is apparent that the feeder beaches could be located closer to the inlet at these times than during the summer months when the net drift is negligable although the total eastward drift appears relatively high.

Having looked at the littoral drift situation at one point it is worthwhile to consider the regional trends of littoral drift implicated by the drift roses in this area.

Heading eastward along the Panhandle Coast we note a strong concavity in the trend of the shoreline as we approach Panama City.

* Editors note: The use of 4 or 5 significant figures in the results of these calculations is not to imply the accuracy of the data to these same figures but rather to prevent confusion to the reader in the magnitudes of drift derived from the roses. As has been noted previously, the values of littoral drift are only gross estimates anyway and thus it would not be unreasonable to round off to the nearest 1000 or 10,000 cubic yards in these values.

Viewing the orientation of the shoreline on the annually averaged littoral drift roses in Figures A 299, A 286, A 273, and A 260 we note that the total westward (positive) and total eastward (negative) drift lines approach each other; that is, the net drift westward gets smaller and smaller as we go eastward, that is, as θ_n gets larger.

Eastward from Panama City the natural concavity of the shoreline is broken by St. Joseph Bay. In past times, perhaps hundreds or thousands of years ago, the St. Joseph spit area may have been connected to the barrier chain east of Panama City although no existing evidence to support this hypothesis (to the best knowledge of the author) exists. Realizing the possibility of this past occurrance though, a smooth concave curve was continued east of the Panama City area to connect with Cape San Blas, and the location of this curve will be considered as an idealized shoreline in this area.

If we continue viewing the littoral drift along this idealized shoreline by means of the annual littoral drift roses for this area we note that eastward of Panama City a null point in the drift occurs east of Panama City at a shoreline orientation of $\theta_n = 228°$. This null point is an "unstable" type null point (see Reference (3)). As noted in Reference (3) this type of null point signifies that the natural movement of beach material would be away from this area. Thus if such an "idealized" shoreline had existed in past time, the natural littoral drift movements in this area would have caused the barrier to break through over long periods of time. The fact that this may have happened lends a certain credibility to the shape of the total littoral drift rose.

In Figure 6 the magnitude and direction of littoral drift along the section of shoreline from Perdido Pass to Cape San Blas has been plotted.

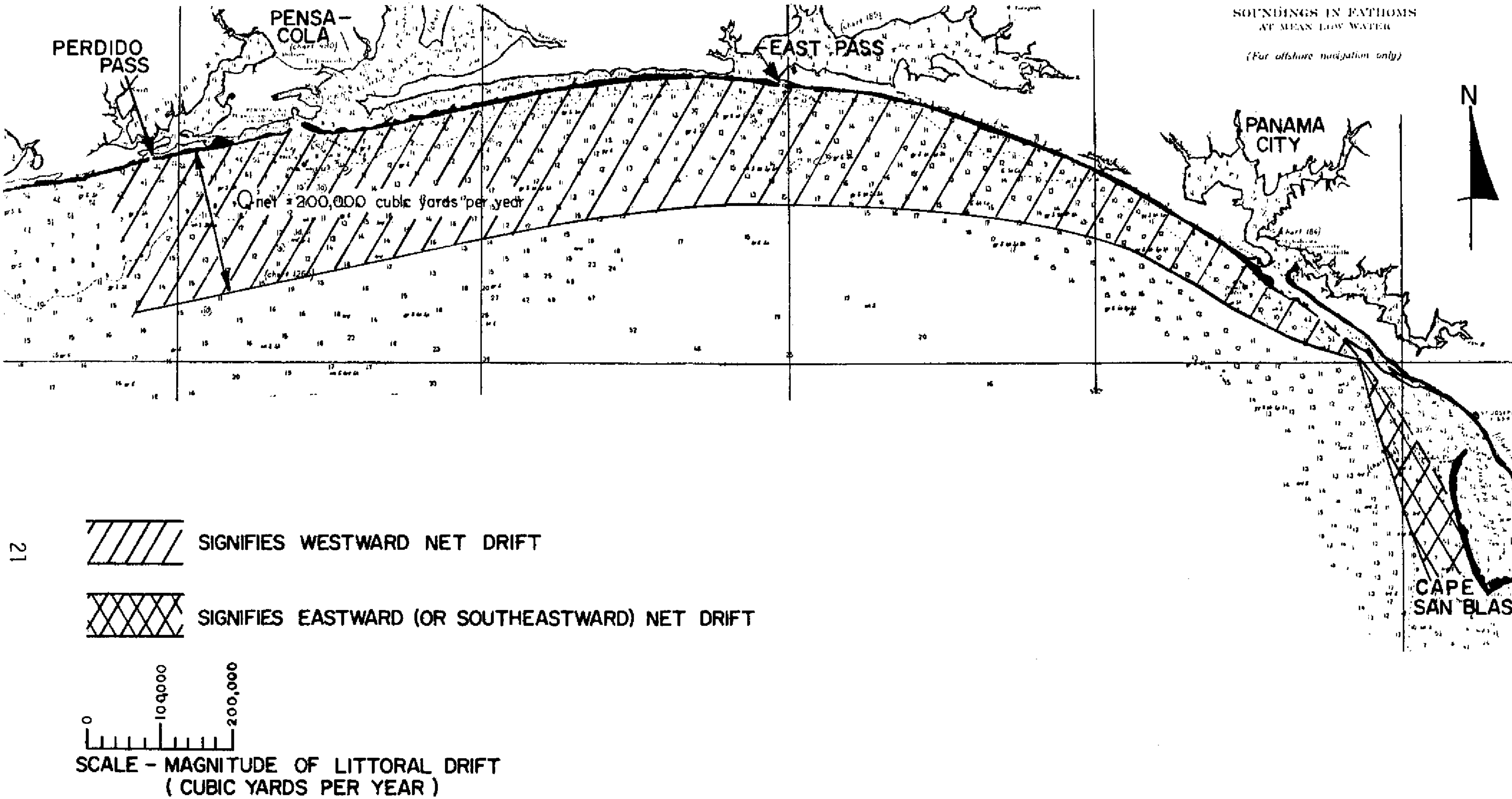


FIGURE 6. VIEW OF NET LITTORAL DRIFT ALONG "IDEALIZED" PANHANDLE COAST

Eastward from Panama City, the net drift has been drawn from the "idealized" beach as shown by the dashed curve.

As noted in this Figure and discussed earlier, the net littoral drift westward decreases in an eastward direction. The rate of change of this drift quantity should, from a theoretical standpoint, equal to the erosion (and be proportional to shoreline recession) experienced along the shoreline in this area.

Mathematically this relationship is expressed by the continuity of sand equation:

$$\frac{\partial Q_{\ell n}}{\partial x} = -k \frac{\partial \eta}{\partial t} \tag{2}$$

where $Q_{\ell n}$ = net littoral drift (cubic yards per year)

x = position along the shoreline parallel to the beach (in feet)

η = horizontal position of shoreline perpendicular to the beach (in feet)

k = a constant; Reference (7) provides a rule of thumb for this constant = 1 cubic yard / foot (i.e. 1 cubic yard of material eroded per foot of beach recession)

The negative sign in the equation implies that a recession of the shoreline is equivalent to an increasing net littoral drift in the direction of net littoral drift.

In the present case it is apparent that an erosion of the present shoreline would be experienced in the area from Panama City to East Pass and that the material eroded from this area should be moving to the west. This analysis of the sand movement appears to be in general agreement with the sand movement hypothesis from a geomorphological standpoint, Reference (11). This area is devoid of barrier islands indicating an area lacking an abundance of sand. Indications exist, Reference (11), that this area has been in recent geologic times a source of sand for areas to the west. The area from East Pass to Perido Pass on the other hand has been in geologically recent time an area of accretion, as interpreted by the existance of Santa Rosa Island, a barrier island normally signifying an abundance of unconsolidated sand material in the offshore profile. In more recent times though Santa Rosa Island appears to be eroding in some sections, and receives less sand from the area eastward of Santa Rosa Island now than in the past. As noted on the littoral drift diagram, Figure 6, Santa Rosa Island is now an area almost in a state of equilibrium, that is, almost as much sand appears to be supplied to the area as is lost from the area. Prior to the existance of the barrier island as noted by the mainland shoreline though, the westward littoral drift would have been smaller in quantity (past θ_n angles greater than present θ_n angles) and hence the area would have provided an environment more suitable for accretion.

Virtually no "hard" data* exists on which to compare the monthly computed littoral drift rates based on ship wave observations to "true" monthly littoral drift rates in the Panhandle. A comparison can be made though of the ship wave observation computed rates with computed littoral drift rates using LEO data. The LEO data source is a source of localized "Littoral Environmental Observations," made by observers at given sites along the coast under the sponsorship of the Coastal Engineering Research Center, U.S. Army Corps of Engineers. The data consists of observations of a great many

* "Hard" data refers to such data as evidenced by surveyed accretion or erosion rates at structures impeding the movement of sand along the shoreline as opposed to "soft" data, which might be theoretically calculated rates of sand movement based on local wave observations at a site.

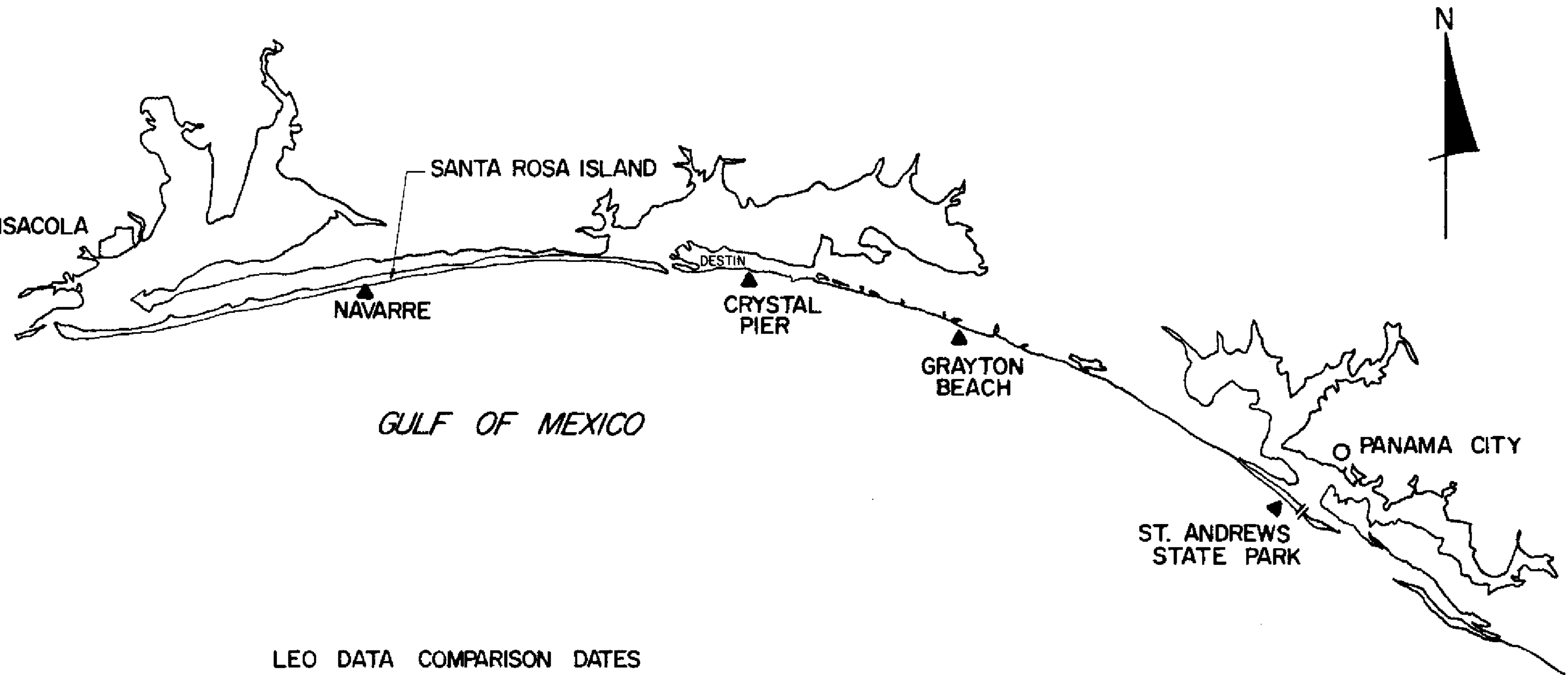
wind, wave, and beach response parameters (i.e. wind direction and magnitude, wave height, wave period, wave direction, longshore current, beach slope) taken with rudimentary tools and recorded on special coding forms. This program is discussed in great detail in Reference (12).

The LEO Data can be used to theoretically calculate monthly littoral drift rates at selected LEO sites along the panhandle. The sites chosen for comparison of the computed littoral drift rose monthly net drift values and the LEO calculated monthly net drift values are shown in Figure 7.

The littoral drift calculations for the LEO data are based on wave height and longshore current velocity observations according to an equation discussed in Appendix C which can be derived using the longshore energy flux versus littoral drift relationship of Reference (5), and the longshore current relationship of Longuet - Higgins, Reference (13).

Both the LEO net monthly littoral drift calculations and the littoral drift rose net monthly littoral drift calculations have been summarized in cumulative net littoral drift diagrams for four sites shown in Figure 7. The cumulative drift plots are shown in Figures 8 thru 11. The annual net drift quantities from both the littoral drift roses have been "calibrated" to a "best estimate" of the true littoral drift at the respective sites. This was done by multiplying the value of net annual drift obtained at Perdido Pass (from Reference (10)) by the ratio of the net annual drift obtained at the site for the orientation of shore considered (from the respective littoral drift rose) to the net annual drift obtained at the site using the shoreline orientation at Perdido Pass. In equation form this "best estimate" of net annual littoral drift is:

$$\text{Value of littoral drift at a given site} = \underset{\text{(Value at Perdido Pass)}}{200{,}000 \text{ cubic yards per year}} \times \frac{Q_\ell \text{net } (\theta_n = \text{Value at site})}{Q_\ell \text{net } (\theta_n = 168°)}$$



LEO DATA COMPARISON DATES

SITE	DATA DATES	NO. OF OBSERVATIONS
NAVARRE	OCT. 1969 - AUG. 1970	300
CRYSTAL PIER	SEPT. 1969 - AUG. 1970	344
ST. ANDREWS STATE PARK	SEPT. 1969 - AUG. 1970	341
GRAYTON BEACH	SEPT. 1969 - AUG. 1970	360

FIGURE 7. LEO COMPARISON SITES IN PANHANDLE

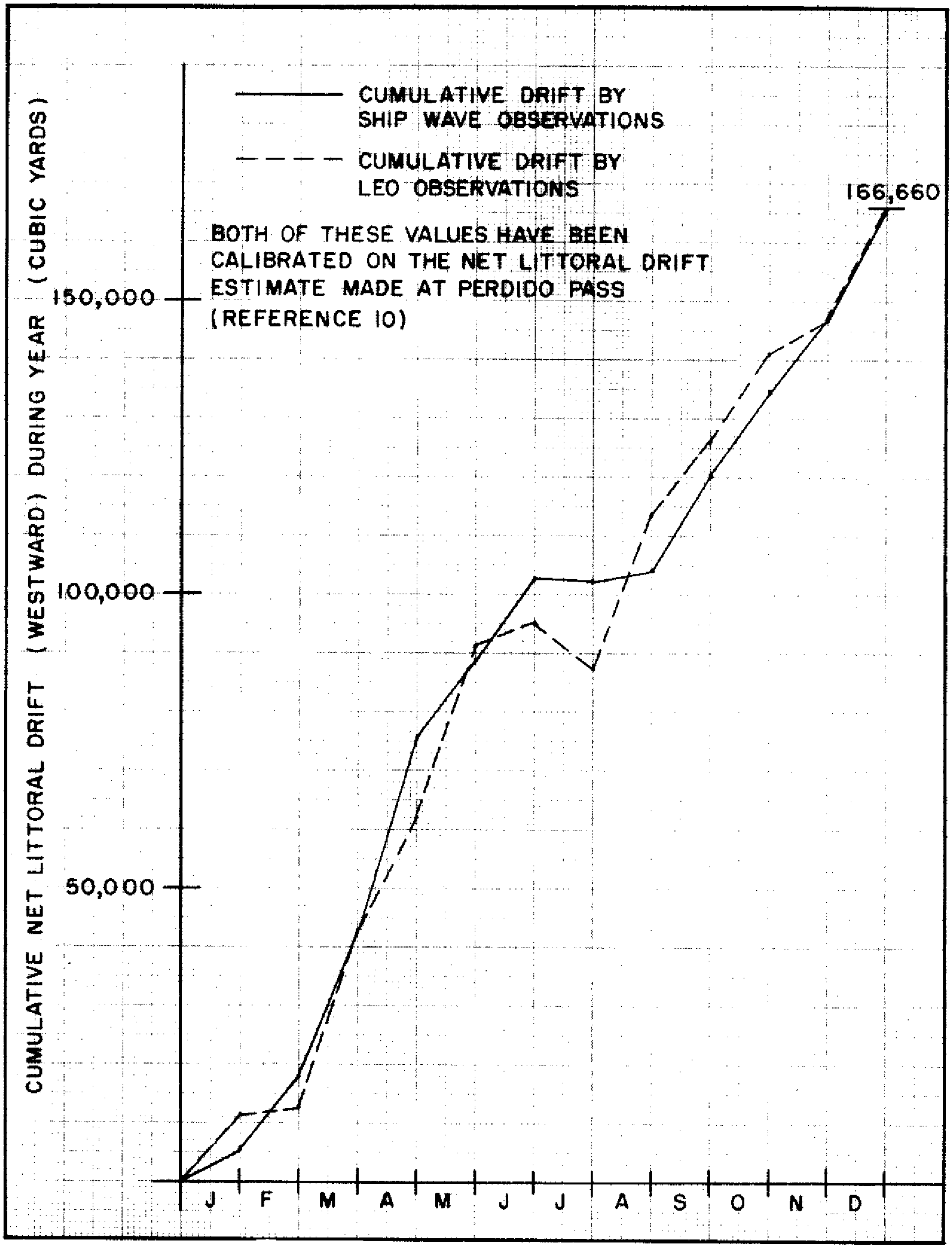


FIGURE 8. CUMULATIVE NET LITTORAL DRIFT AT CRYSTAL PIER BY SHIP WAVE DATA AND BY LEO DATA

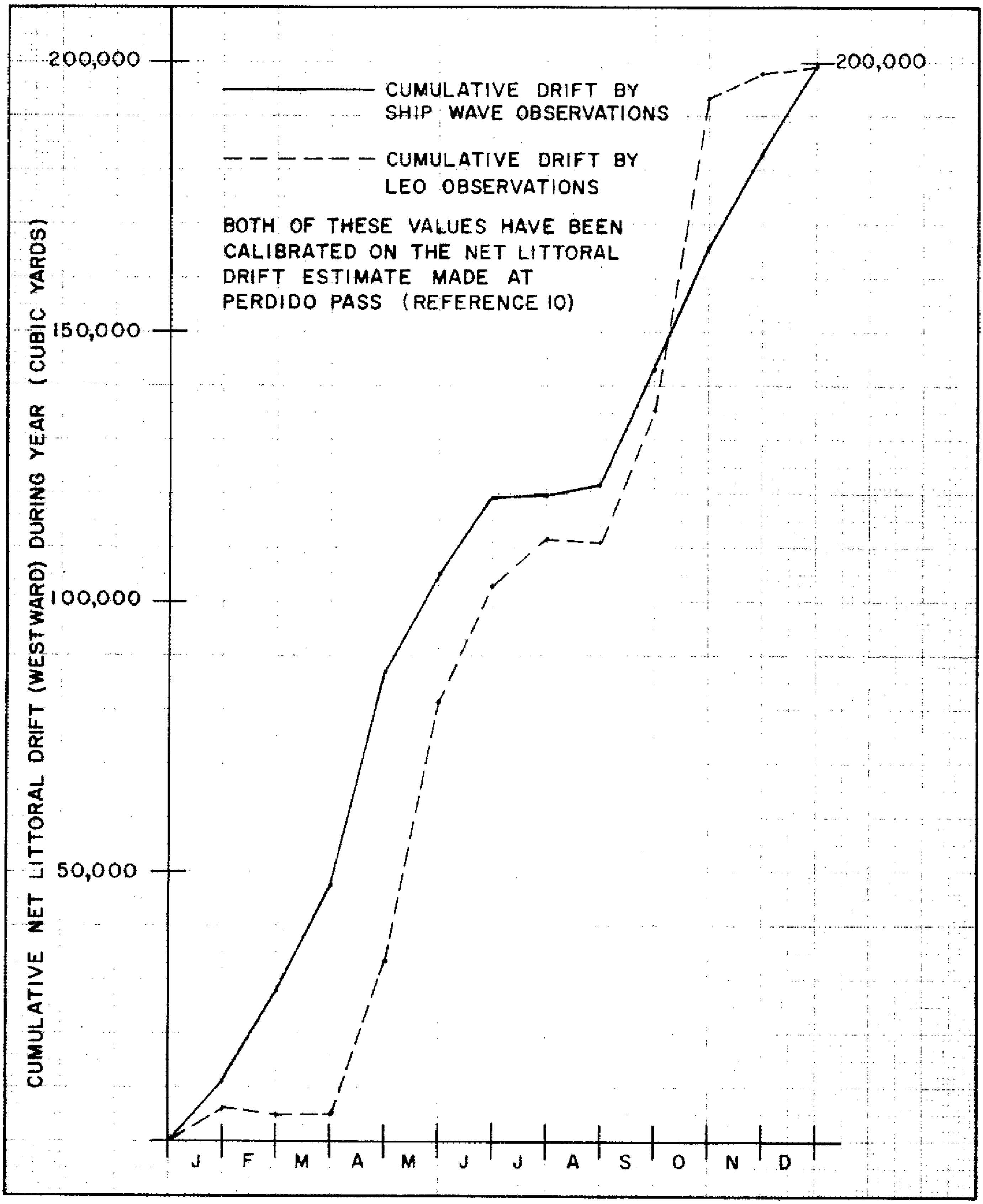


FIGURE 9. CUMULATIVE NET LITTORAL DRIFT AT NAVARRE BY SHIP WAVE DATA AND BY LEO DATA

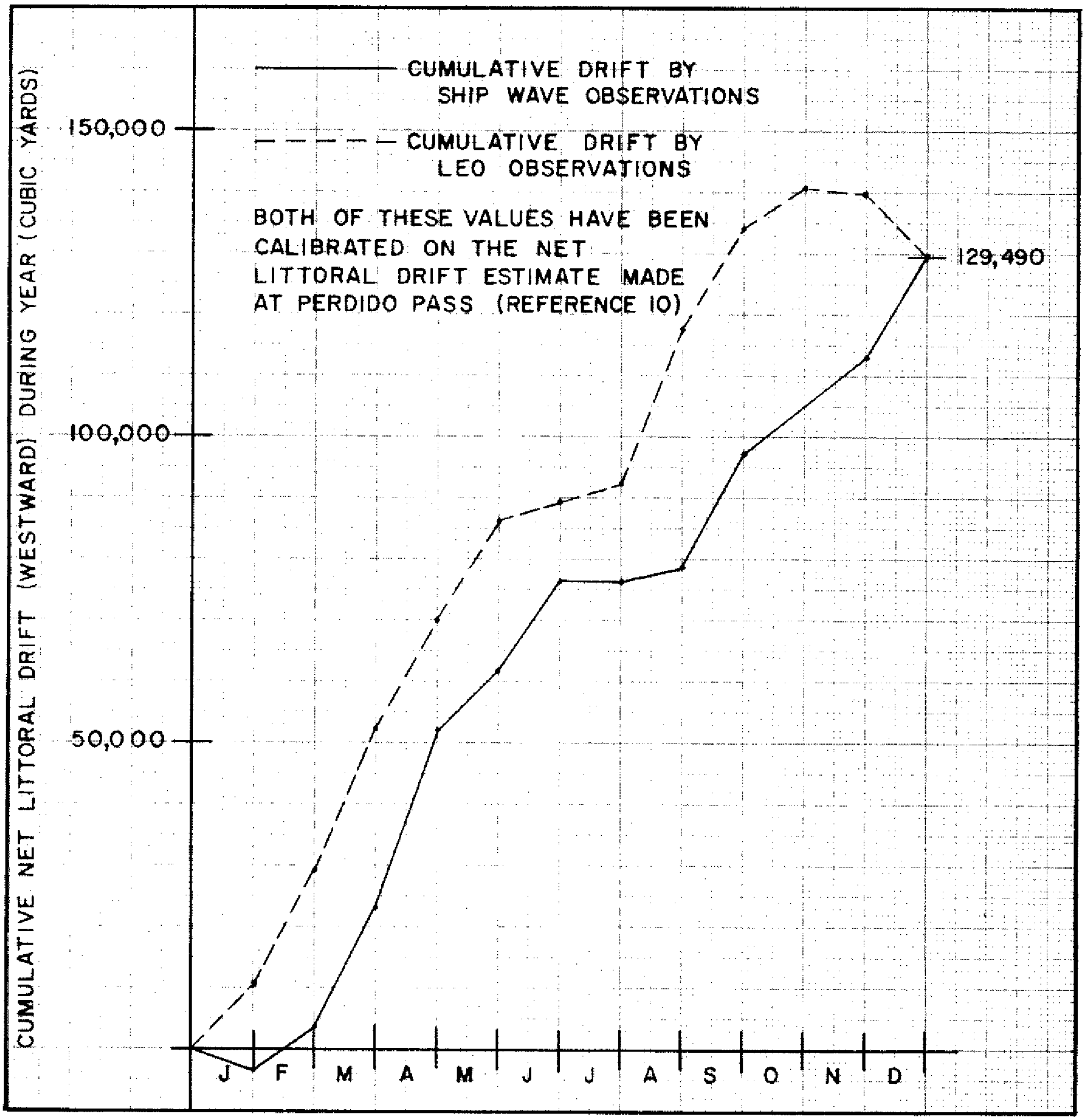


FIGURE 10. CUMULATIVE NET LITTORAL DRIFT AT GRAYTON BEACH BY SHIP WAVE DATA AND BY LEO DATA

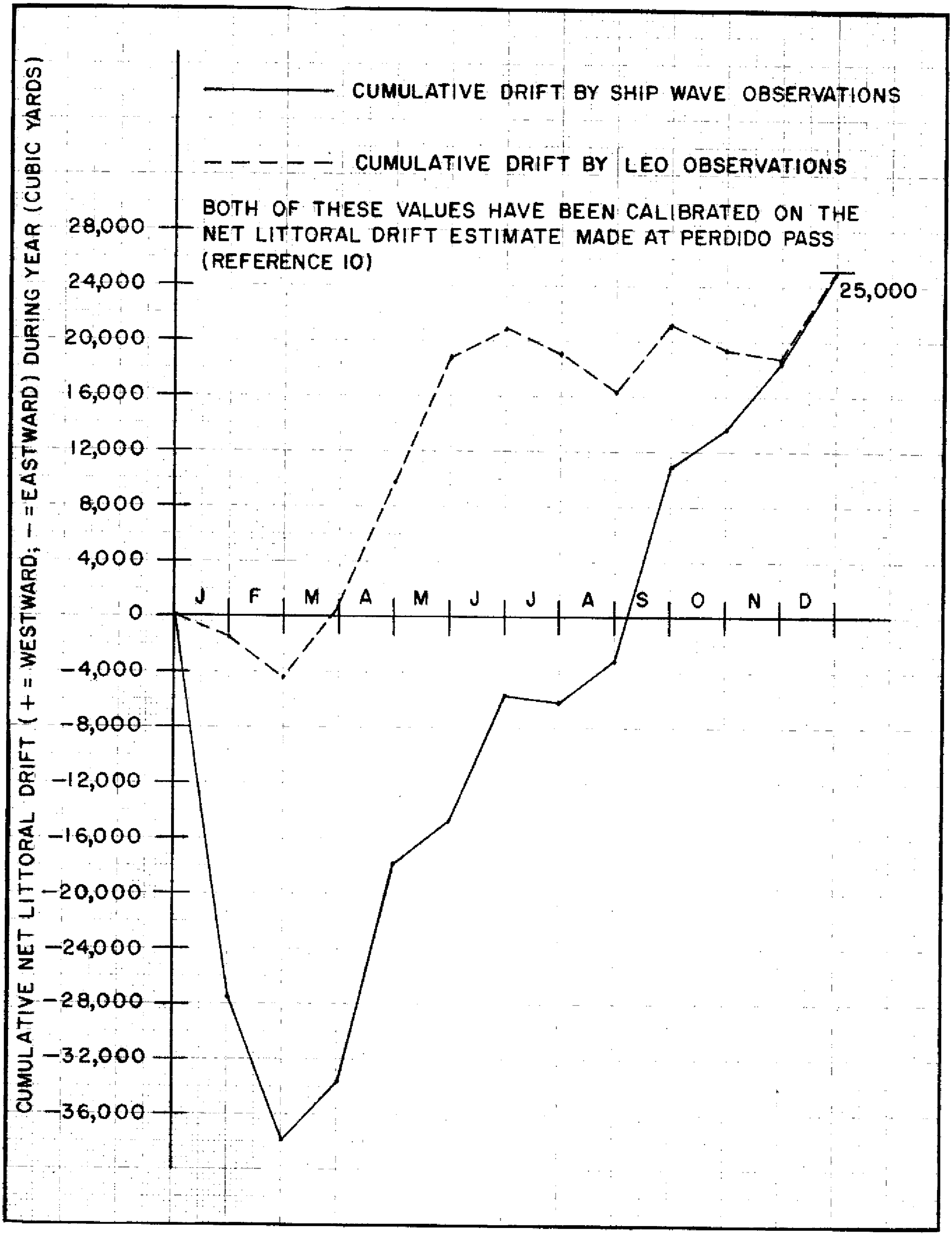


FIGURE 11. CUMULATIVE NET LITTORAL DRIFT AT ST. ANDREWS PARK PIER BY SHIP WAVE DATA AND BY LEO DATA

The monthly LEO data were then "calibrated" by constraining the annual value of littoral drift given by the LEO data to equal the "calibrated" annual littoral drift rose value.

The purpose of using the cumulative net littoral drift plots as opposed to a month by month comparison is to show if the seasonal variability of littoral drift is approximately the same by both methods as expressed by slopes in these plots. This cumulative net drift would be of importance if an obstruction to littoral drift such as a jetty or groin were constructed at the given site. Such a diagram can be used to predict the impoundment rate at the structure at a given time.

Monthly drift rates appear as the slope in these cumulative plots, thus where the slopes of the plots are equal, the monthly "calibrated" drift rates given by the two methods would also be equal. As can be seen from Figures 8 thru 11, the data comparison at Crystal Pier gives reasonable agreement throughout the year and the data comparison at Navarre and Grayton Beaches is reasonable for April thru September in light of assumptions necessary in littoral drift calculations of this type. The remainder of the months for Navarre and Grayton Beach, and the comparison at St. Andrews State Park is somewhat poor. In fact, at St. Andrews Park net eastward drifts are predicted (negative slopes) by the LEO data during many months when the ship wave data predicts rather large quantities of westward drift (i.e. August, October, November).

The poor comparison at St. Andrews State Park may be due to a violation of the assumption of Snell's Law of Refraction in the littoral drift rose calculations, due to the proximity of Cape San Blas. The situation shown by the littoral drift rose calculations could possibly represent a closer approximation to the actual drift situation along the beach in the surrounding area though since St. Andrews Beach State Park LEO observations were within 1/2 to 2/3 of a mile from the St. Andrews Bay entrance, and thus may be influenced by both tidal current and wave sheltering effects of the inlet. As to which plot of cumulative littoral drift is better is not known at this time.

An important point to note in these comparisons is that since the calculations were "calibrated" on the assumed net annual drift, the cumulative total eastward and cumulative total westward drift rates are not necessarily equal. In fact at St. Andrews State Park, the gross drift (total East and total West) as predicted by the "calibrated" littoral drift rose calculations is over two times the gross annual drift from the "calibrated" LEO observations.

It is worthwhile to mention that observations by Bruno, Reference (14) noted that often longshore current observations are in a direct contradiction to that which would be expected by the direction obtained from breaking waves. As noted in that Reference, this may be due to the influence of winds or irregular nearshore bathemetry.

In view of the present lack of knowledge of the littoral drift movement along the panhandle, it is felt that the present littoral drift roses should provide conservative estimates of the littoral drift movement in that region, for design purposes. These roses can be further refined by "calibrating" them in a manner as shown previously. As "hard" data becomes available, the drift roses can be "recalibrated" to give better estimates of littoral drift on a seasonal basis.

EXAMPLE ON THE LOWER EAST COAST OF FLORIDA

A second comparison of the results of present calculations can be made on the lower East Coast of Florida at Palm Beach Inlet (also referred to as North Lake Worth Inlet) and Boynton Inlet (also referred to as South

Lake Worth Inlet). Sand pumping plants are in operation on the North sides of both of these inlets. The Palm Beach Inlet Plant has been in operation since 1958 and the Boynton Inlet Plant since 1937. A history of those inlets and a brief description of the plants is contained in References (15), (16), and (17). In the latter part of 1967 a new plant at Boynton Inlet was constructed and placed into operation. Records of the pumping rates at this plant after construction of the new plant are thought to be most indicative of the true sand movement at this inlet.

A cumulative net littoral drift curve has been constructed from the monthly littoral drift roses for each of the plants, Figures 12 and 13, with the cumulative pumping rates of the plants superimposed. The actual net littoral drift quantities from the littoral drift roses have been "adjusted" such that the cumulative amounts of littoral drift in the pumping periods shown are equal to the total amounts of sand bypassed by the plant. This is necessary because, as noted in Reference (15), the plants are only bypassing a portion of the littoral drift which moves to the inlet. The rest of the sand moved Southward to each of the inlets appears to be either naturally bypassed by the inlet or trapped in the inner or outer shoals. The true net littoral drift at Palm Beach Inlet has been estimated in Reference (16), to be on the order of 200,000 cubic yards per year as determined by accretion rates at the North jetty of the inlet surveyed over a 14 year interval after original construction of the jetty. A summary of this littoral drift estimate is presented in Appendix B. The net littoral drift rate at Boynton Inlet should be approximately the same as at Palm Beach since the orientation of the shoreline into the wave climate is basically the same at both inlets and the same wave climate prevails at both inlets.

Based on 200,000 cubic yards of material moved Southward annually (the estimated net littoral drift rate), the ratio of material bypassed by the in-

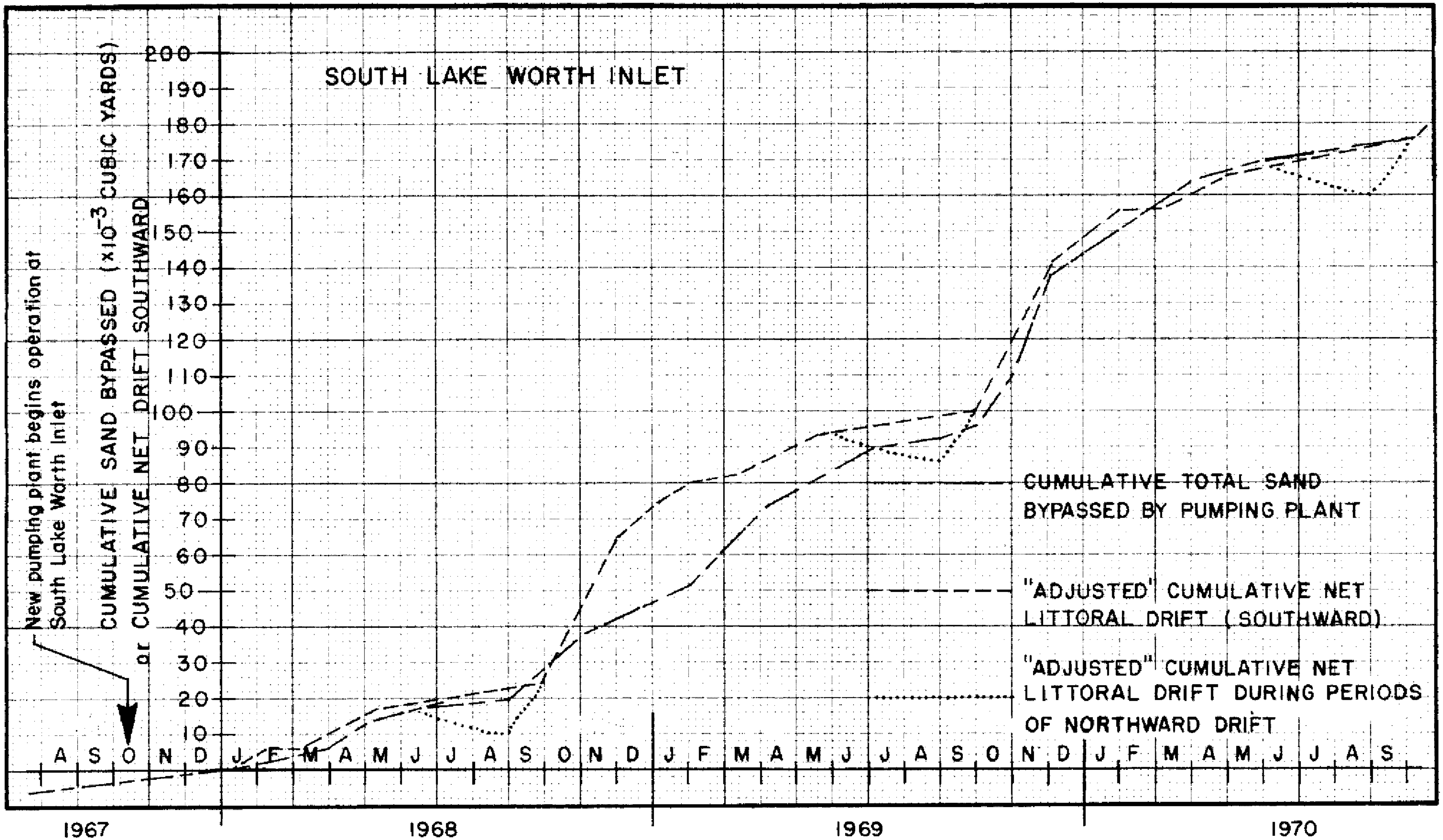


FIGURE 12. COMPARISON OF CUMULATIVE SAND BYPASSED AT SOUTH LAKE WORTH INLET AND "ADJUSTED" CUMULATIVE NET SOUTHWARD DRIFT

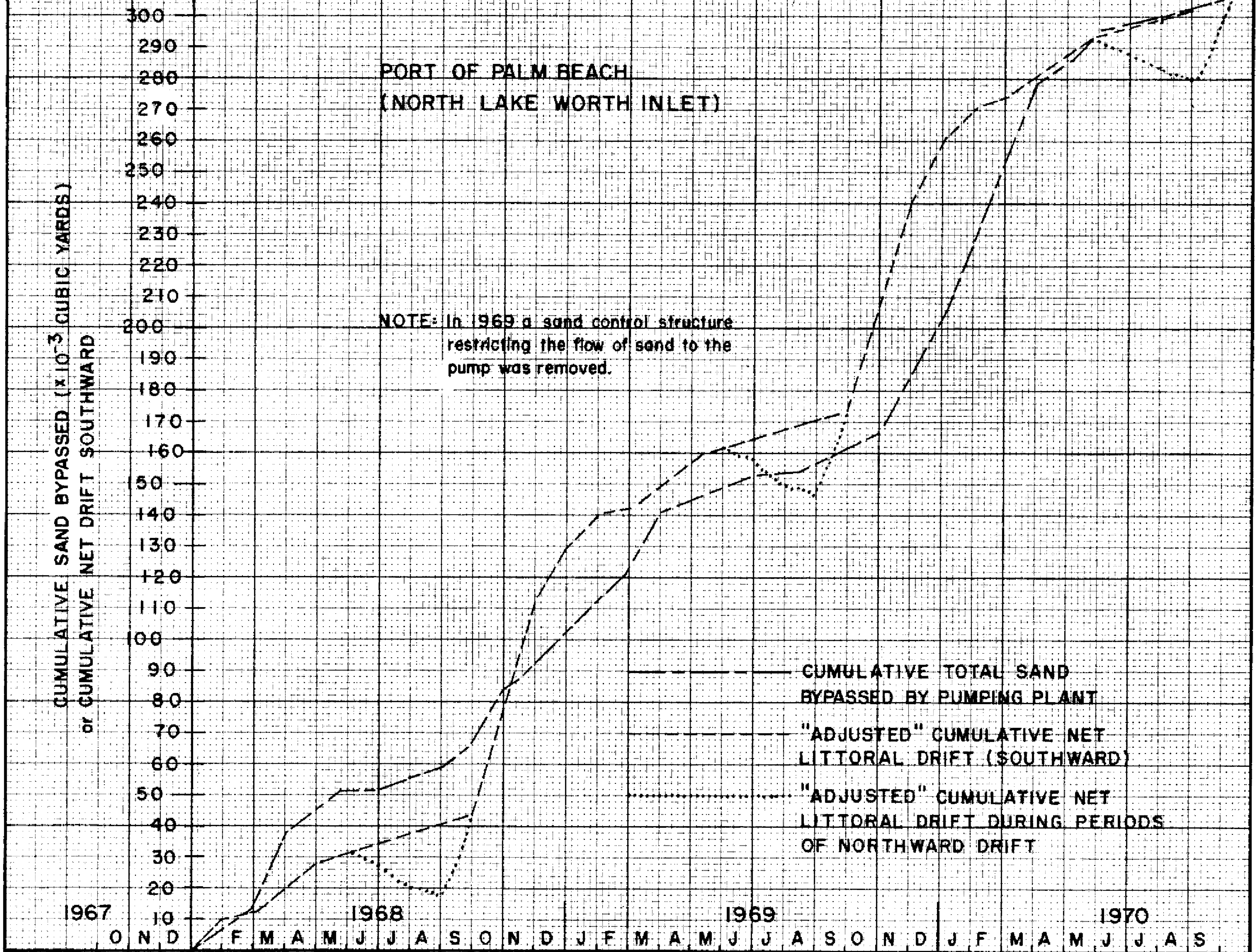


FIGURE 13. COMPARISON OF CUMULATIVE SAND BYPASSED AT PALM BEACH INLET AND "ADJUSTED" CUMULATIVE NET SOUTHWARD DRIFT

lets to the net amount of material moving Southward appears to be 0.65 and 0.37 respectively for Palm Beach Inlet and South Lake Worth Inlet.

Both Figure 12 and 13 with "calibrated" monthly values of net littoral drift show a reasonable comparison of the seasonal southward movement of sand at the inlets.

It appears from this comparison that the seasonally predicted movement of sand in this area is a reasonable facsimile of what actually happens and thus, the monthly littoral drift roses should therefore provide reasonable values for design purpose when "calibrated" on good estimates of the true littoral drift in a given area.

V. SUMMARY

A method has been presented, whereby littoral drift estimates can be made on a monthly basis and results have been summarized in the form of littoral drift roses by means of which a user can compute the total, gross, or net littoral drift on a monthly averaged basis along the sandy portions of Florida's shoreline.

The methodology used to compute the littoral drift roses involves a number of assumptions, the most important of which are:
(1) an "idealized" shoreline with parallel straight offshore contours and no sheltering effects or anomalous effects (such as due to tidal inlets) present, (2) the littoral drift is a linear function of the longshore energy flux at the breaking zone; the constant used for the present computations relating the longhsore energy flux to the littoral drift is C = 125.

When using the littoral drift roses, Assumption (1) physically means that Snell's Law of Refraction is valid and also that wave action rather than tidal current is the responsible agent for the sand movement. If either of these criteria are not suspected to hold at least reasonably well for the area under consideration, then the drift rose data should not be used.

Assumption (2) notes the inclusion in the present computations of a constant that still remains relatively unknown. Therefore, it would be best to "calibrate" the littoral drift rose values based on good estimated values of littoral drift taken from surveyed accretion or erosion rates at littoral barriers (i.e. jetties, long groins), when such estimates exist. An example of one such calibration was given for the Perdido Pass area. Where the roses cannot be calculated due to a lack of "hard" data on the true drift, the roses should provide a conservative estimate of littoral drift for that area.

The littoral drift roses in addition to providing estimates of the drift quantities at a given site, can provide an interpretation of geomorphologic trends in shoreline pattern (i.e. areas of accretion or erosion) over a given area when combined with the continuity equation.

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APPENDICES

APPENDIX A

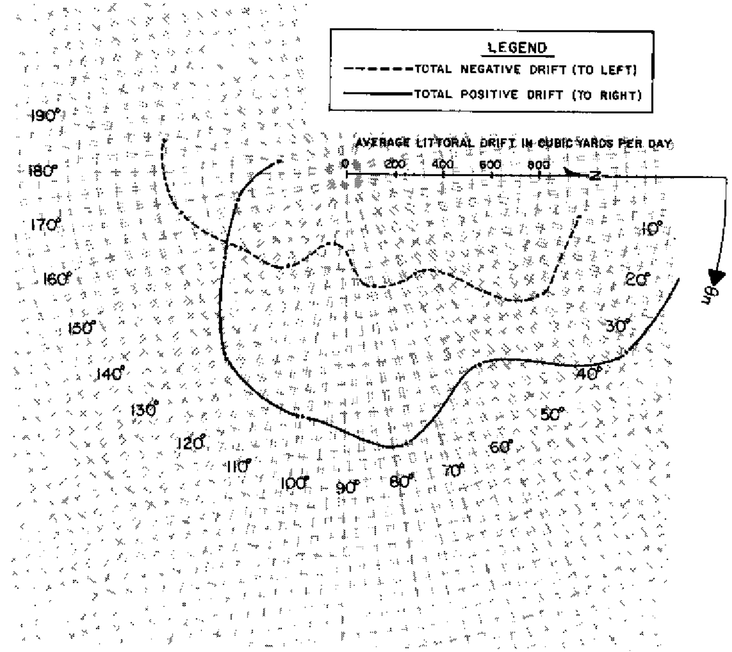


FIGURE A-1 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - JANUARY

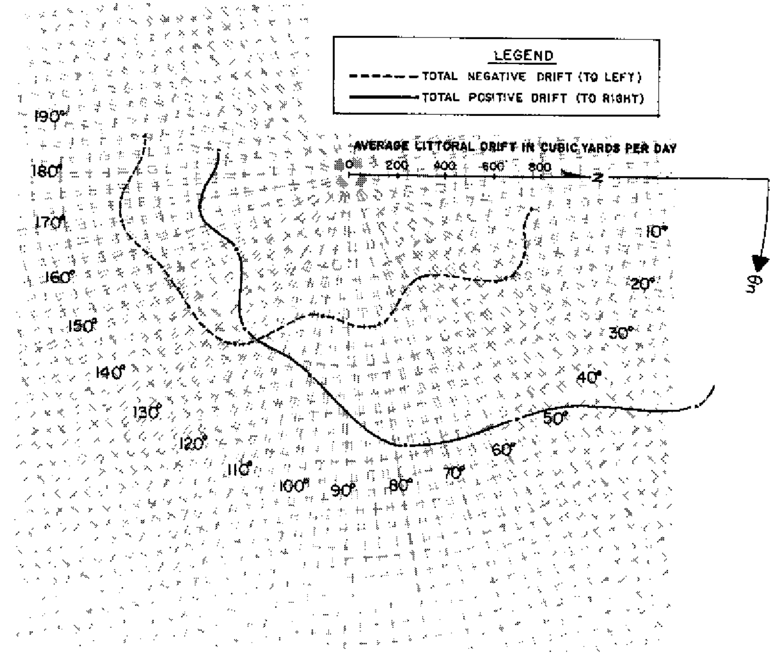


FIGURE A-2 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - FEBRUARY

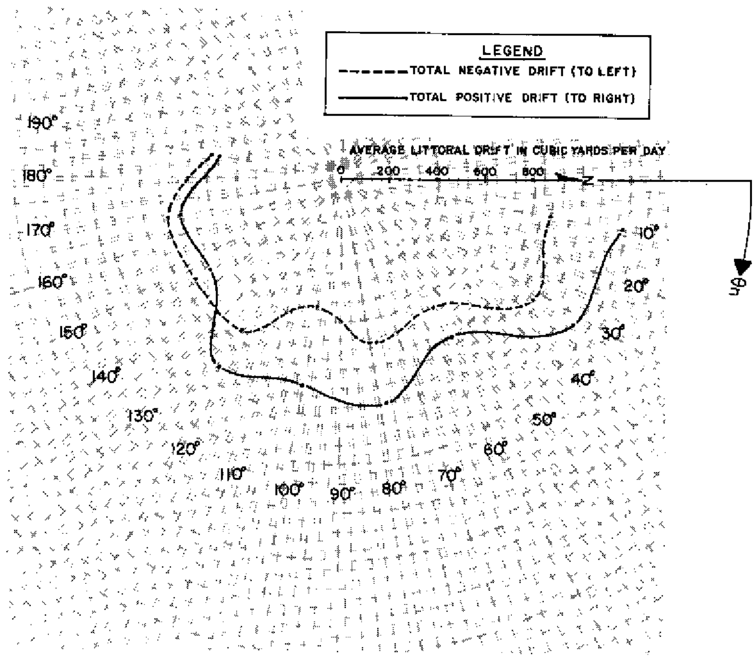


FIGURE A-3 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - MARCH

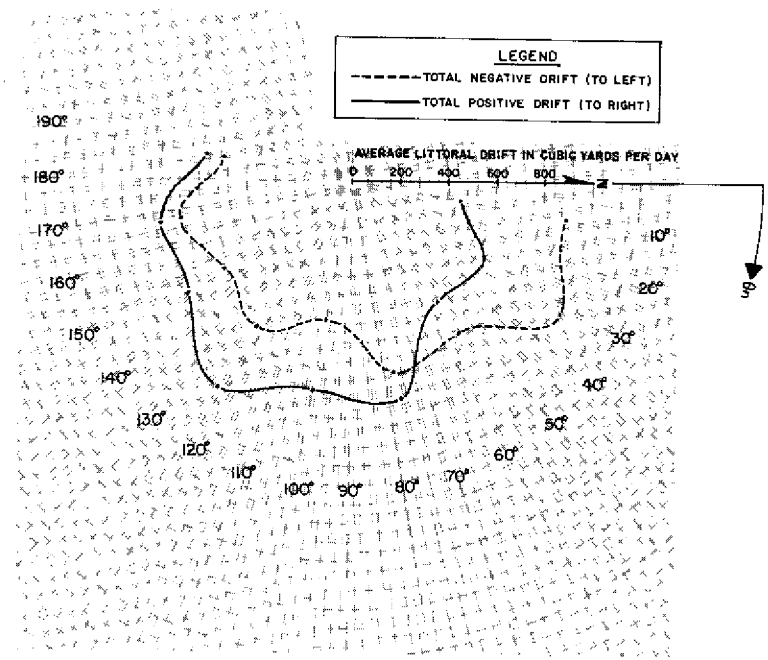


FIGURE A-4 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - APRIL

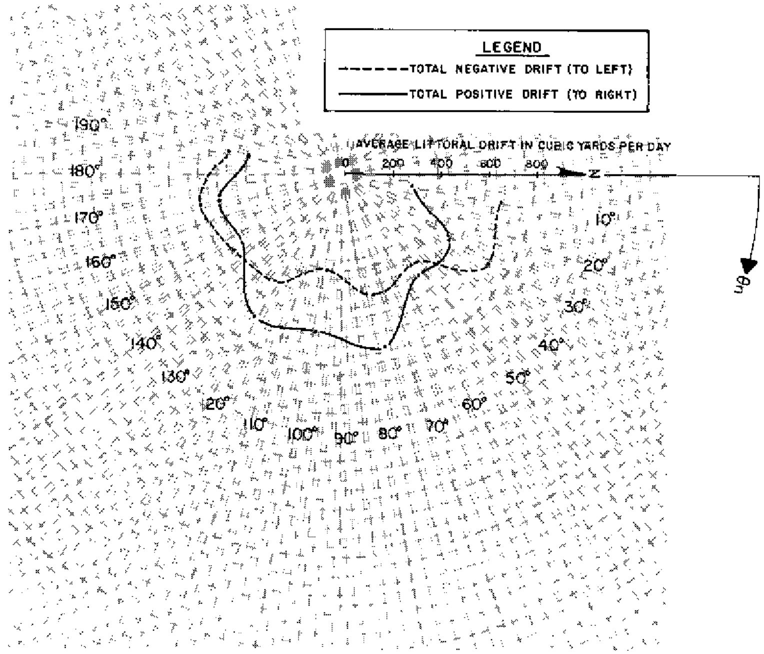


FIGURE A-5 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - MAY

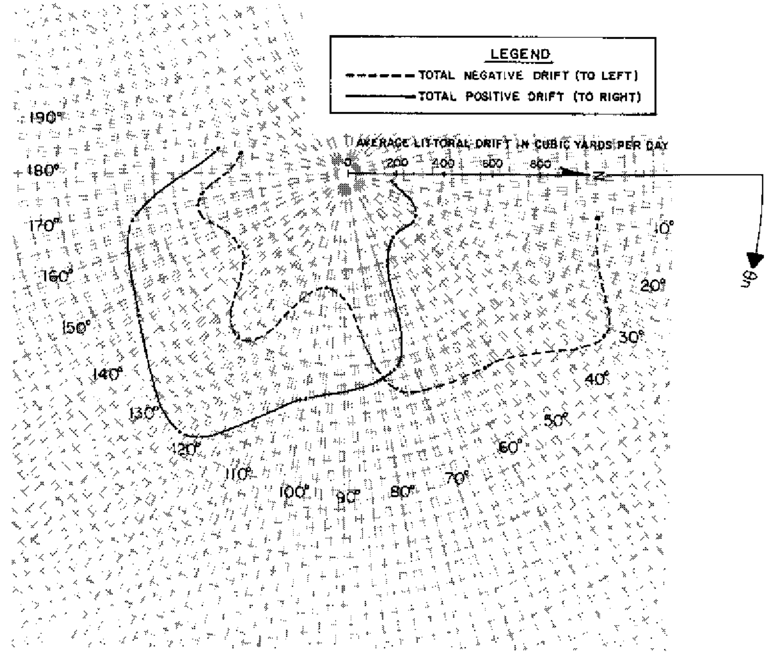


FIGURE A-6 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - JUNE

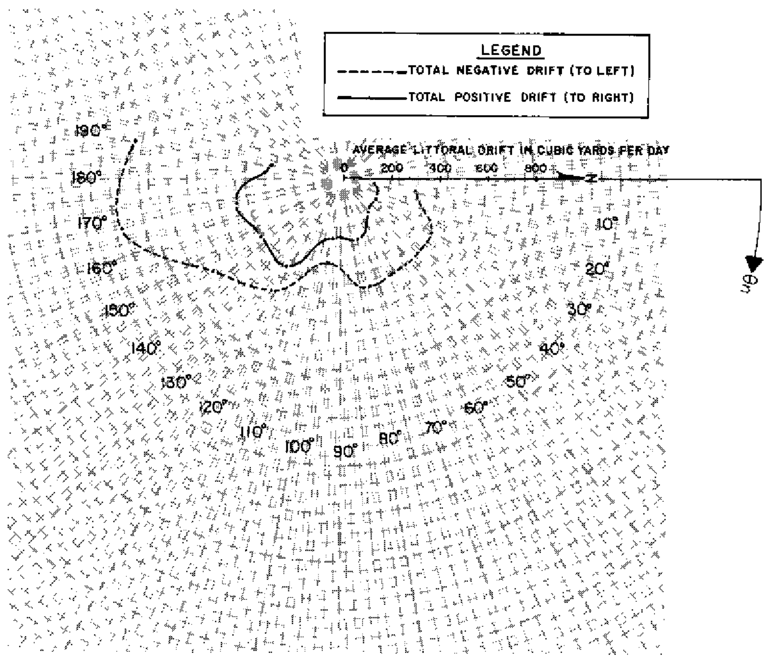


FIGURE A-7 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - JULY

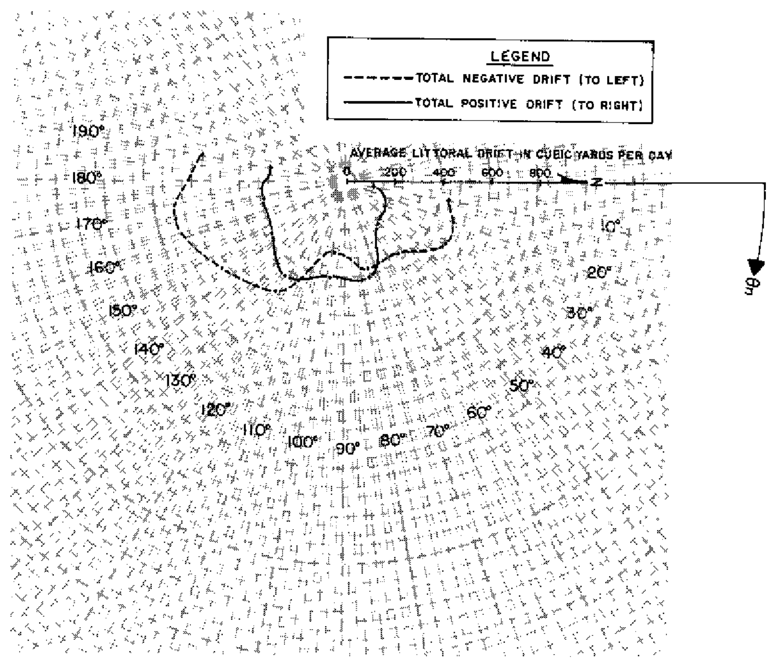


FIGURE A-8 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - AUGUST

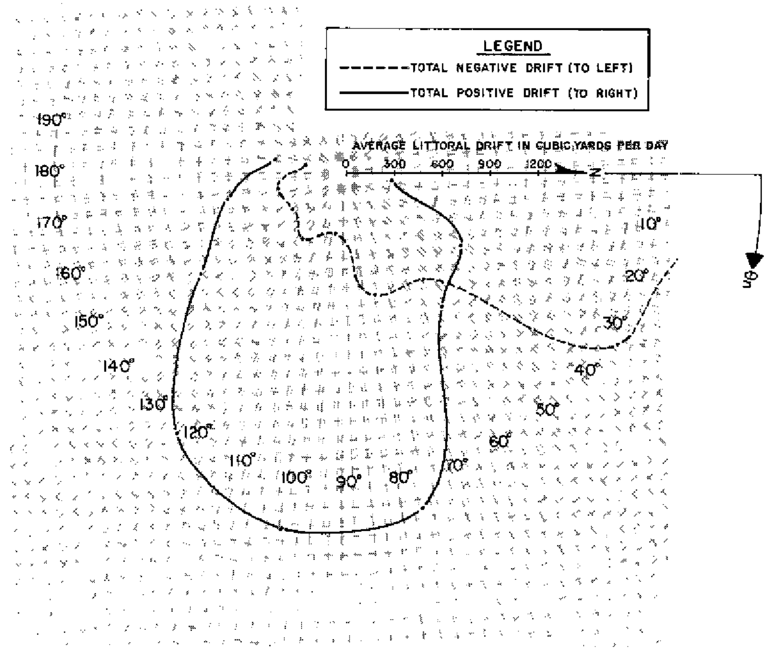


FIGURE A-9 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - SEPTEMBER

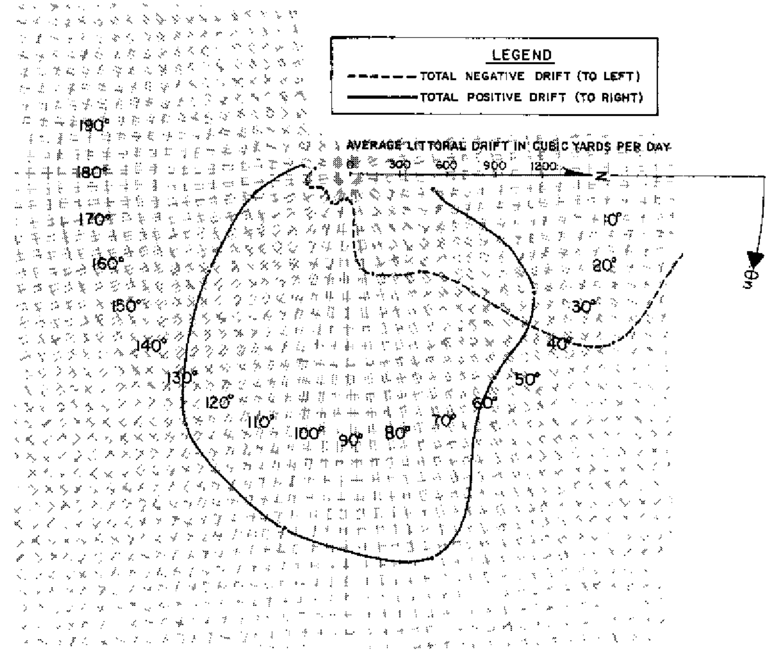


FIGURE A-10 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - OCTOBER

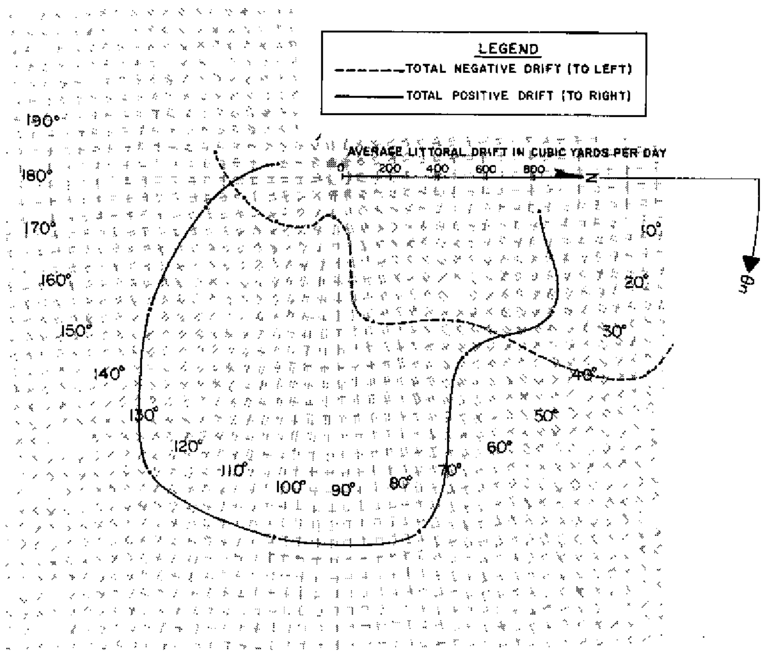


FIGURE A-11 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - NOVE ER

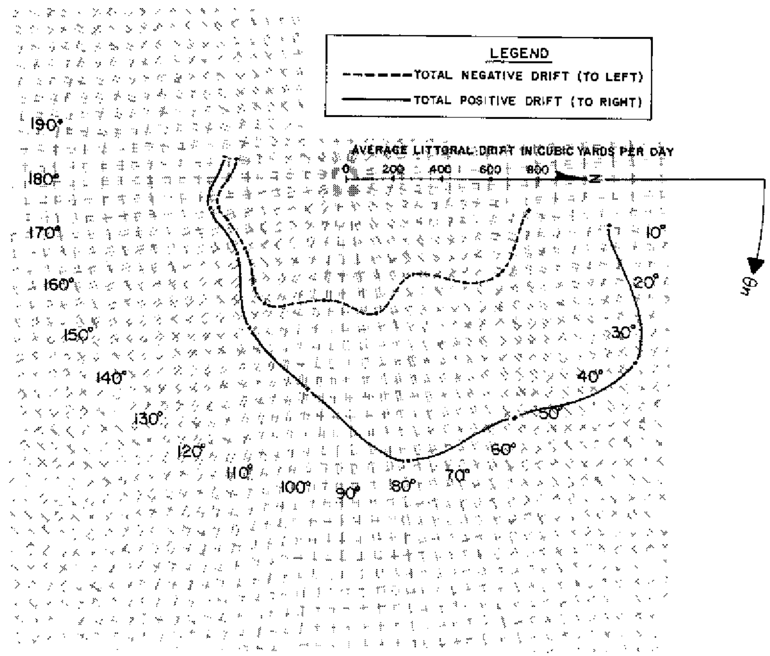


FIGURE A-12 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA - DECEMBER

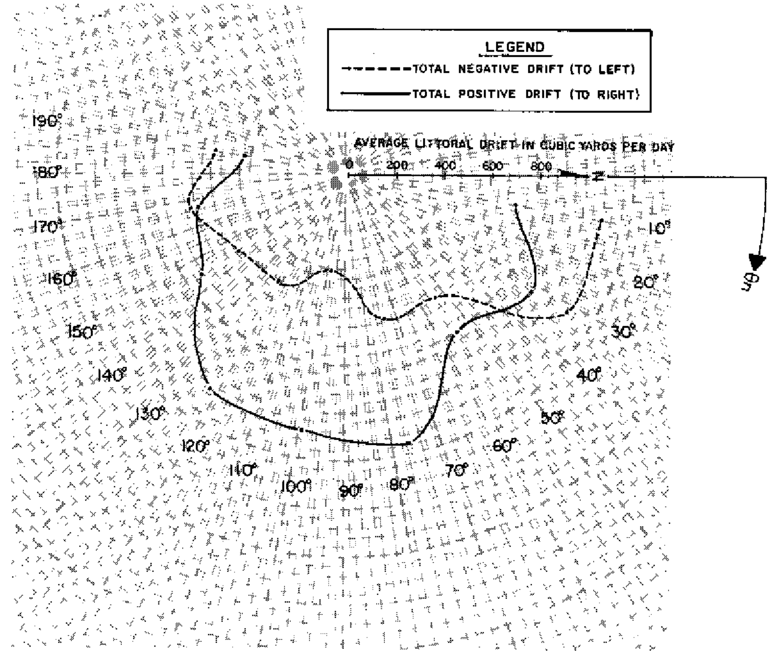


FIGURE A-13 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FERNANDINA BEACH TO ST. JOHNS RIVER, FLORIDA

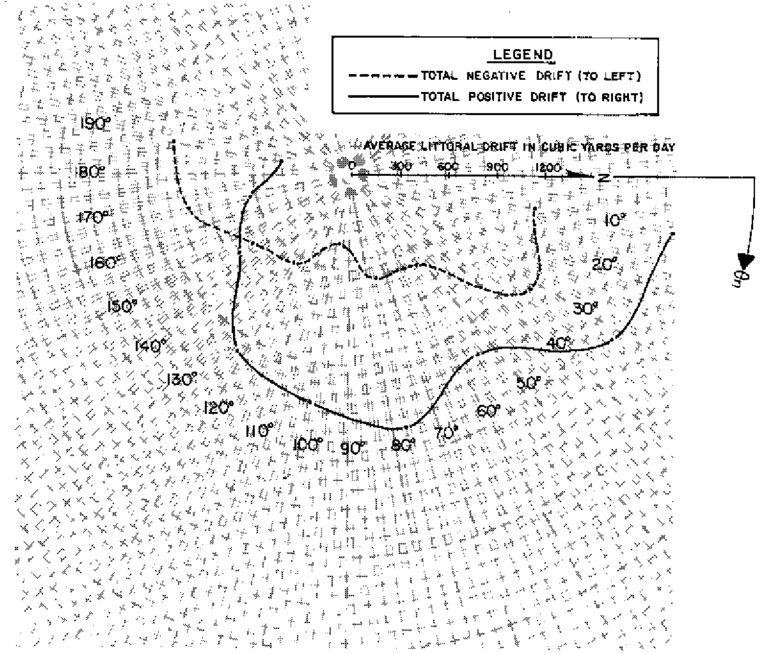


FIGURE A-14 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - JANUARY

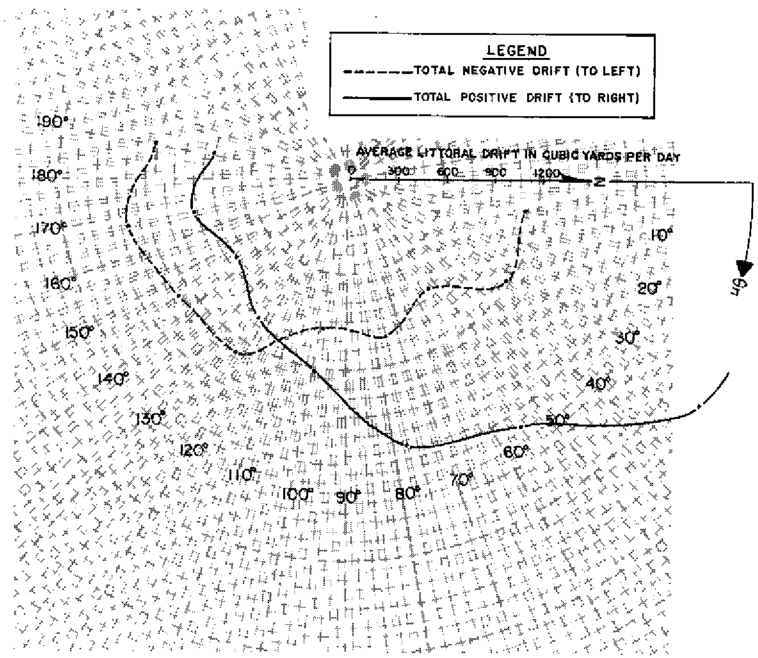


FIGURE A-15 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - FEBRUARY

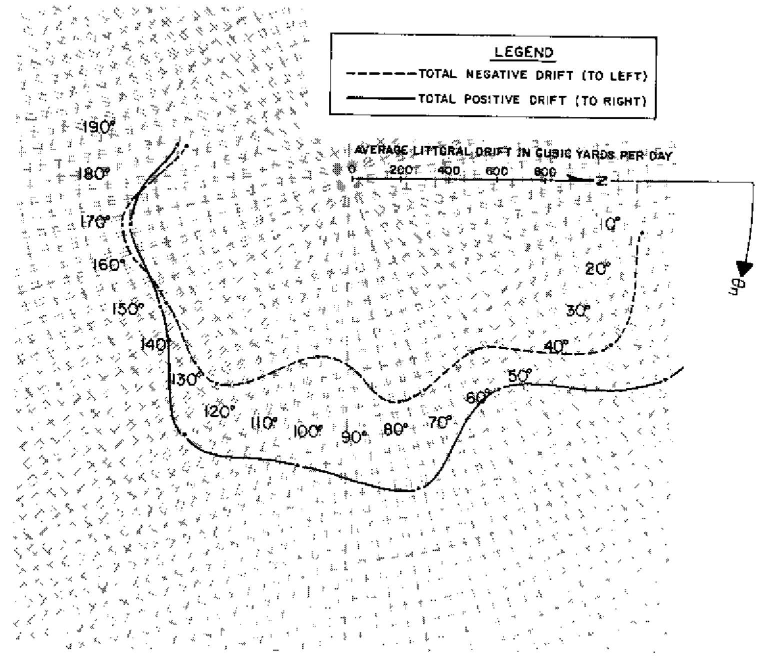


FIGURE A-16 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - MARCH

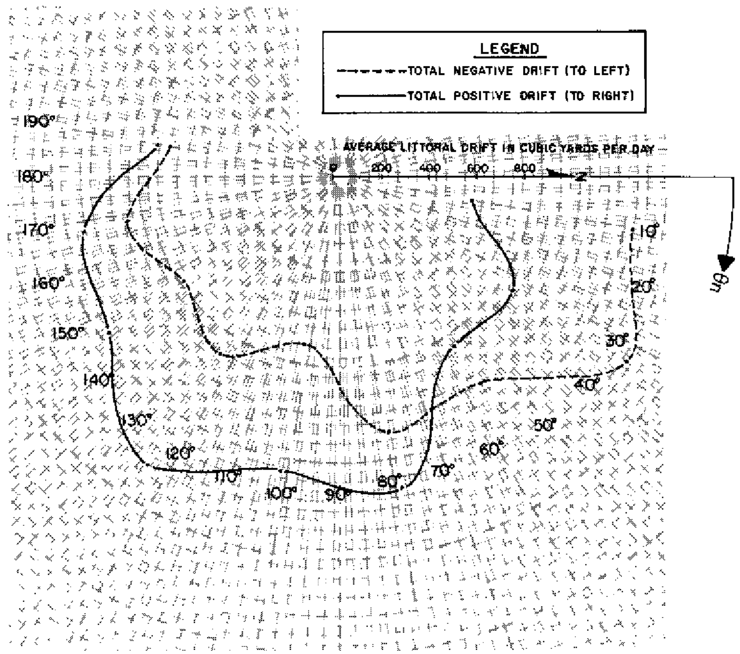


FIGURE A-17 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - APRIL

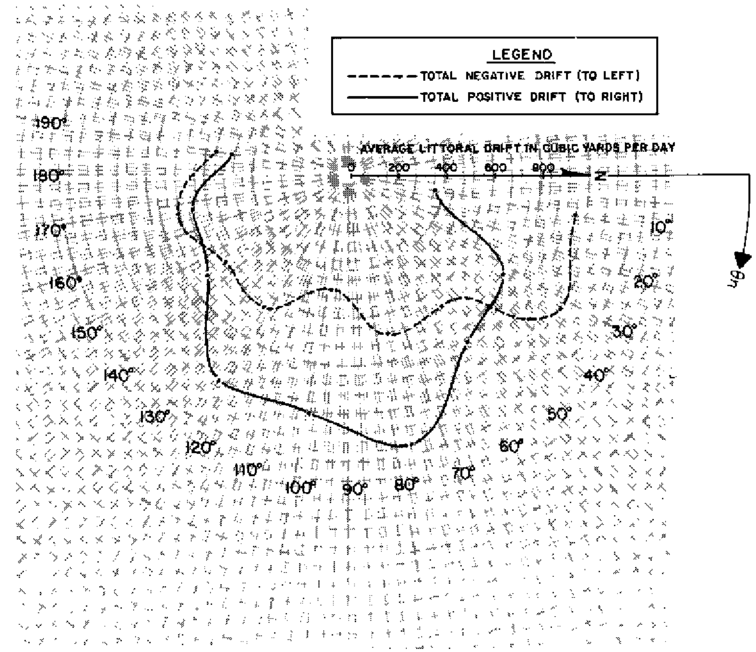


FIGURE A-18 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - MAY

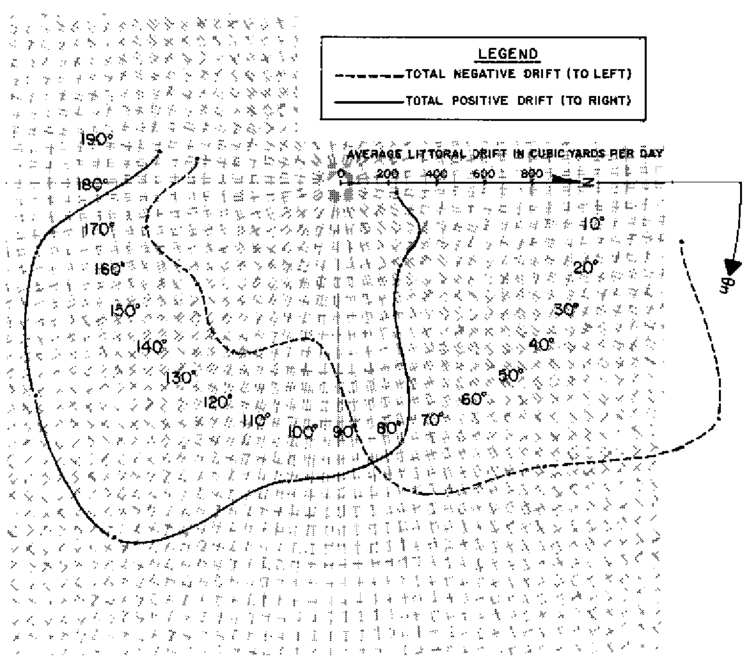


FIGURE A-19 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORI' - JUNE

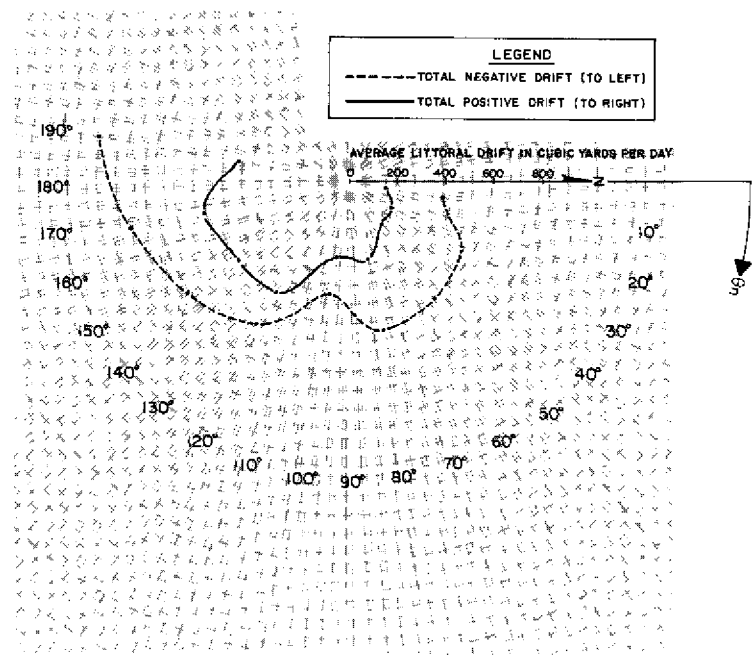


FIGURE A-20 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - JULY

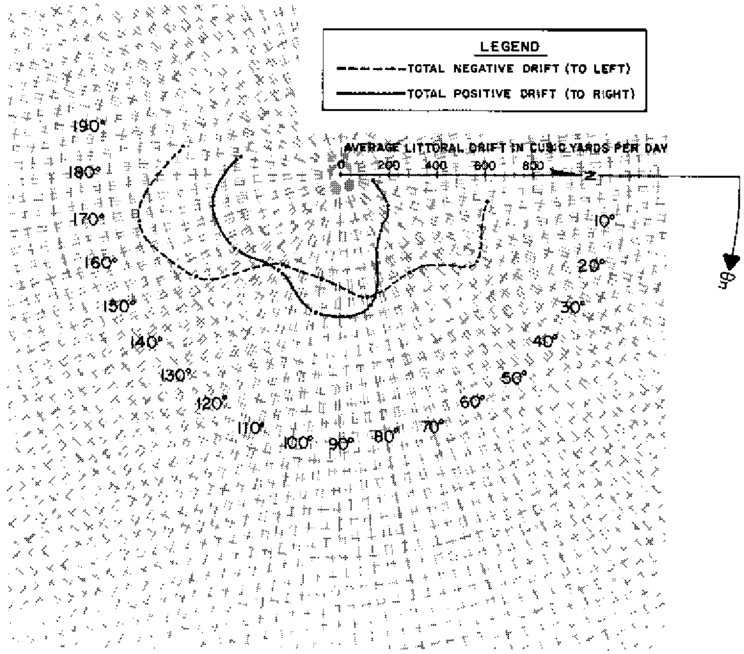


FIGURE A-21 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - AUGUST

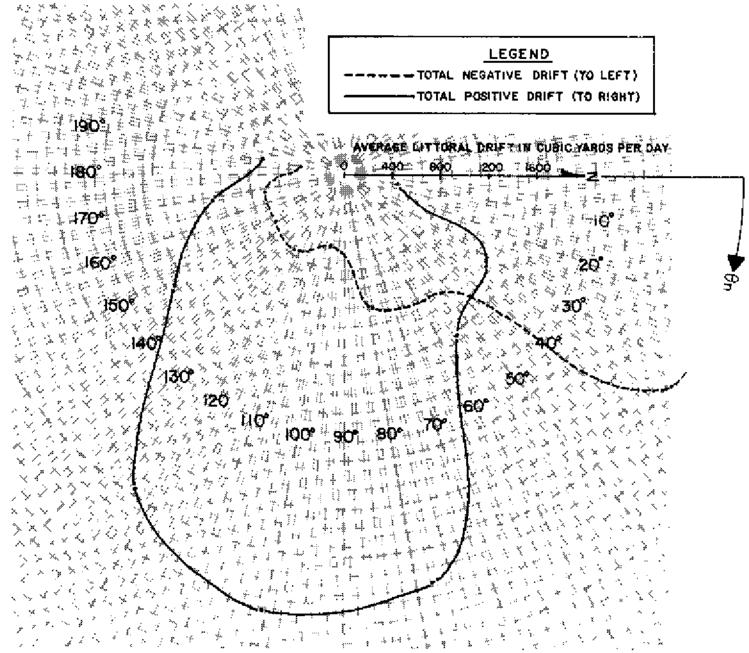


FIGURE A-22 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - SEPTEMBER

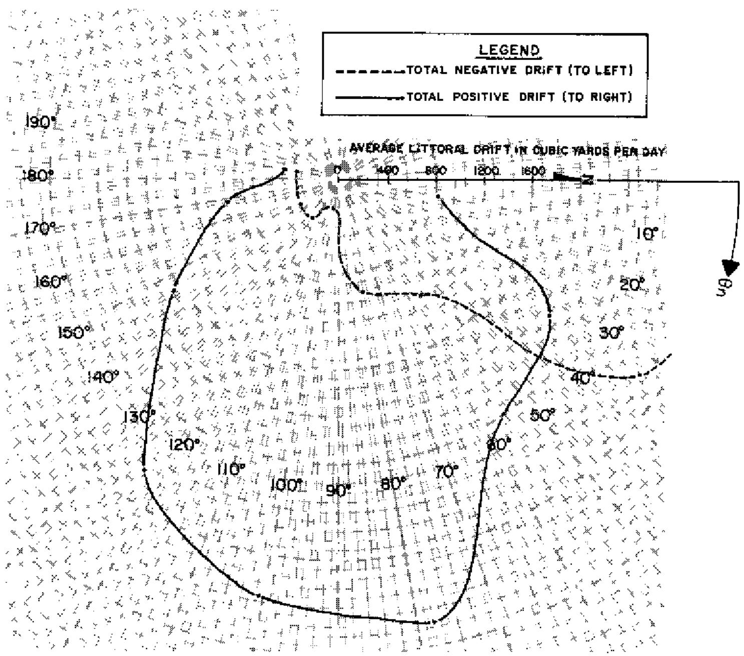


FIGURE A-23 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - OCTOBER

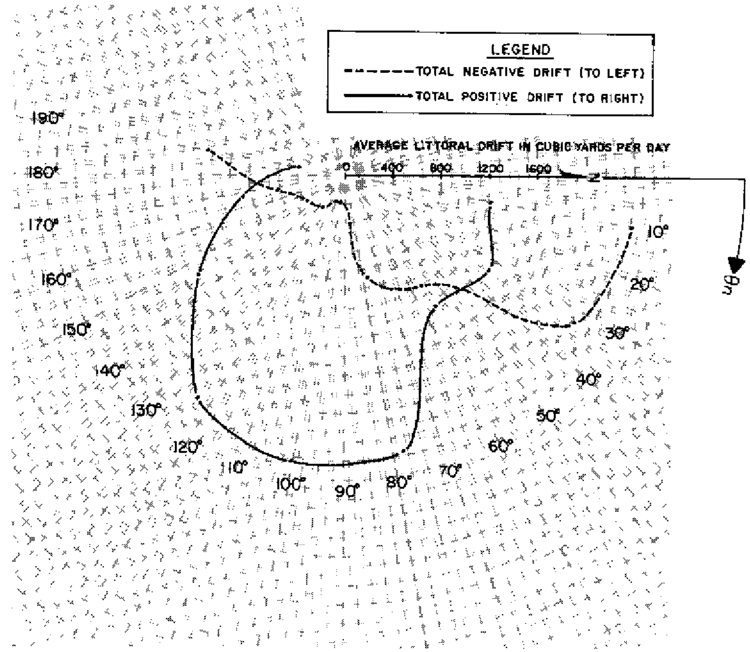


FIGURE A-24 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - NOVEMBER

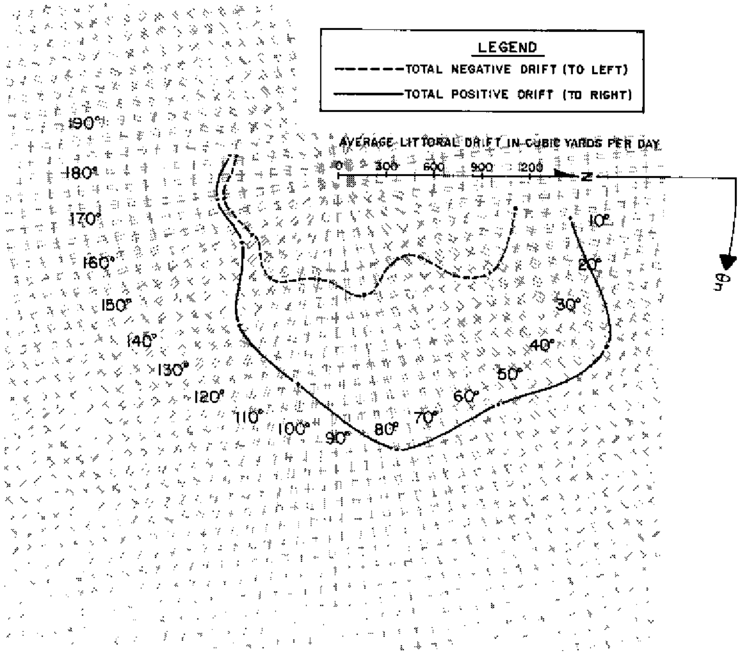


FIGURE A-25 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA - DECEMBER

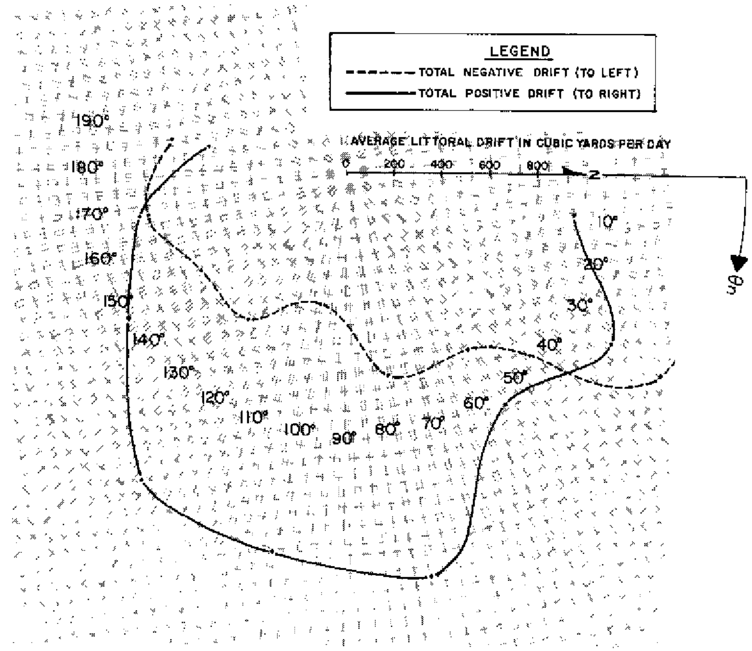


FIGURE A-26 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOHNS RIVER TO ST. AUGUSTINE INLET, FLORIDA

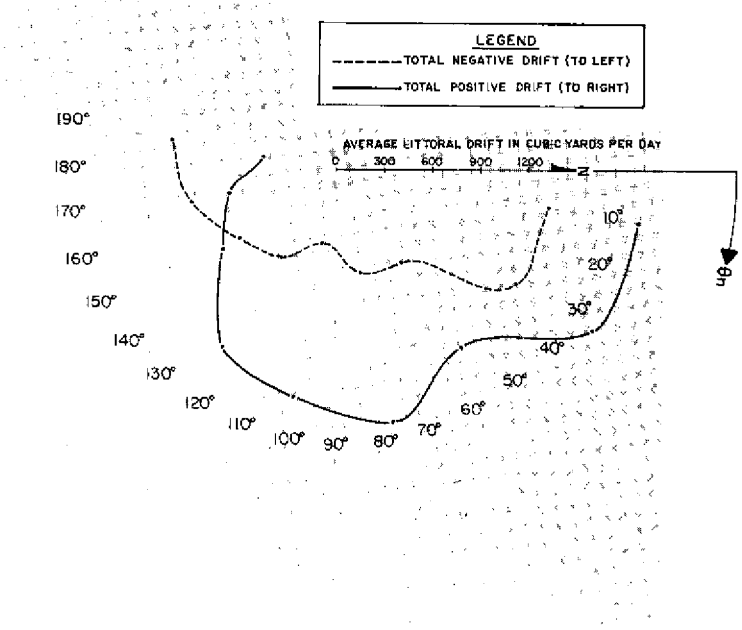


FIGURE A-27 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - JANUARY

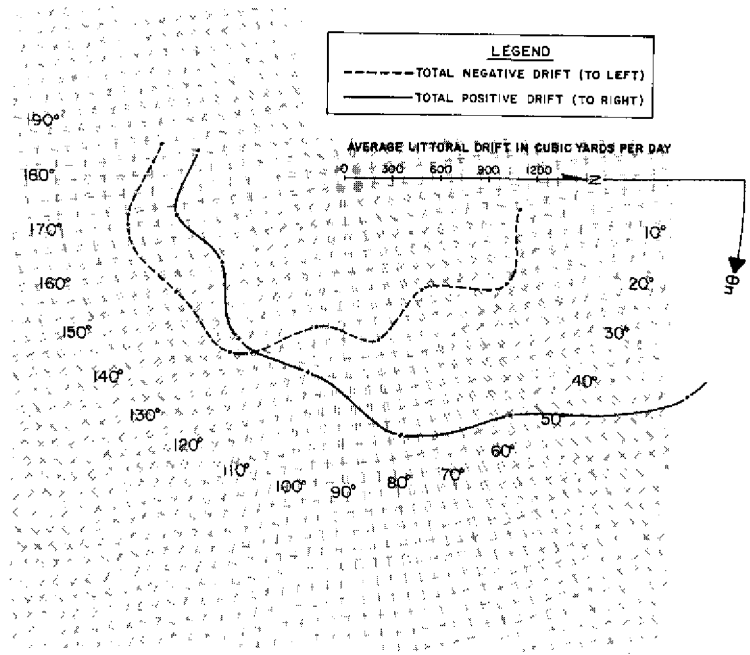


FIGURE A-28 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - FEBRUARY

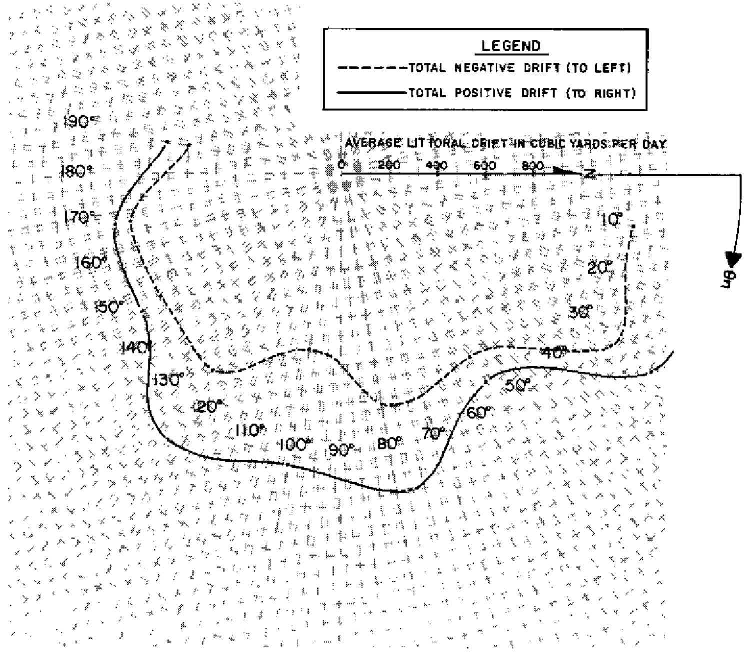


FIGURE A-29 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - MARCH

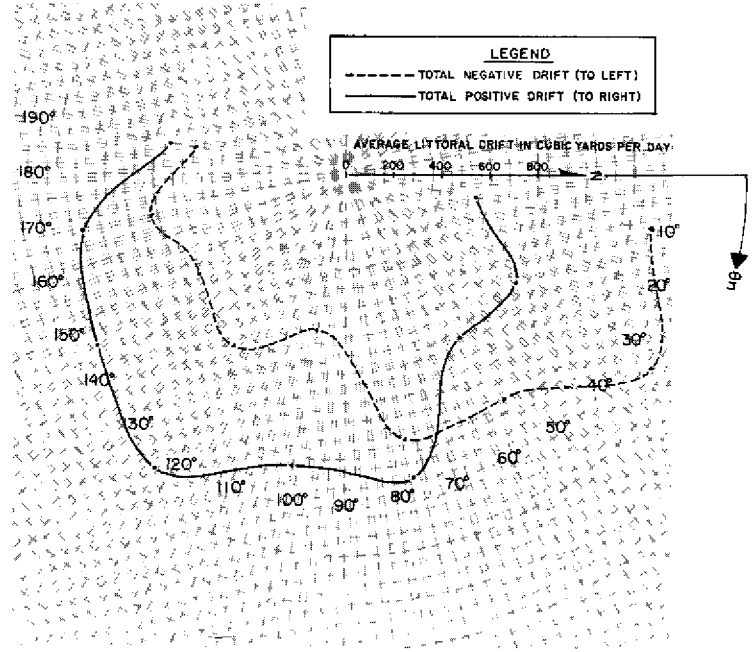


FIGURE A-30 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - APRIL

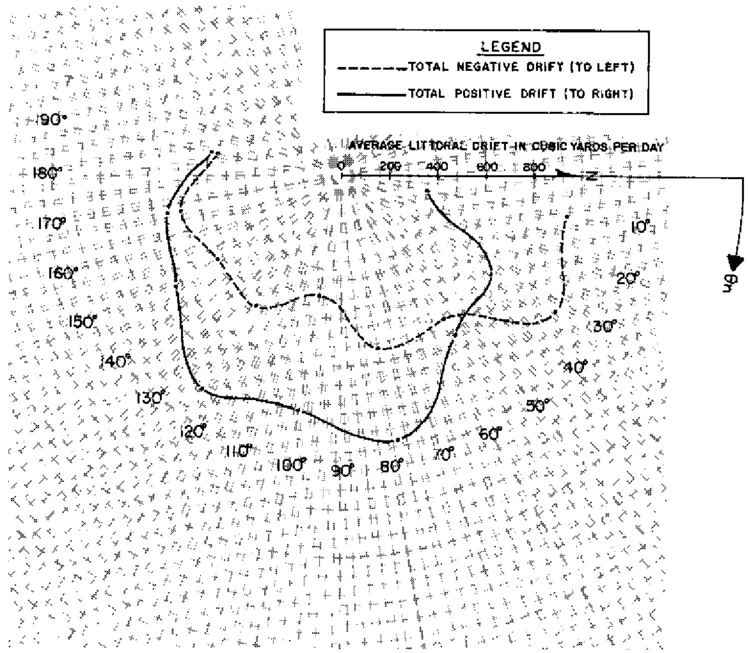


FIGURE A-31 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - MAY

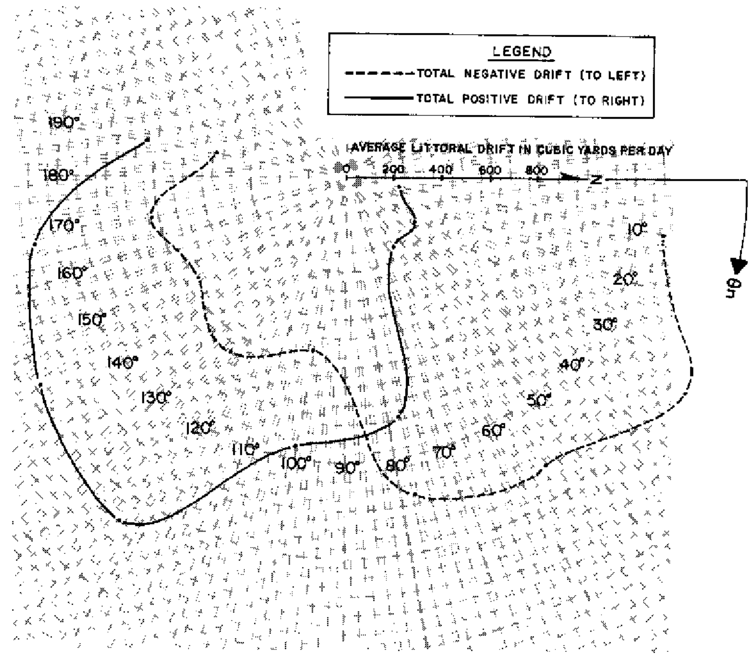


FIGURE A-32 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - JUNE

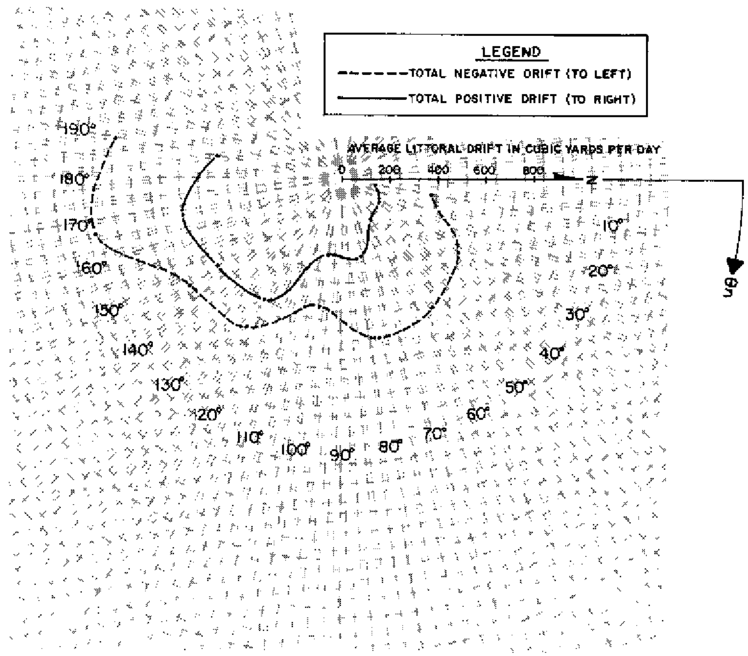


FIGURE A-33 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - JULY

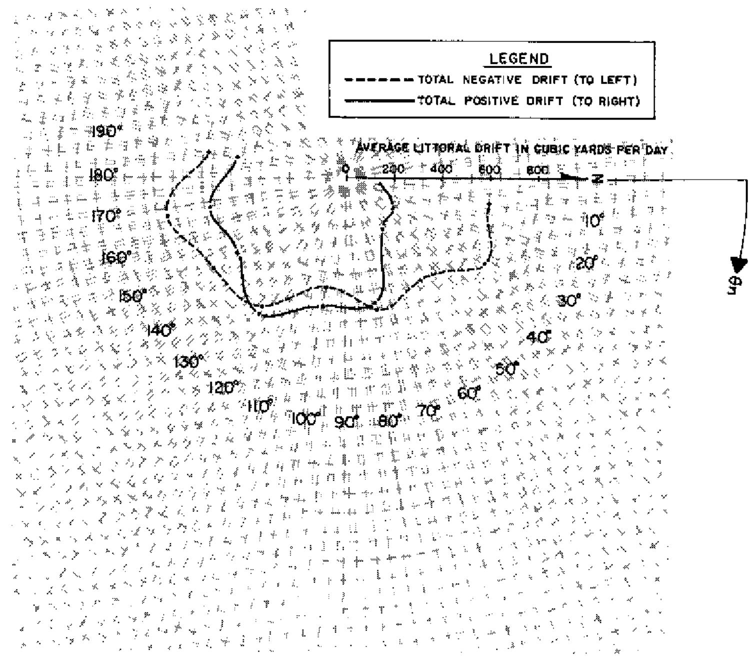


FIGURE A-34 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - AUGUST

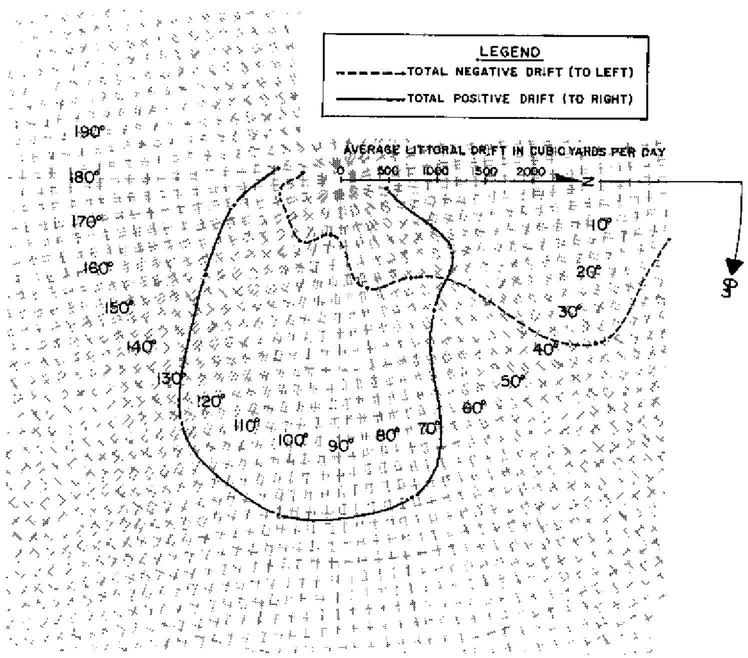


FIGURE A-35 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - SEPTEMBER

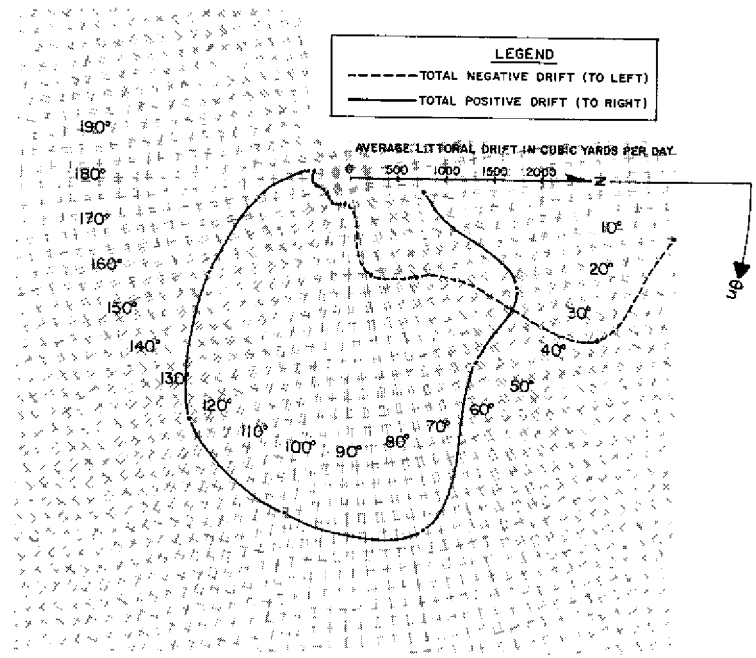


FIGURE A-36 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - OCTOBER

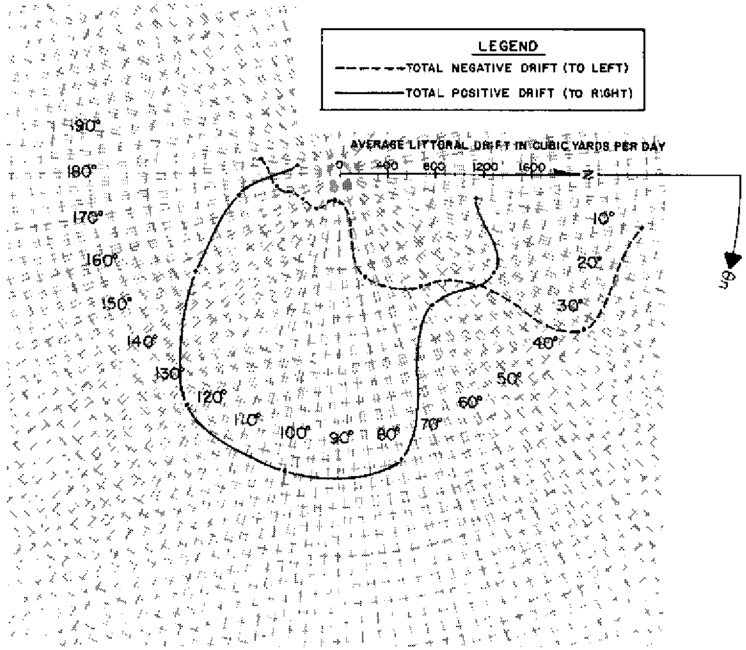


FIGURE A-37 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - NOVEMBER

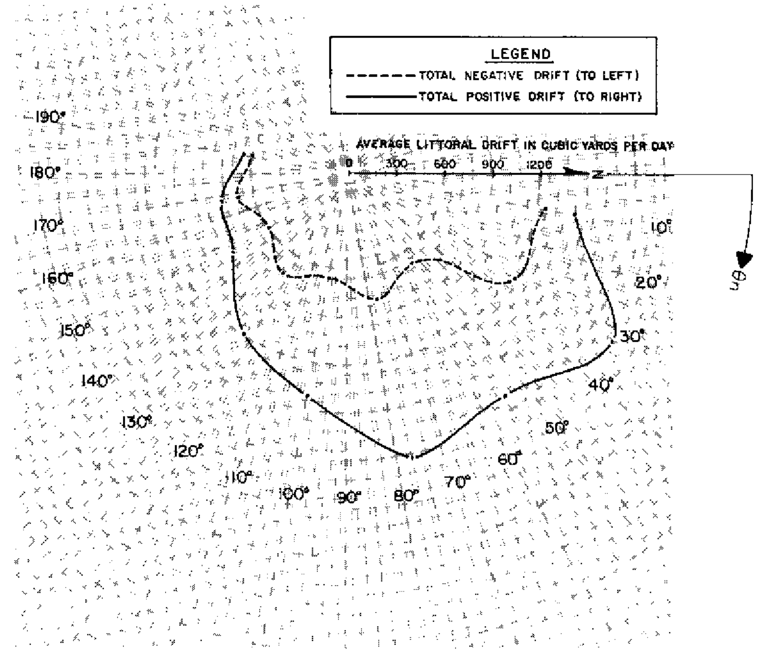


FIGURE A-38 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA - DECEMBER

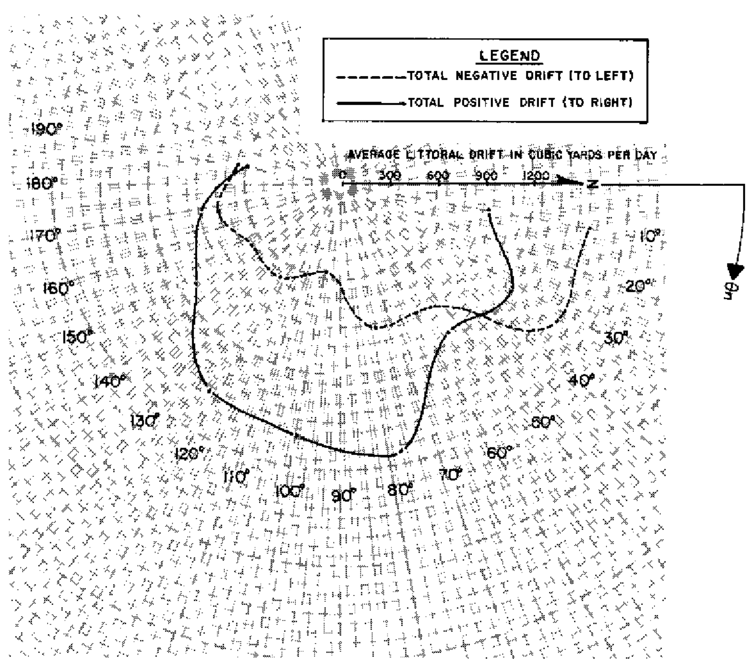


FIGURE A-39 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. AUGUSTINE INLET TO MATANZAS INLET, FLORIDA

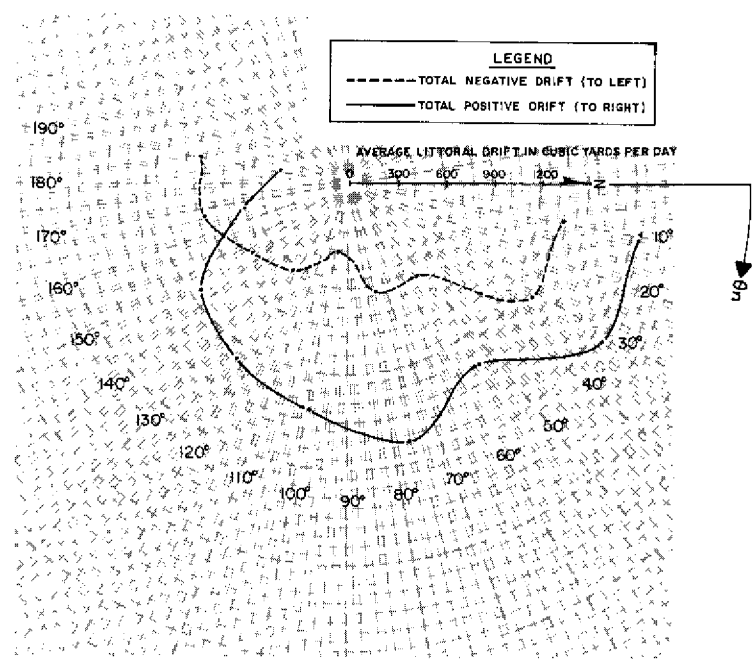


FIGURE A-40 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - JANUARY

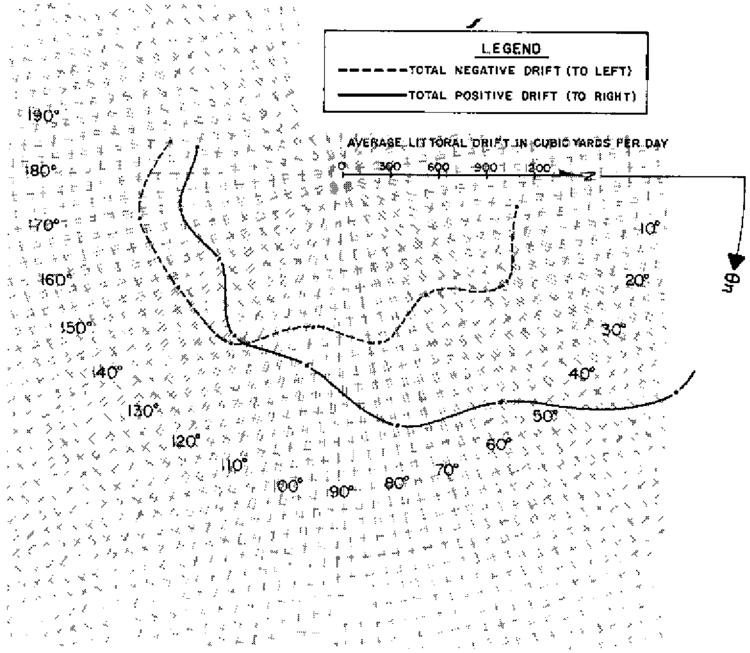


FIGURE A-41 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - FEBRUARY

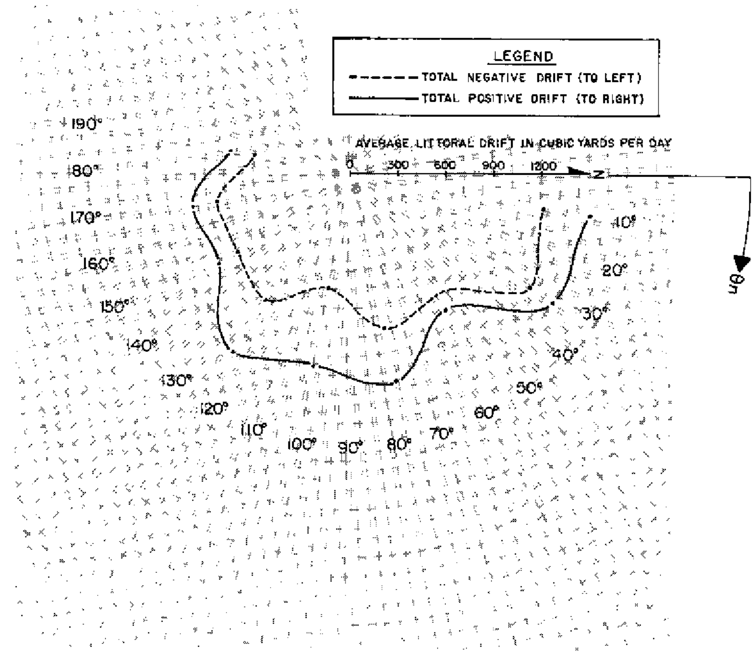


FIGURE A-42 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - MARCH

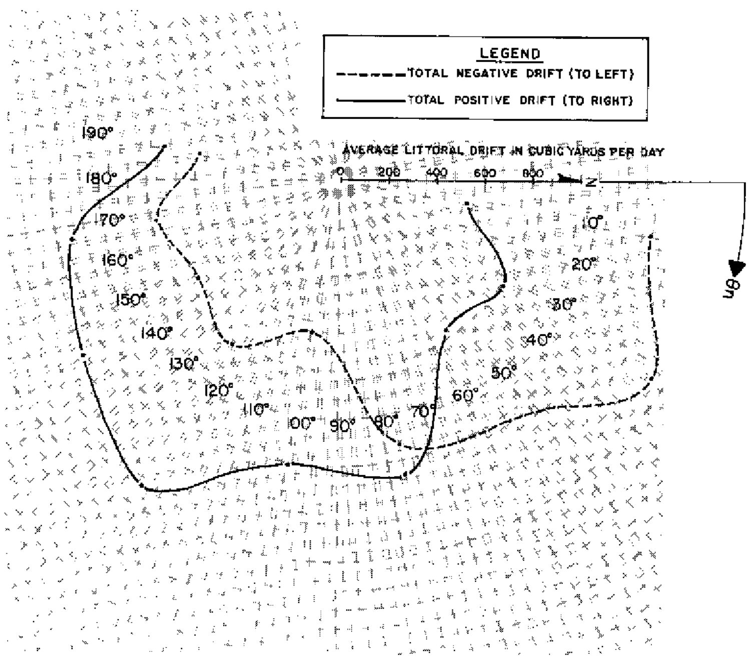


FIGURE A-43 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - APRIL

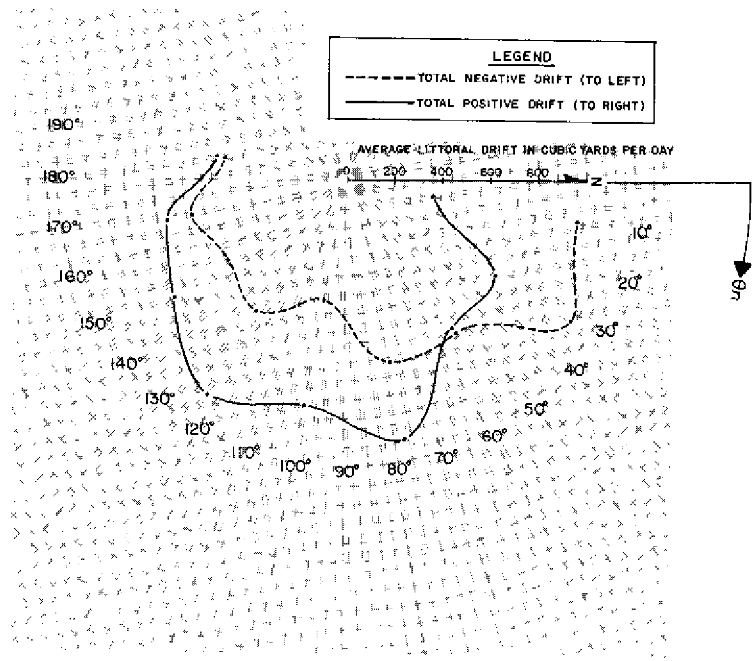


FIGURE A-44 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - MAY

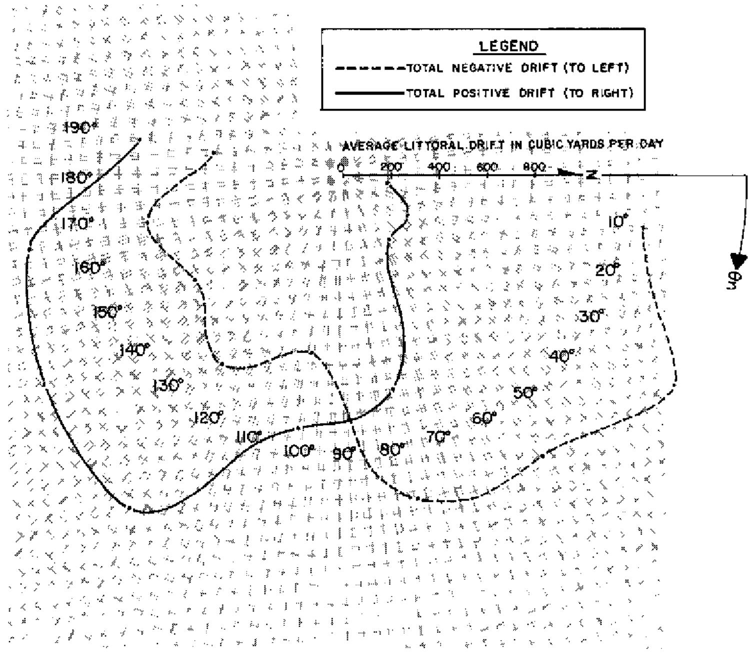


FIGURE A-45 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - JUNE

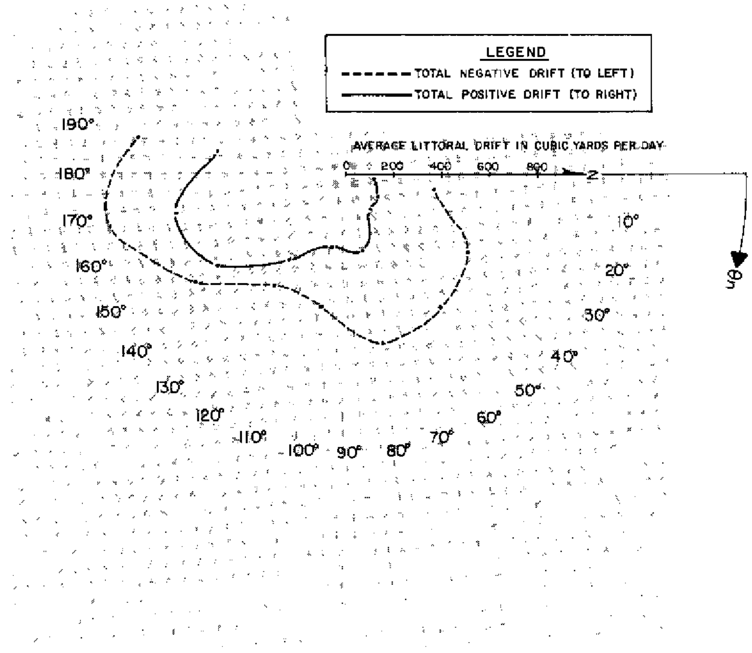


FIGURE A-46 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - JULY

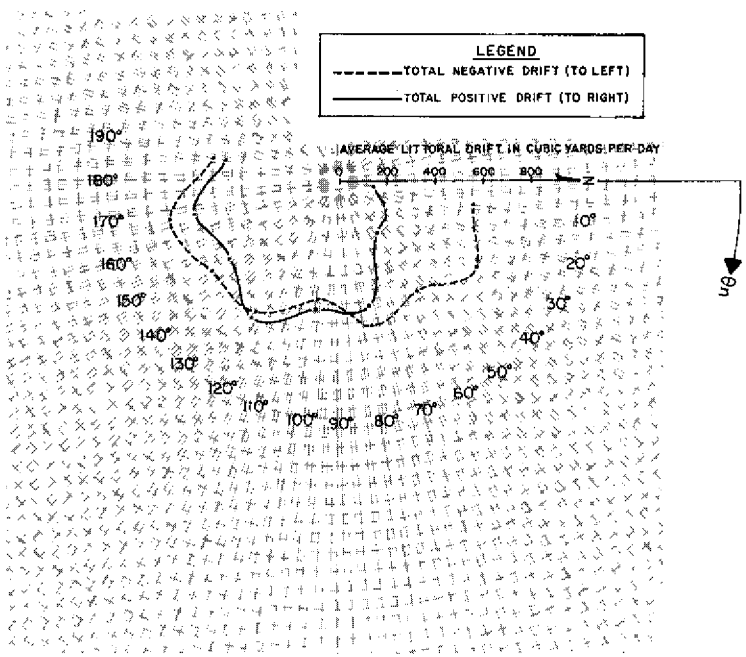


FIGURE A-47 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - AUGUST

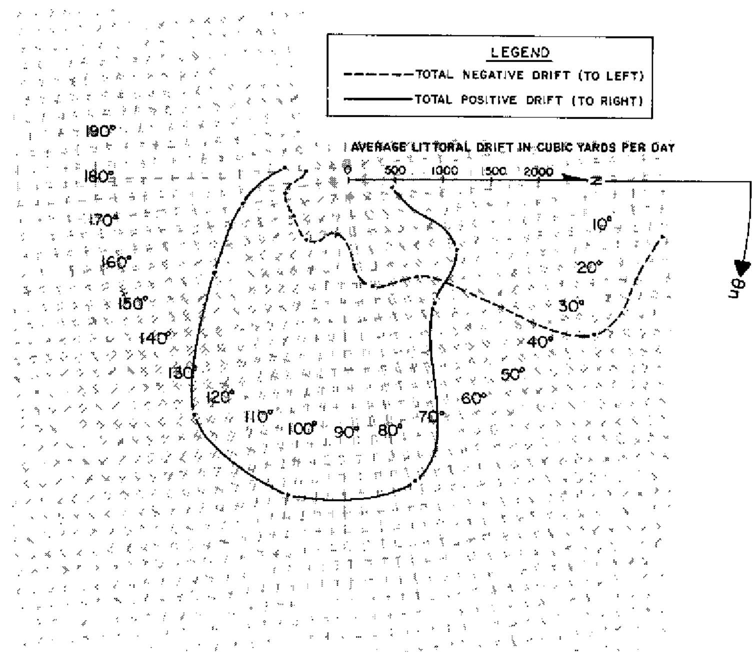


FIGURE A-48 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - SEPTEMBER

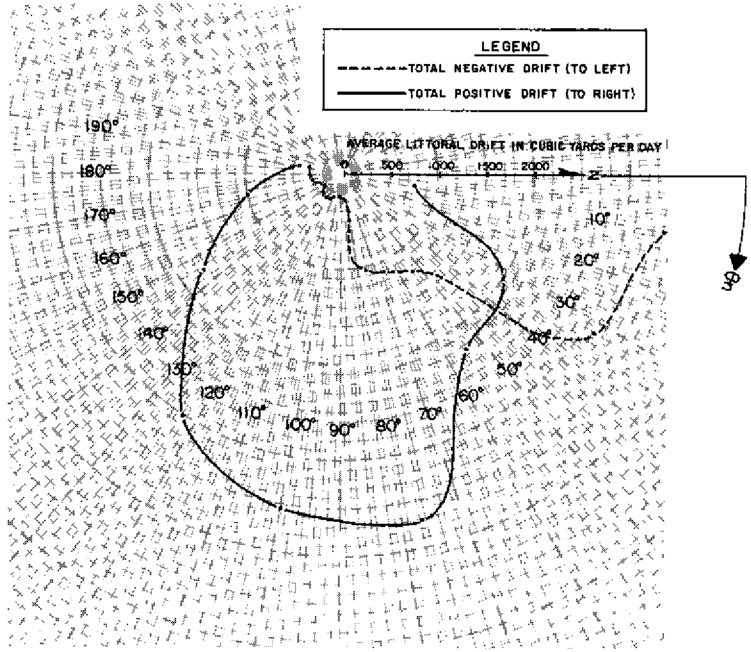


FIGURE A-49 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - OCTOBER

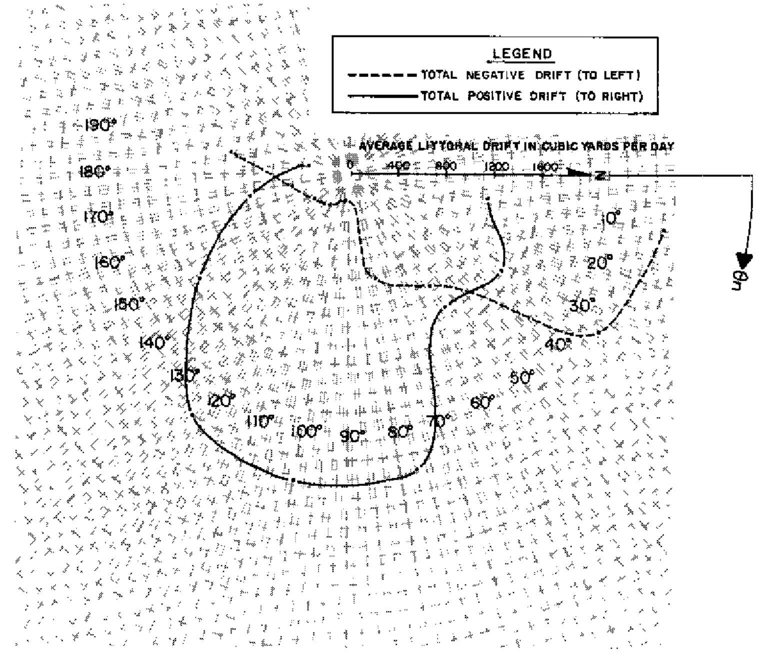


FIGURE A-50 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - NOVEMBER

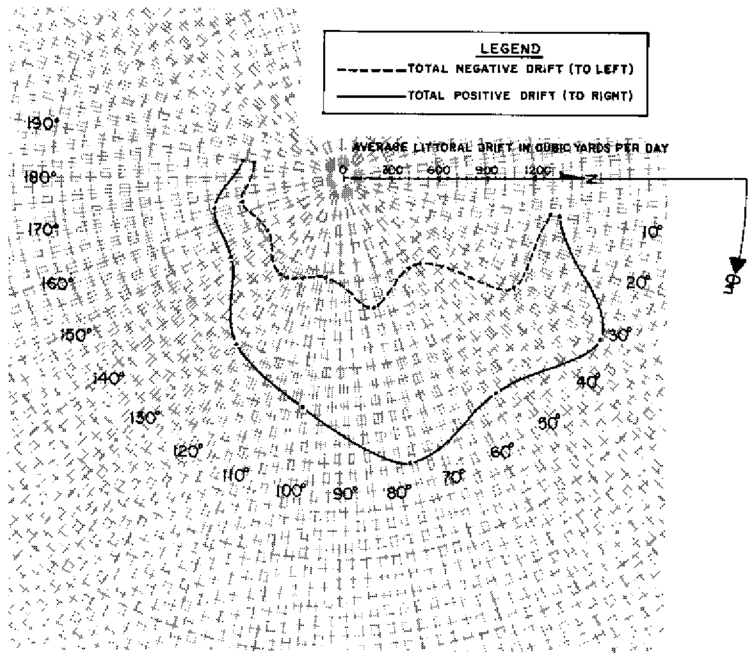


FIGURE A-51 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA - DECEMBER

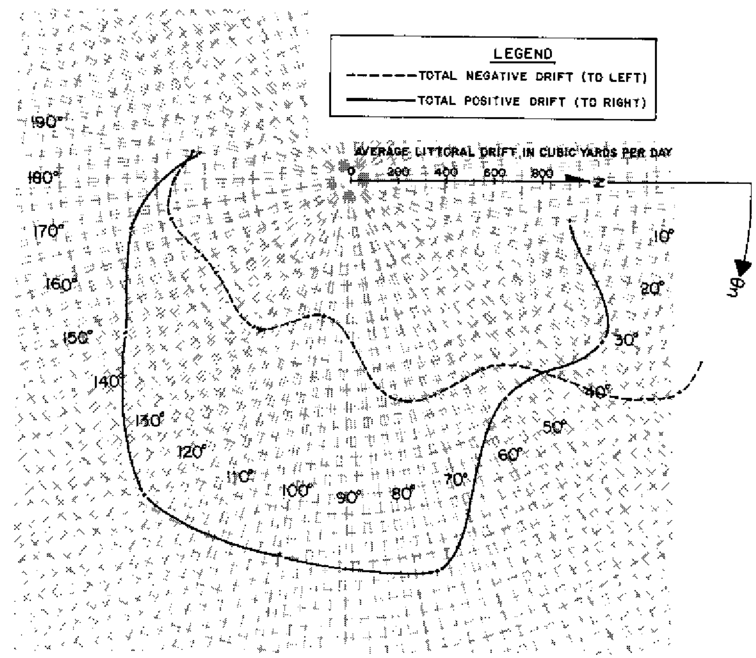


FIGURE A-52 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - MATANZAS INLET TO PONCE DE LEON INLET, FLORIDA

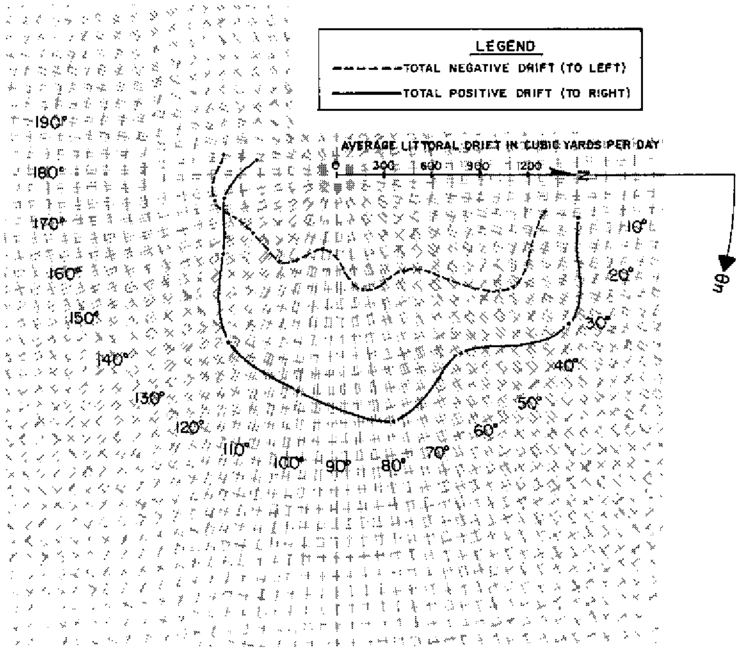


FIGURE A-53 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - JANUARY

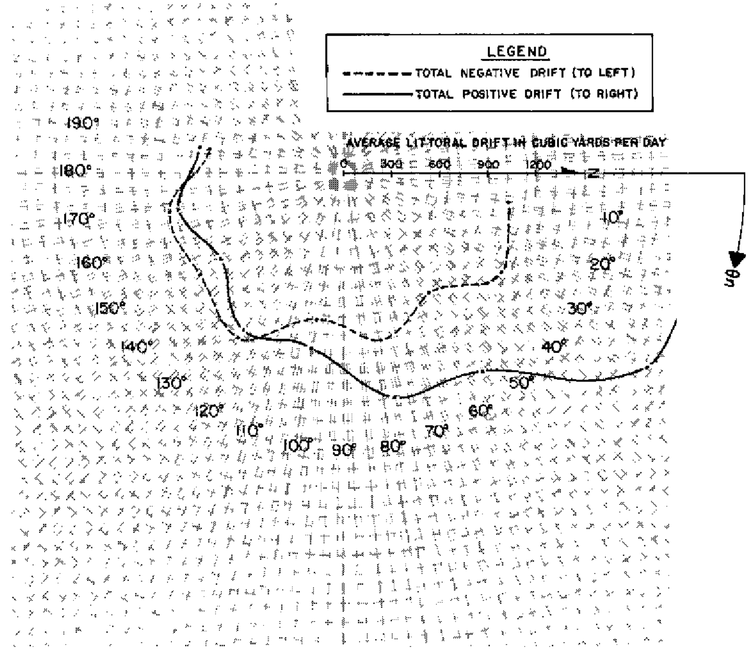


FIGURE A-54 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - FEBRUARY

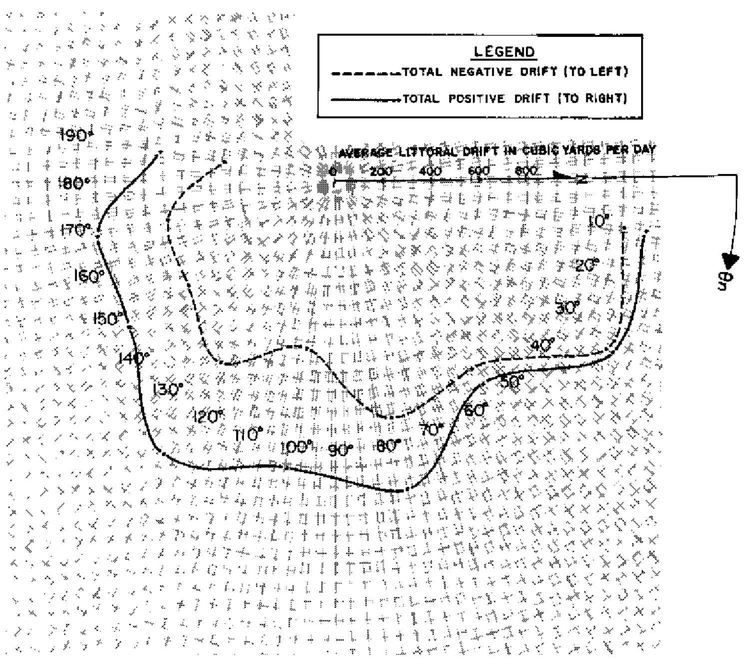


FIGURE A-55 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - MARCH

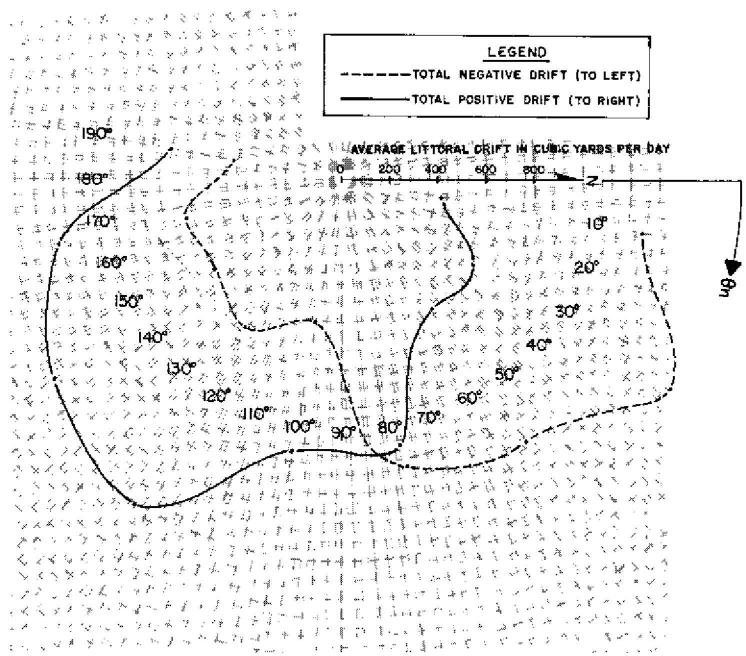


FIGURE A-56 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - APRIL

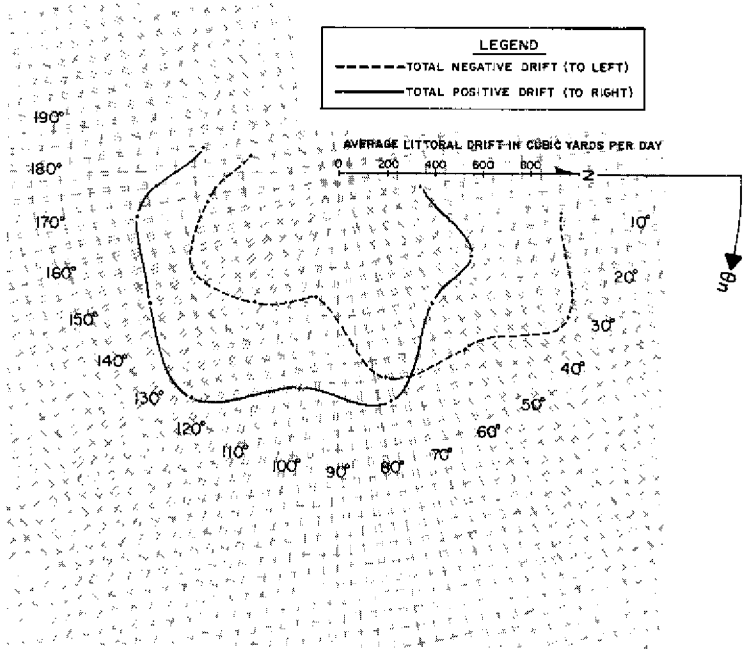


FIGURE A-57 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - MAY

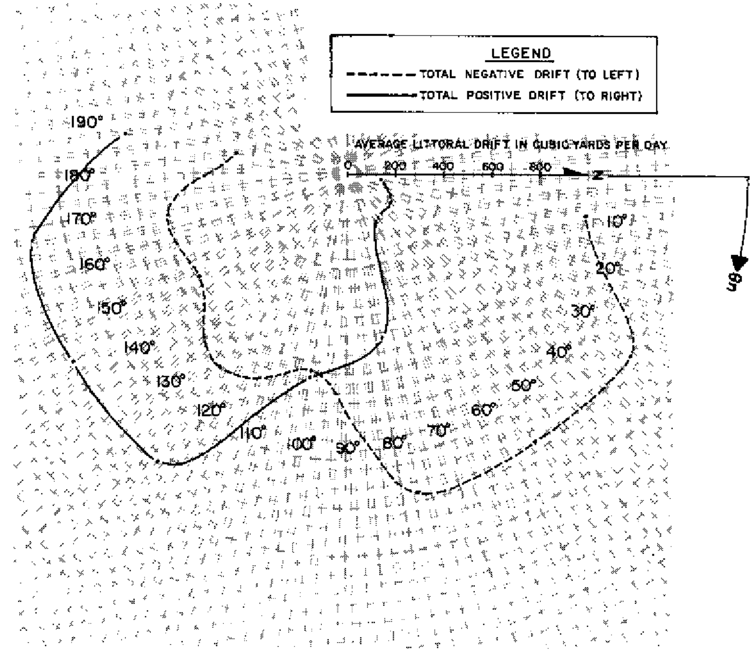


FIGURE A-58 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - JUNE

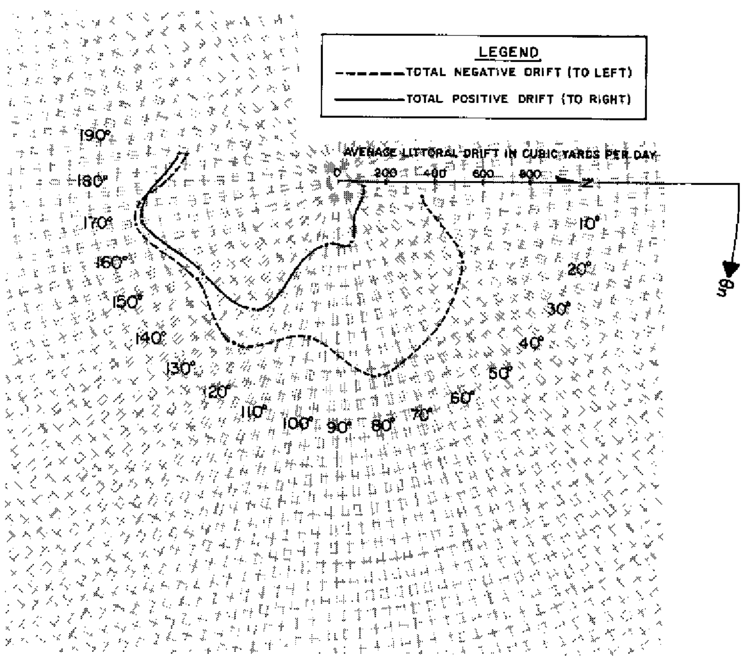


FIGURE A-59 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - JULY

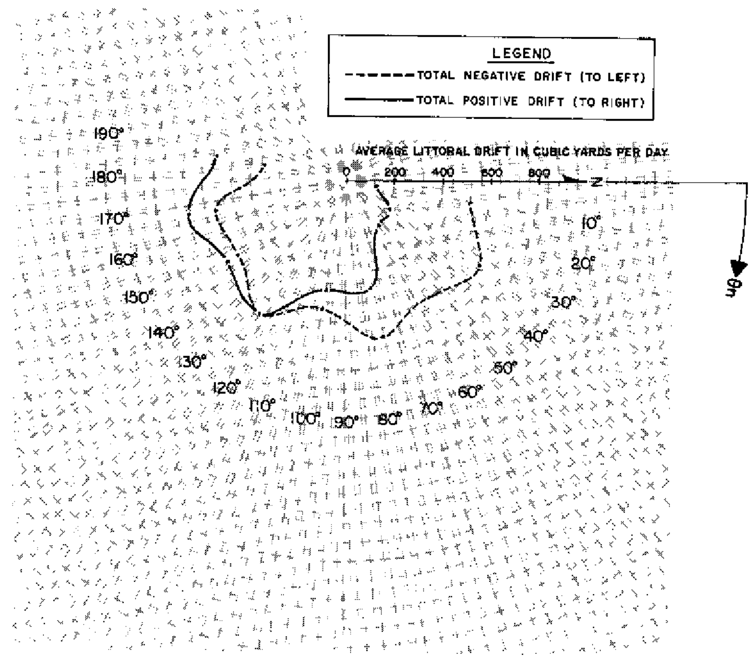


FIGURE A-60 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - AUGUST

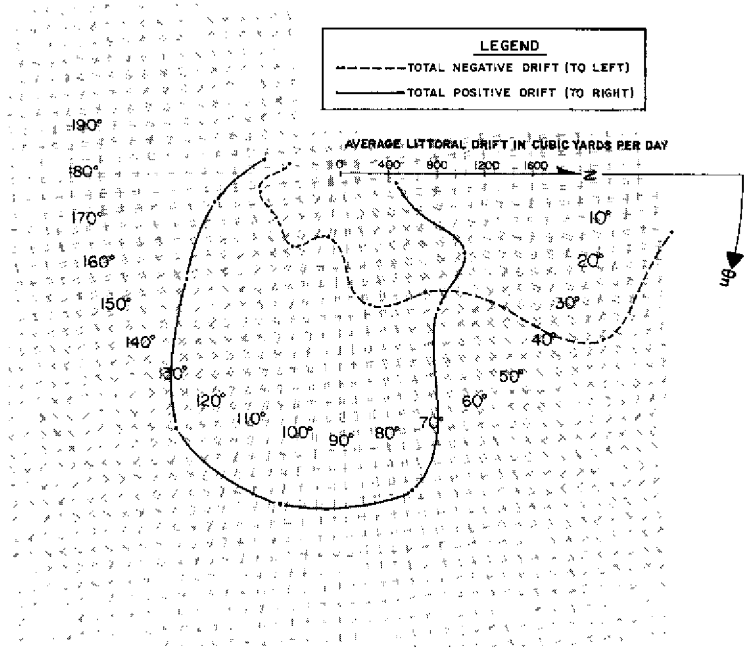


FIGURE A-61 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - SEPTEMBER

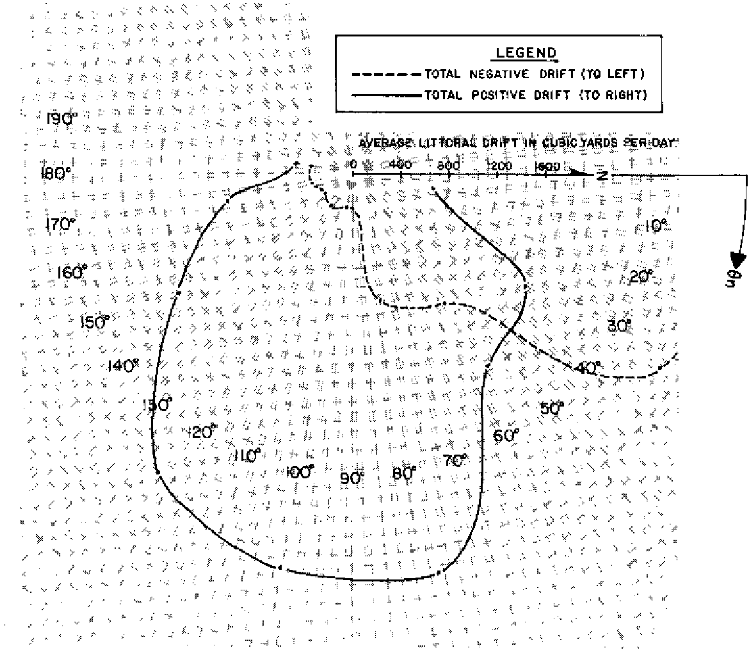


FIGURE A-62 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - OCTOBER

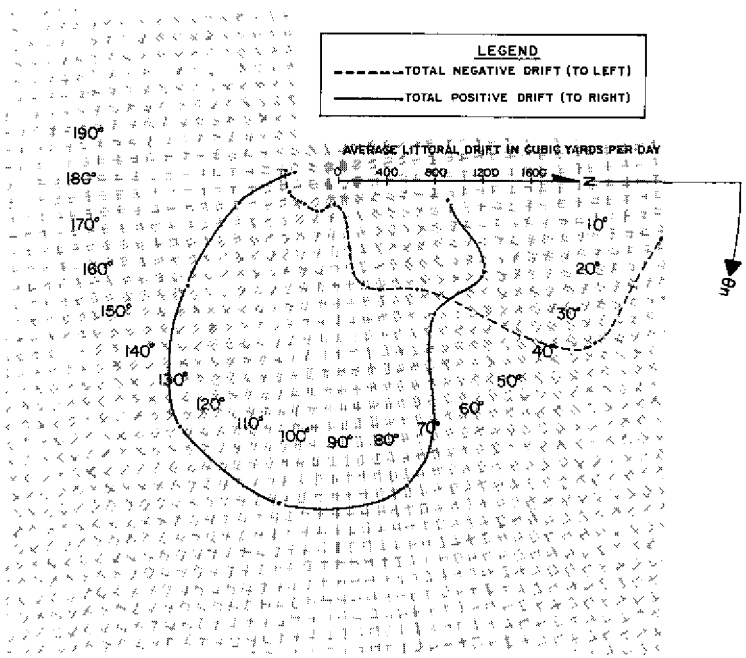


FIGURE A-63 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - NOVEMBER

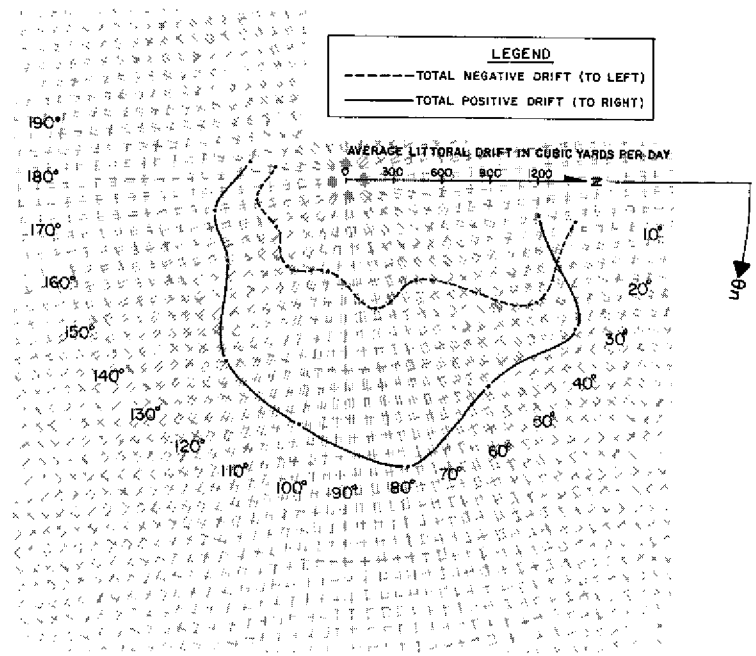


FIGURE A-64 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA - DECEMBER

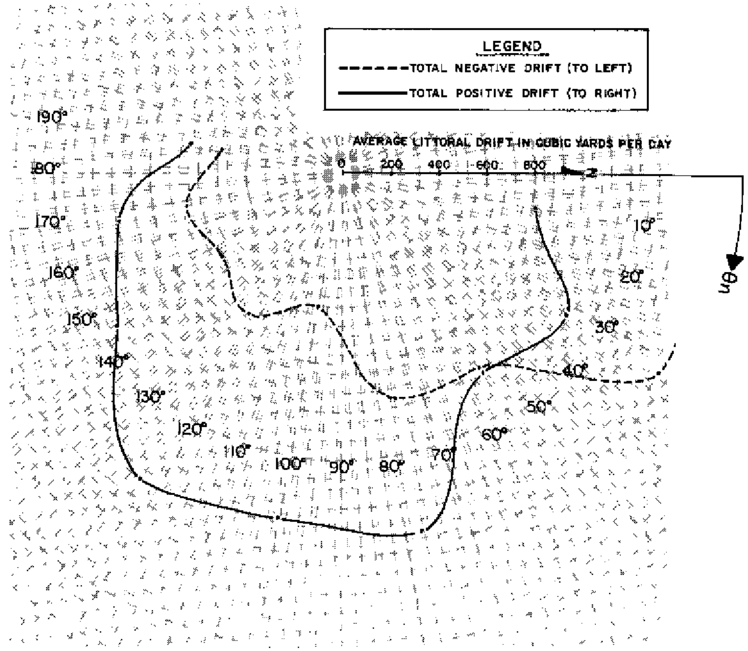


FIGURE A-65 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PONCE DE LEON INLET TO CAPE KENNEDY, FLORIDA

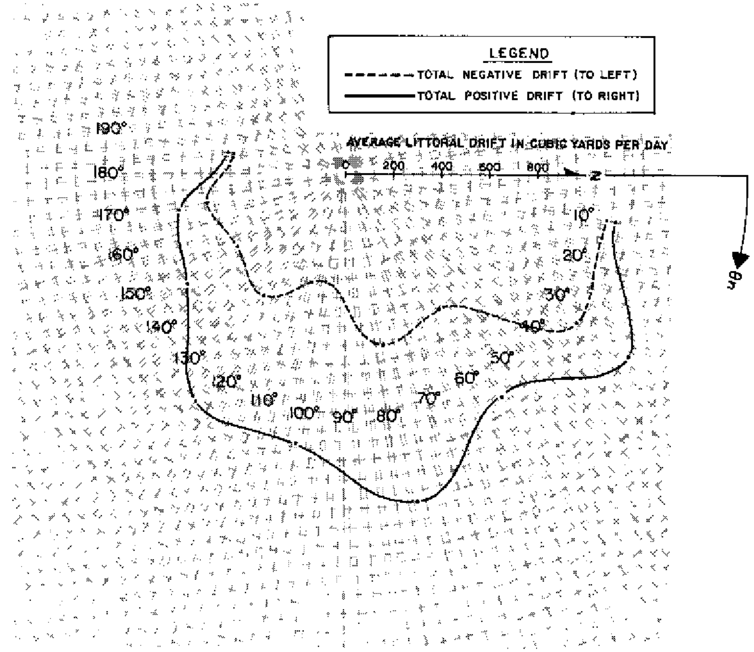


FIGURE A-66 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - JANUARY

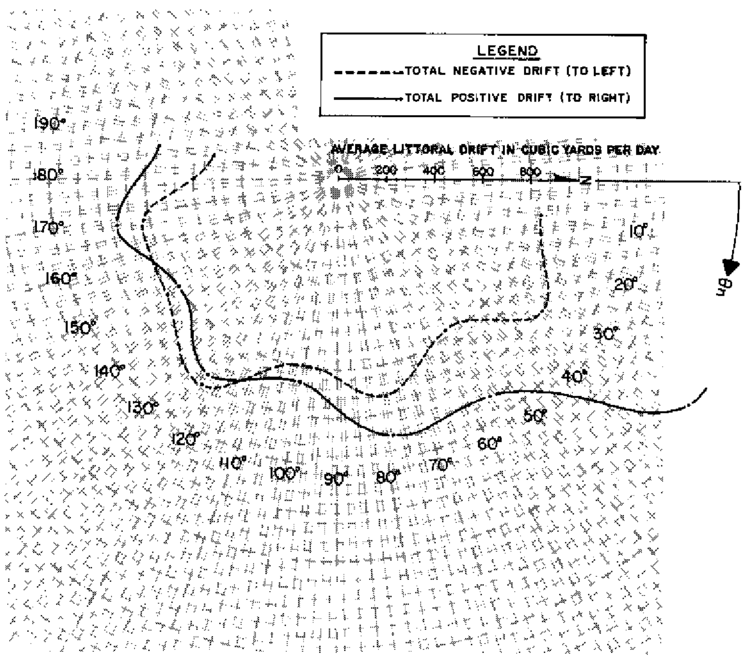


FIGURE A-67 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - FEBRUARY

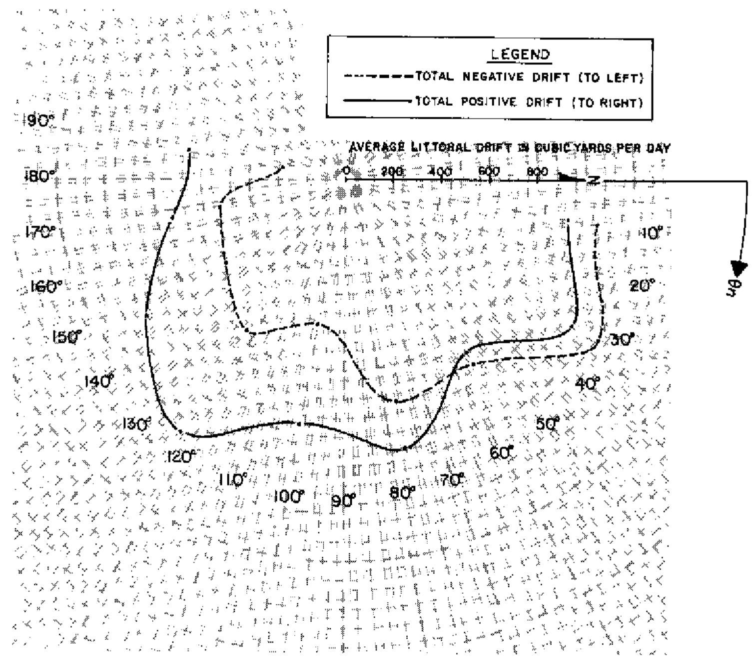


FIGURE A-68 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - MARCH

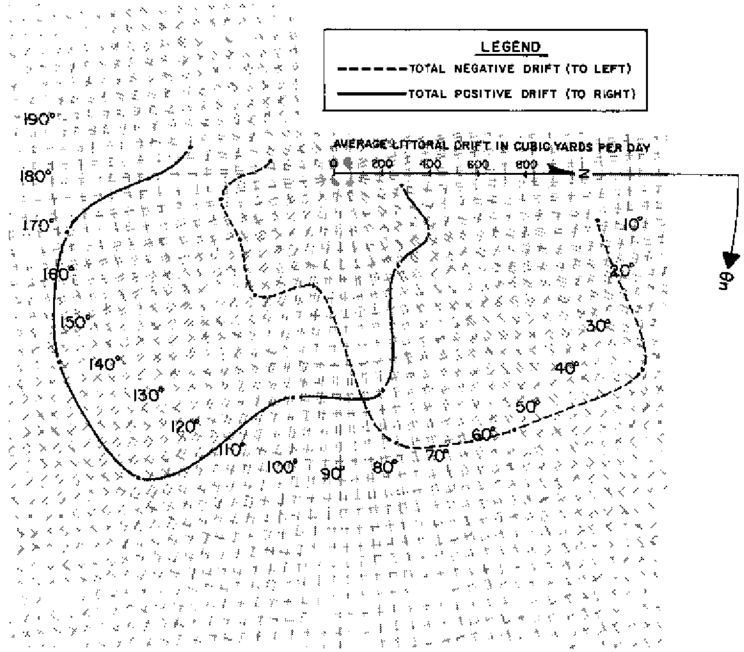


FIGURE A-69 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - APRIL

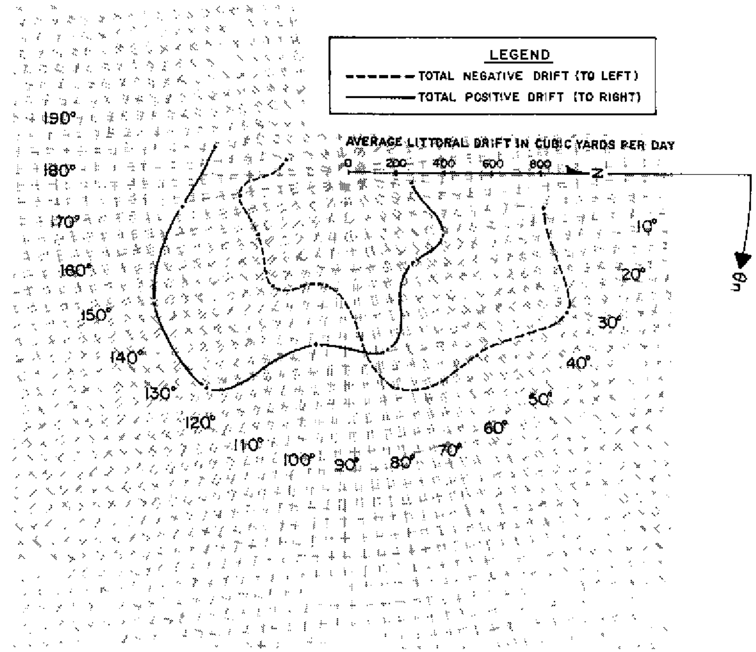


FIGURE A-70 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - MAY

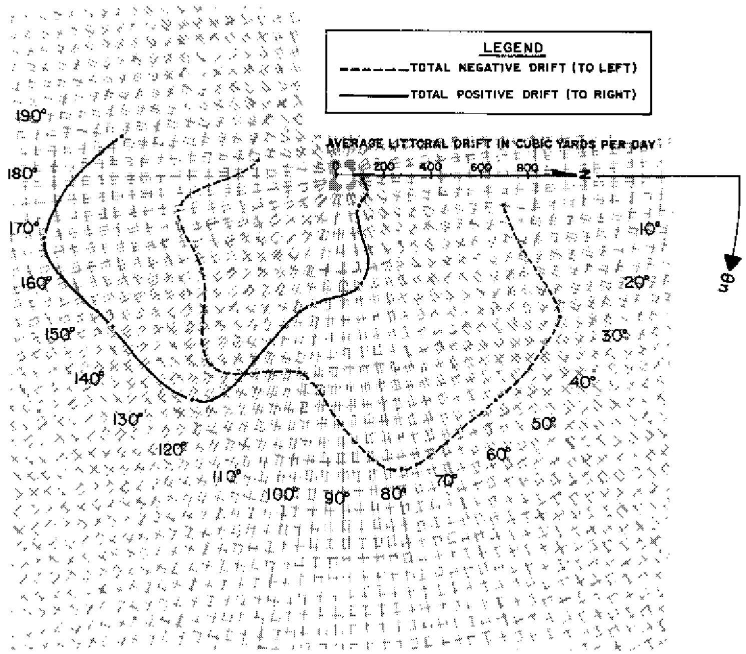


FIGURE A-71 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - JUNE

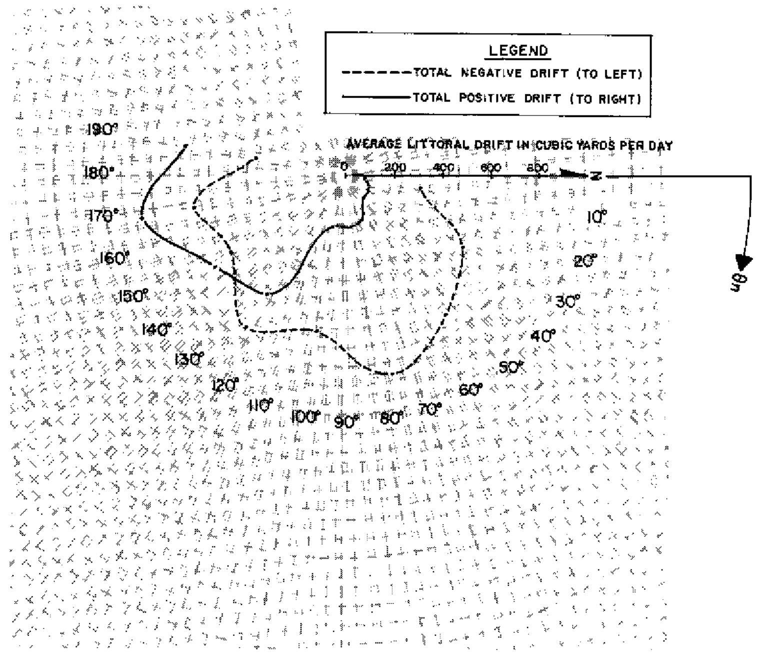


FIGURE A-72 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - JULY

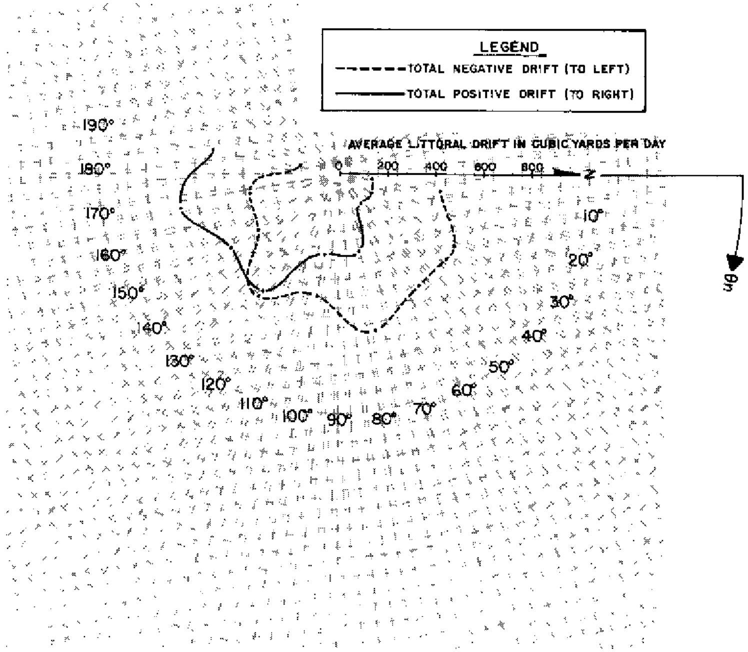


FIGURE A-73 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - AUGUST

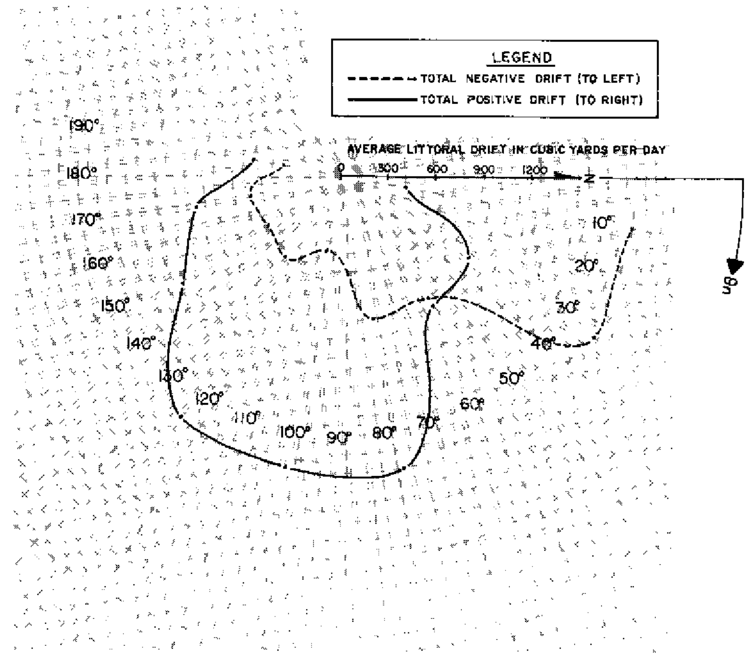


FIGURE A-74 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - SEPTEMBER

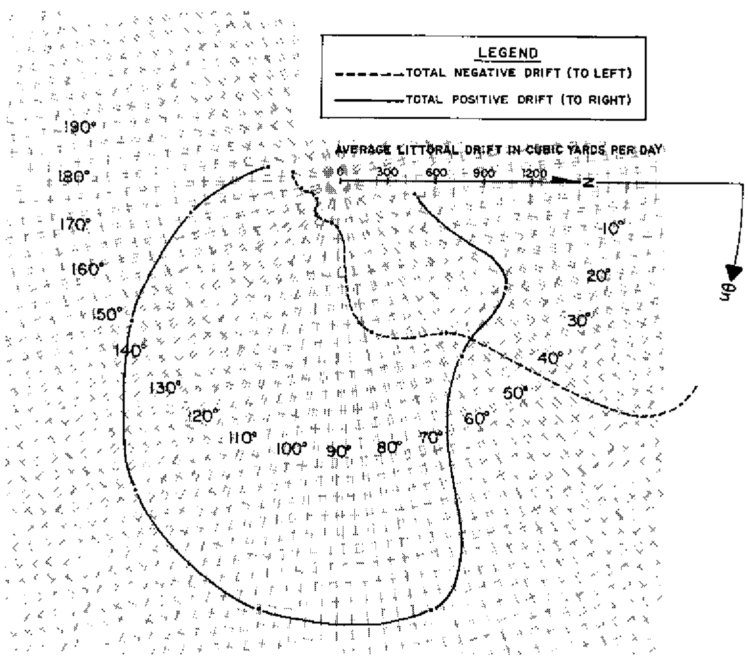


FIGURE A-75 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - OCTOBER

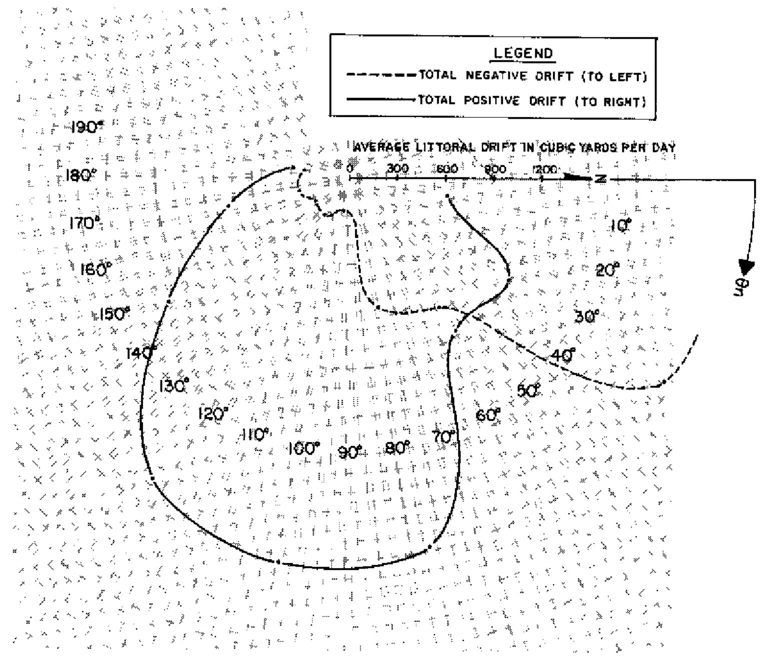


FIGURE A-76 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - NOVEMBER

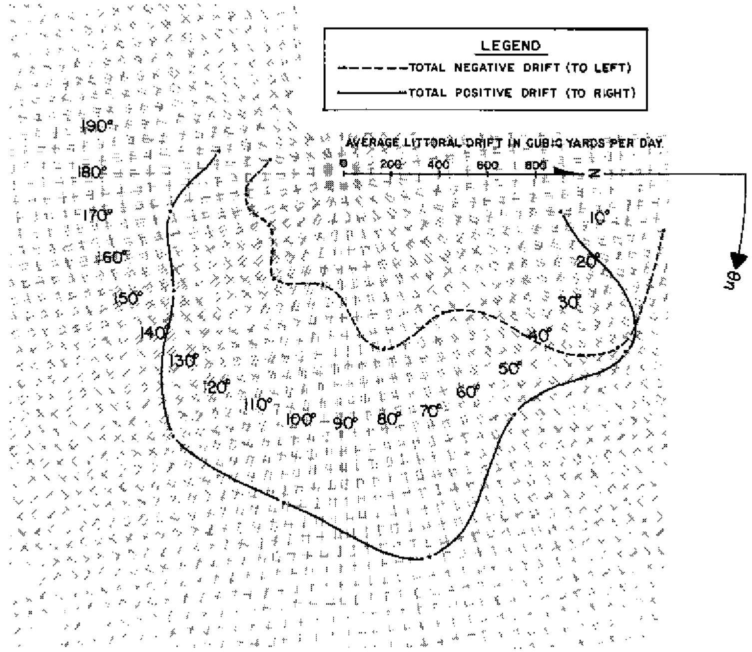


FIGURE A-77 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA - DECEMBER

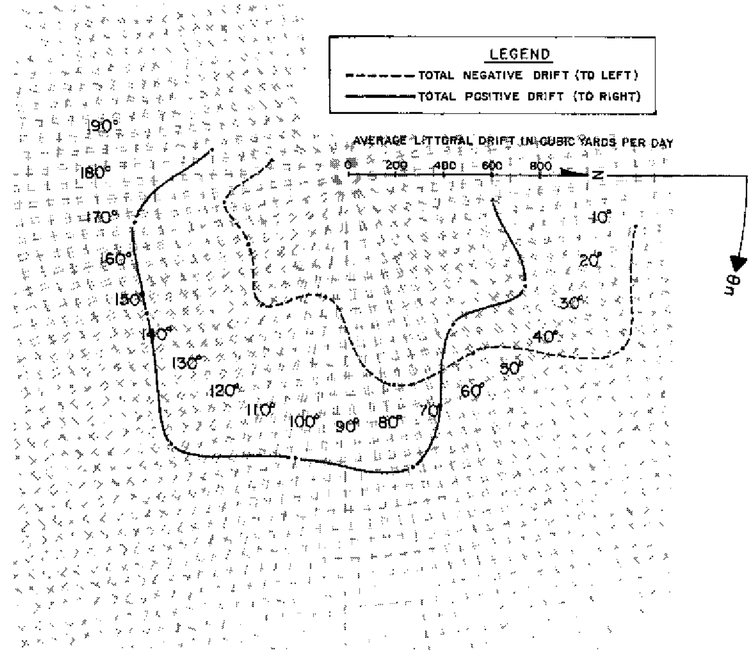


FIGURE A-78 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE KENNEDY TO SEBASTIAN INLET, FLORIDA

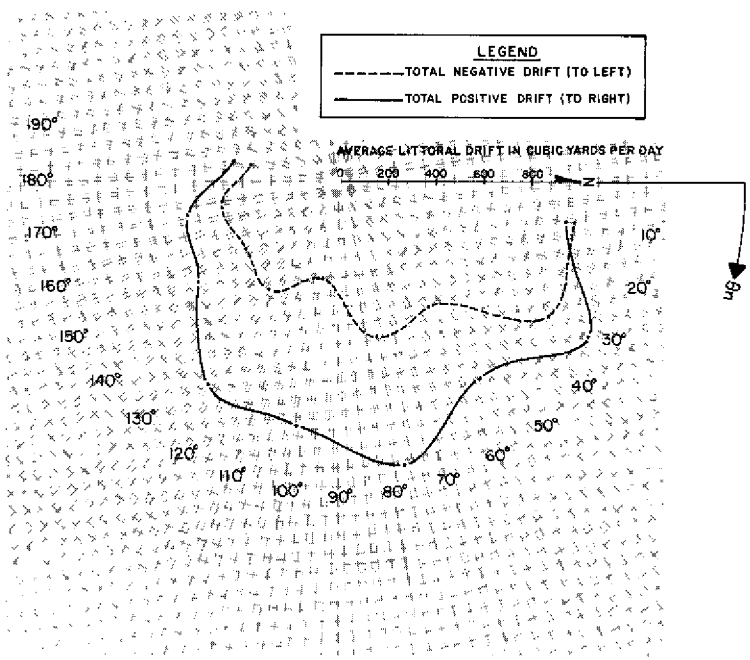


FIGURE A-79 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - JANUARY

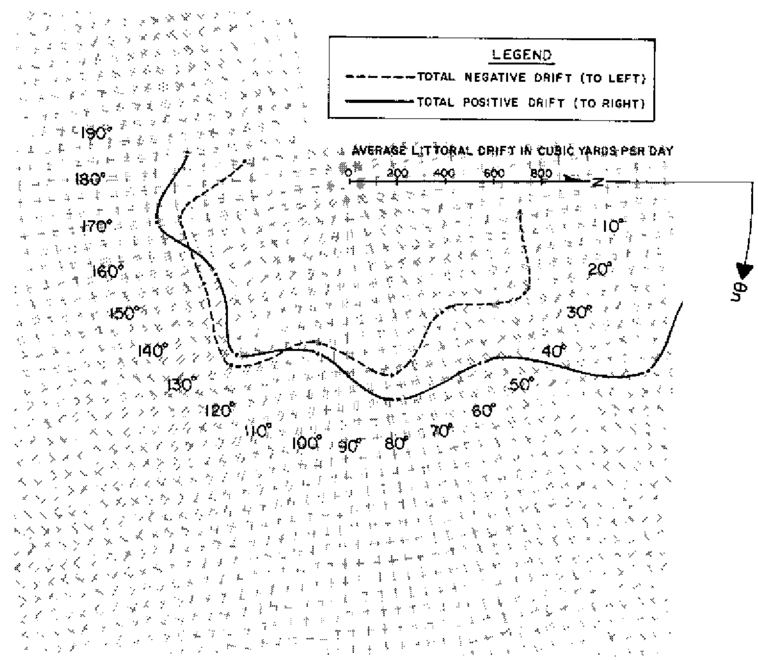


FIGURE A-80 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - FEBRUARY

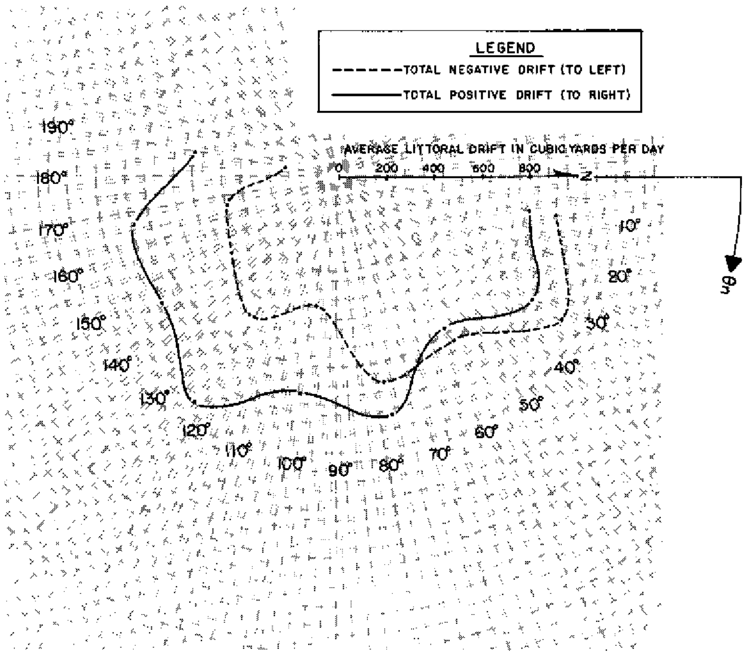


FIGURE A-81 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - MARCH

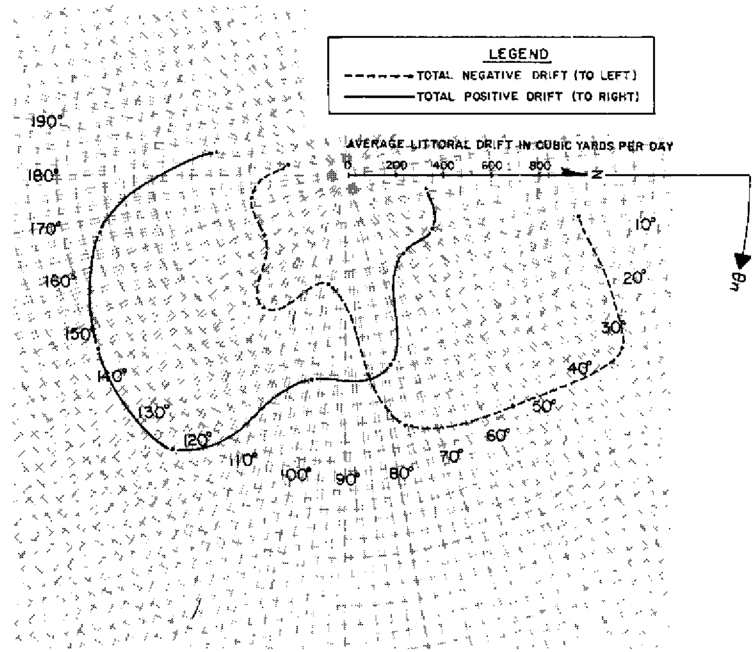


FIGURE A-82 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - APRIL

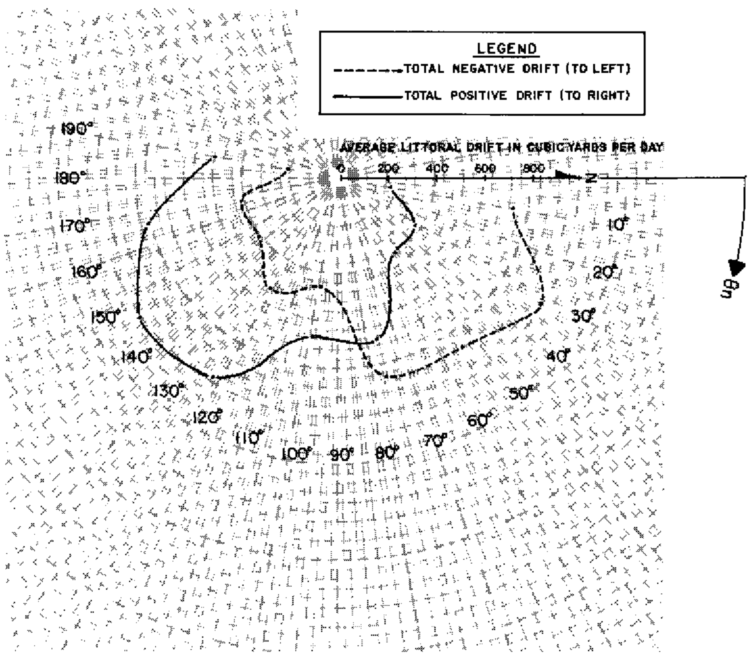


FIGURE A-83 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - MAY

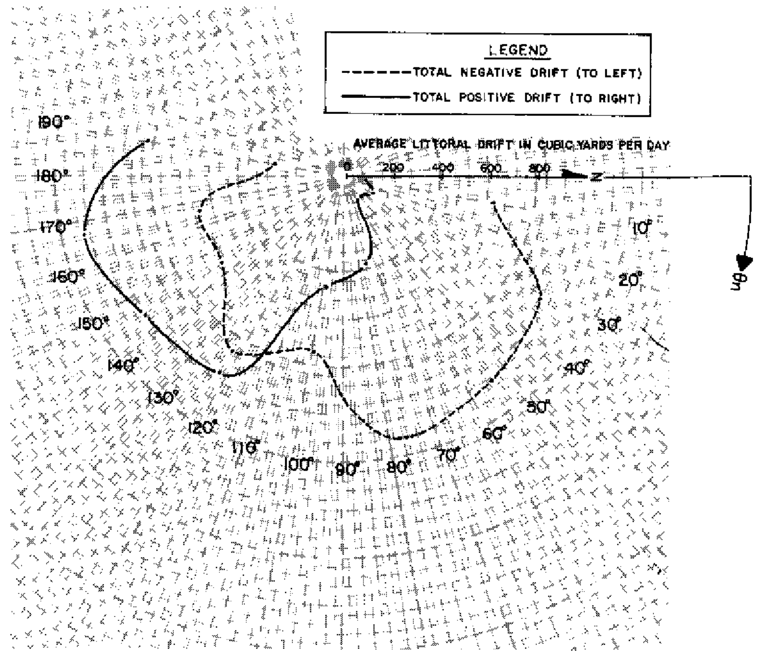


FIGURE A-84 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - JUNE

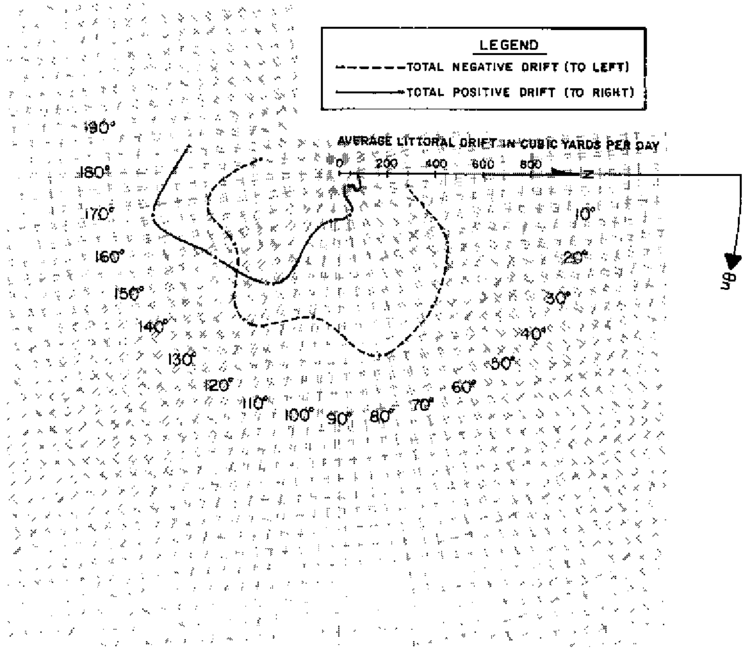


FIGURE A-85 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - JULY

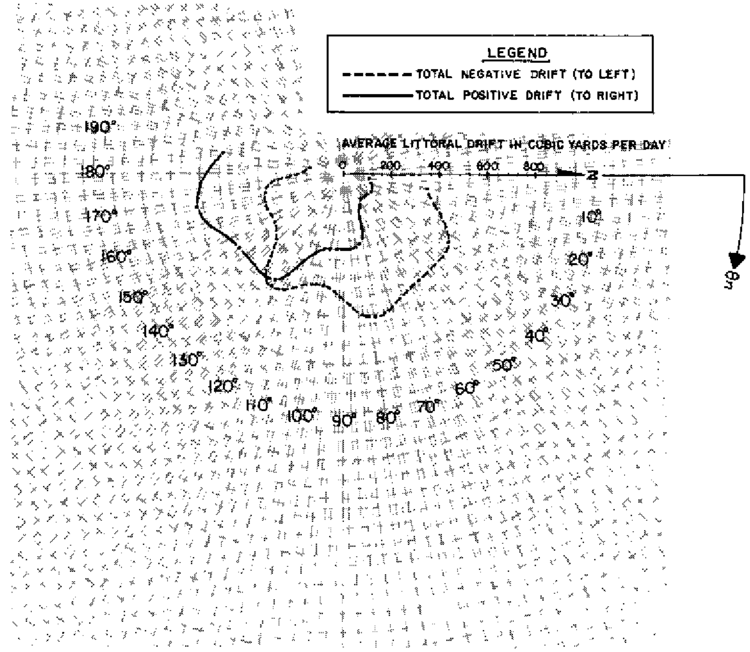


FIGURE A-86 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - AUGUST

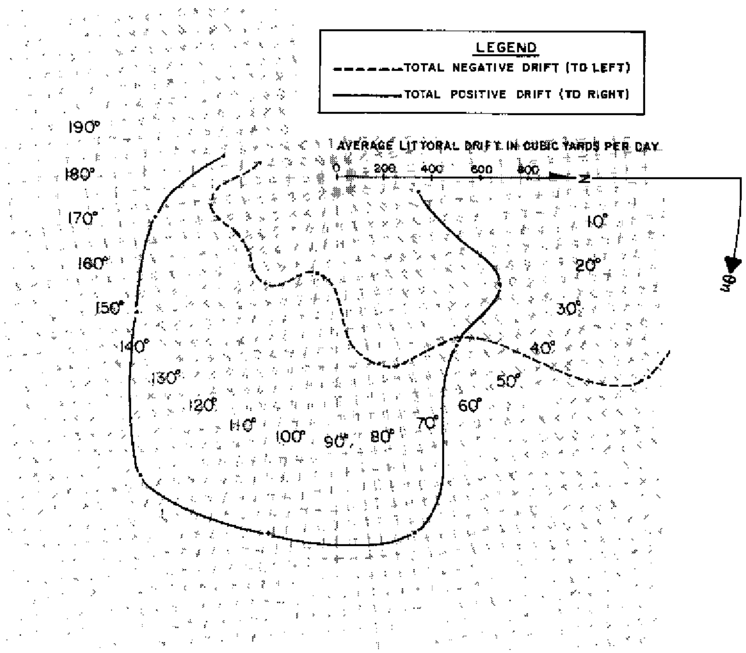


FIGURE A-87 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - SEPTEMBER

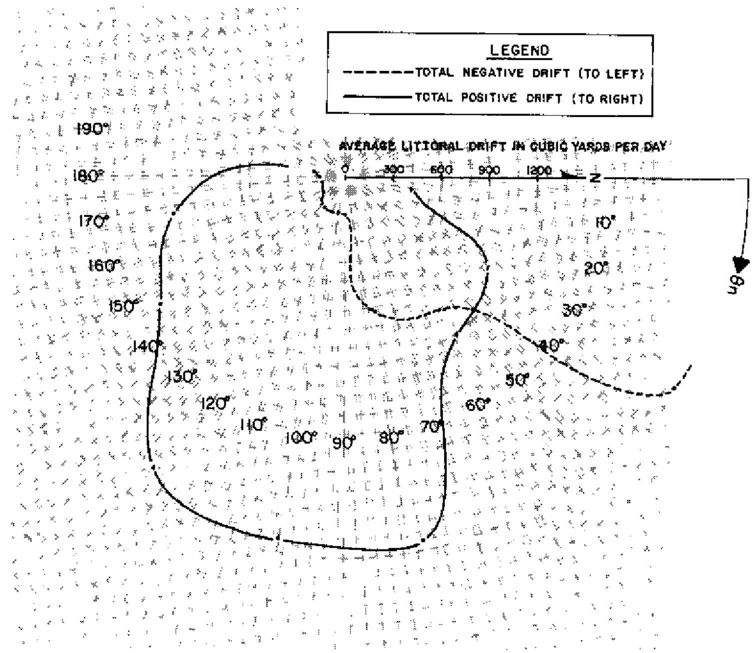


FIGURE A-88 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - OCTOBER

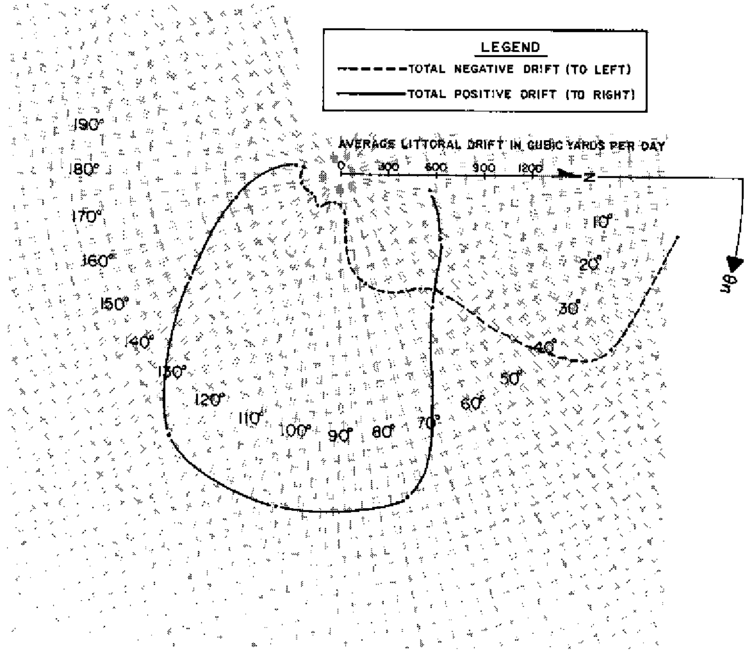


FIGURE A-89 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - NOVEMBER

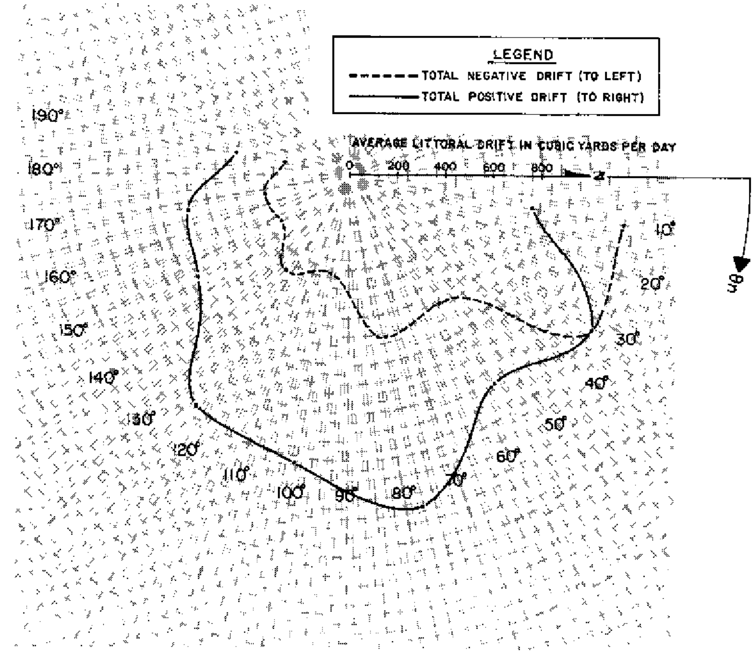


FIGURE A-90 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA - DECEMBER

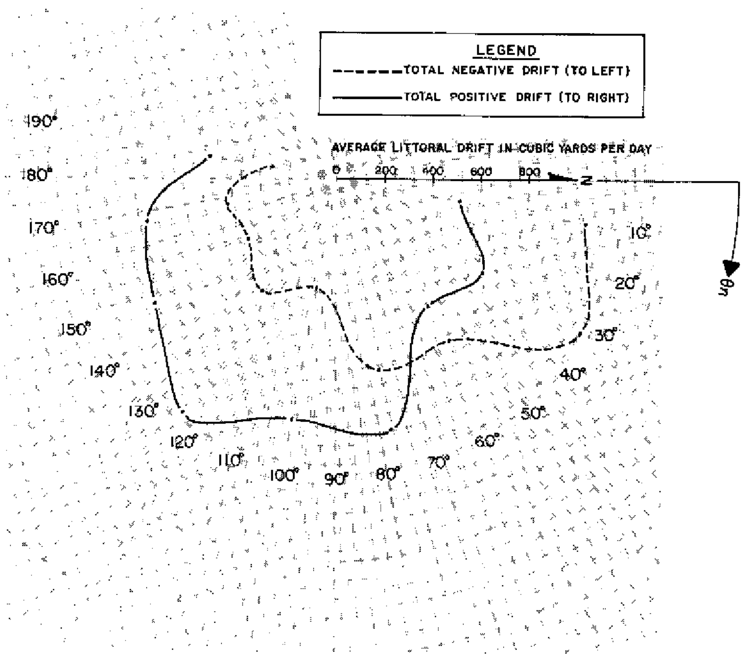


FIGURE A-91 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SEBASTIAN INLET TO FORT PIERCE INLET, FLORIDA

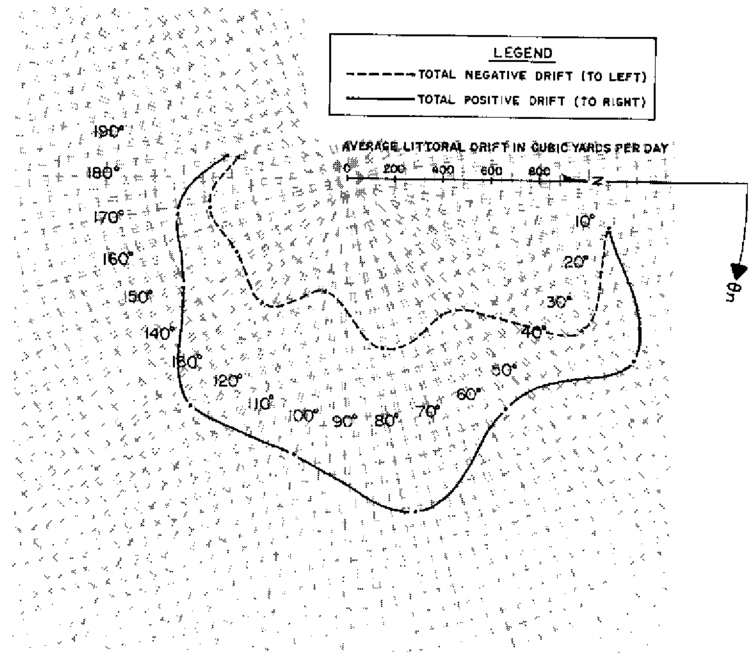


FIGURE A-92 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - JANUARY

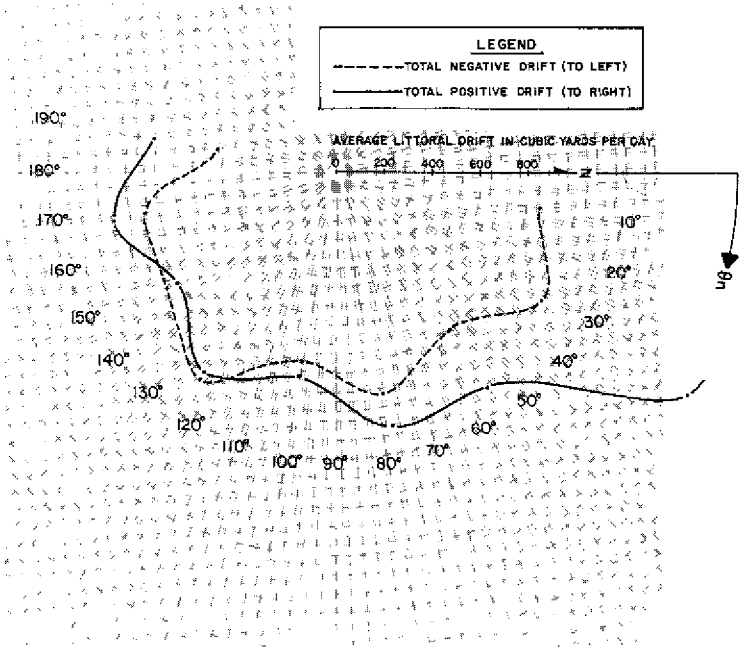


FIGURE A-93 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - FEBRUARY

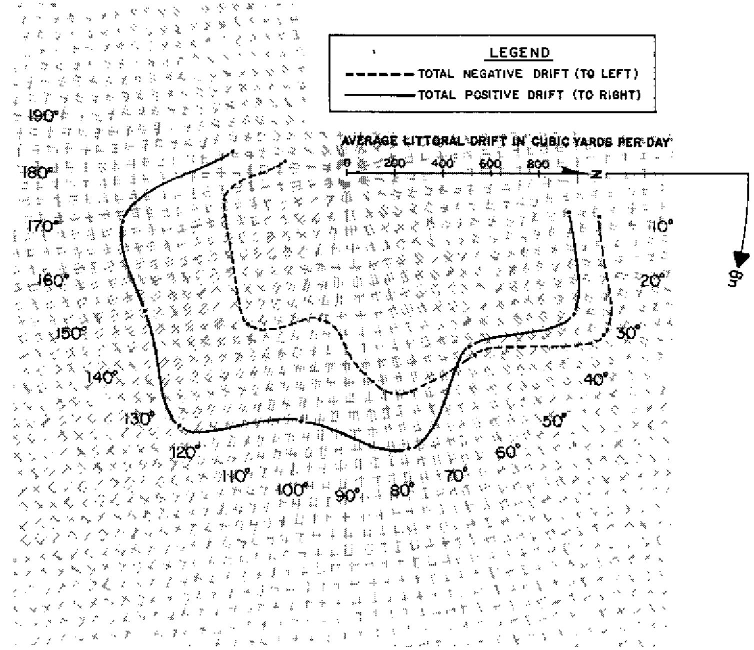


FIGURE A-94 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - MARCH

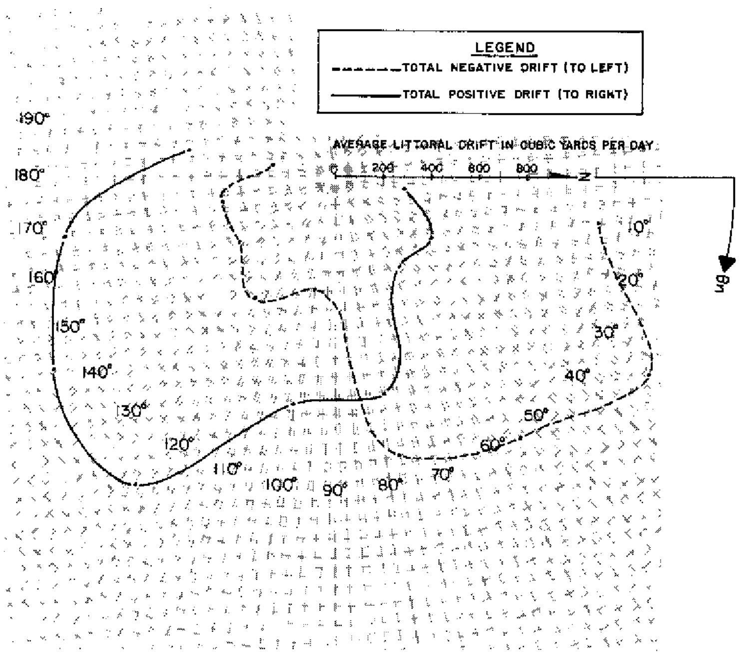


FIGURE A-95 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - APRIL

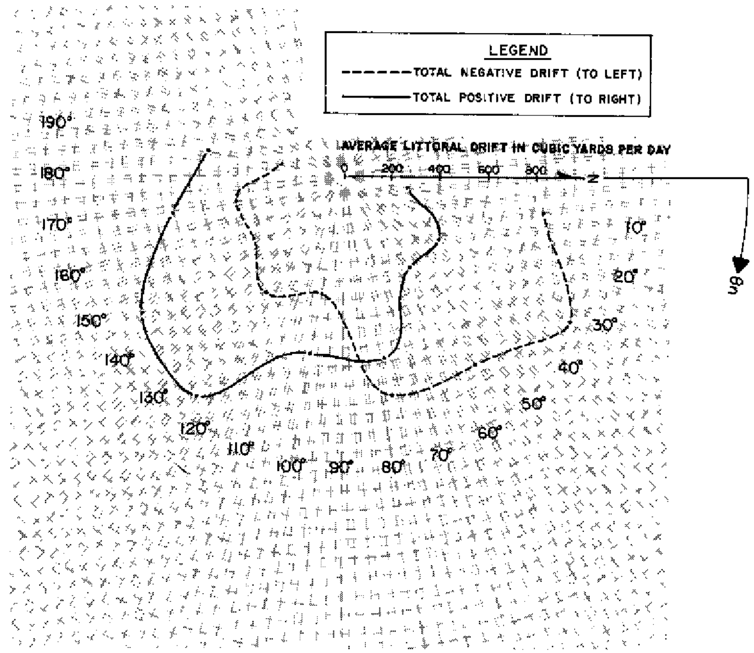


FIGURE A-96 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - MAY

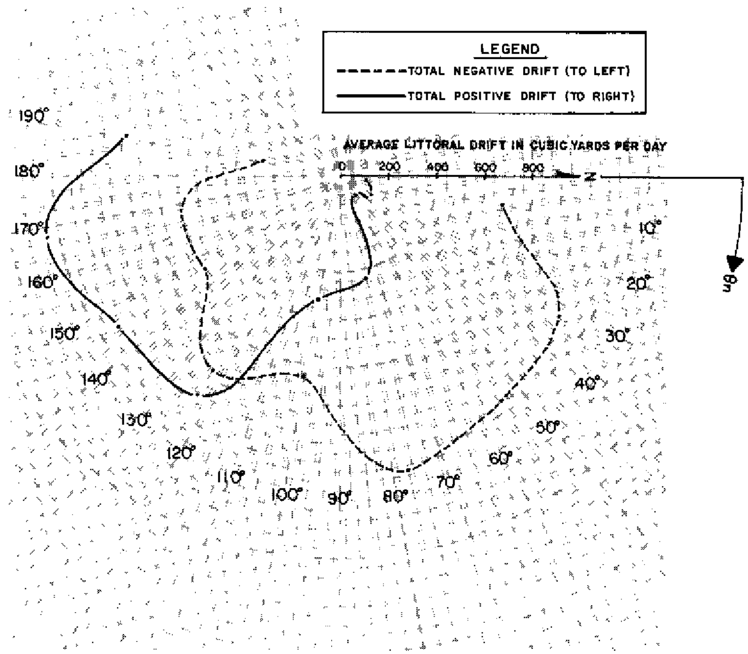


FIGURE A-97 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - JUNE

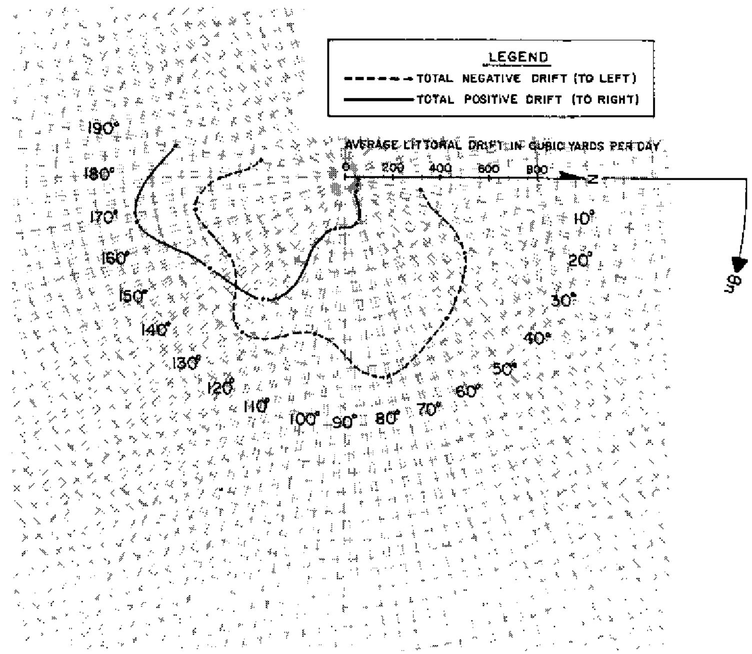


FIGURE A-98 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - JULY

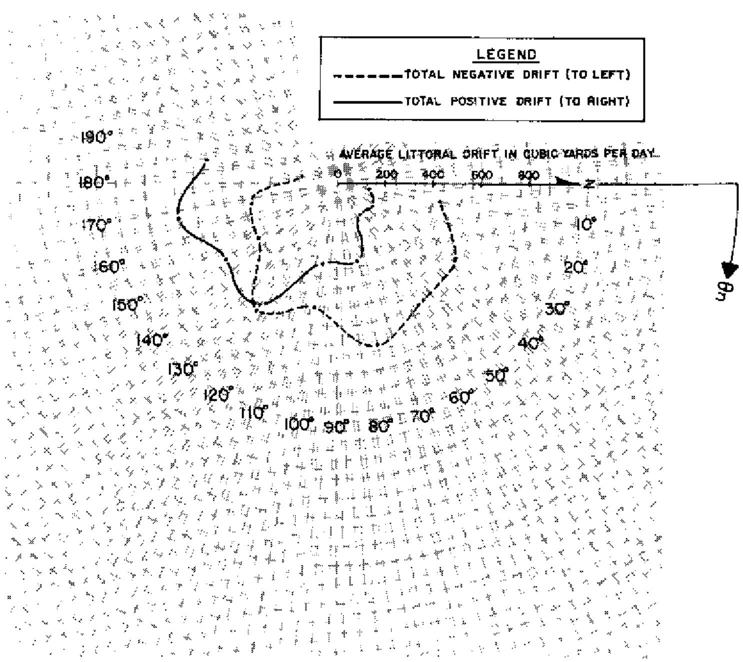


FIGURE A-99 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - AUGUST

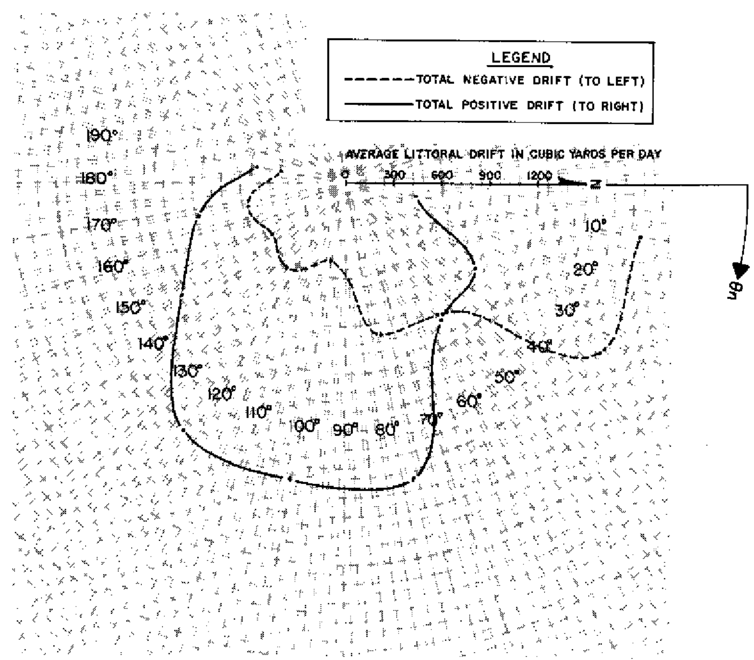


FIGURE A-100 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - SEPTEMBER

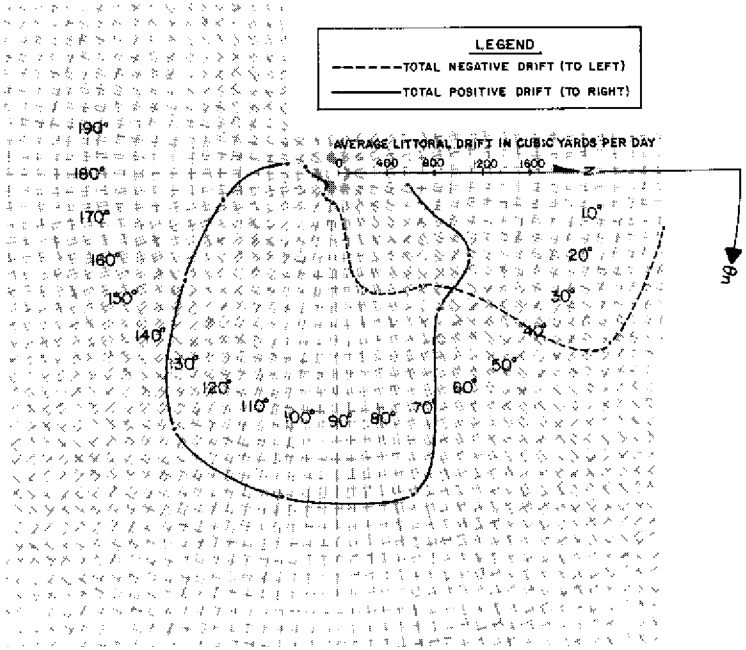


FIGURE A-101 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - OCTOBER

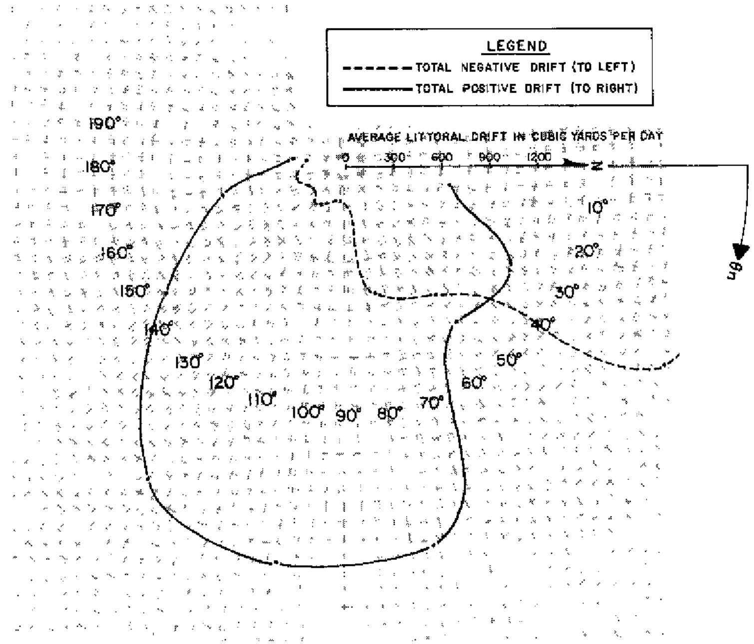


FIGURE A-102 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - NOVEMBER

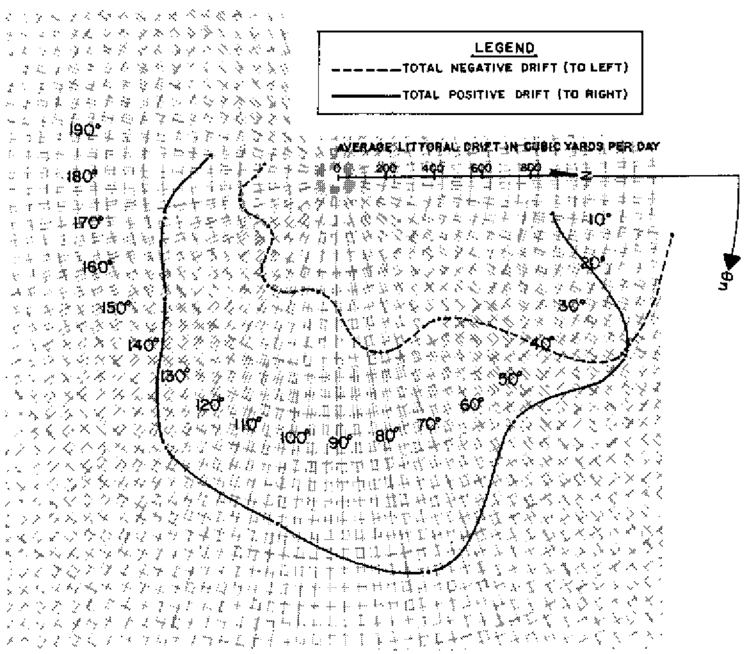


FIGURE A-103 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA - DECEMBER

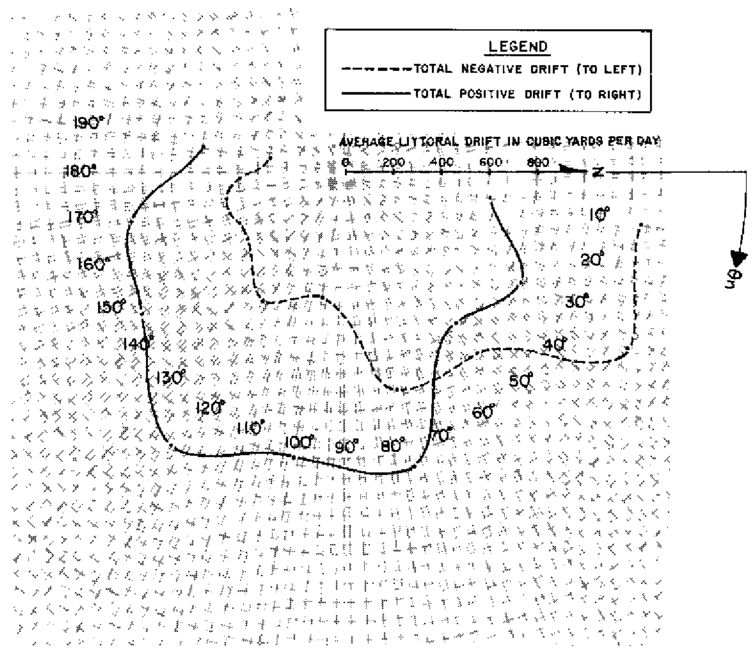


FIGURE A-104 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - FORT PIERCE INLET TO ST. LUCIE INLET, FLORIDA

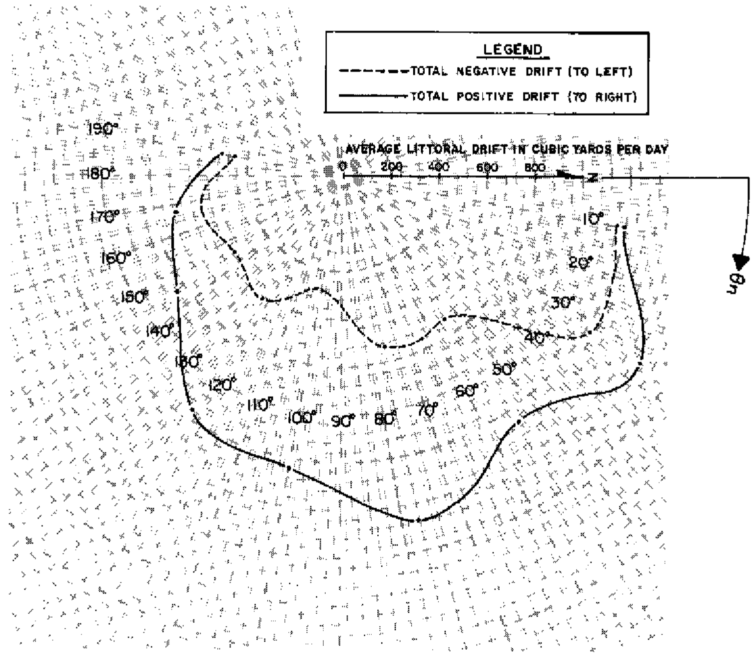


FIGURE A-105 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - JANUARY

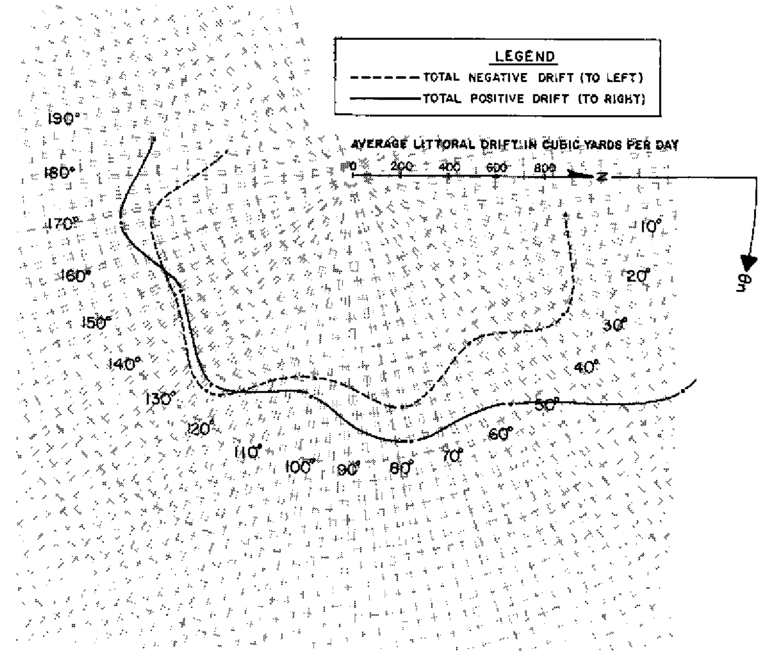


FIGURE A-106 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - FEBRUARY

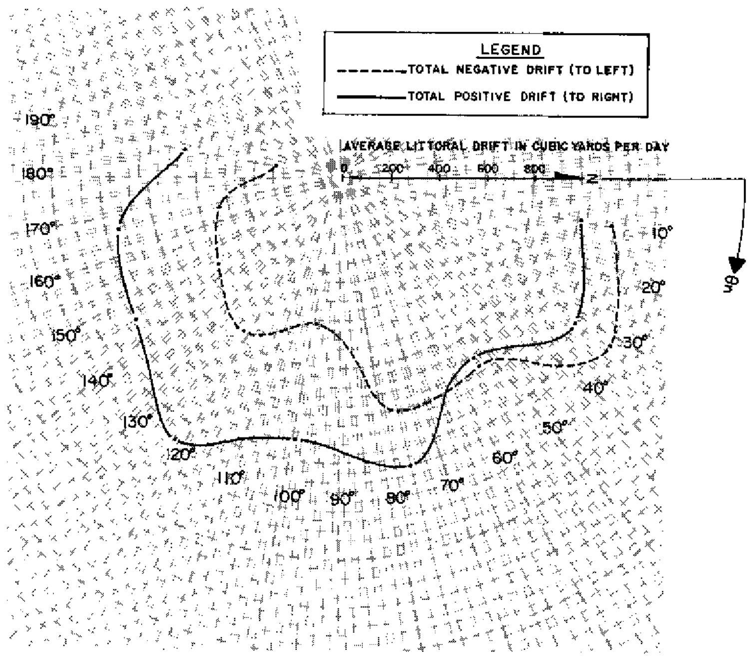


FIGURE A-107 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - MARCH

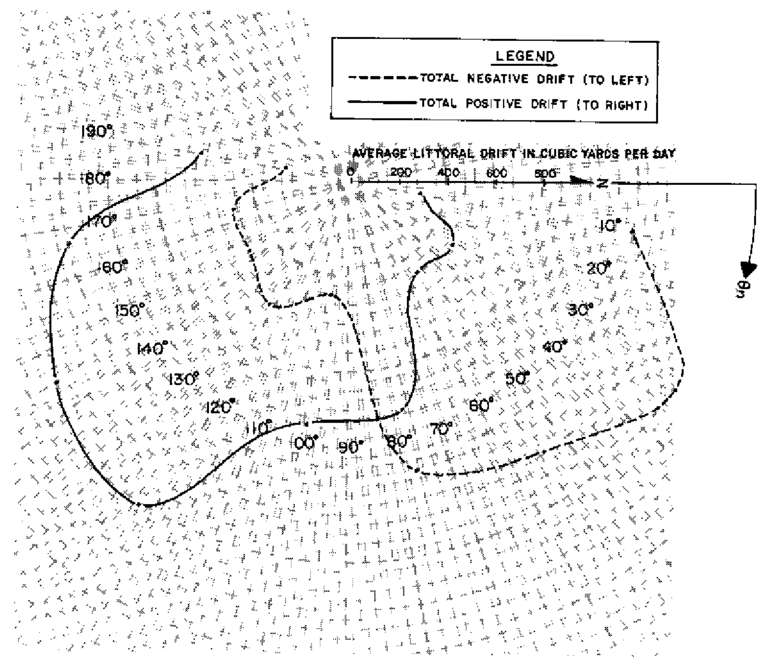


FIGURE A-108 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - APRIL

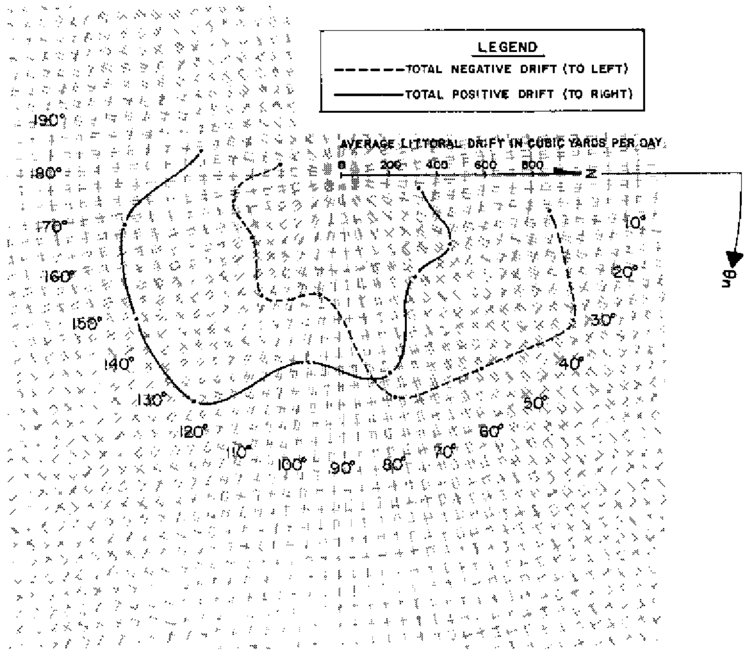


FIGURE A-109 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - MAY

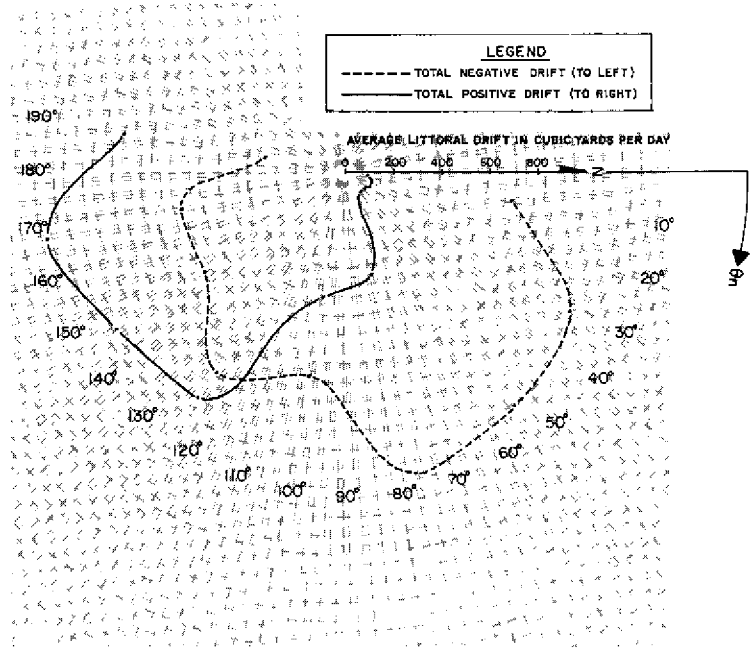


FIGURE A-110 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - JUNE

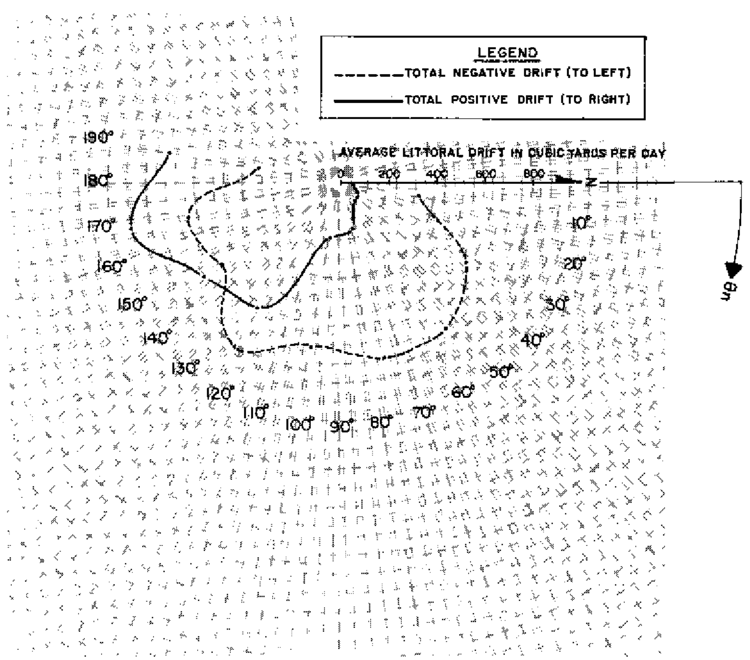


FIGURE A-111 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - JULY

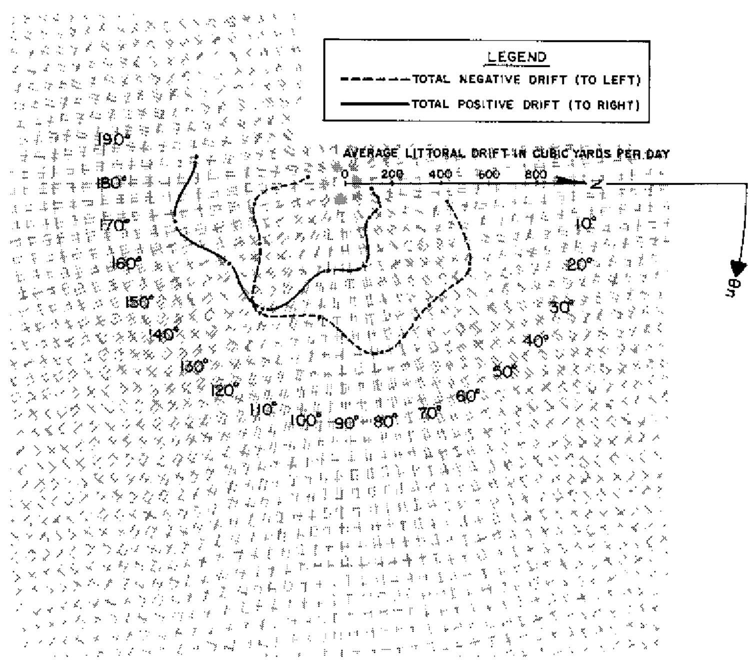


FIGURE A-112 VARIATION OR AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - AUGUST

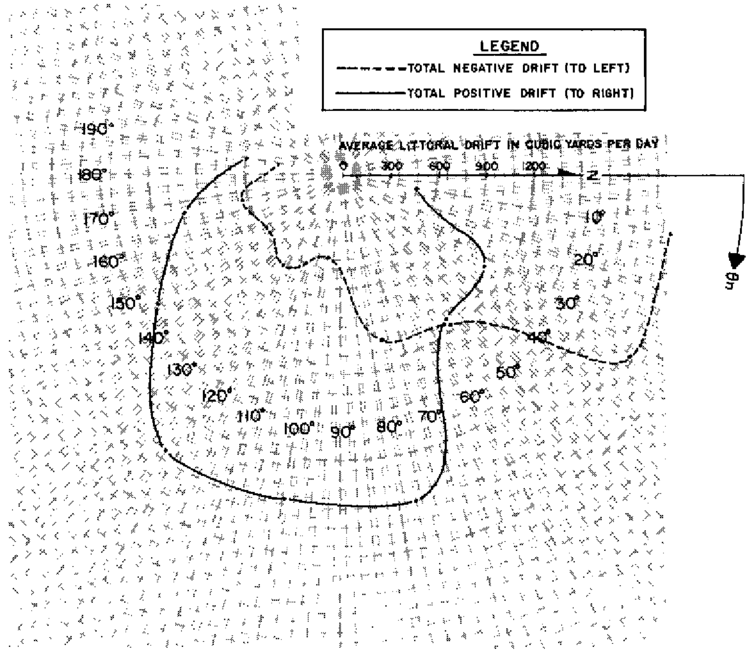


FIGURE A-113 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - SEPTEMBER

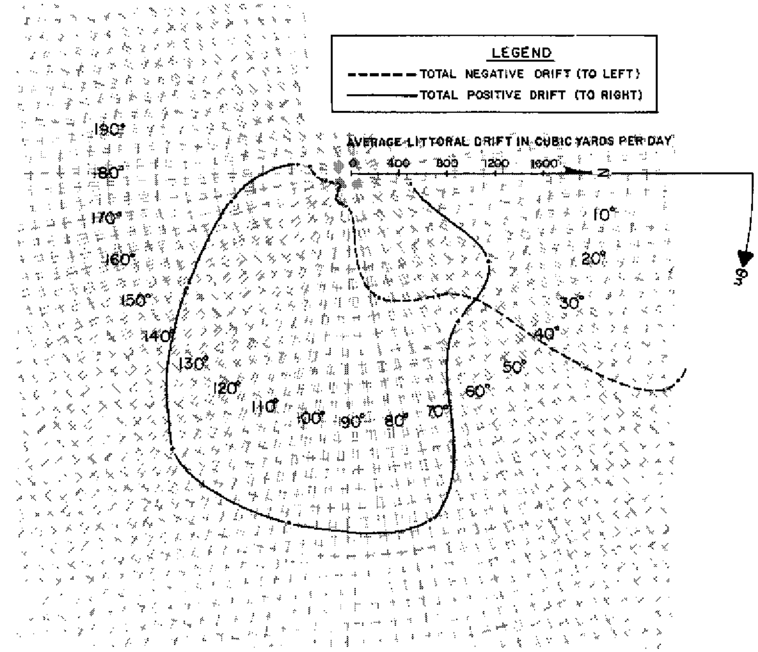


FIGURE A-114 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - OCTOBER

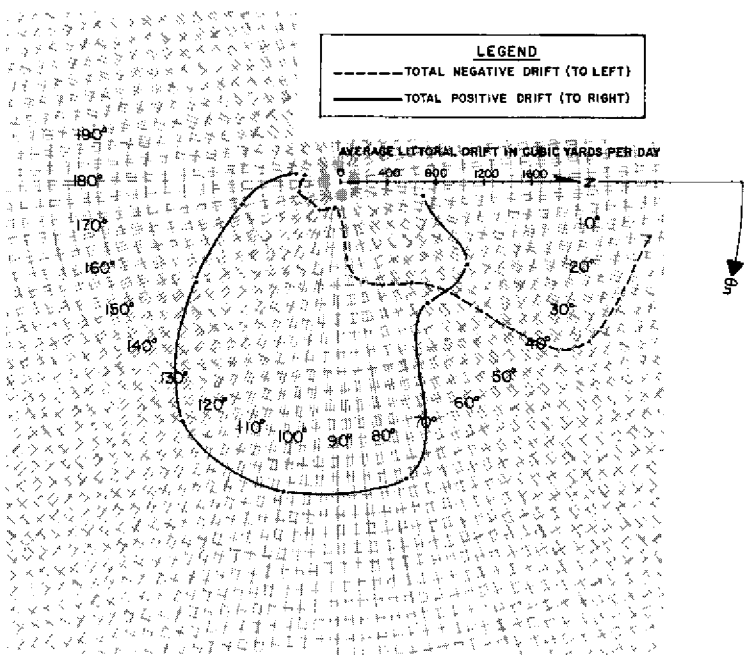


FIGURE A-115 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - NOVEMBER

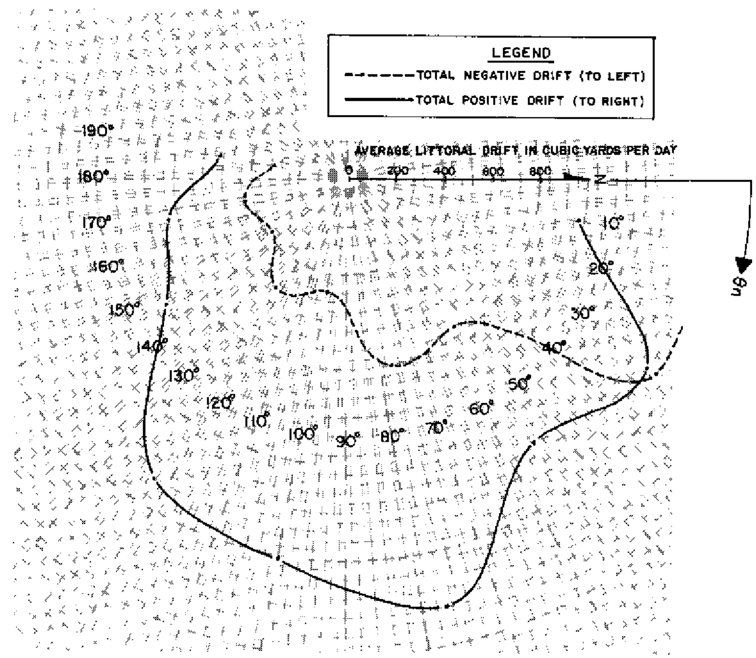


FIGURE A-116 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA - DECEMBER

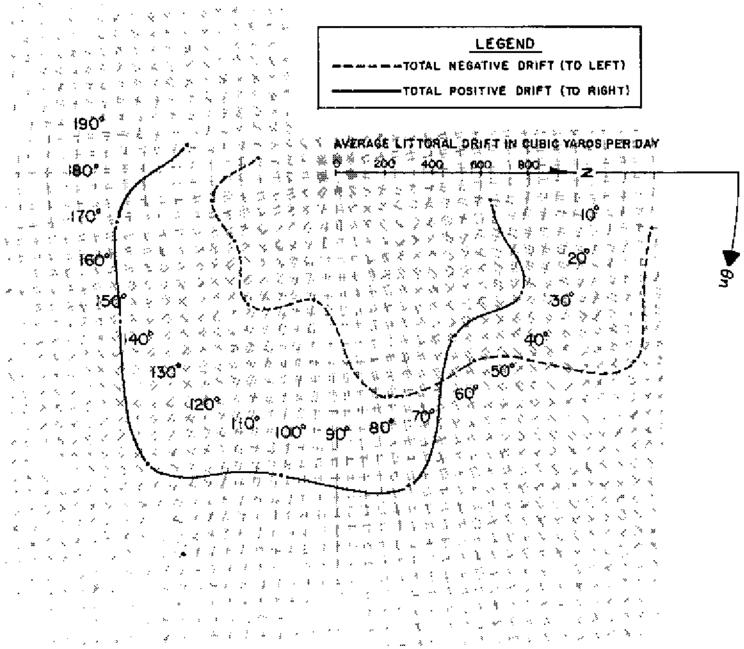


FIGURE A-117 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. LUCIE INLET TO JUPITER INLET, FLORIDA

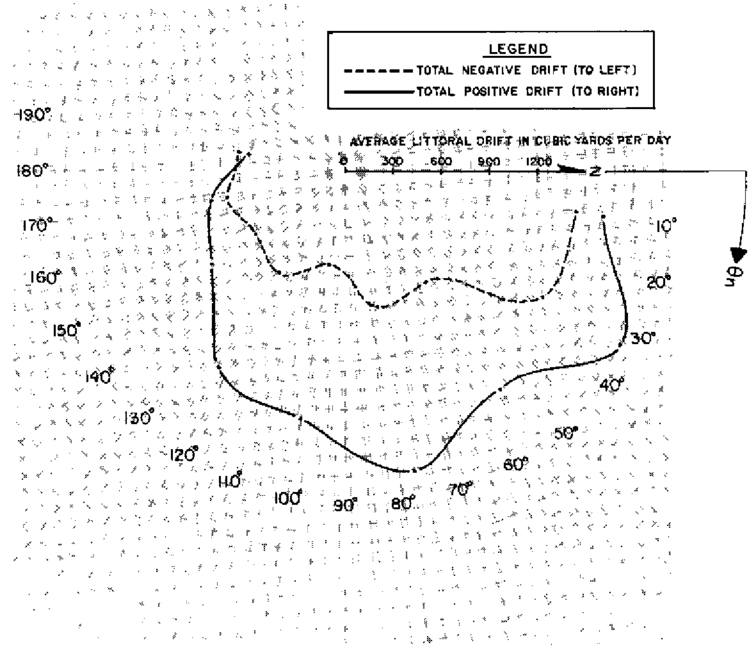


FIGURE A-118 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - JANUARY

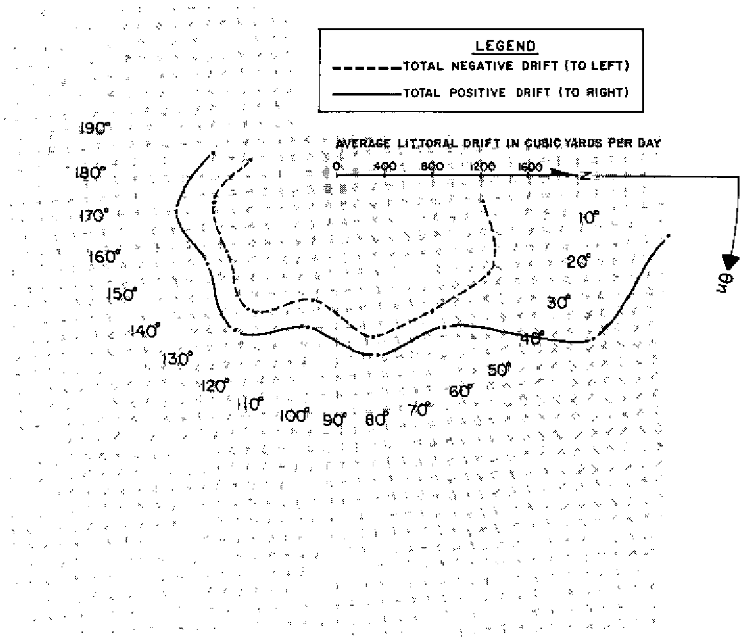


FIGURE A-119 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - FEBRUARY

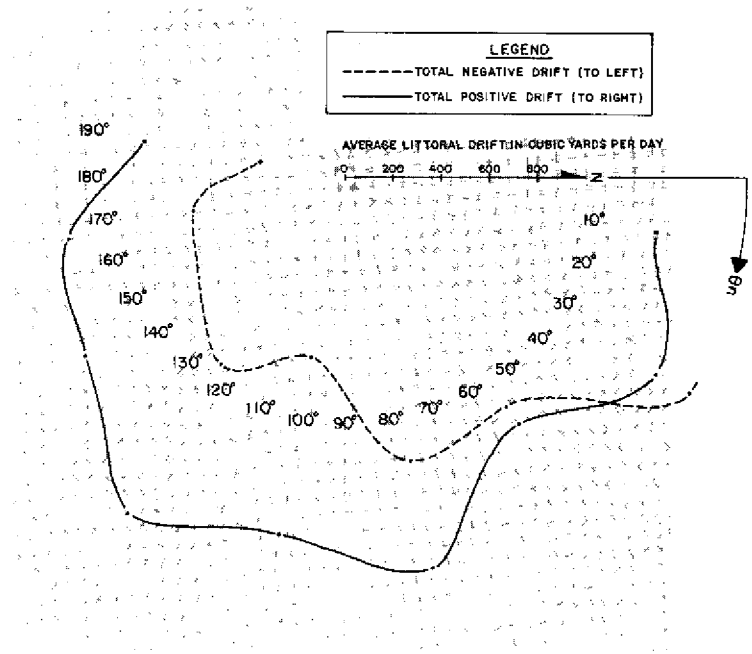


FIGURE A-120 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - MARCH

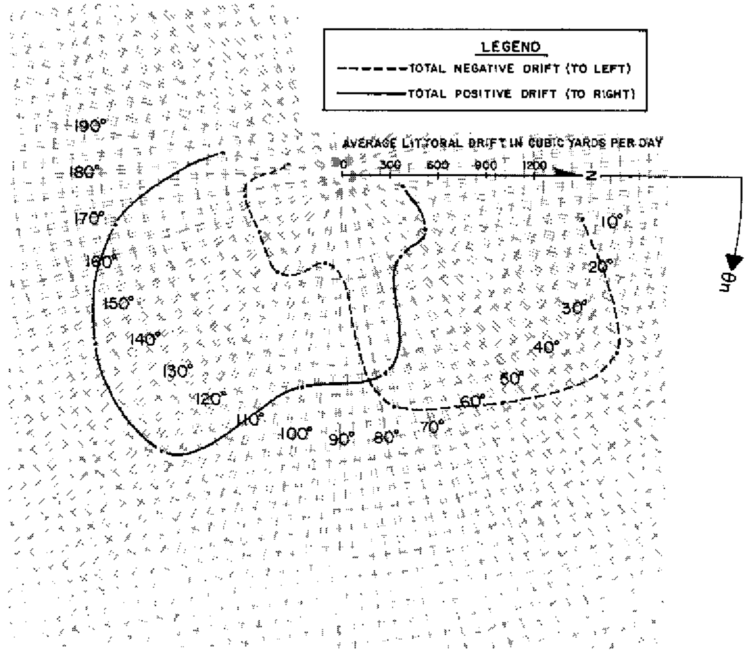


FIGURE A-121 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - APRIL

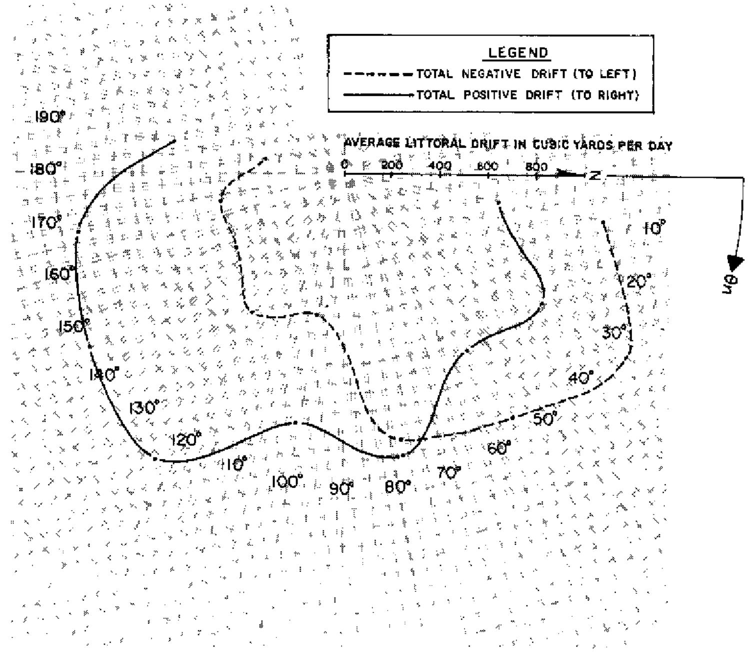


FIGURE A-122 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - MAY

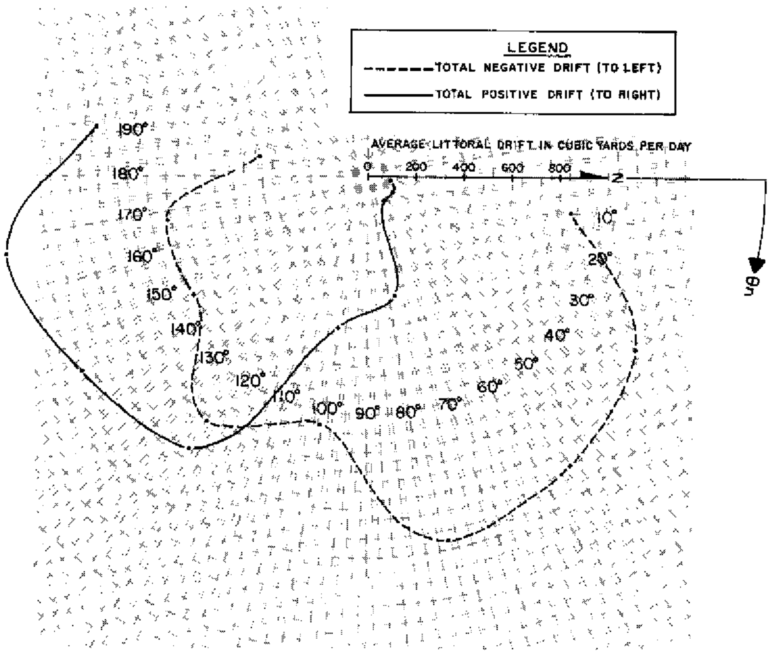


FIGURE A-123 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - JUNE

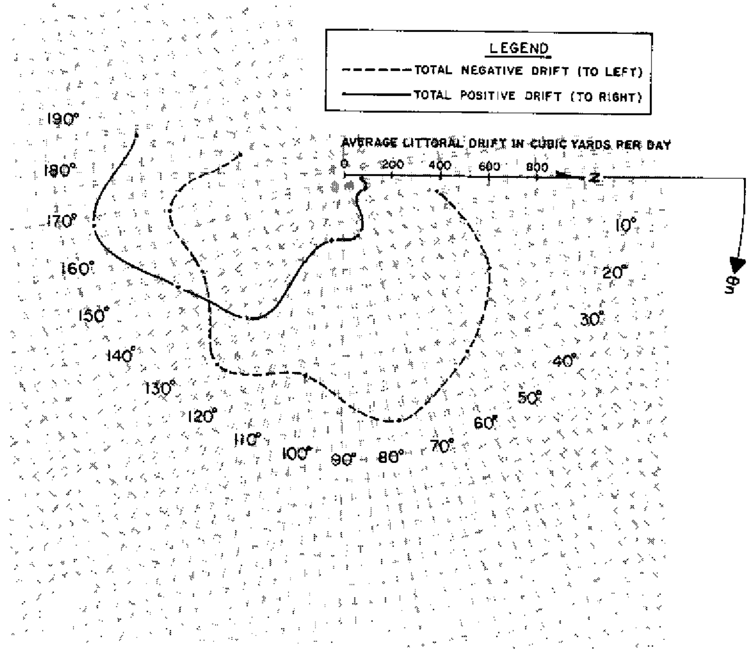


FIGURE A-124 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - JULY

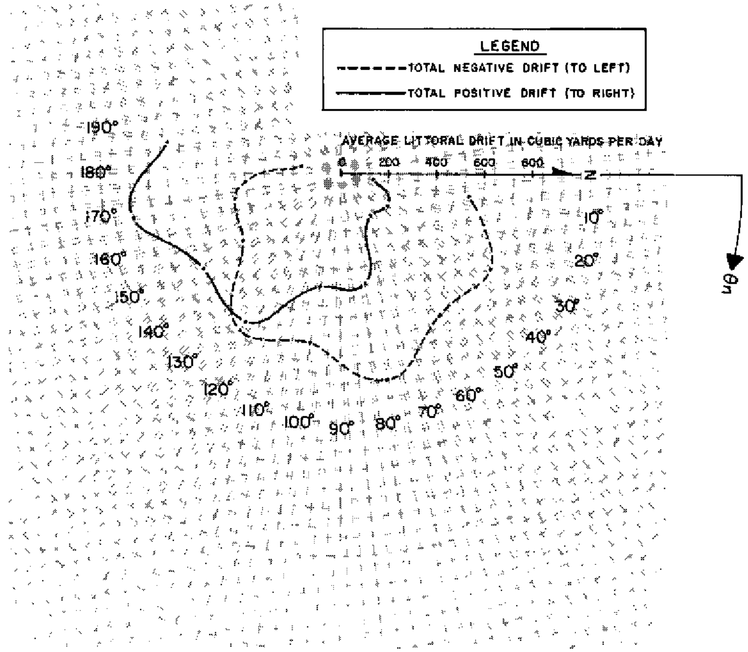


FIGURE A-125 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - AUGUST

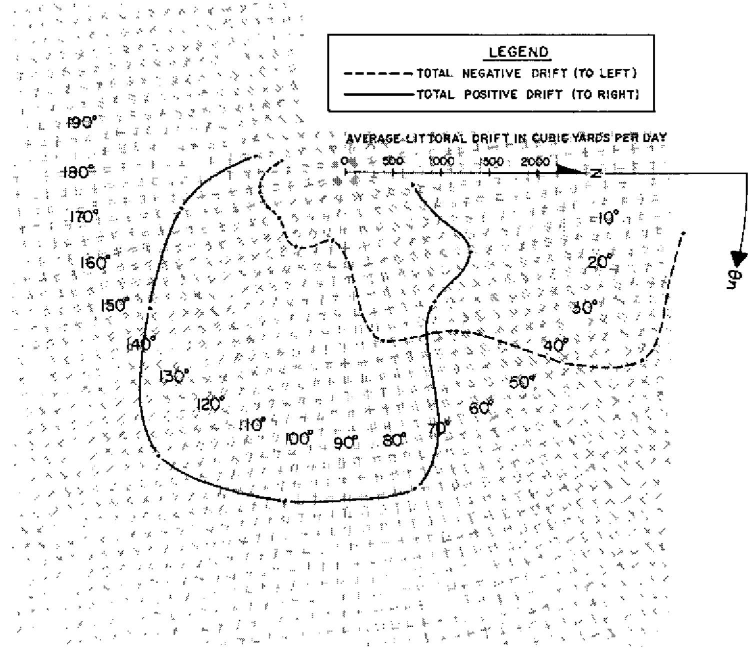


FIGURE A-126 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - SEPTEMBER

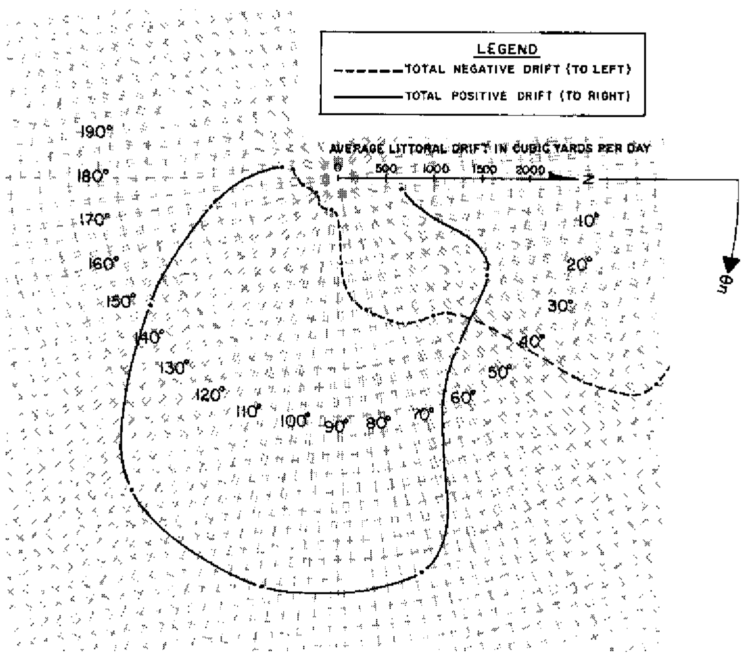


FIGURE A-127 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - OCTOBER

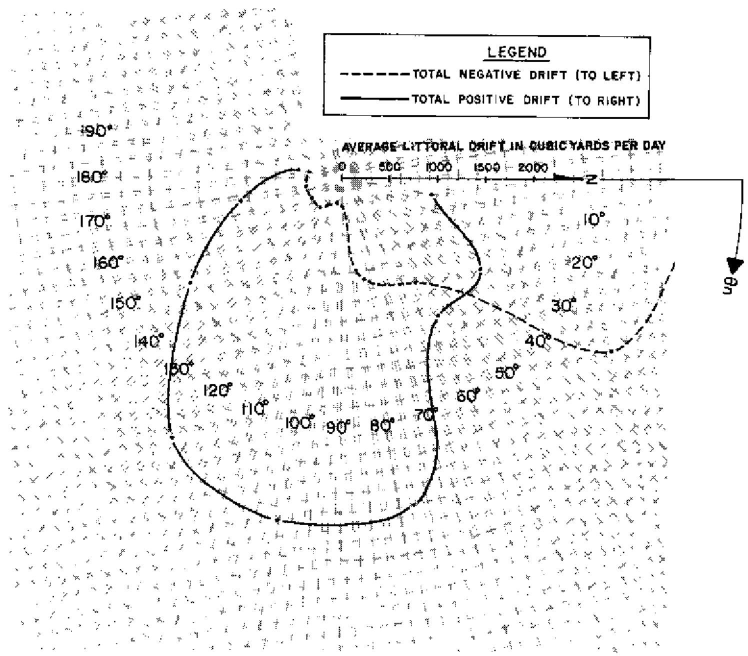


FIGURE A-128 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - NOVEMBER

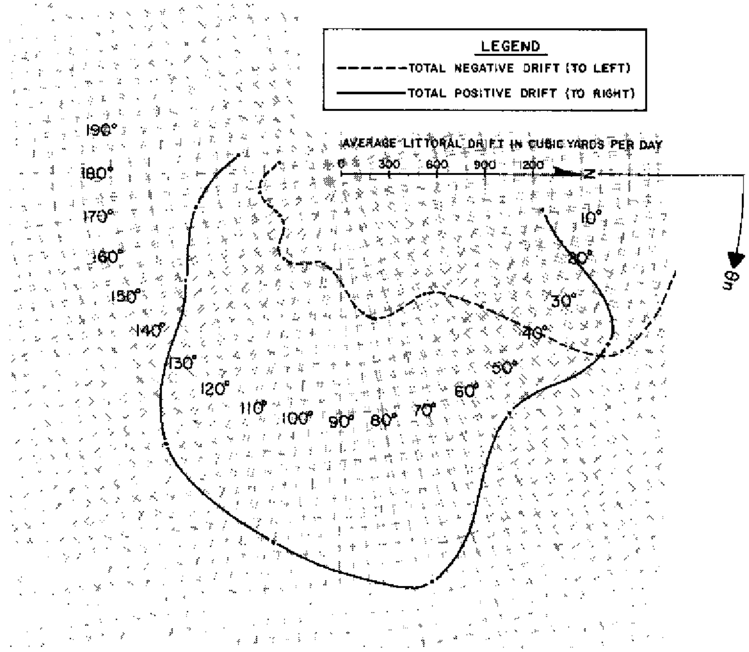


FIGURE A-129 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA - DECEMBER

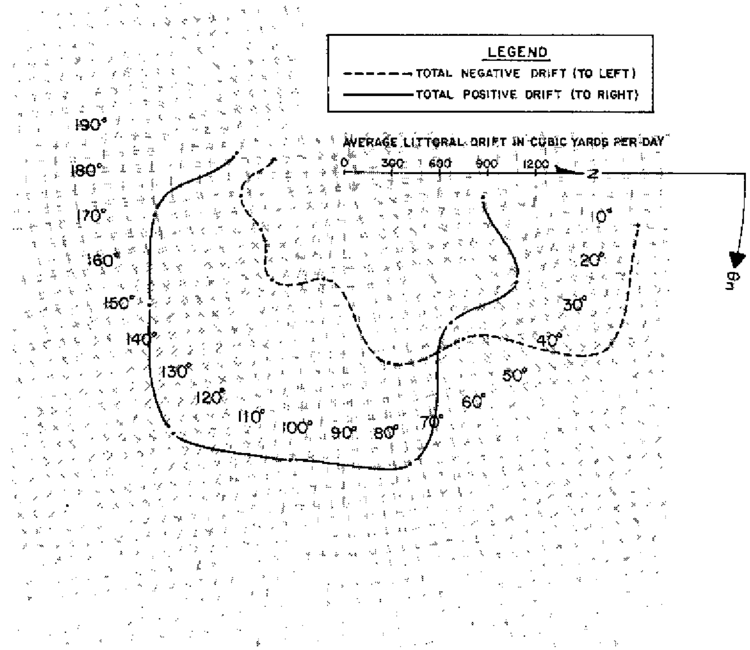


FIGURE A-130 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - JUPITER INLET TO LAKE WORTH, FLORIDA

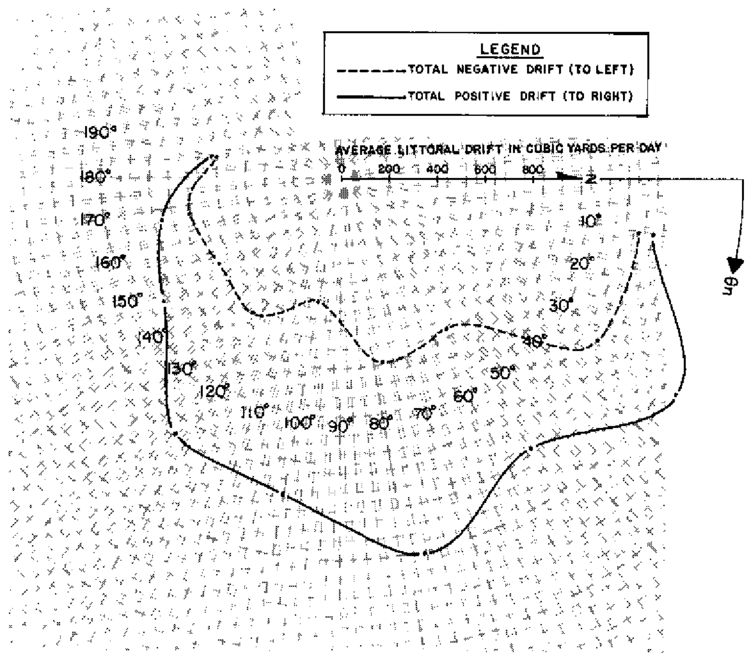


FIGURE A-131 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - JANUARY

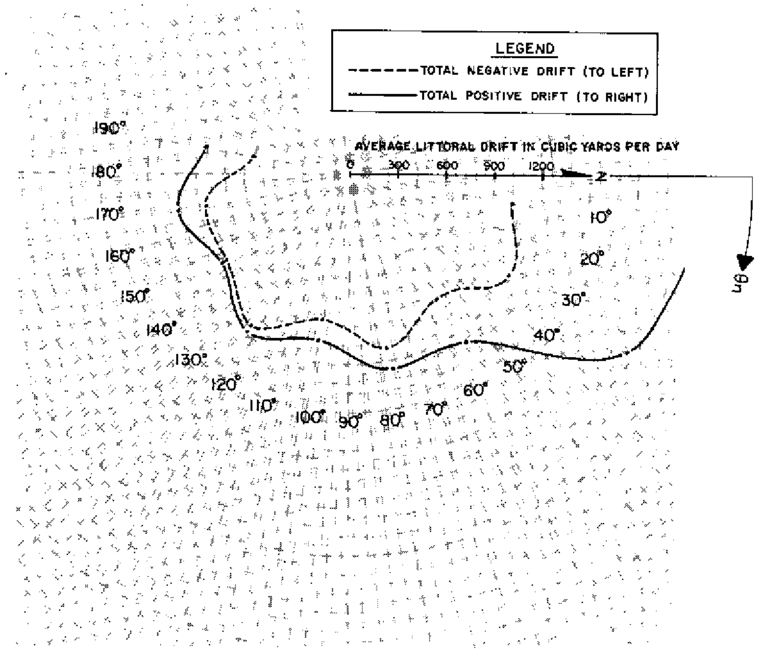


FIGURE A-132 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - FEBRUARY

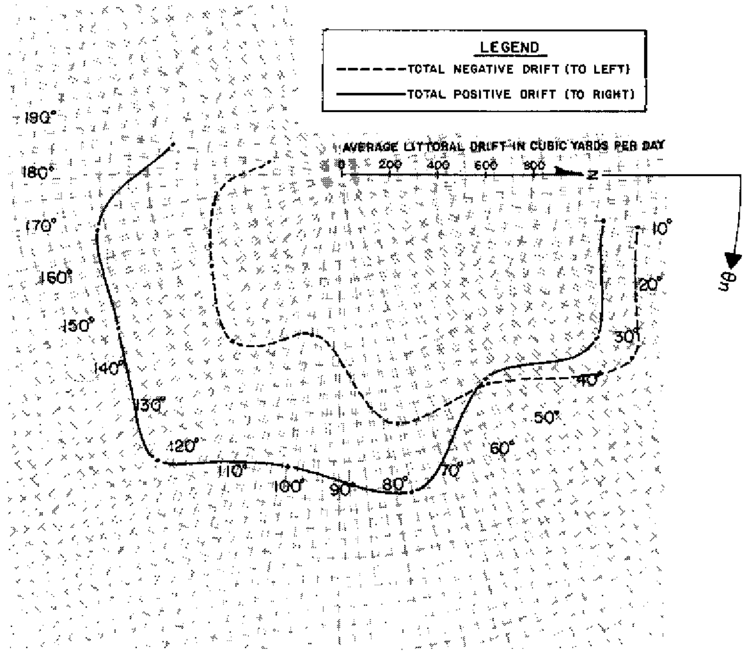


FIGURE A-133 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - MARCH

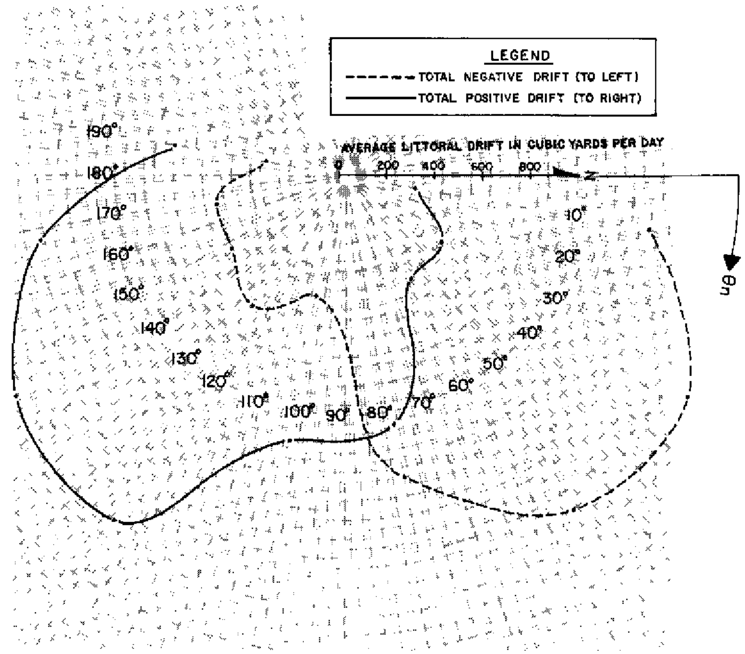


FIGURE A-134 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - APRIL

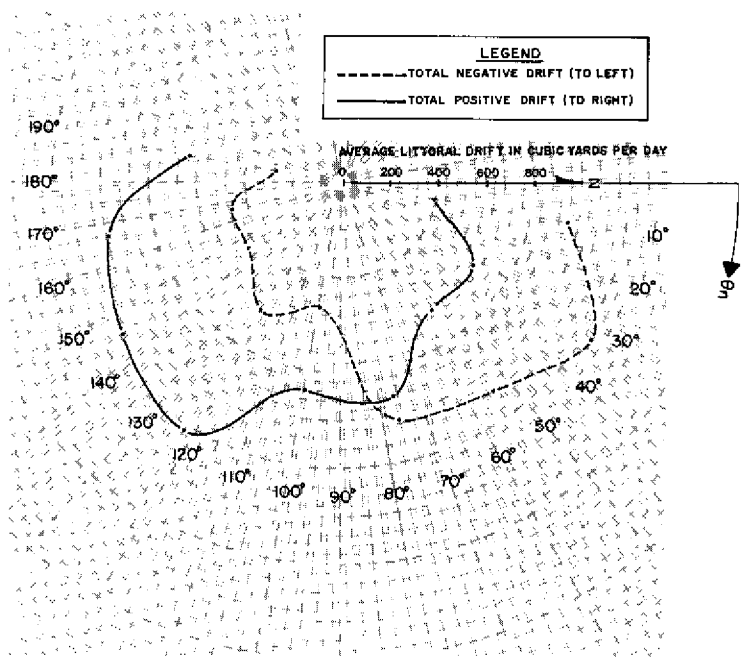


FIGURE A-135 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - MAY

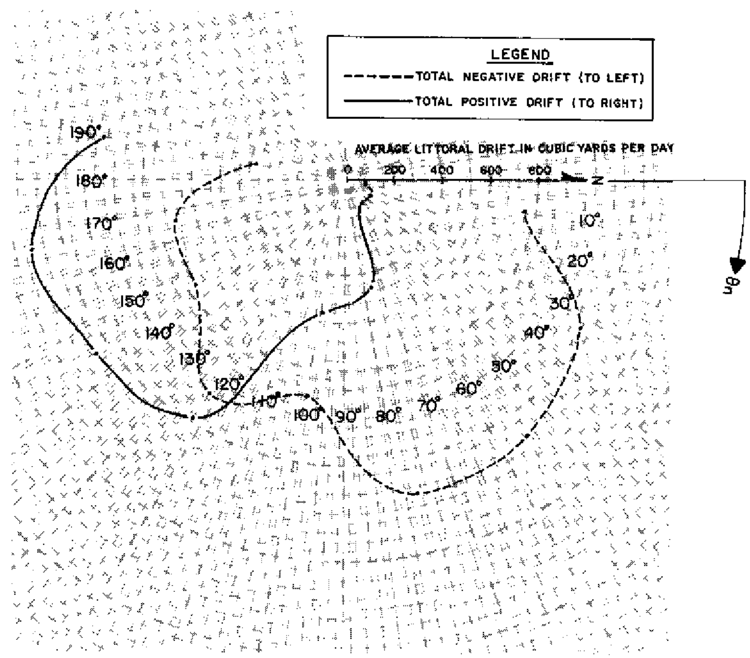


FIGURE A-136 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - JUNE

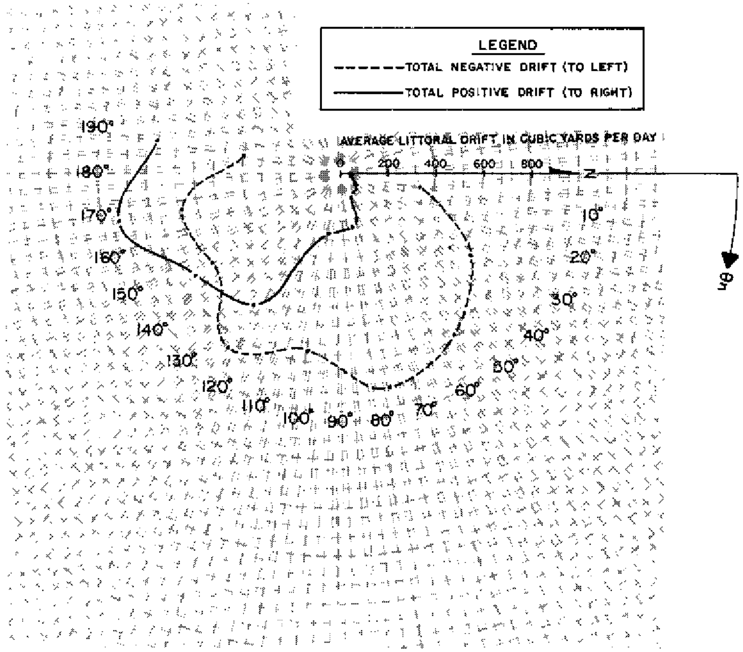


FIGURE A-137 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - JULY

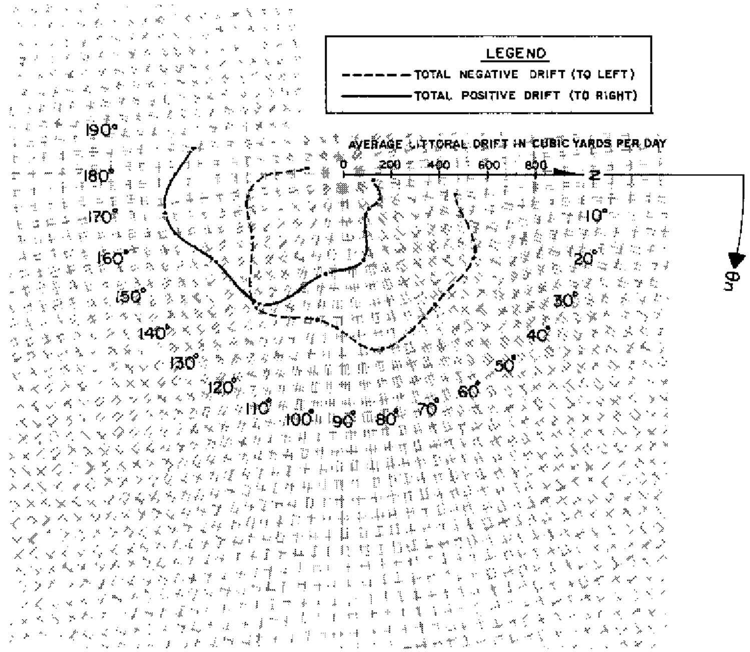


FIGURE A-138 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - AUGUST

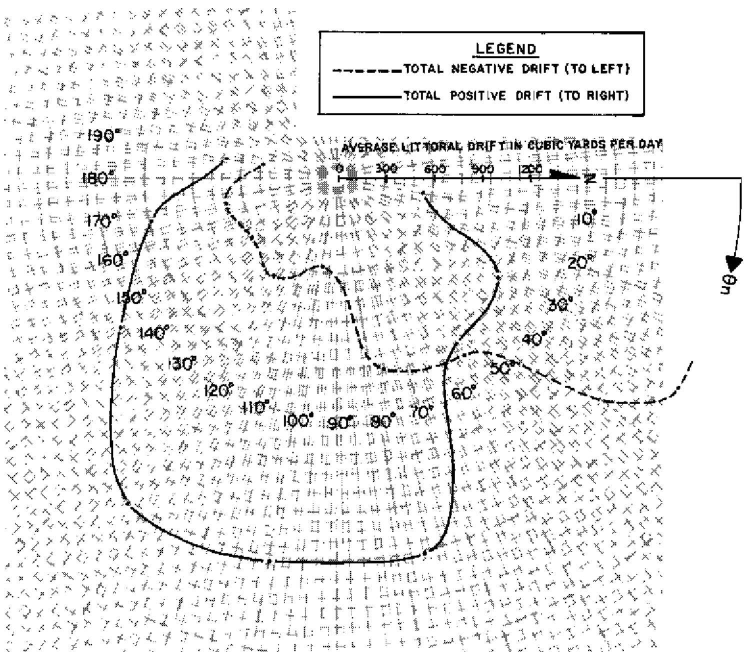


FIGURE A-139 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - SEPTEMBER

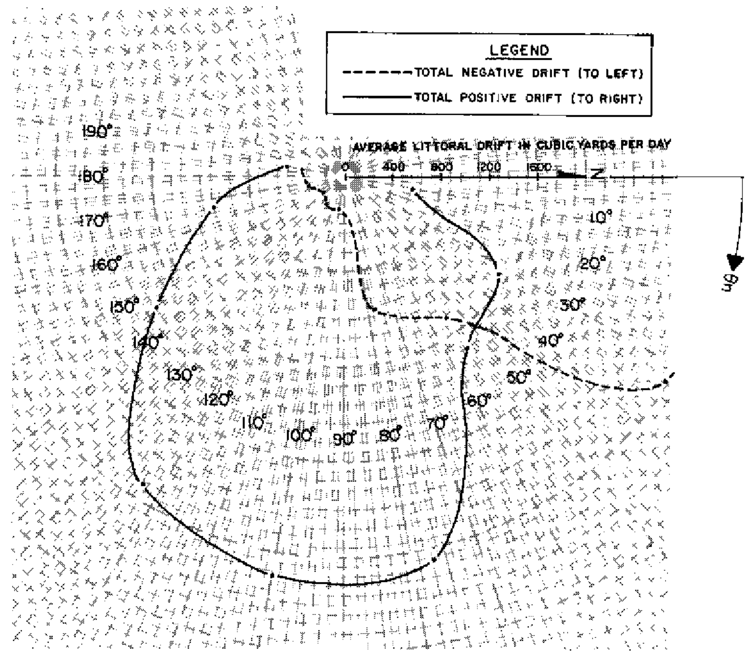


FIGURE A-140 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - OCTOBER

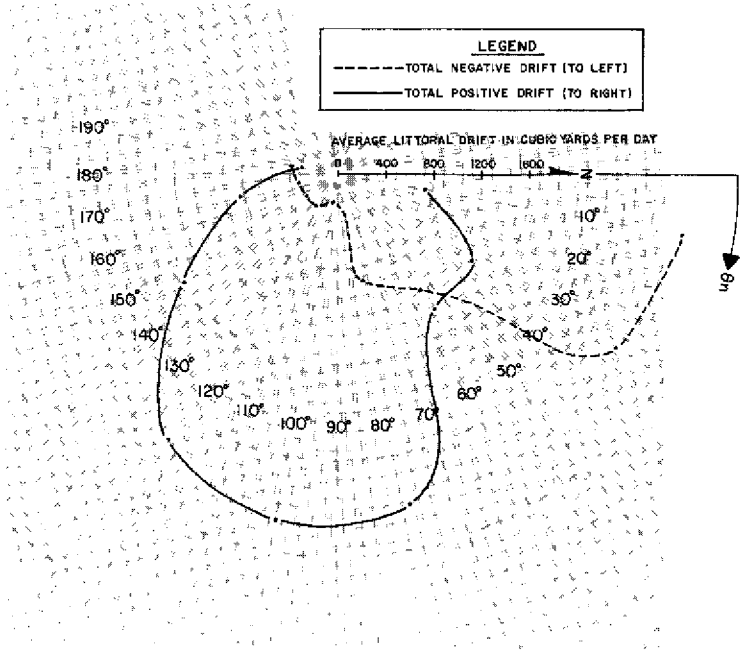


FIGURE A-141 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - NOVEMBER

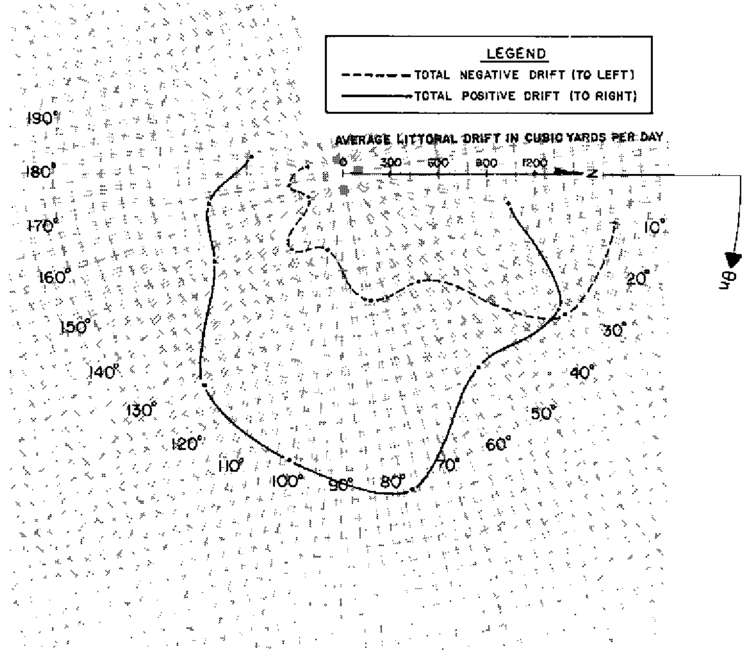


FIGURE A-142 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA - DECEMBER

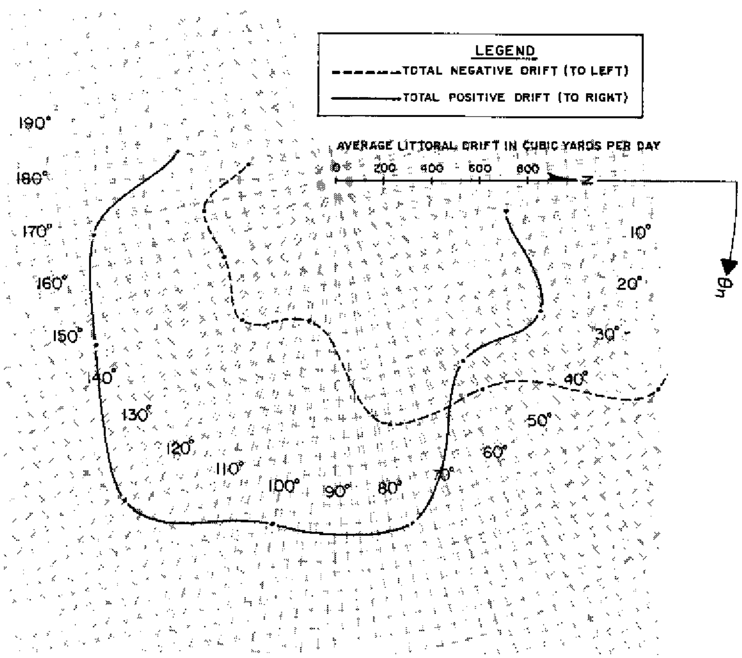


FIGURE A-143 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LAKE WORTH TO HILLSBORO INLET, FLORIDA

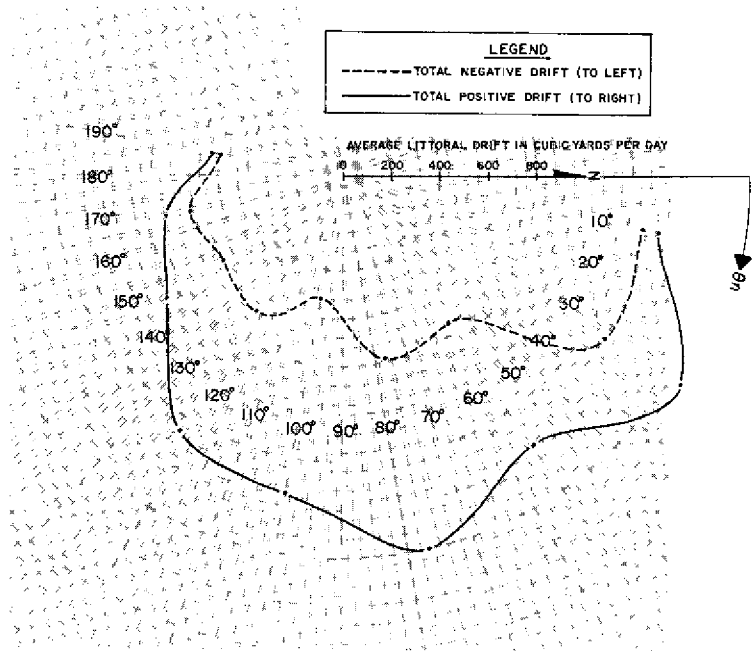


FIGURE A-144 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - JANUARY

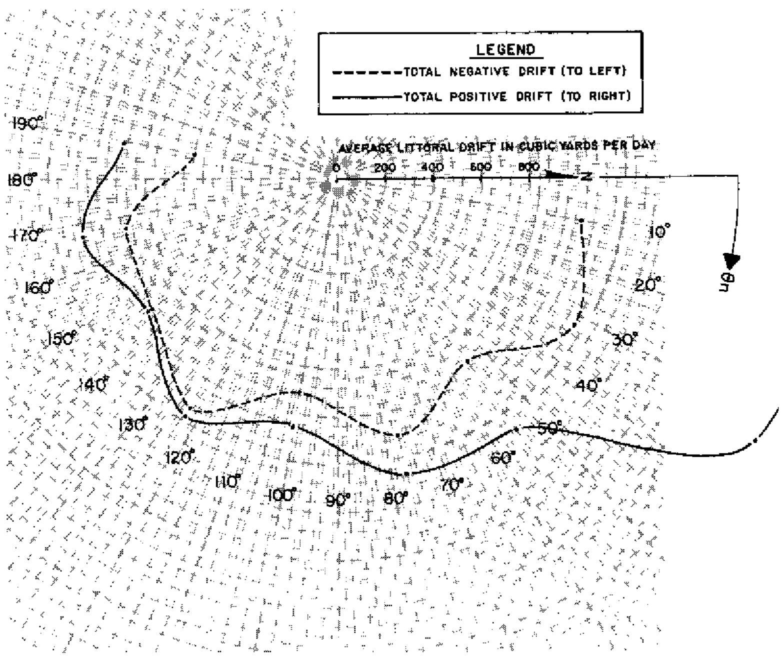


FIGURE A-145 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - FEBRUARY

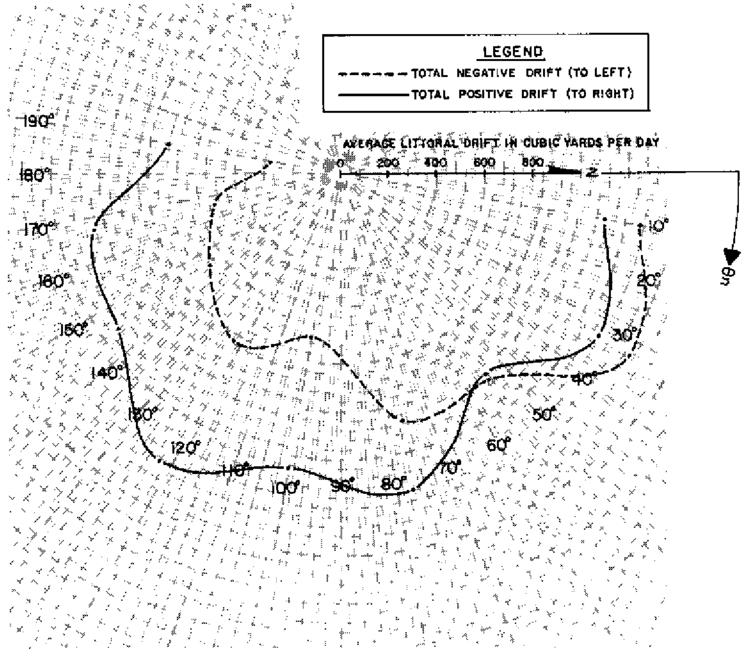


FIGURE A-146 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - MARCH

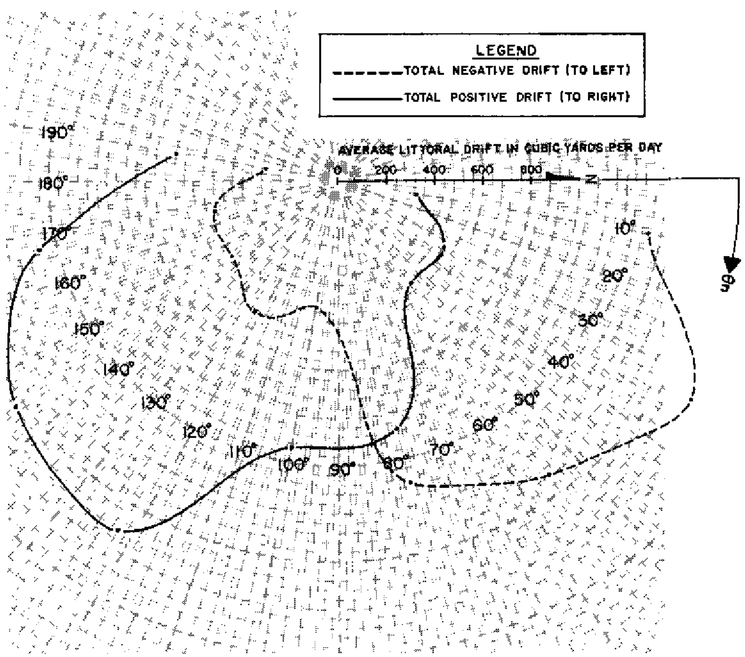


FIGURE A-147 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - APRIL

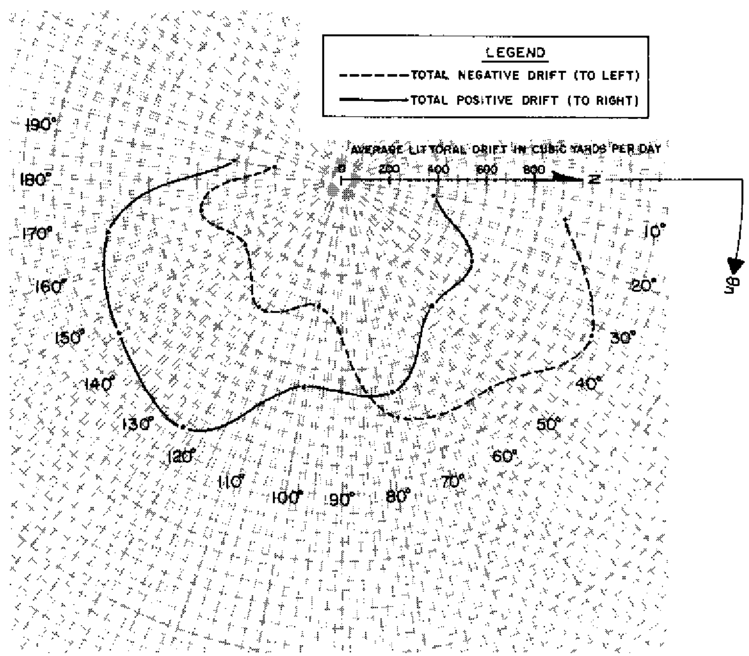


FIGURE A-148 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - MAY

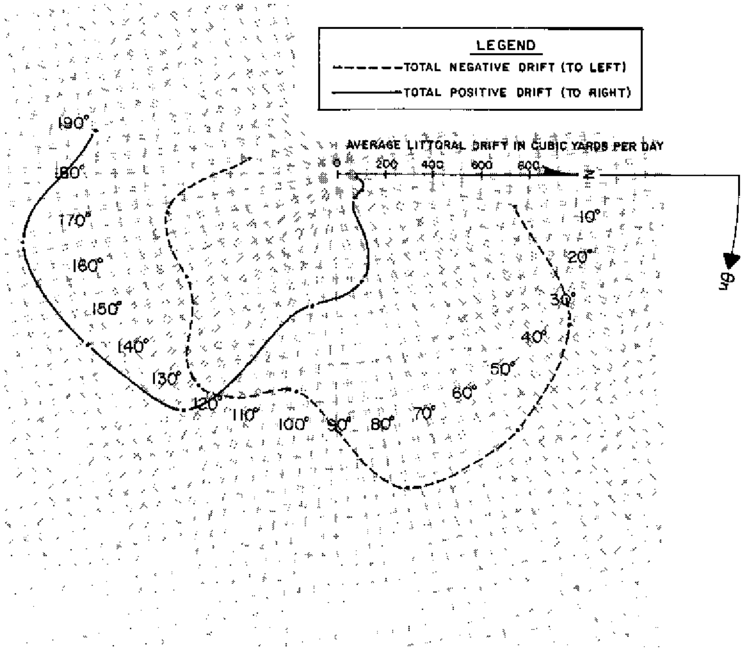


FIGURE A-149 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - JUNE

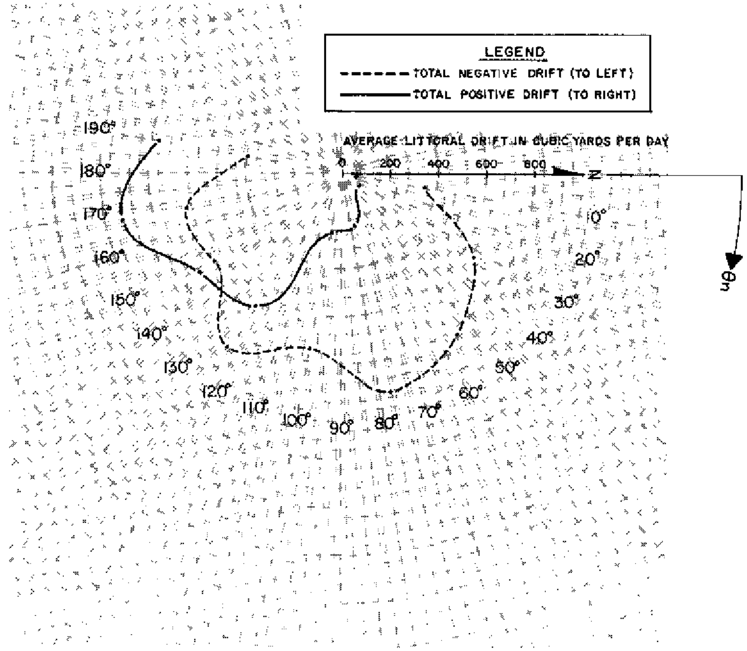


FIGURE A-150 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - JULY

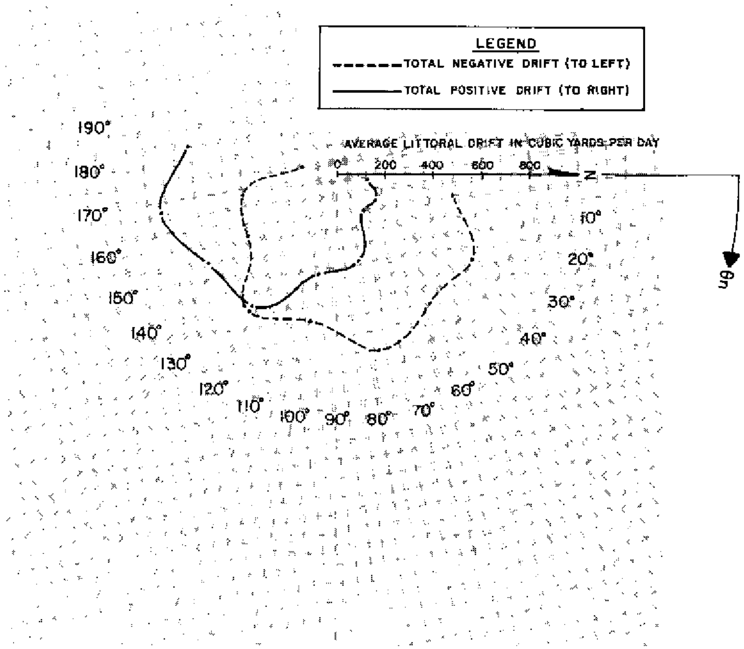


FIGURE A-151 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - AUGUST

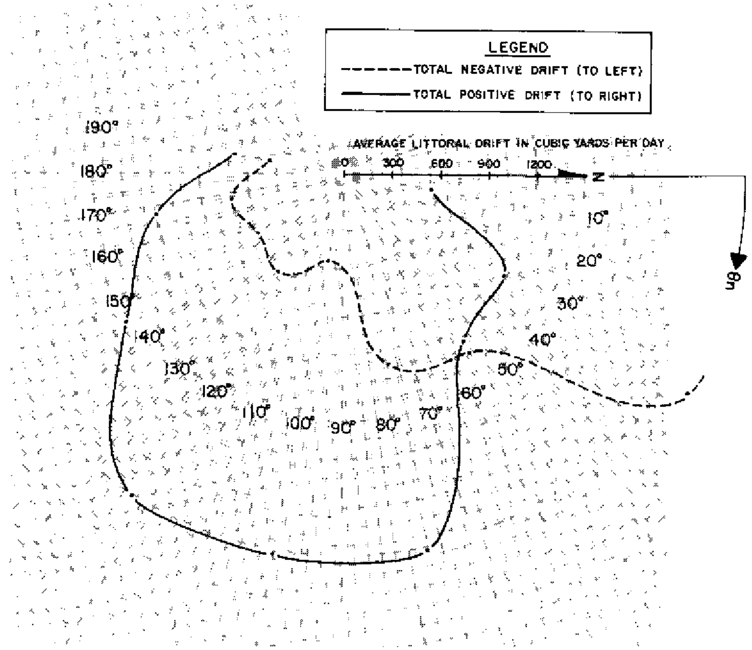


FIGURE A-152 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - SEPTEMBER

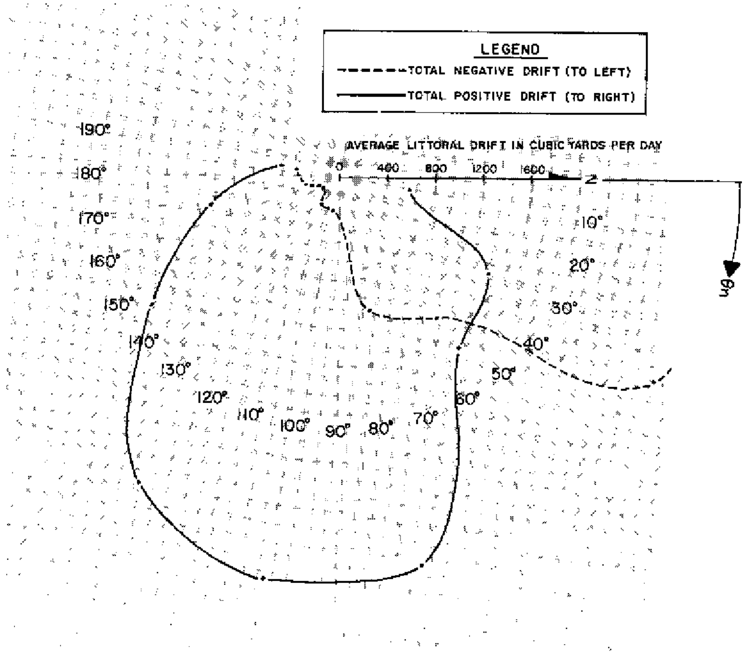


FIGURE A-153 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - OCTOBER

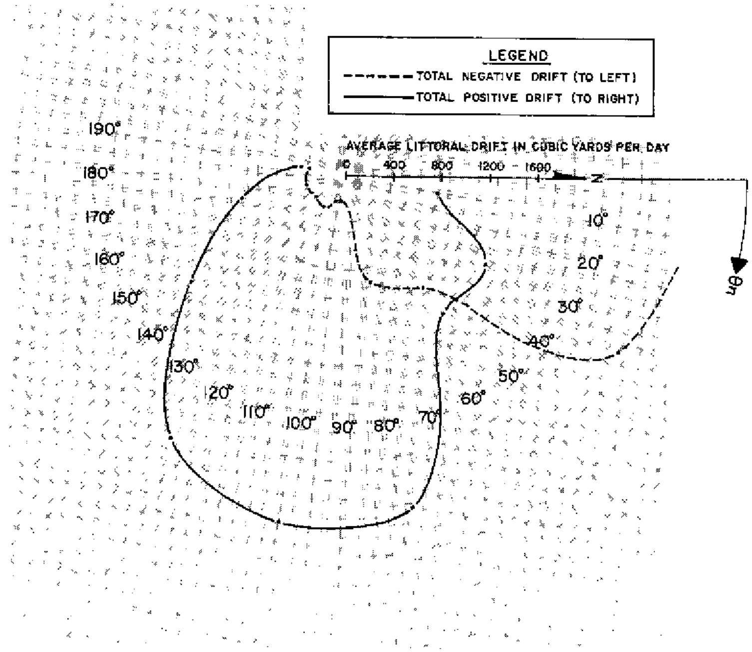


FIGURE A-154 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - NOVEMBER

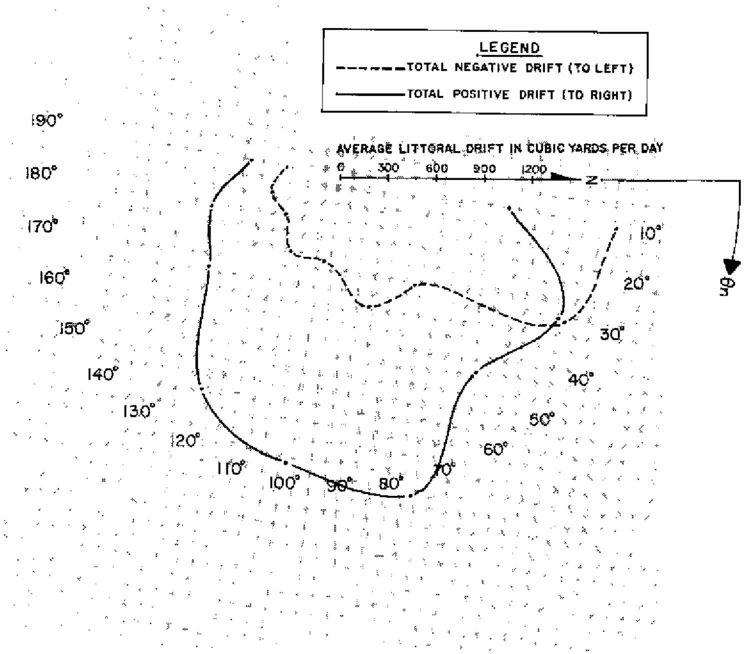


FIGURE A-155 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA - DECEMBER

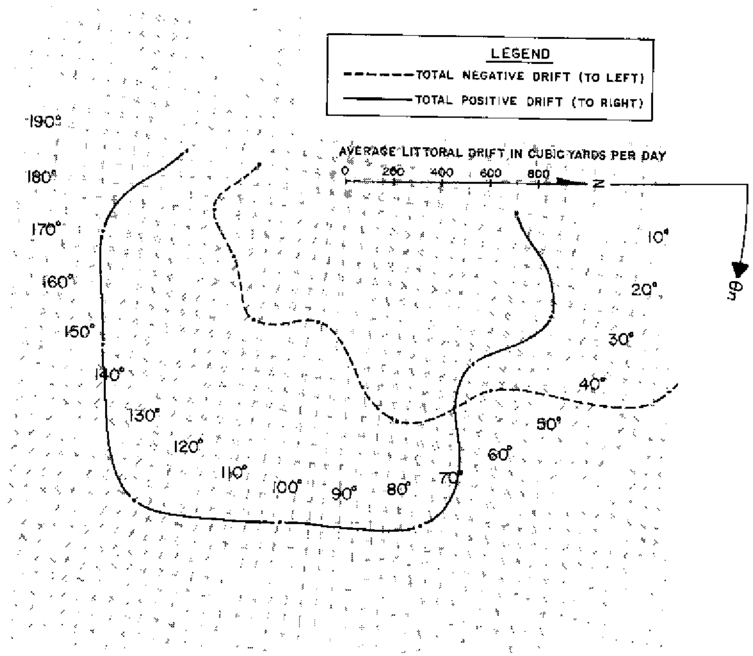


FIGURE A-156 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - HILLSBORO INLET TO CAPE FLORIDA, FLORIDA

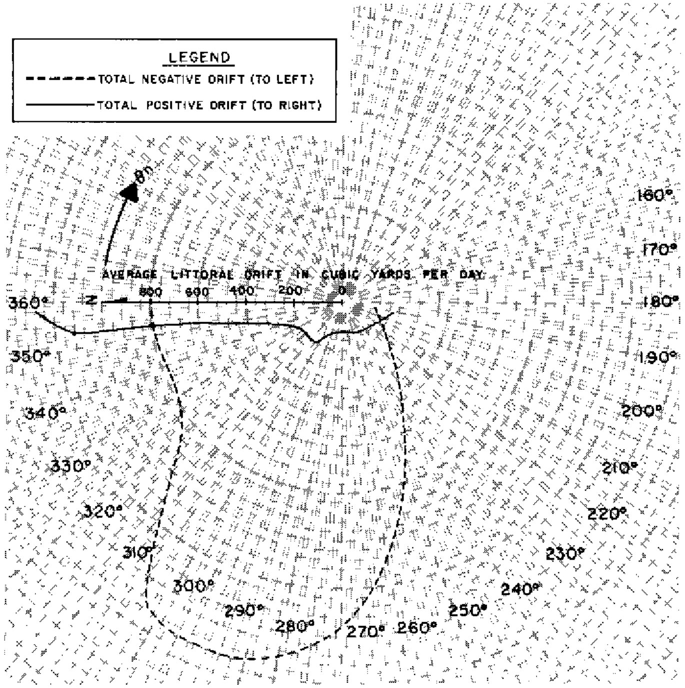


FIGURE A-157 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - JANUARY

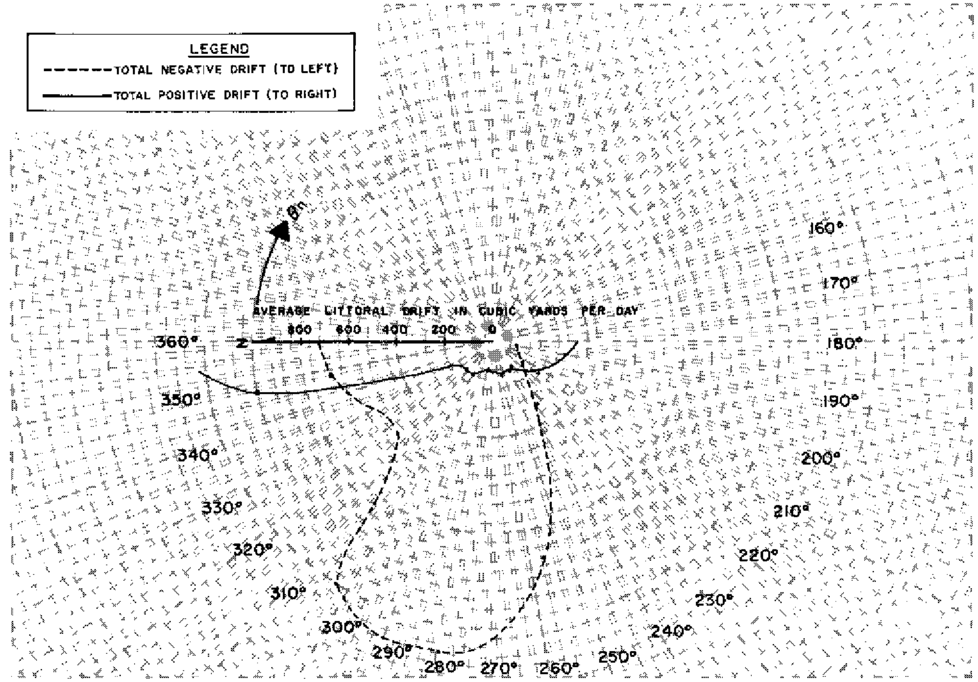


FIGURE A-158 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - FEBRUARY

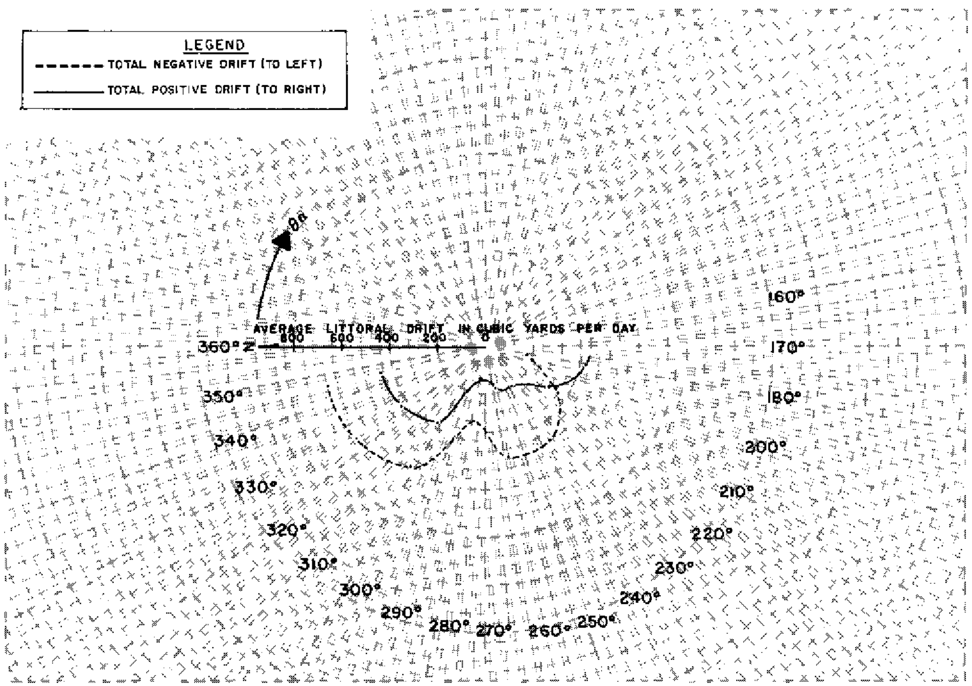


FIGURE A-159 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - MARCH

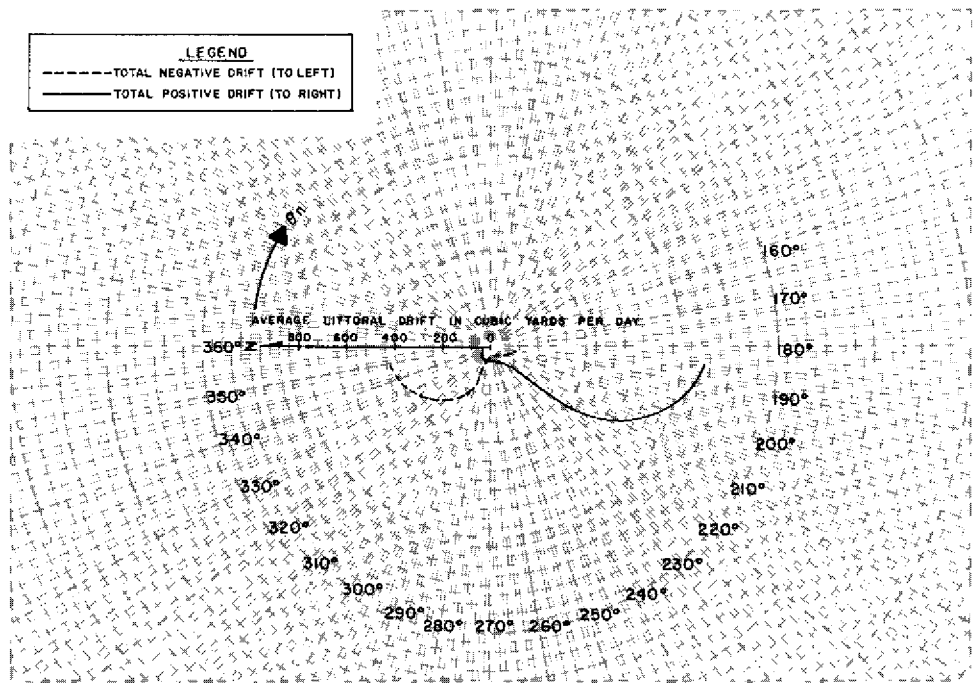


FIGURE A-160 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - APRIL

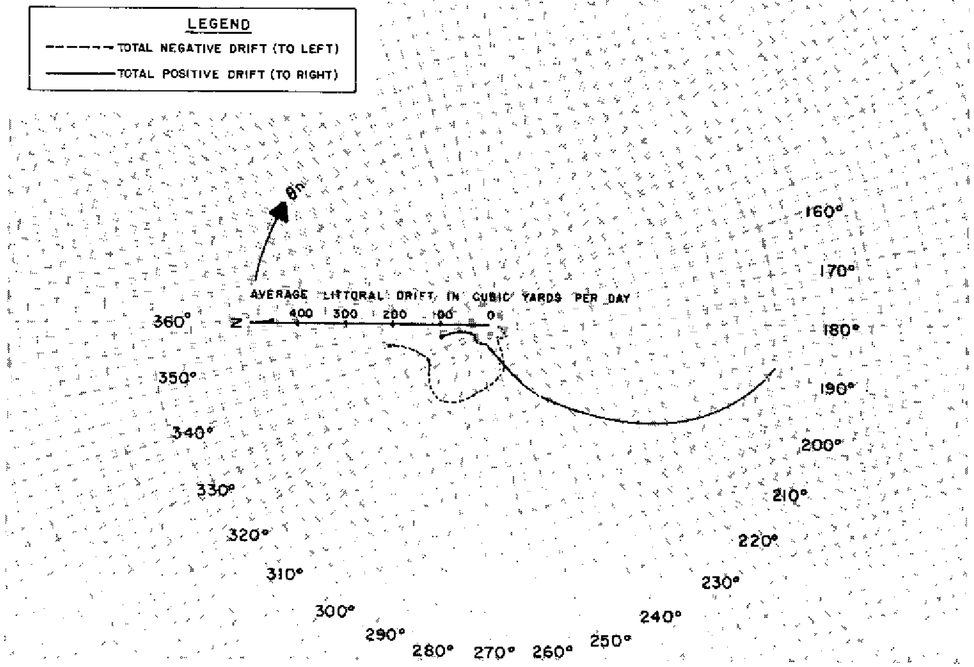


FIGURE A-161 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - MAY

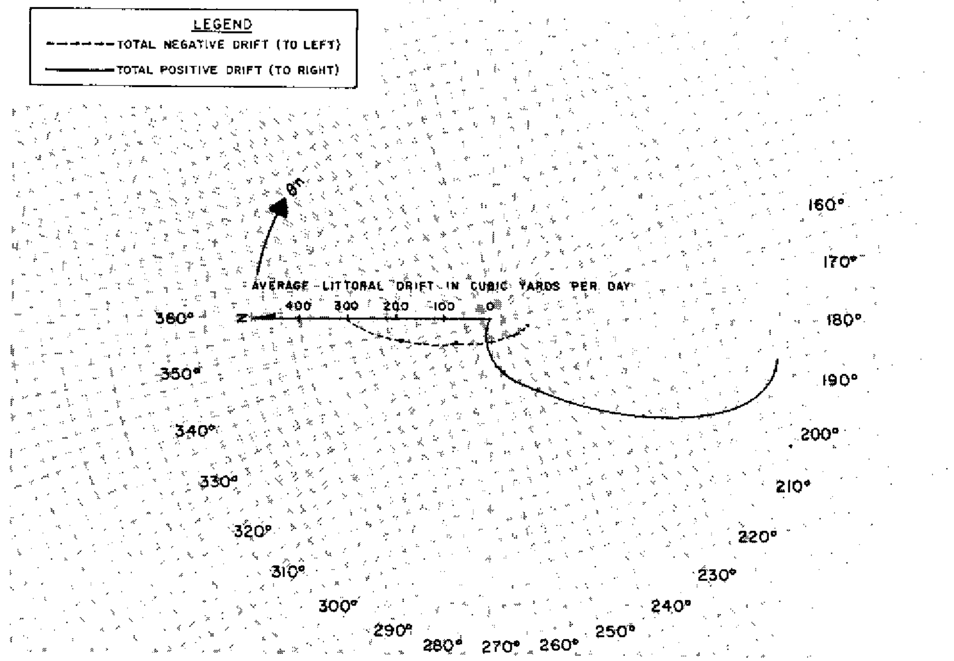


FIGURE A-162 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - JUNE

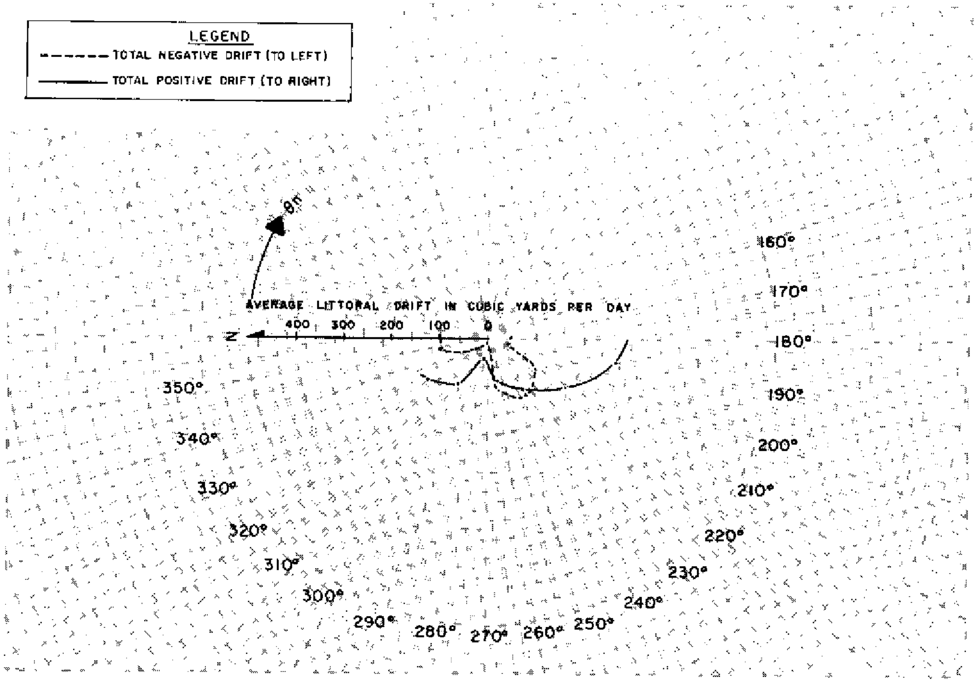


FIGURE A-163 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - JULY

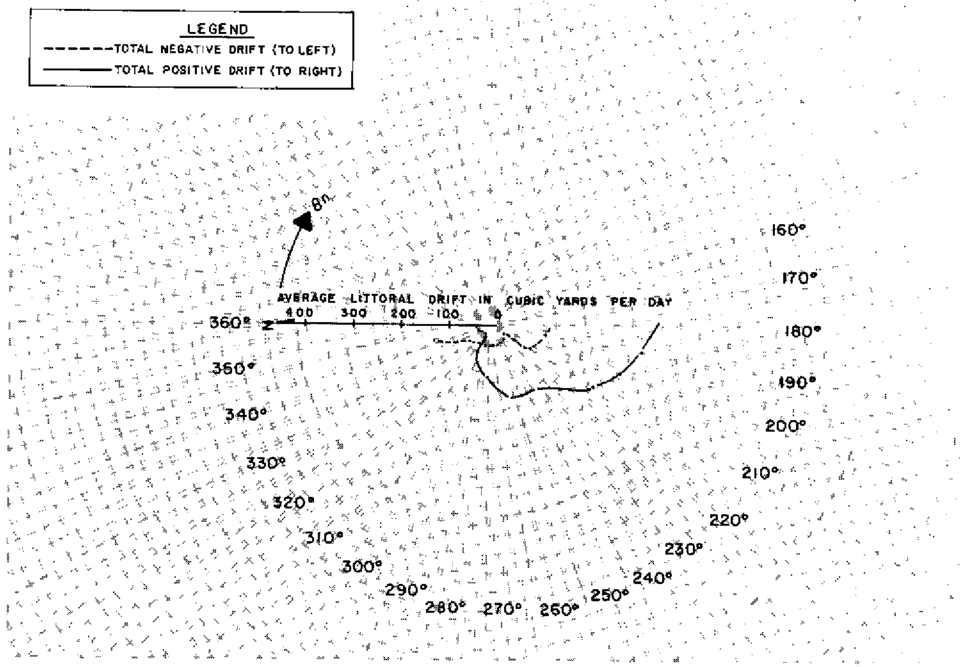


FIGURE A-164 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAF ROMANO, FLORIDA - AUGUST

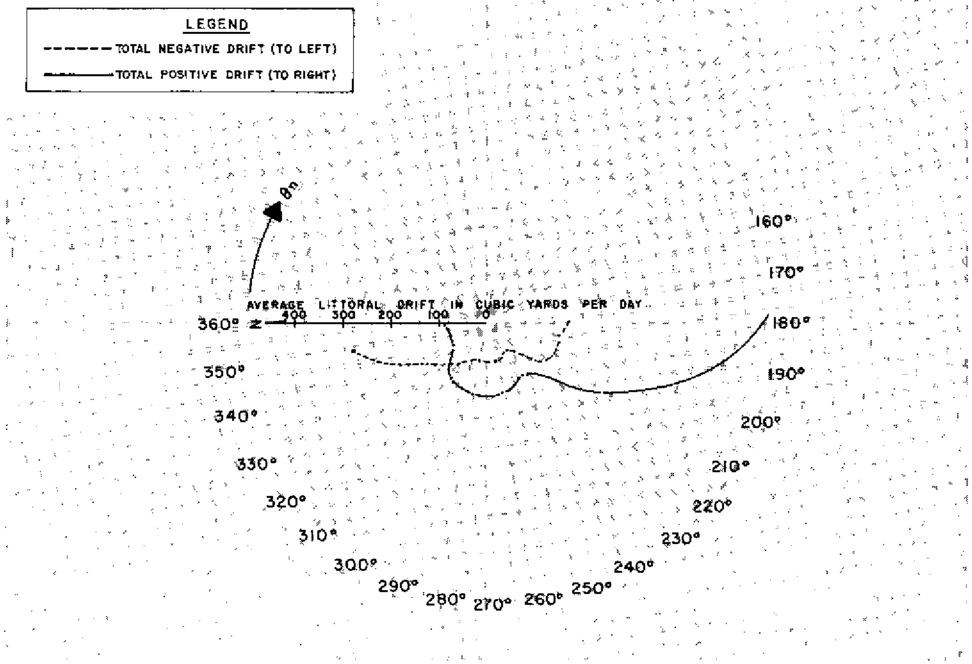


FIGURE A-165 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - SEPTEMBER

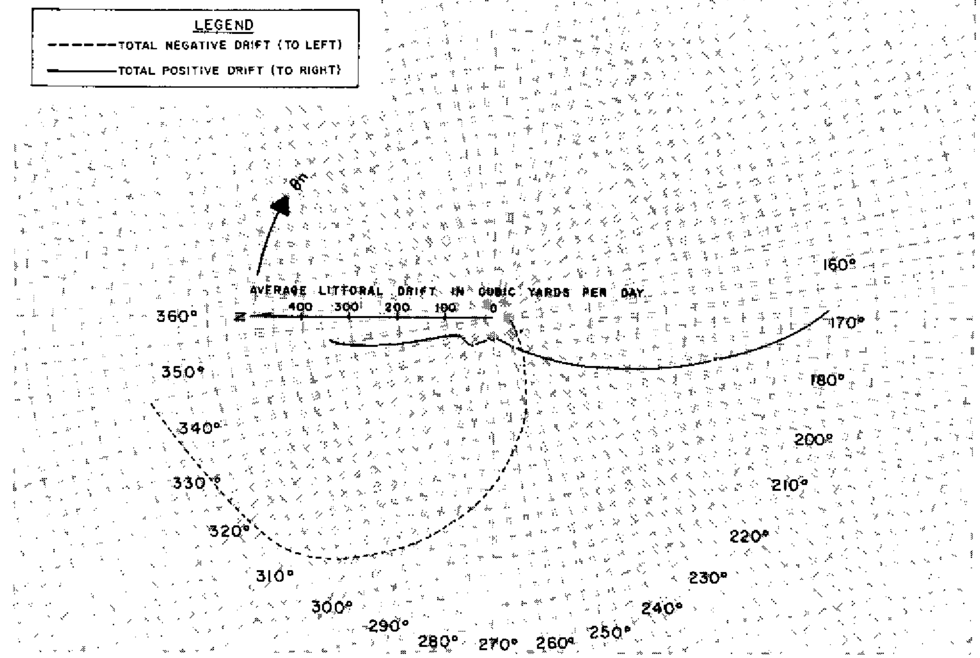


FIGURE A-166 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - OCTOBER

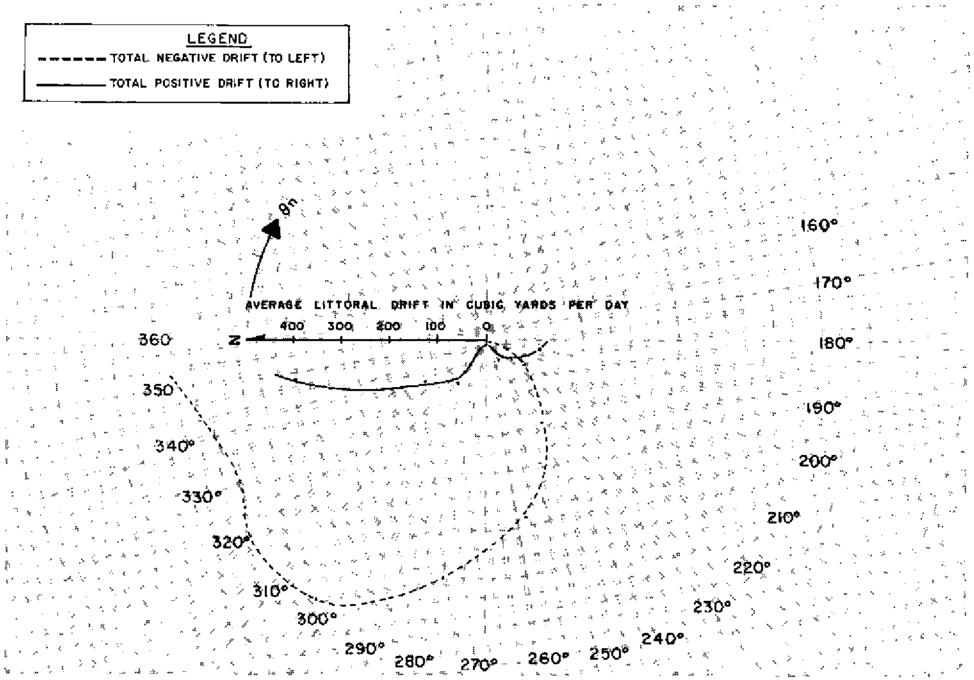


FIGURE A-167 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - NOVEMBER

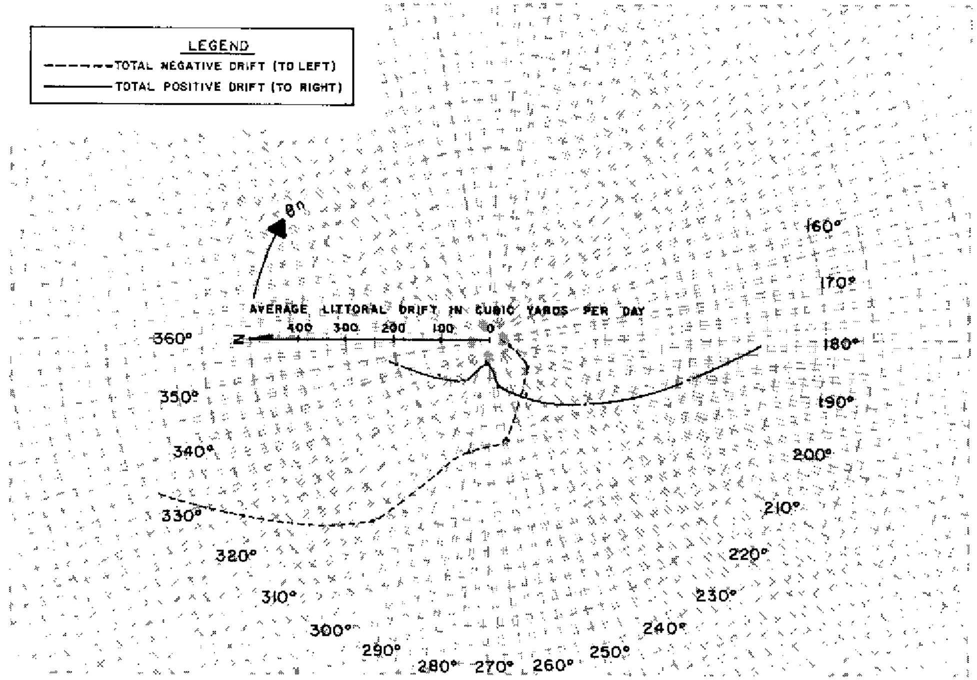


FIGURE A-168 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA - DECEMBER

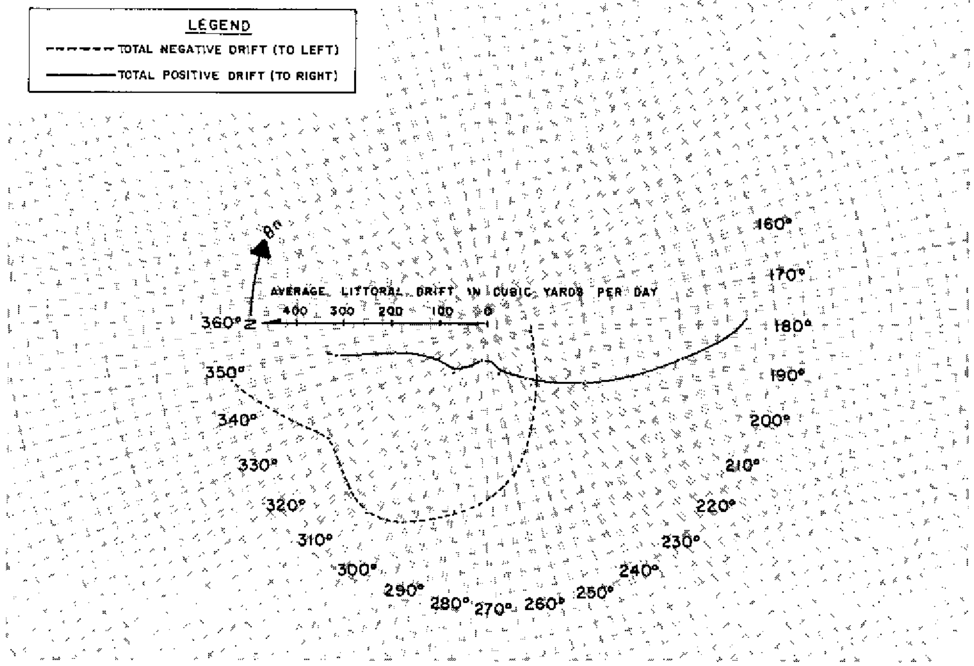


FIGURE A-169 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS BAY TO CAPE ROMANO, FLORIDA

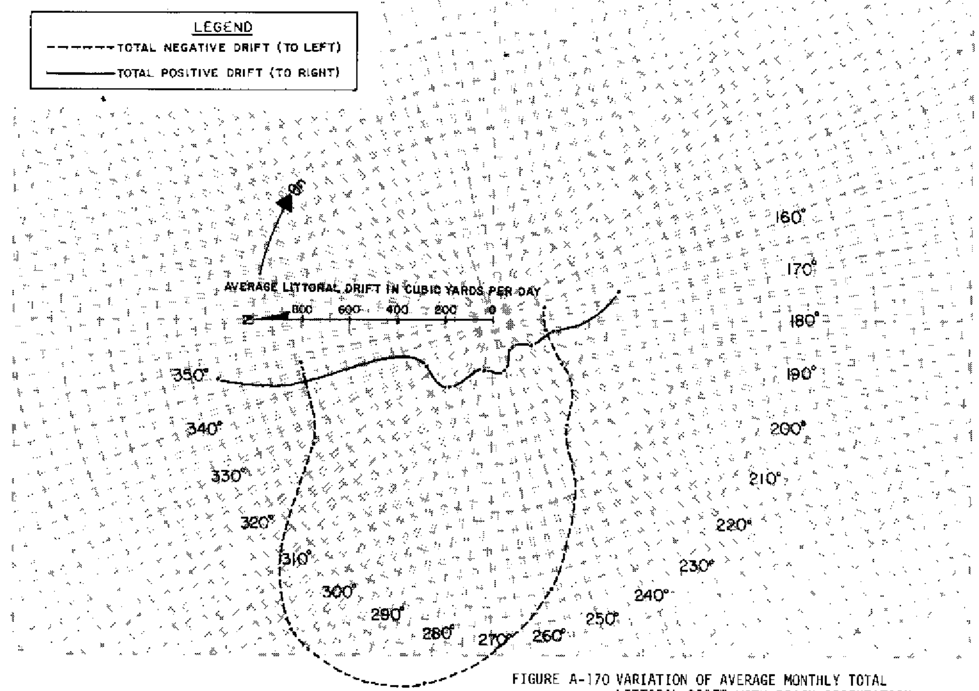


FIGURE A-170 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION SAN CARLOS TO BOCA GRANDE, FLORIDA - JANUARY

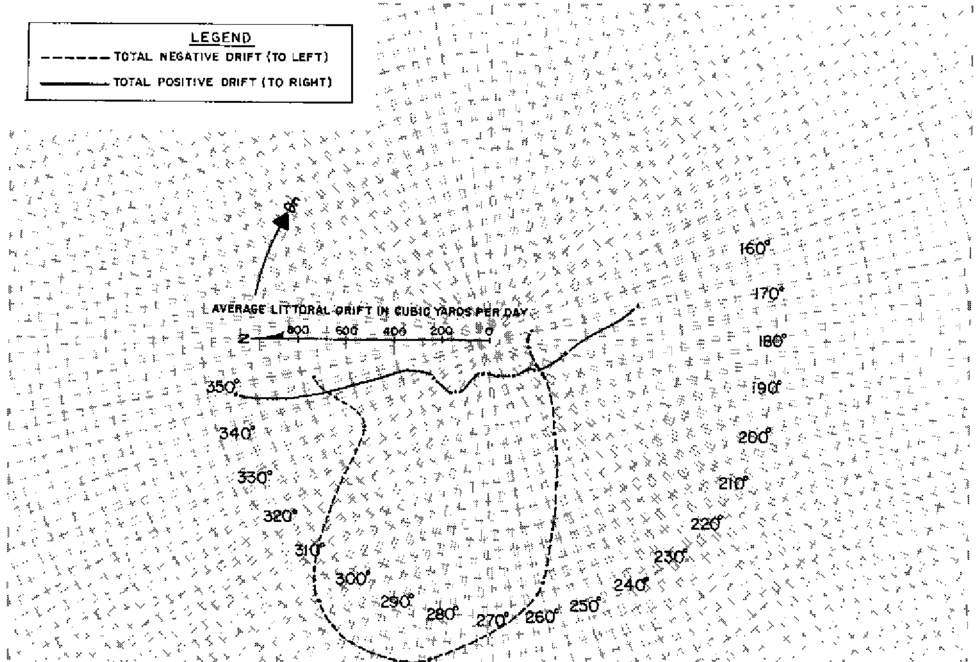


FIGURE A-171 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN [illegible] LOS TO BOCA GRANDE, FLORIDA - FEBRUARY

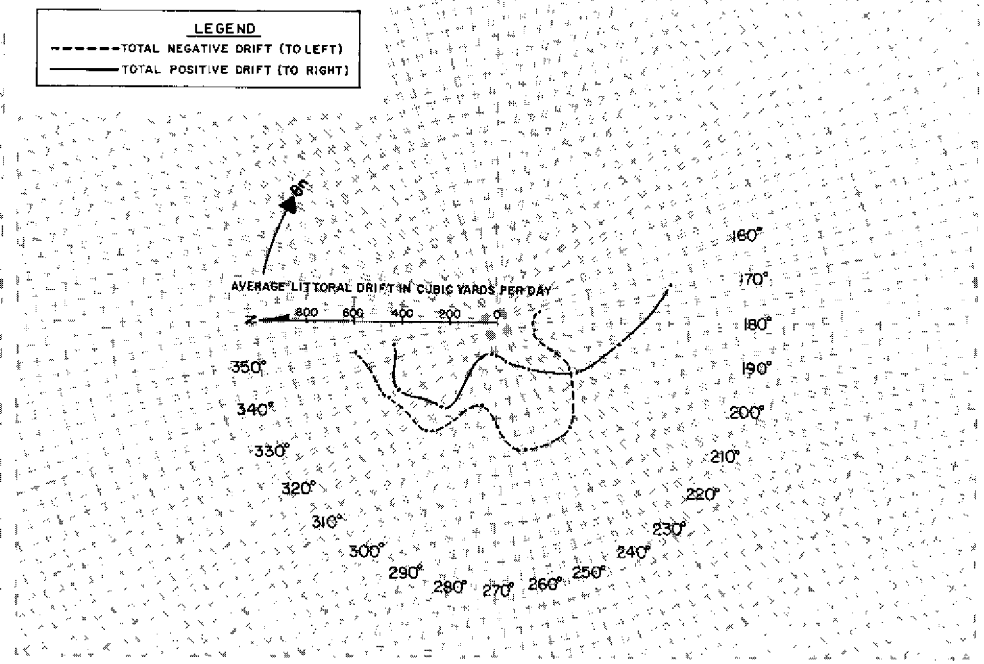


FIGURE A-172 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS TO BOCA GRANDE, FLORIDA - MARCH

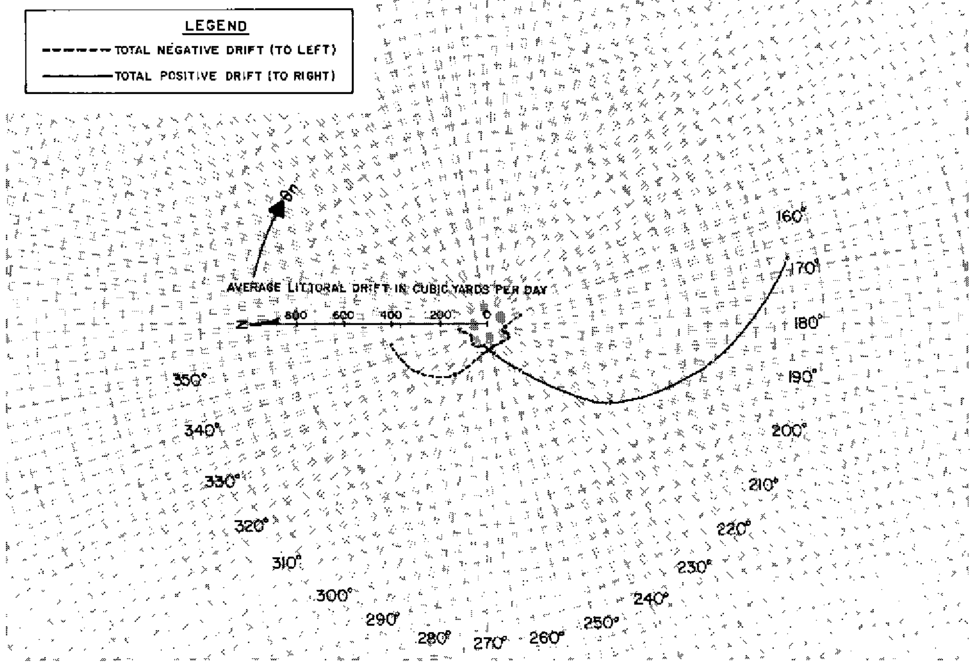


FIGURE A-173 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS TO BOCA GRANDE, FLORIDA - APRIL

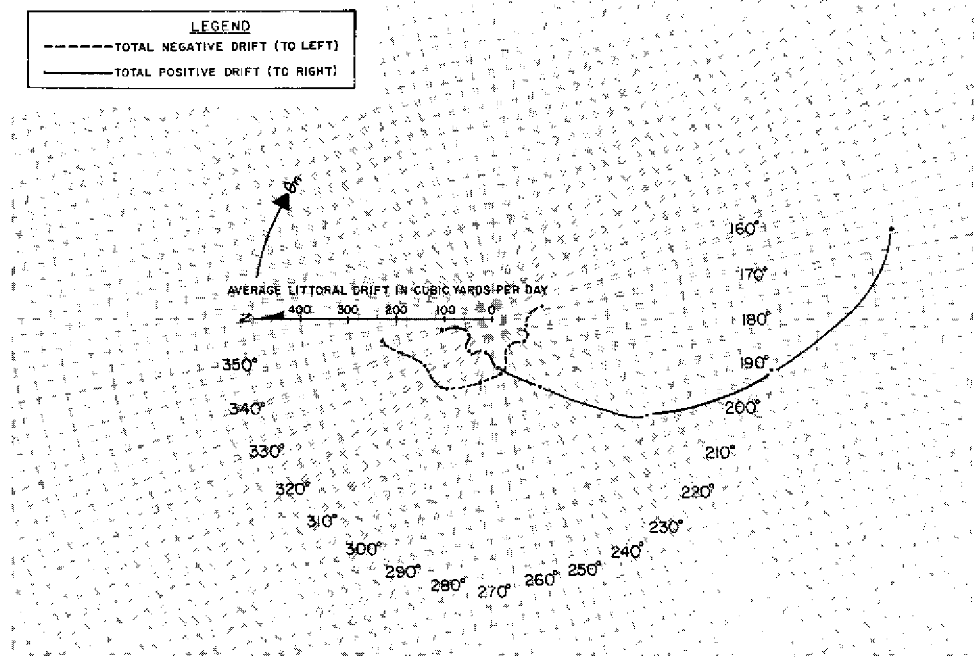


FIGURE A-174 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS TO BOCA GRANDE, FLORIDA - MAY

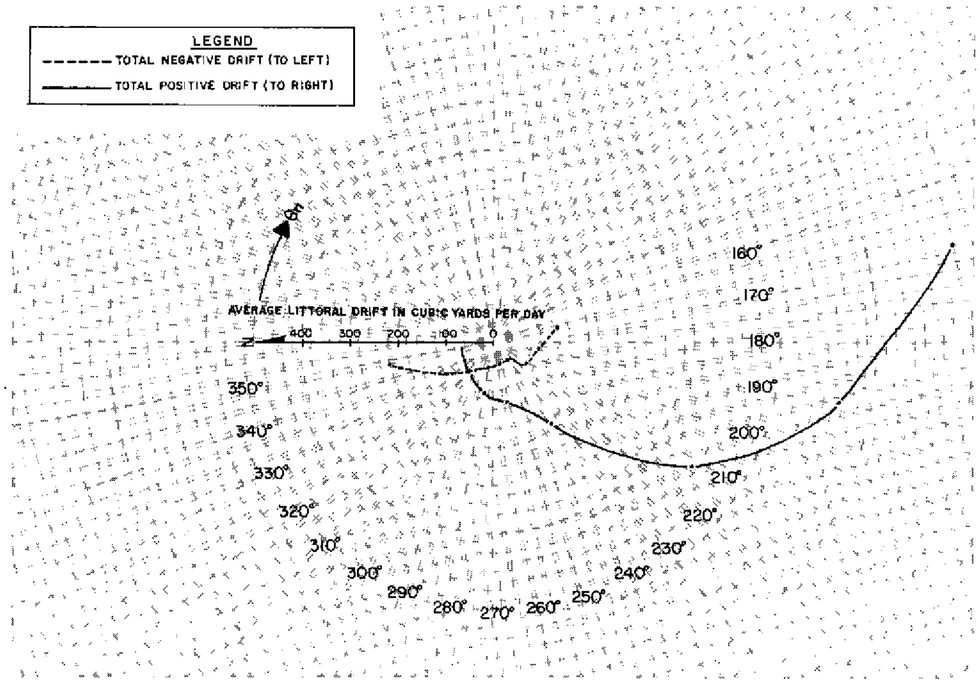


FIGURE A-175 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS TO BOCA GRANDE, FLORIDA - JUNE

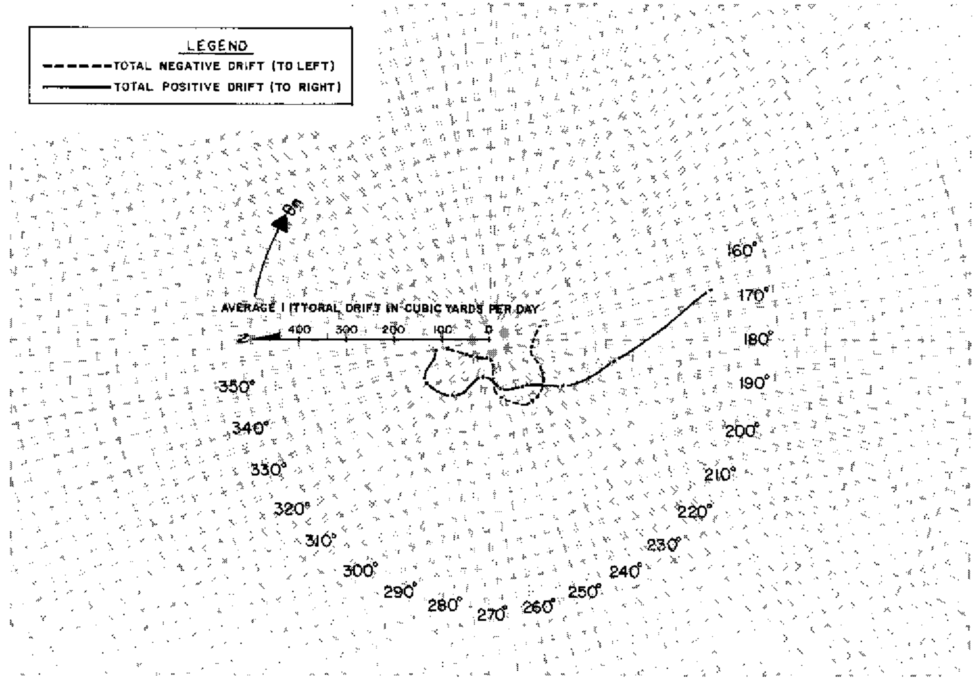


FIGURE A-176 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS TO BOCA GRANDE, FLORIDA - JULY

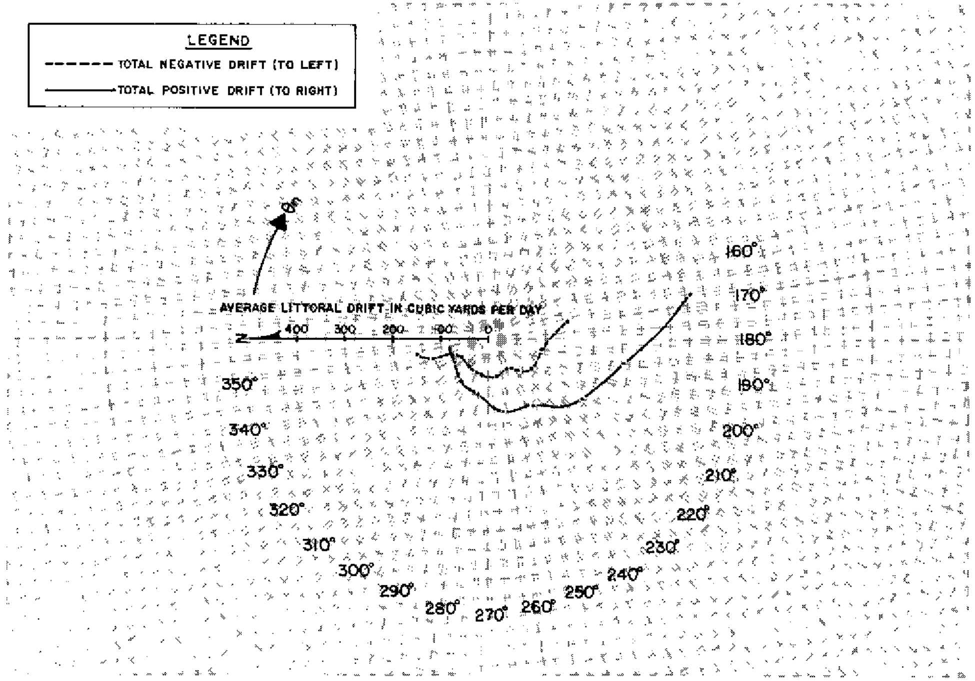


FIGURE A-177 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT
WITH BEACH ORIENTATION - SAN CARLOS TO
BOCA GRANDE, FLORIDA - AUGUST

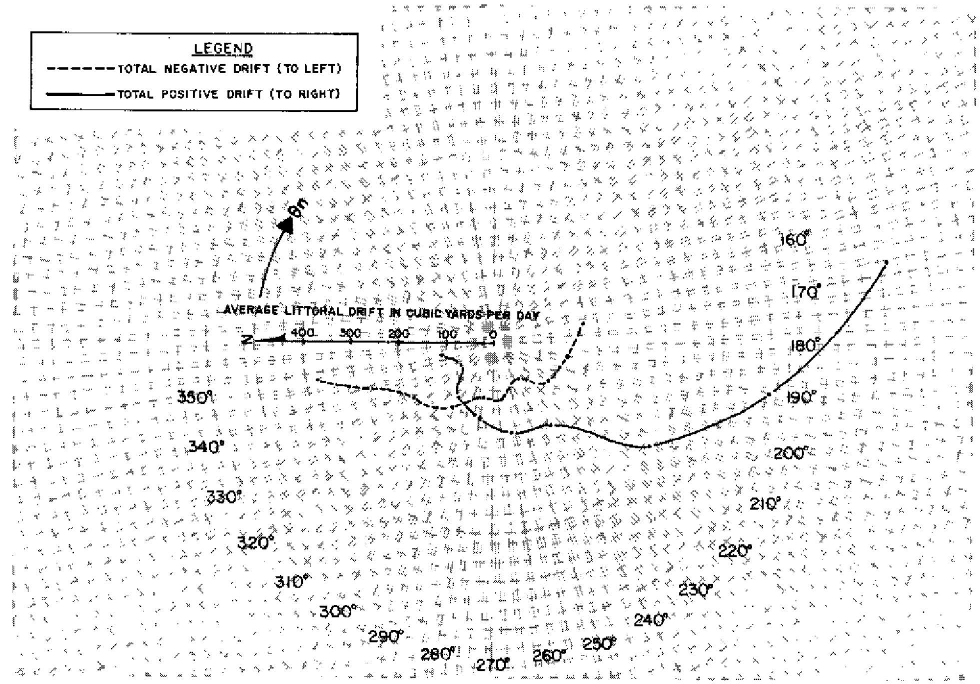


FIGURE A-178 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT
WITH BEACH ORIENTATION - SAN CARLOS TO
BOCA GRANDE, FLORIDA - SEPTEMBER

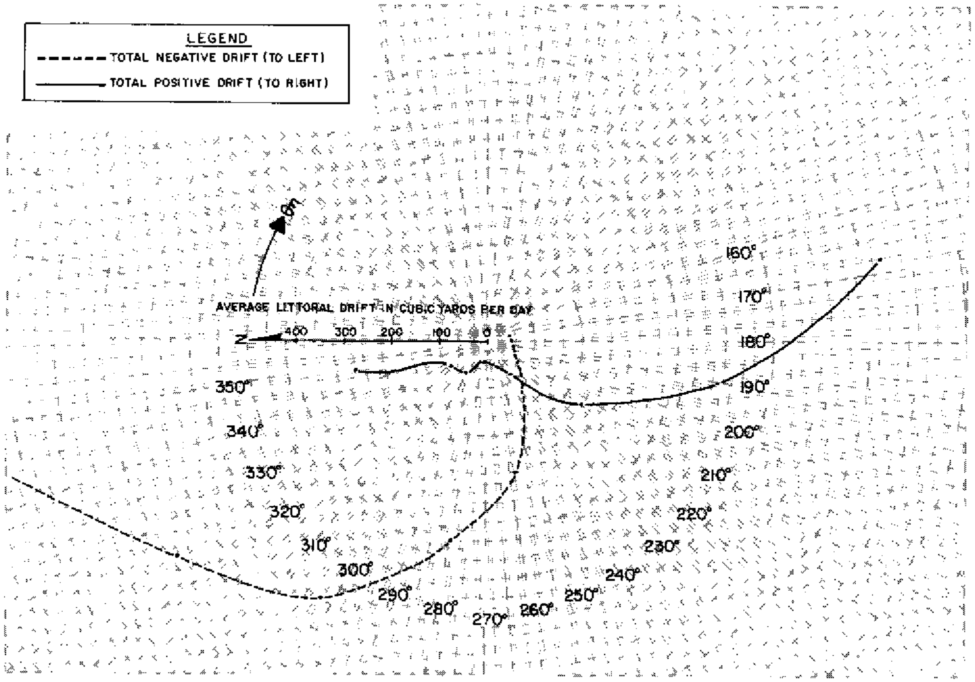


FIGURE A-179 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT
WITH BEACH ORIENTATION - SAN CARLOS TO
BOCA GRANDE, FLORIDA - OCTOBEI

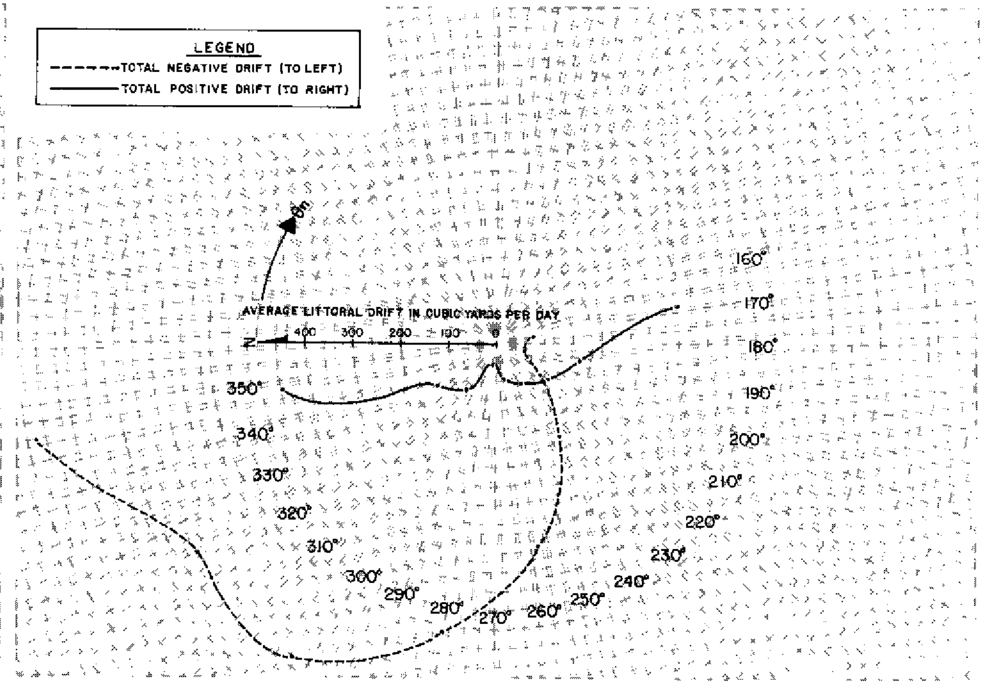


FIGURE A-180 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT
WITH BEACH ORIENTATION - SAN CARLOS TO
BOCA NDE, FLORIDA - NOVEMBER

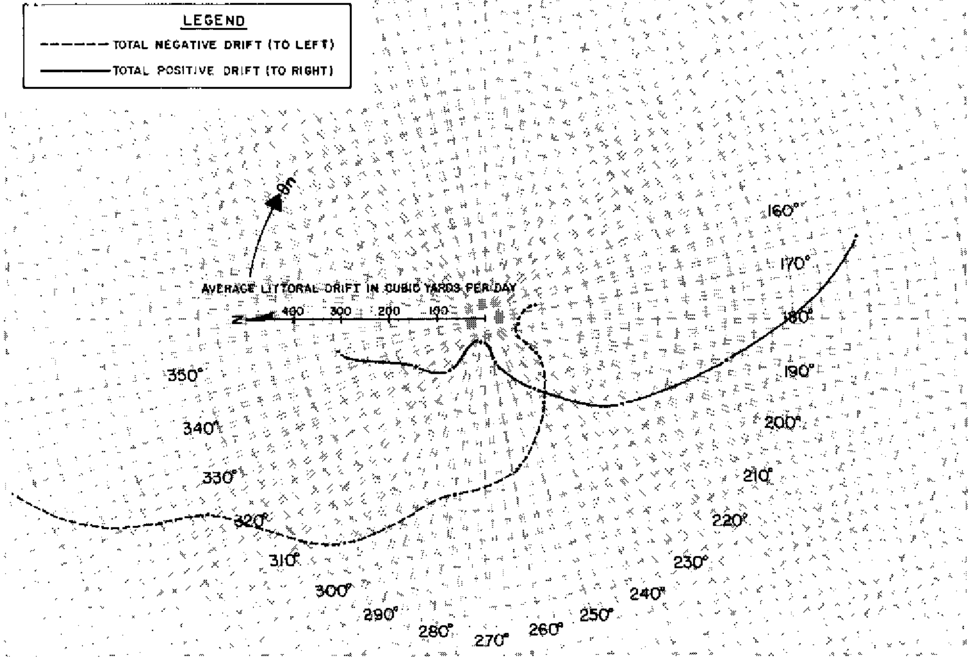


FIGURE A-181 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS TO BOCA GRANDE, FLORIDA - DECEMBER

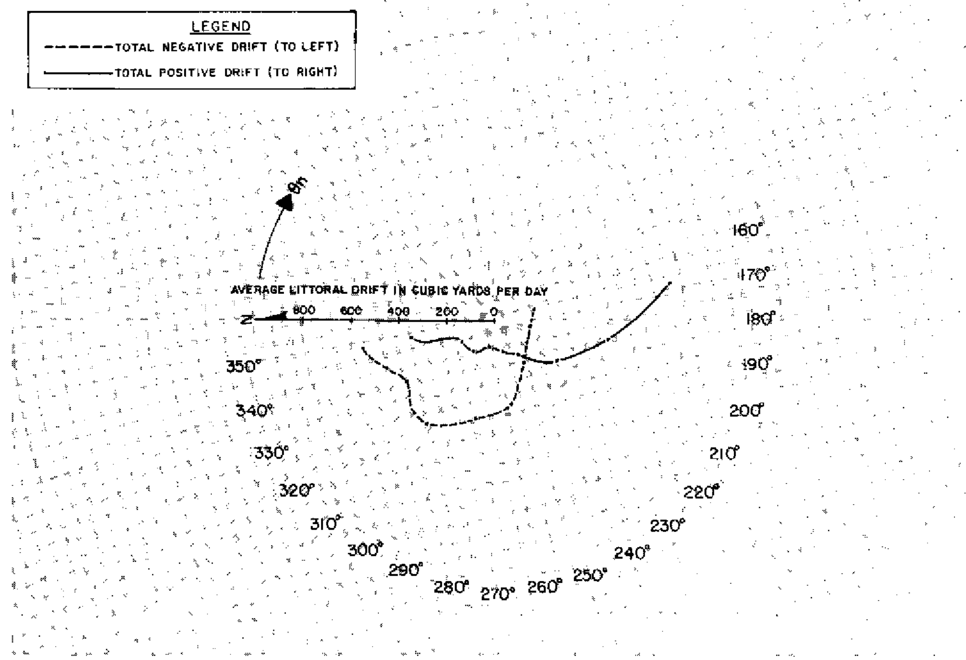


FIGURE A-182 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - SAN CARLOS TO BOCA GRANDE, FLORIDA

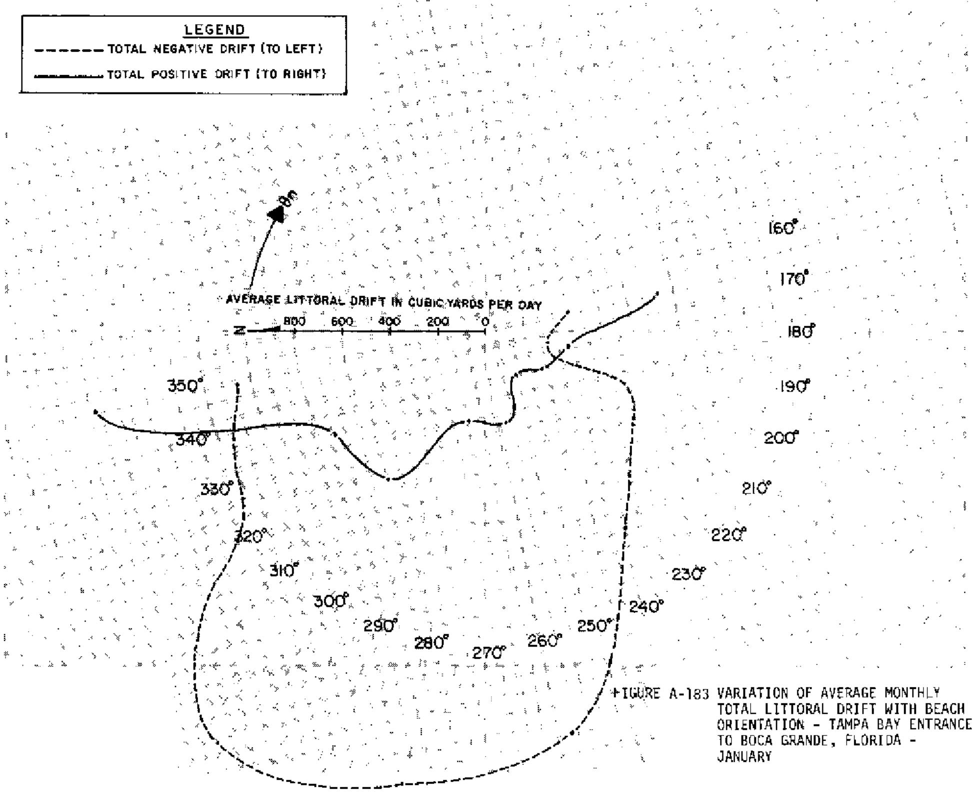


FIGURE A-183 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - JANUARY

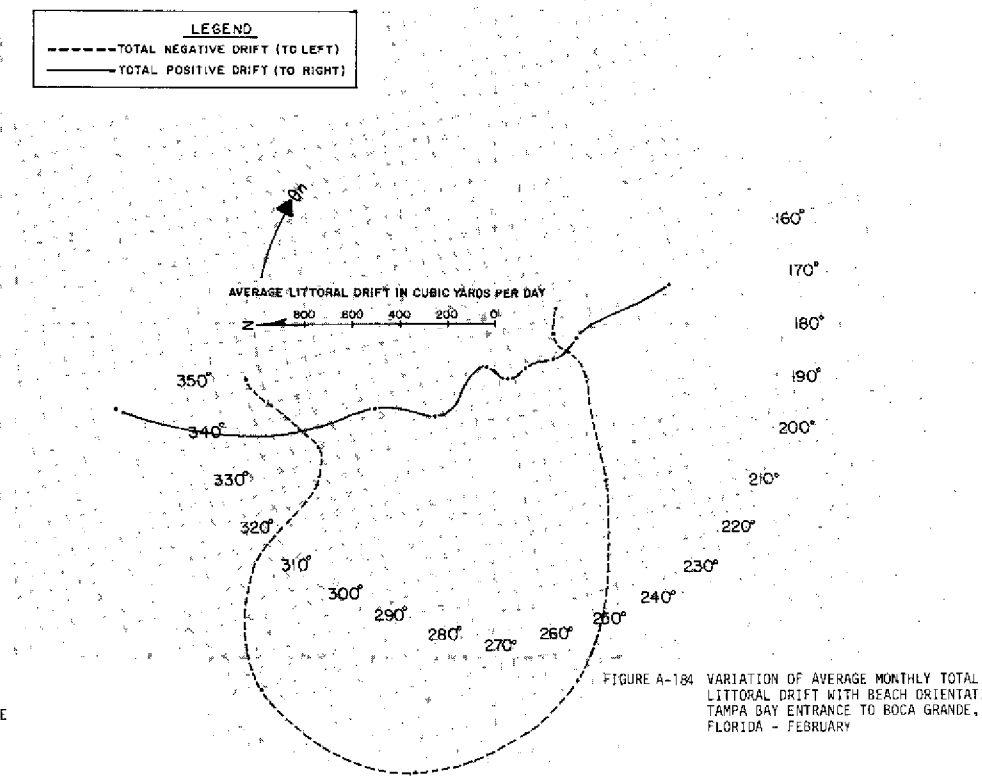


FIGURE A-184 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION-TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - FEBRUARY

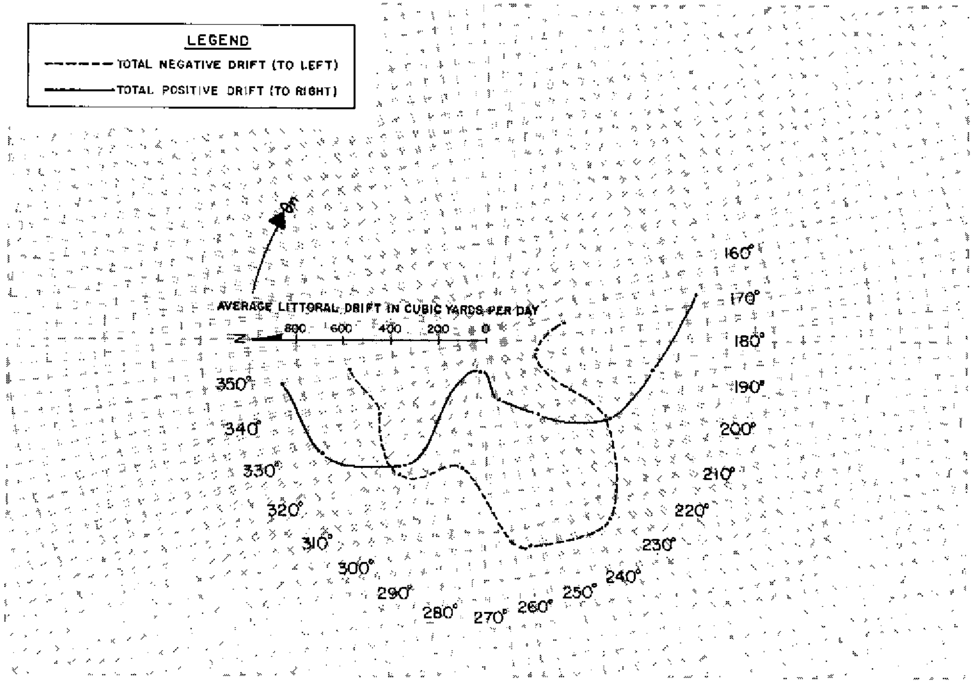


FIGURE A-185 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - MARCH

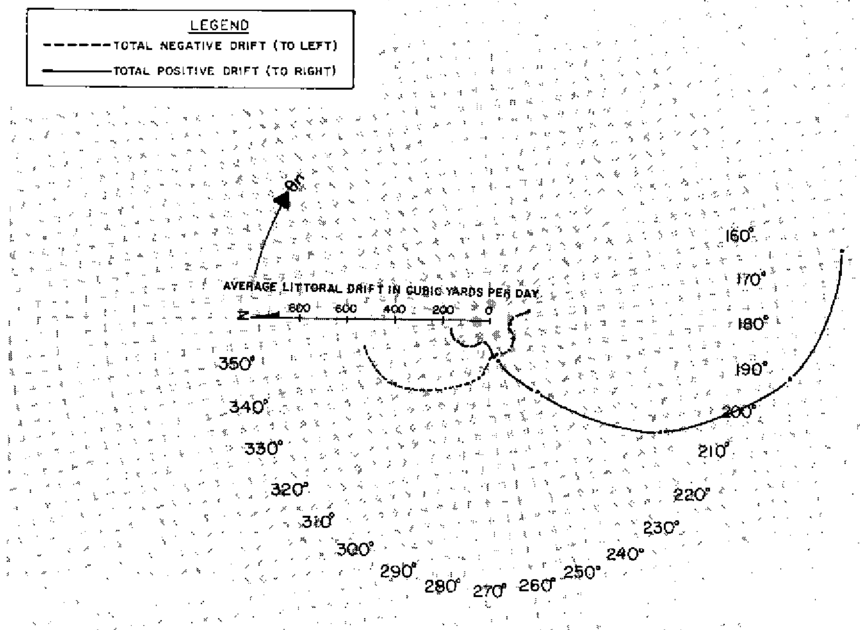


FIGURE A-186 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - APRIL

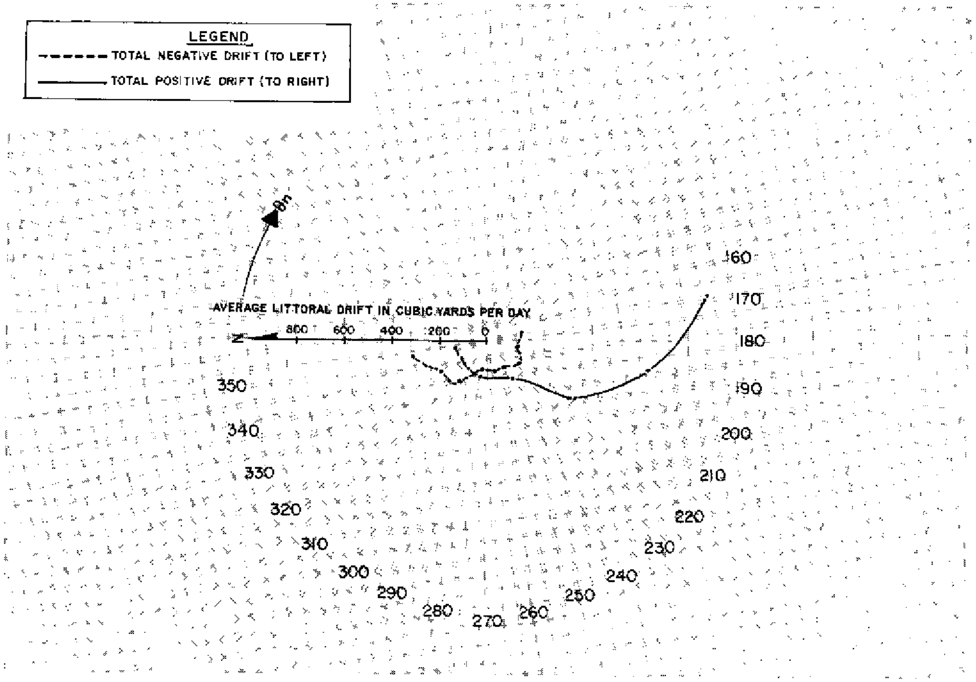


FIGURE A-187 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - MAY

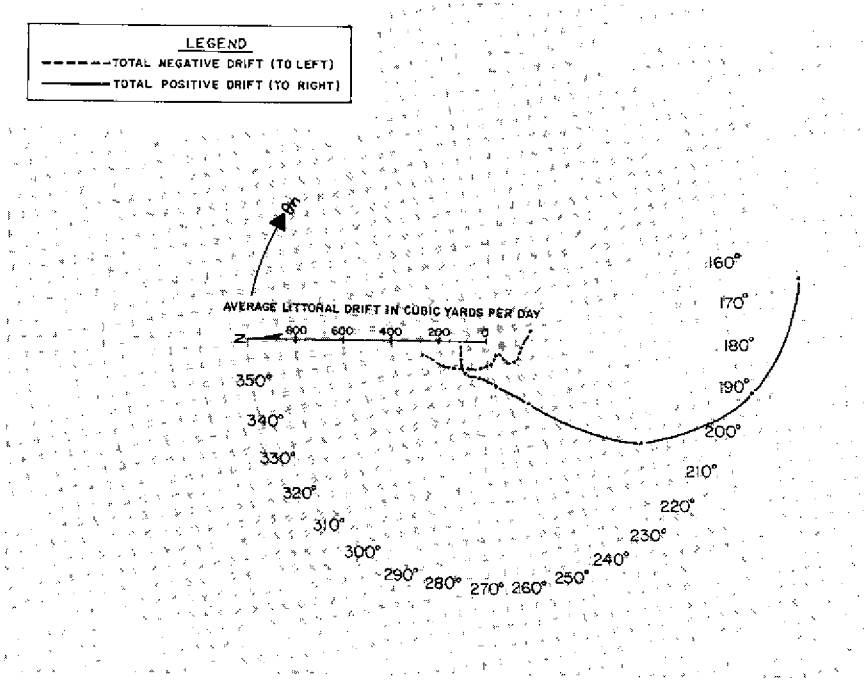


FIGURE A-188 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA NDE, FLORIDA - JUNE

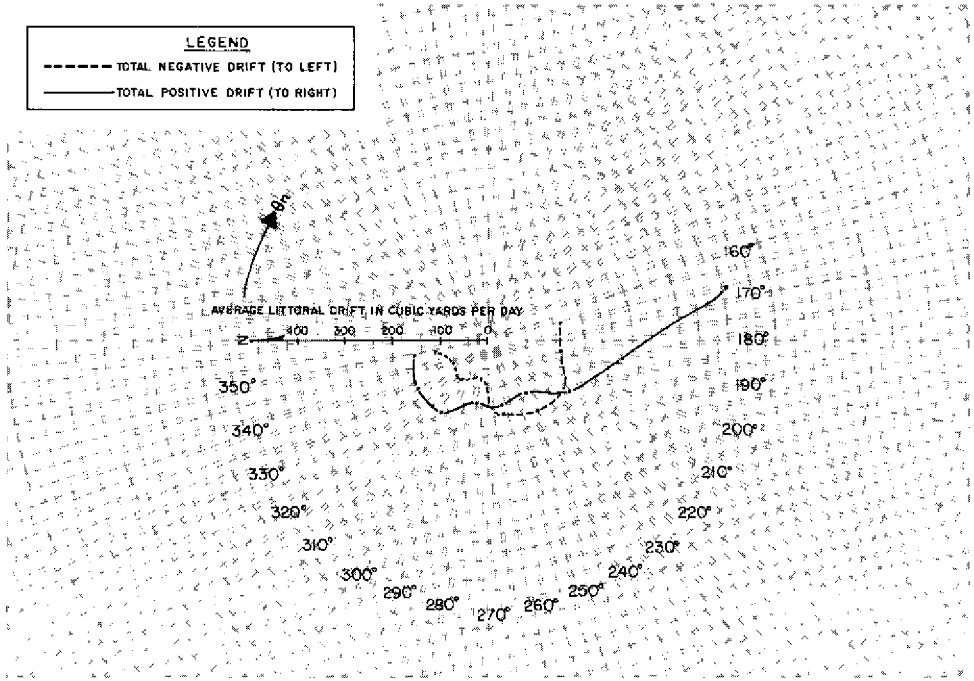


FIGURE A-189 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - JULY

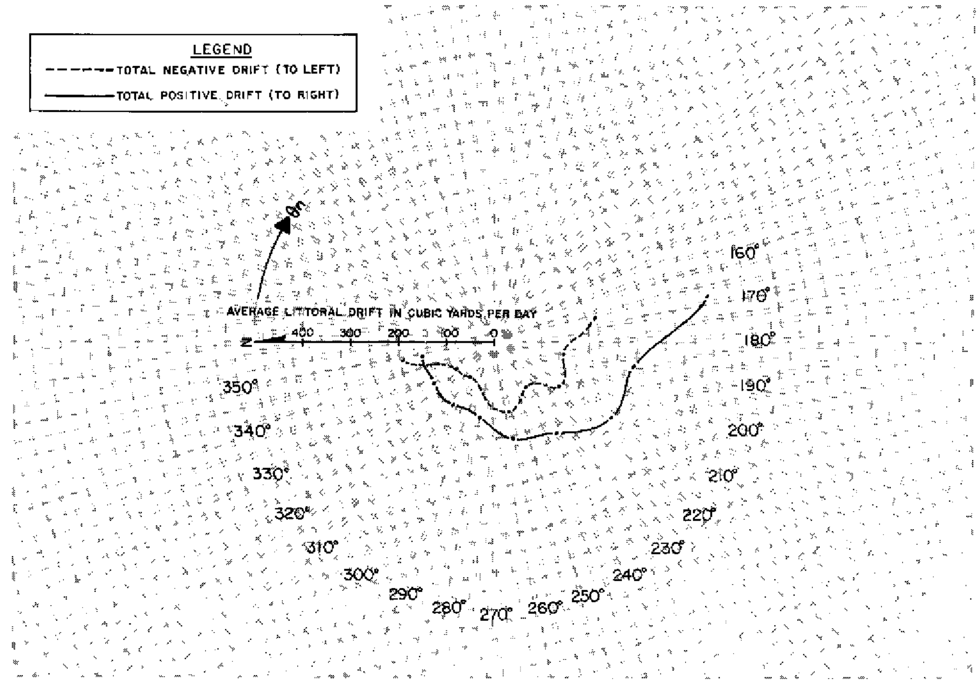


FIGURE A-190 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - AUGUST

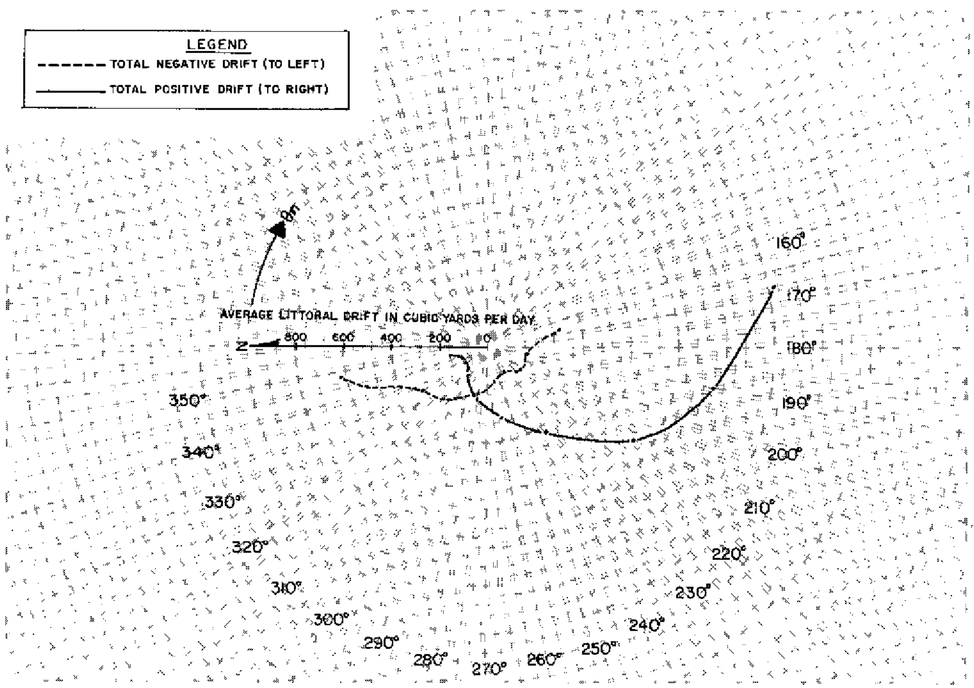


FIGURE A-191 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - SEPTEMBER

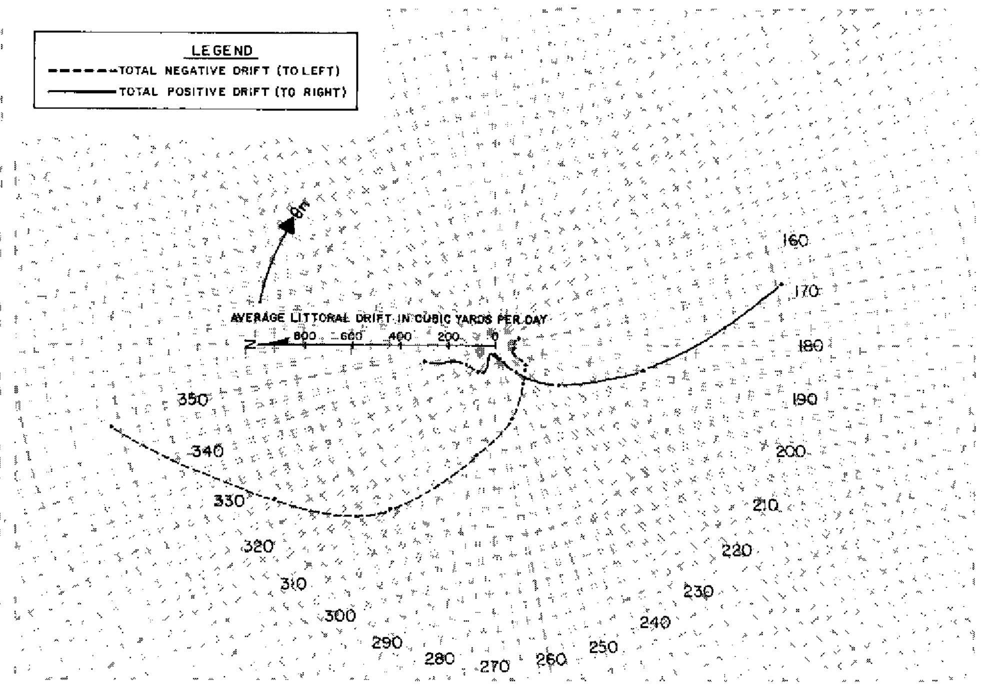


FIGURE A-192 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - OCTOBER

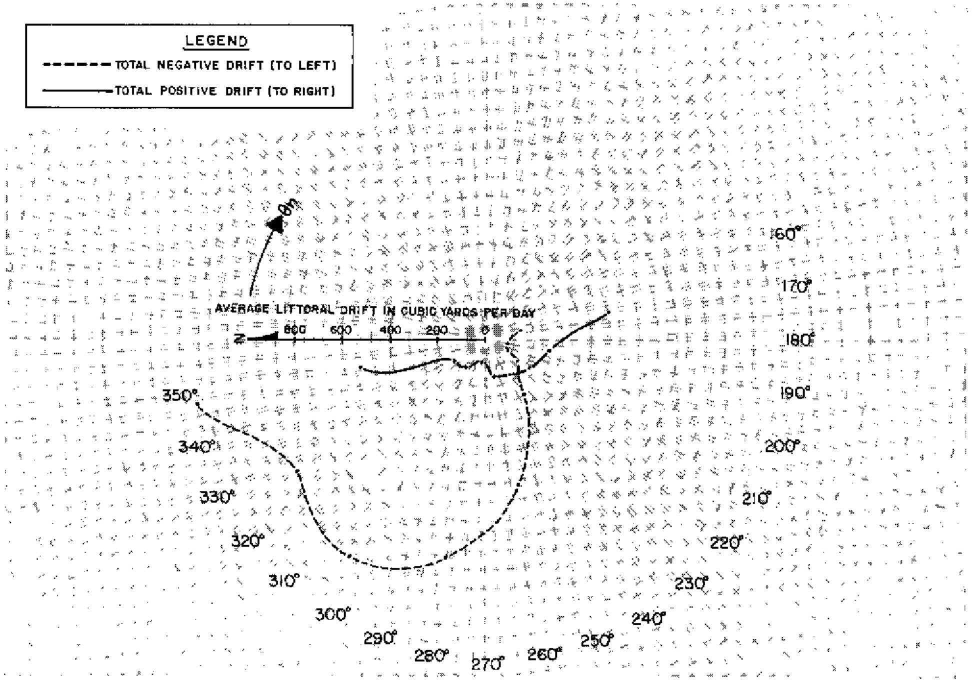


FIGURE A-193 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - NOVEMBER

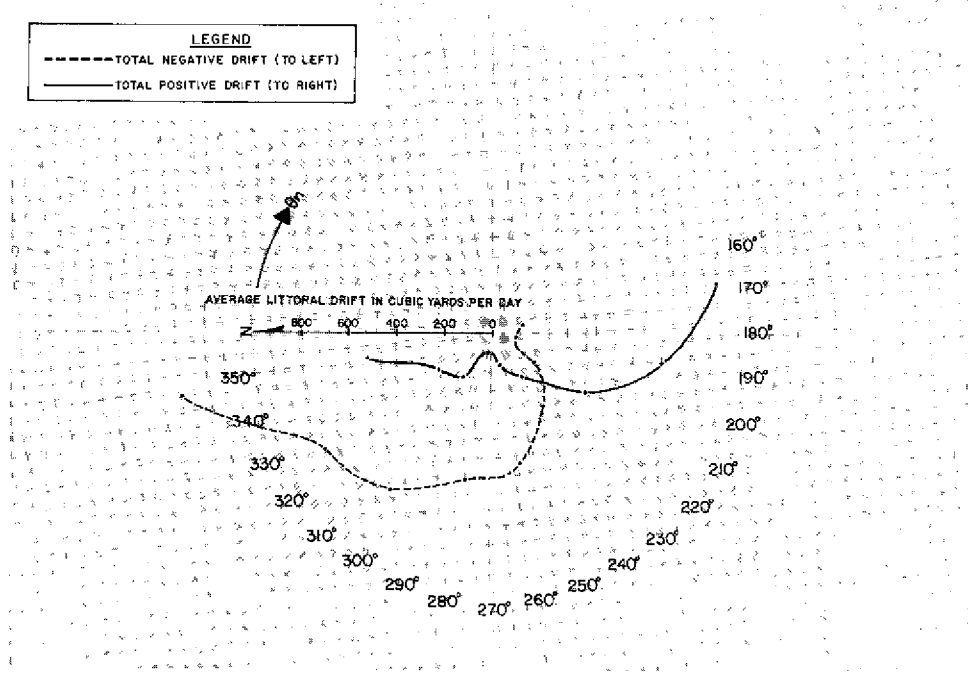


FIGURE A-194 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA - DECEMBER

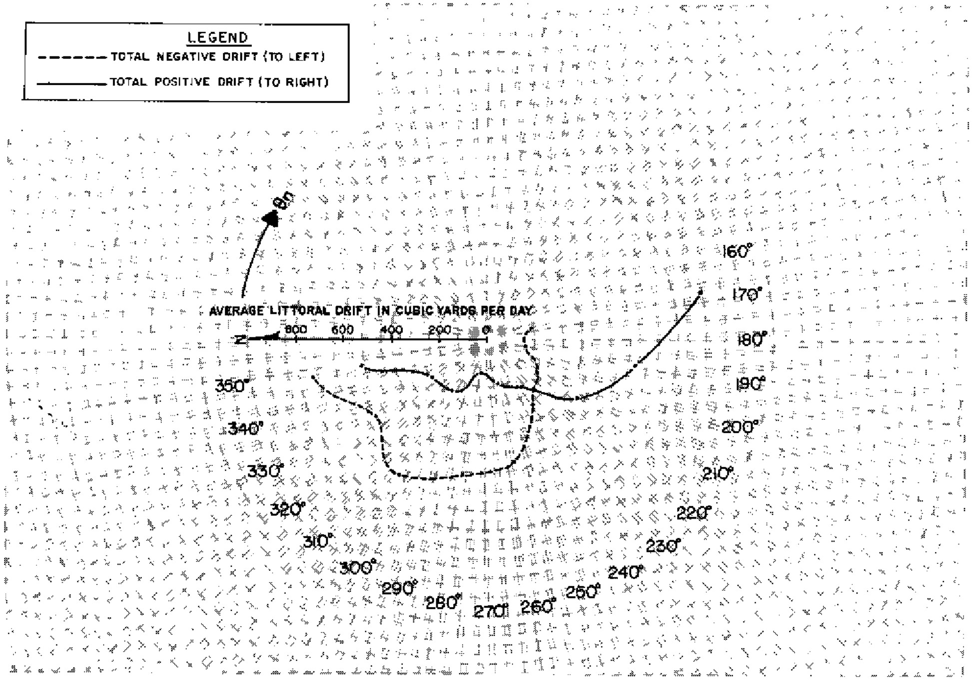


FIGURE A-195 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO BOCA GRANDE, FLORIDA

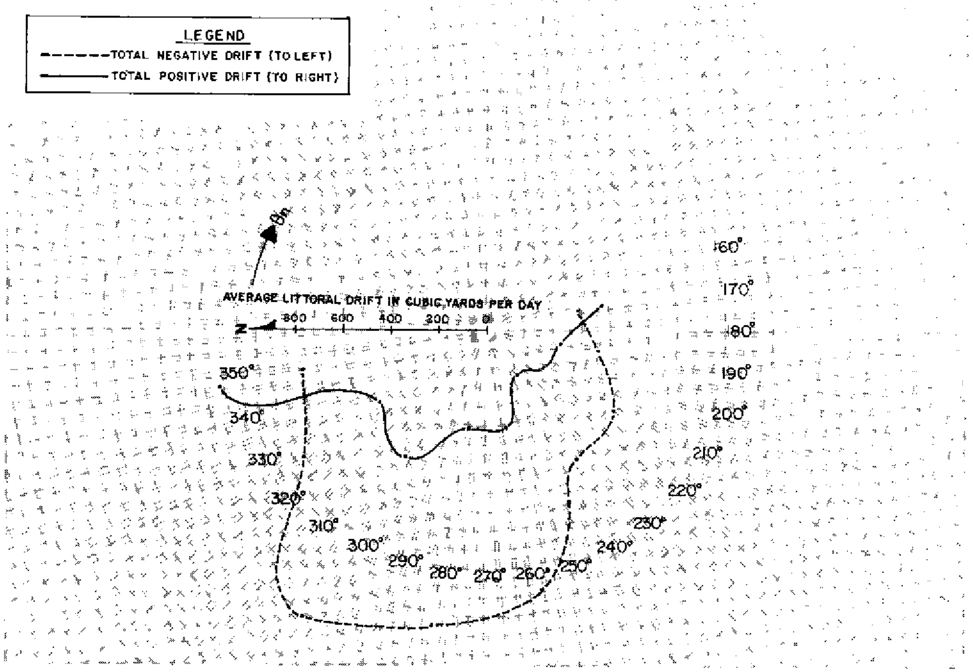


FIGURE A-196 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BFACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPOI PRINGS, FLORIDA - JANUARY

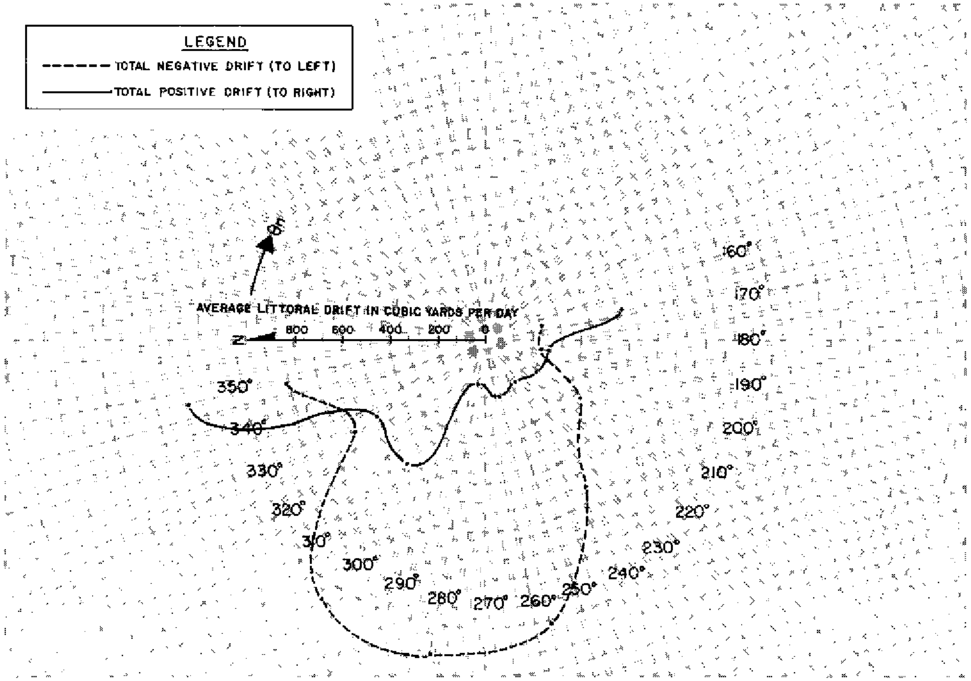


FIGURE A-197 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPON SPRINGS, FLORIDA - FEBRUARY

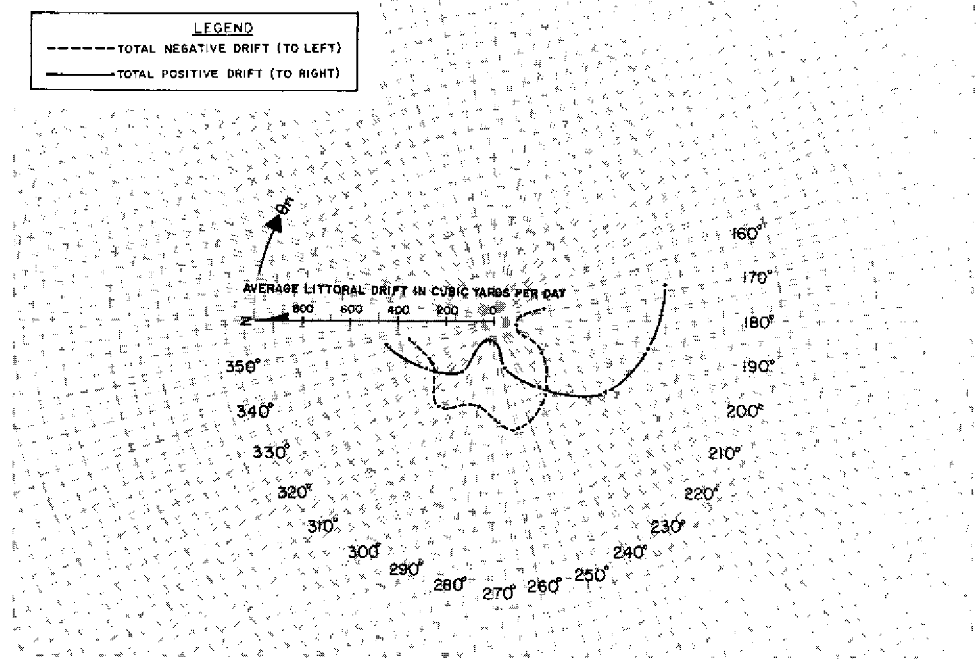


FIGURE A-198 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPON SPRINGS, FLORIDA - MARCH

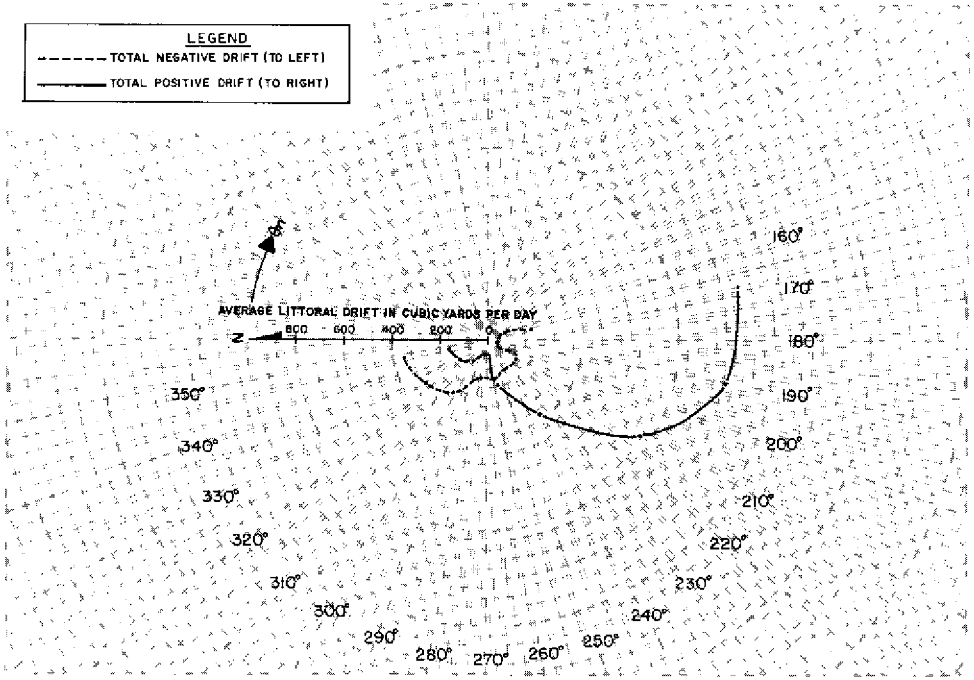


FIGURE A-199 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPON SPRINGS, FLORIDA - APRIL

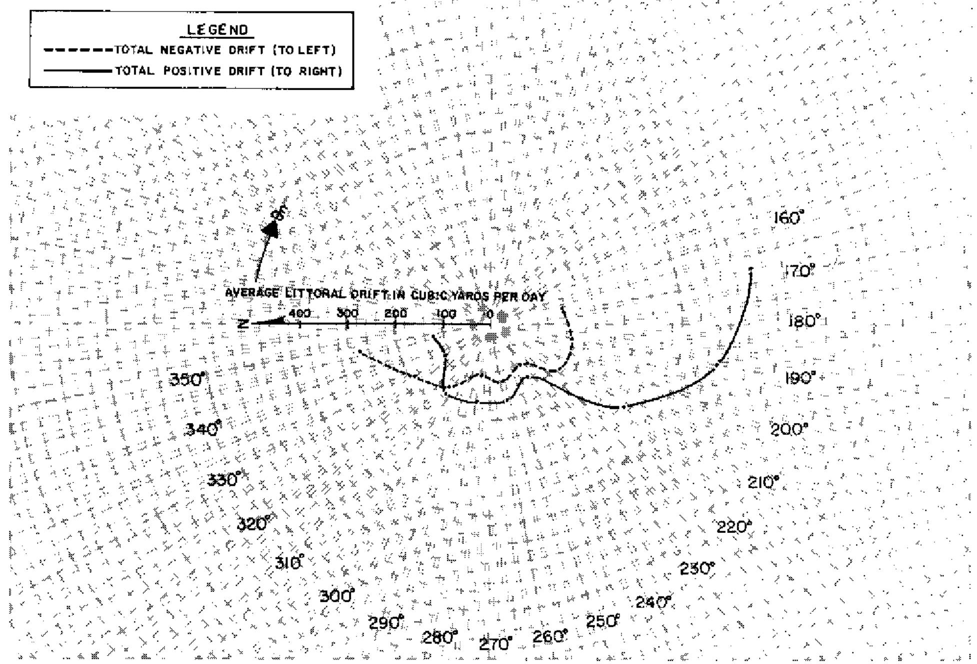


FIGURE A-200 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPON SPRINGS, FLORIDA - MAY

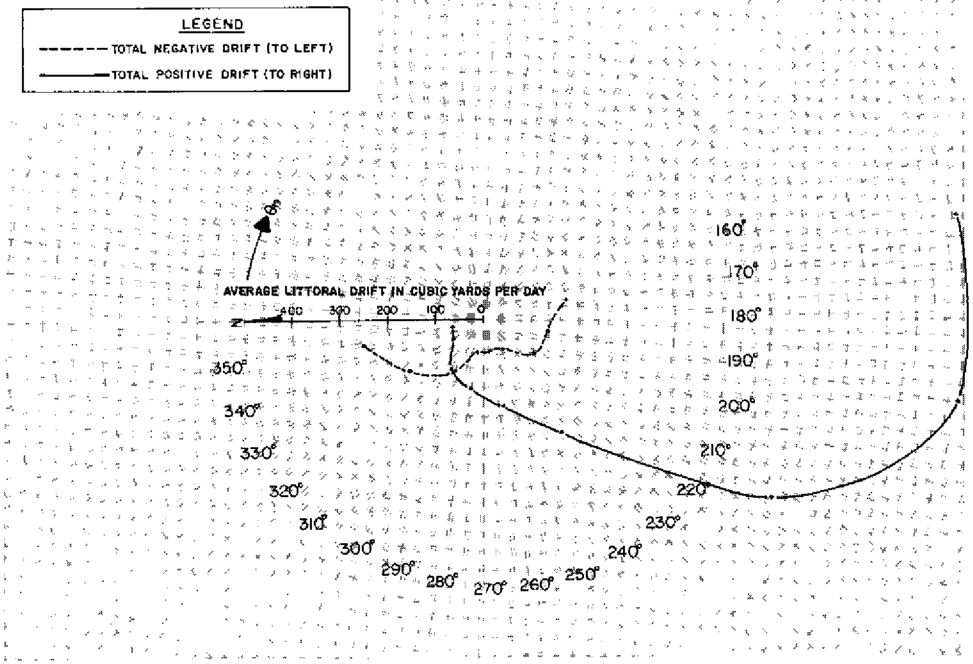


FIGURE A-201 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPON SPRINGS, FLORIDA - JUNE

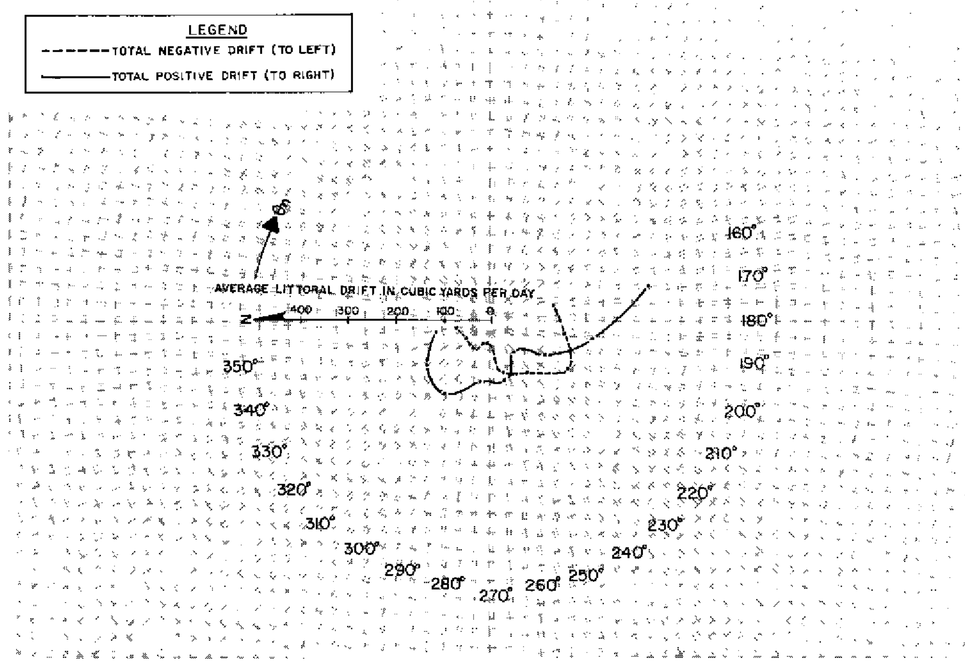


FIGURE A-202 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPON SPRINGS, FLORIDA - JULY

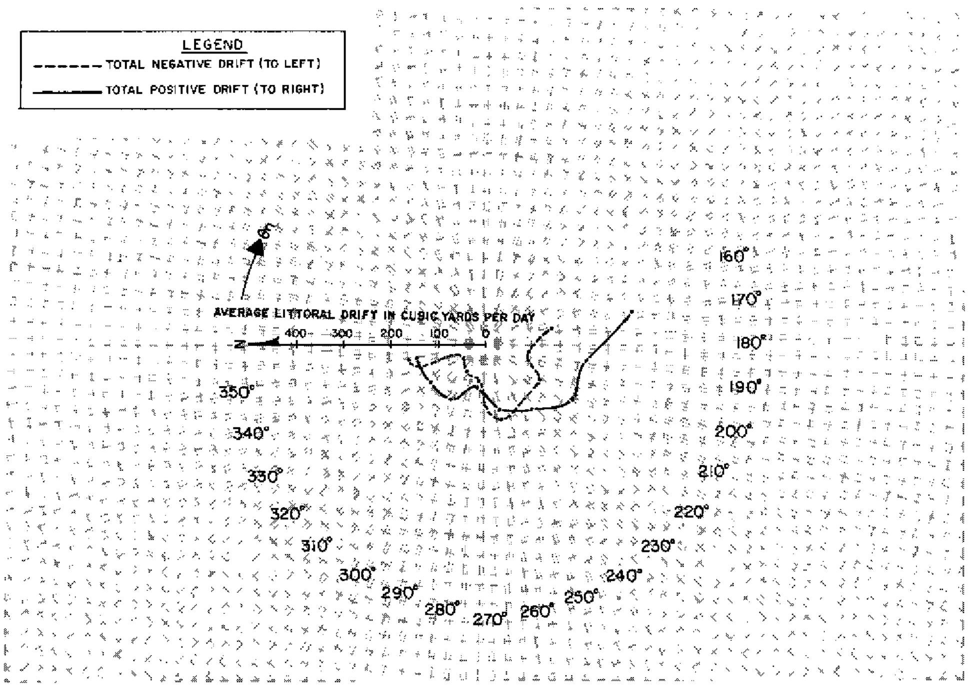


FIGURE A-203 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA [illegible] ENTRANCE TO TARPON SPRINGS, FLORIDA - AUGUST

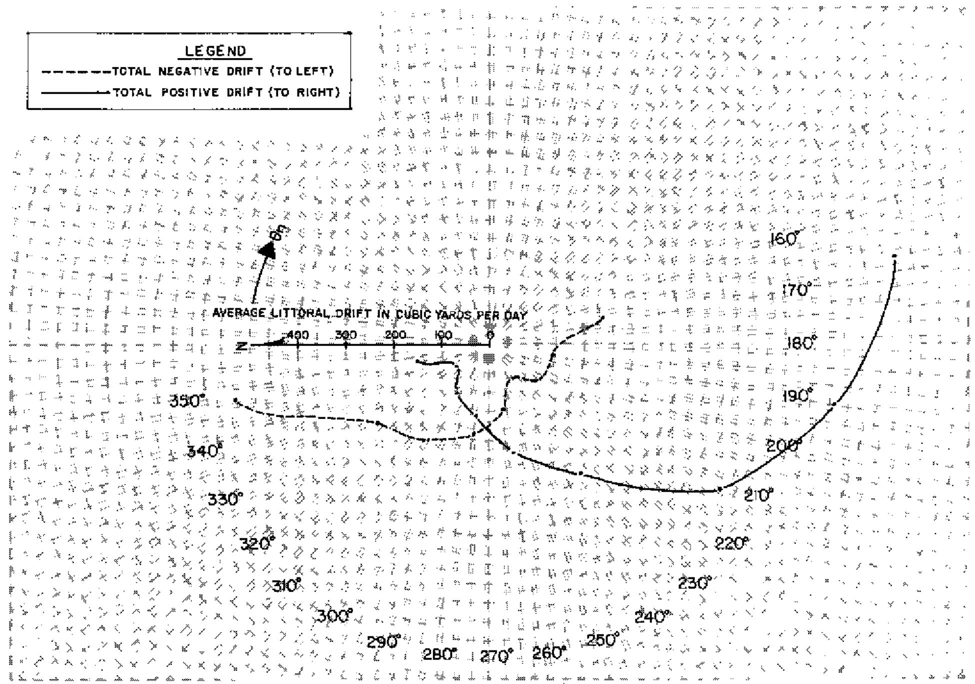


FIGURE A-204 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARP[illegible] SPRINGS, FLORIDA - SEPTEMBER

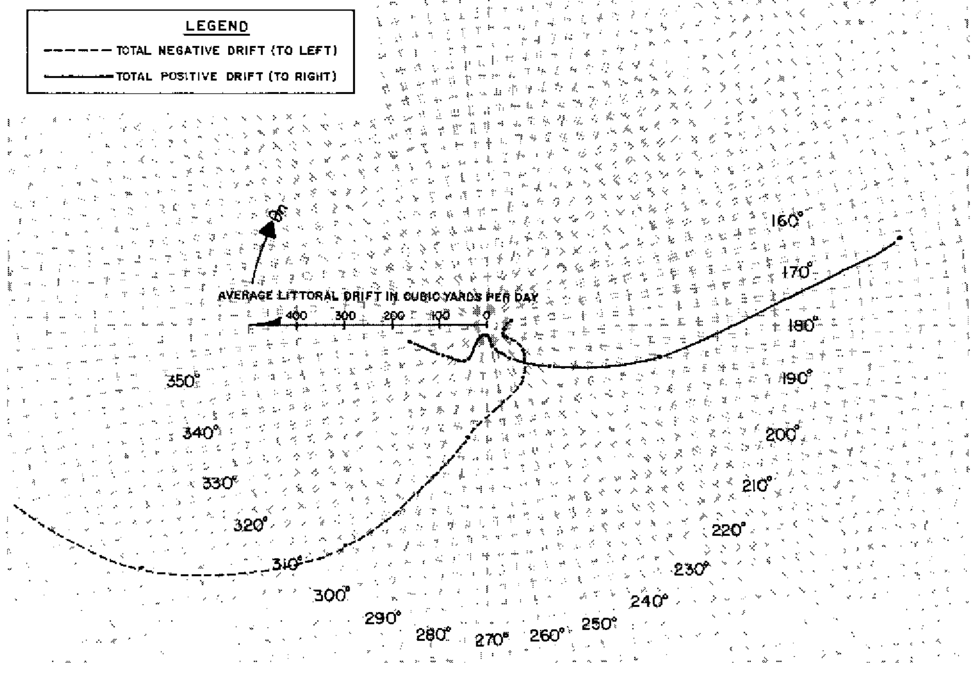


FIGURE A-205 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPON SPRINGS, FLORIDA - OCTOBER

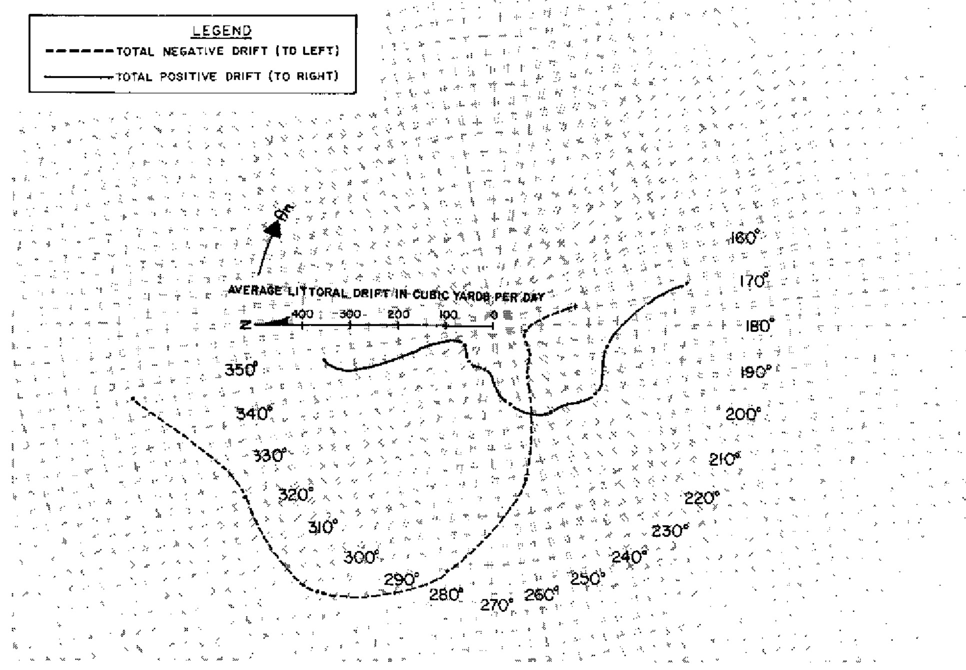


FIGURE A-206 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPON SPRINGS, FLORIDA - NOVEMBER

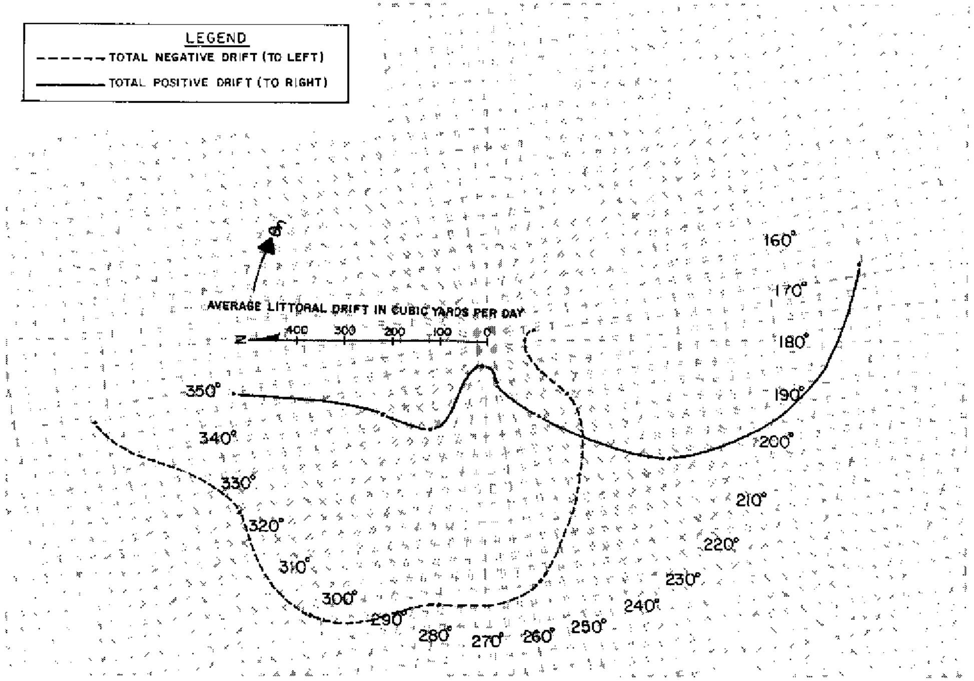


FIGURE A-207 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPON SPRINGS, FLORIDA - DECEMBER

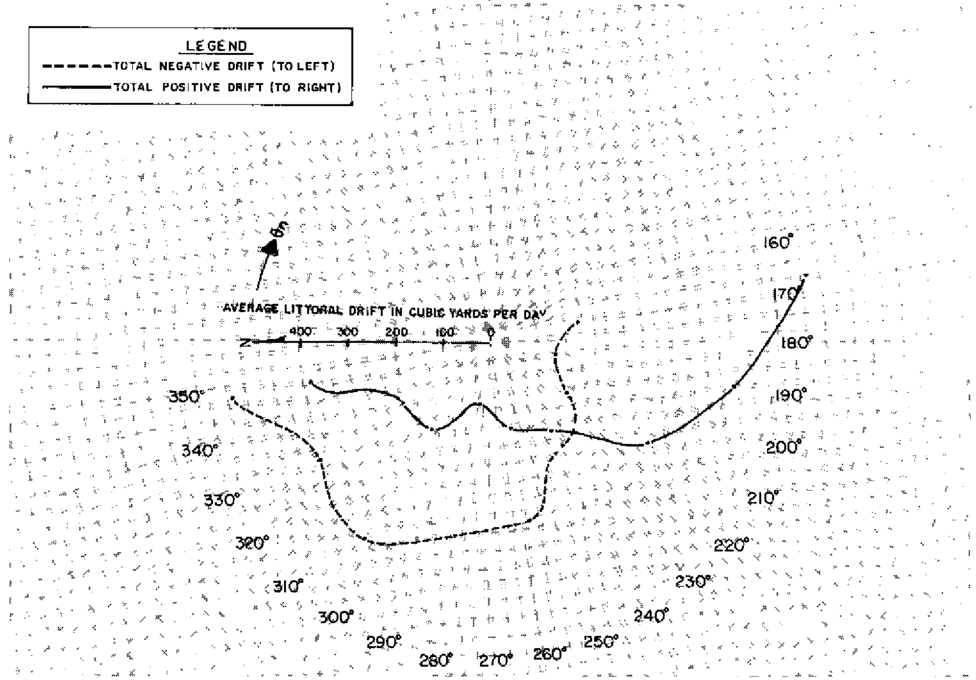


FIGURE A-208 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - TAMPA BAY ENTRANCE TO TARPON SPRINGS, FLORIDA

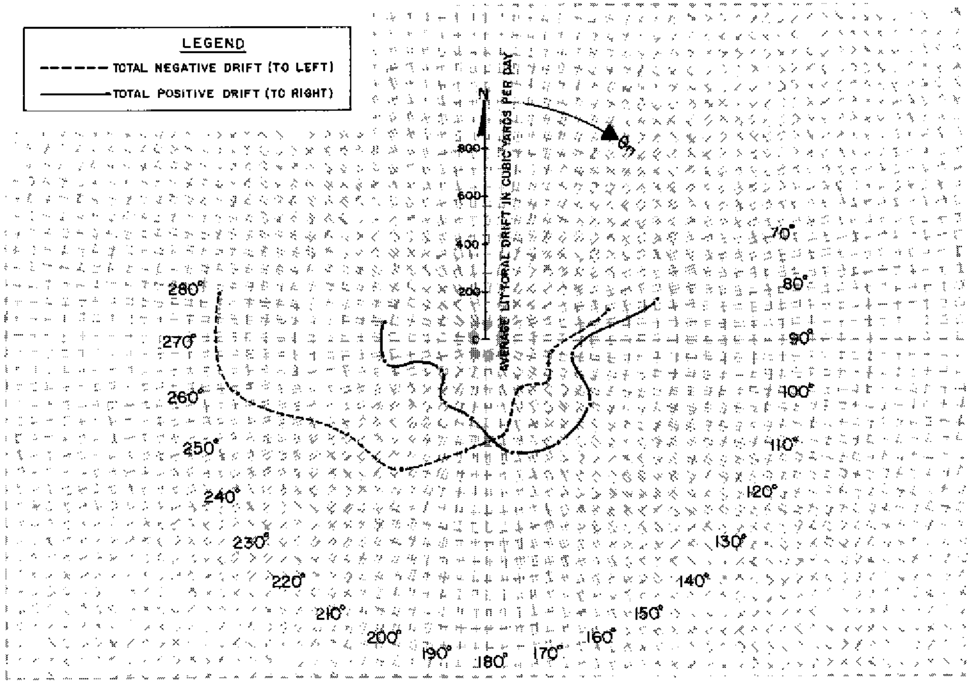


FIGURE A-209 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FLORIDA - JANUARY

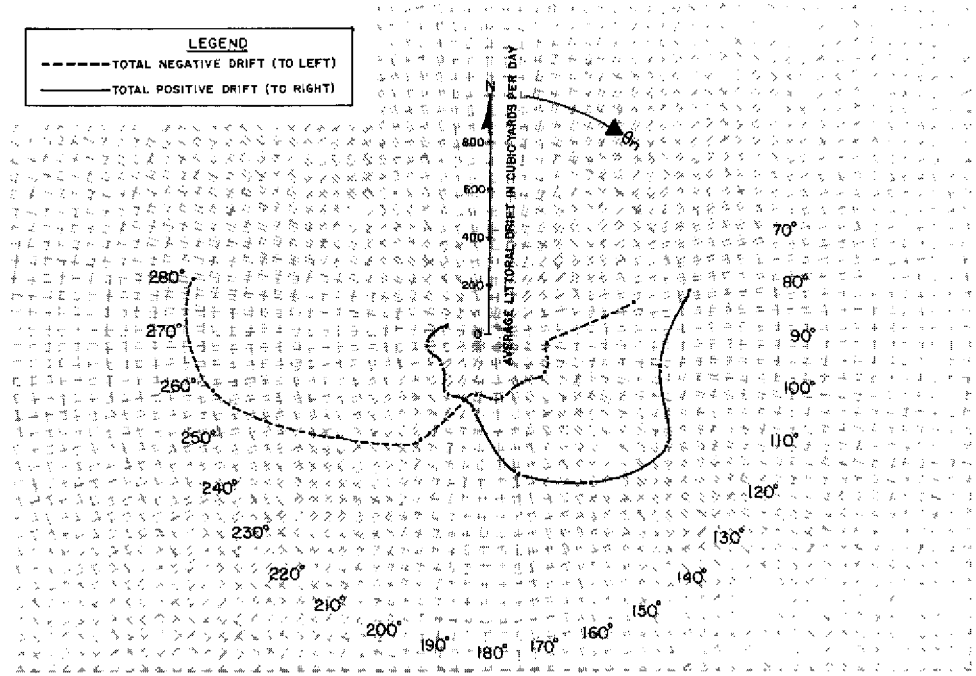


FIGURE A-210 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FLORIDA - FEBRUARY

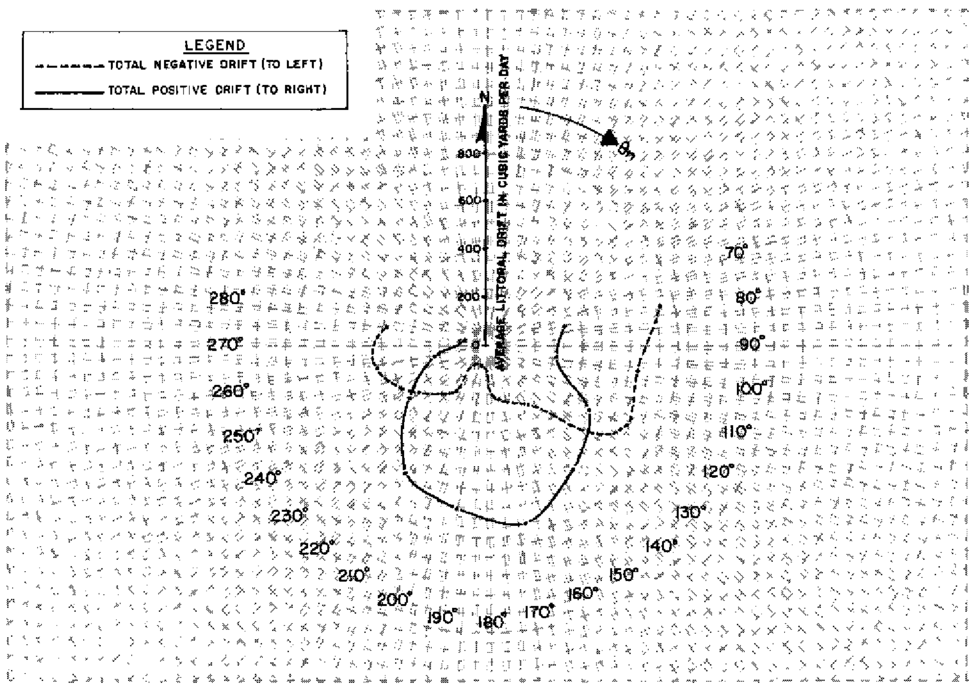


FIGURE A-211 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE PO[illegible] TO CAPE ST. GEORGE, FLORIDA - MARCH

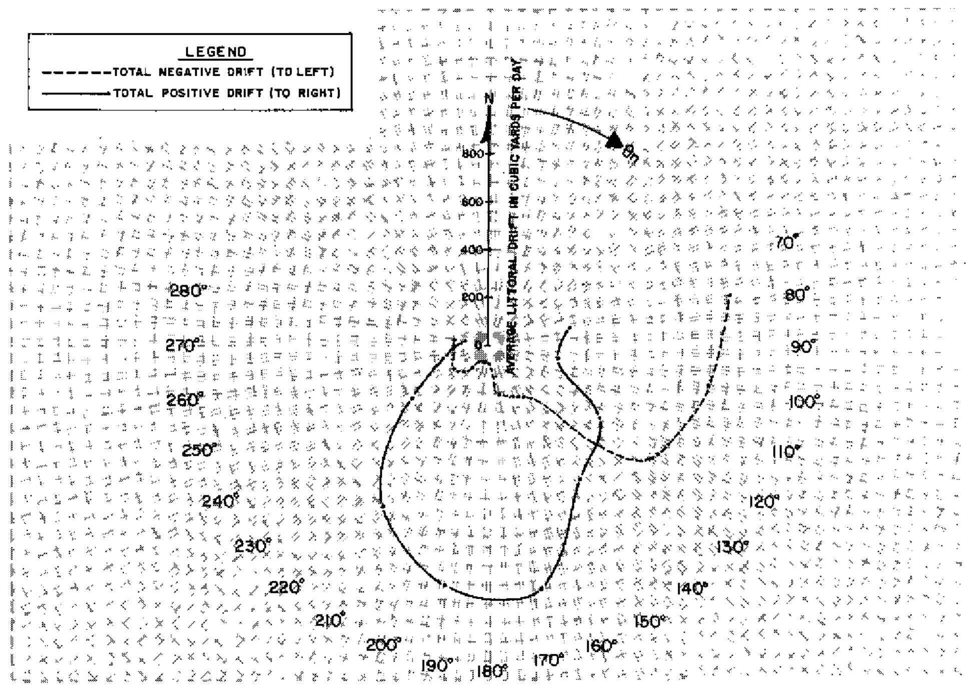


FIGURE A-212 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH OR[illegible]NTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, F[illegible]RIDA - APRIL

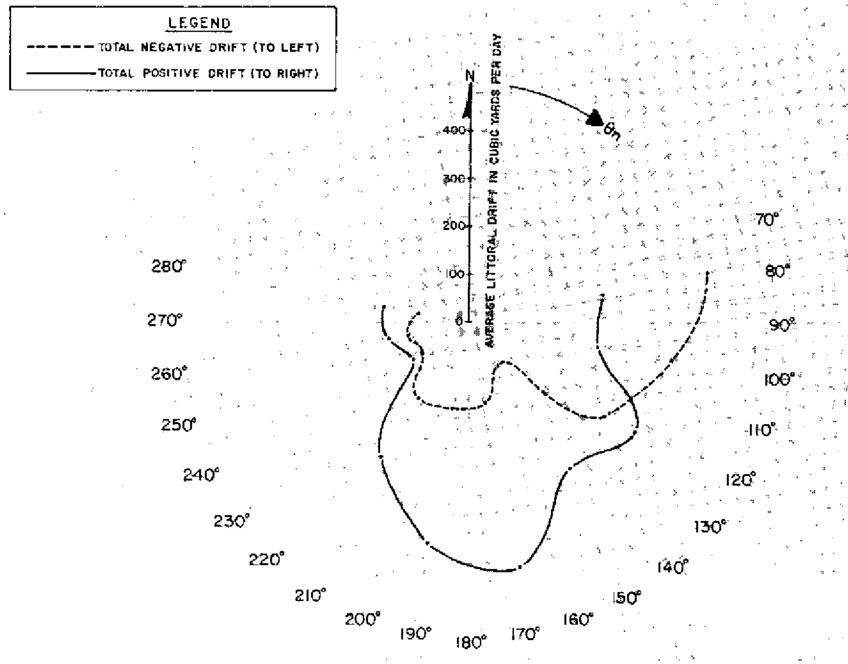


FIGURE A-213 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FLORIDA - MAY

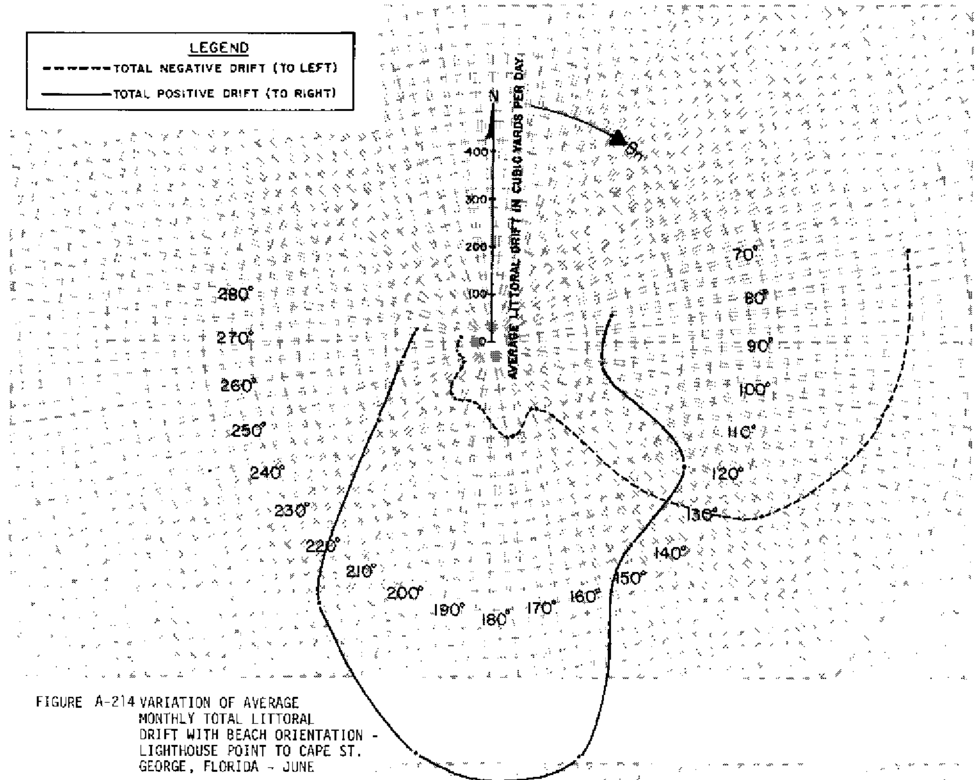


FIGURE A-214 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FLORIDA - JUNE

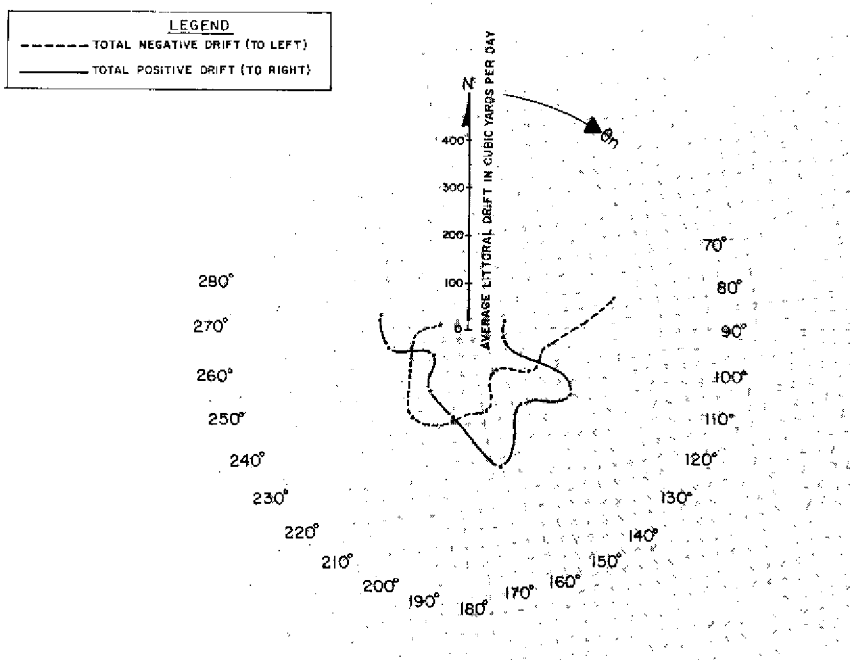


FIGURE A-215 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FLORIDA - JULY

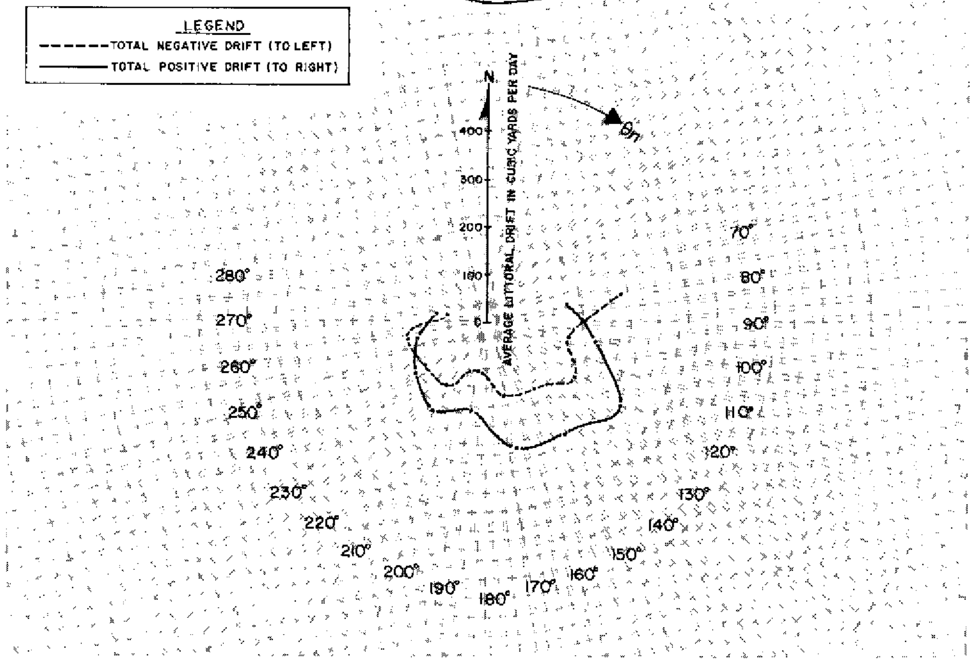


FIGURE A-216 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FLORIDA - AUGUST

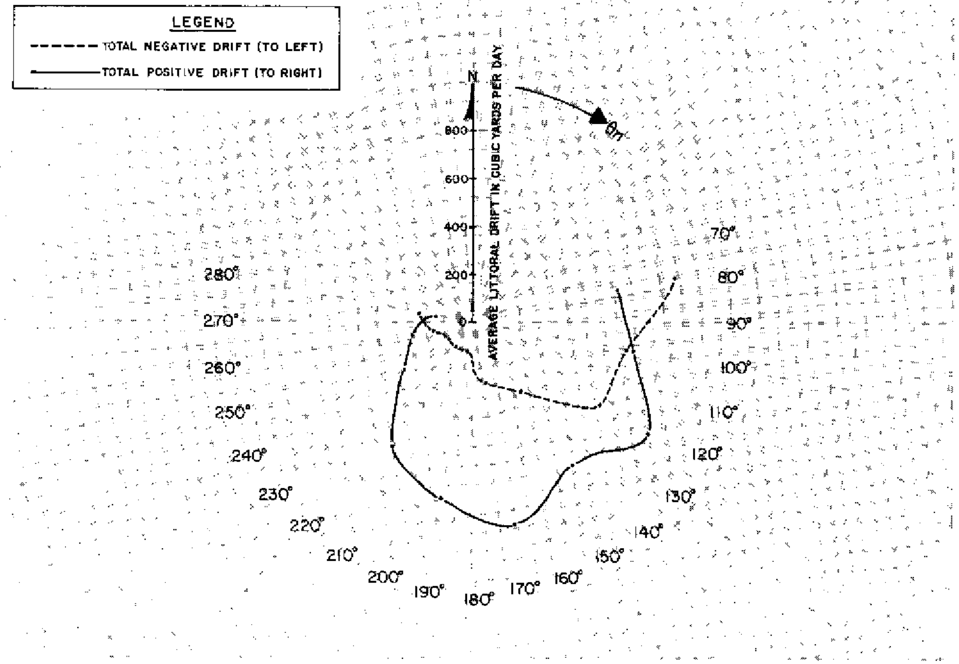


FIGURE A-217 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FLORIDA - SEPTEMBER

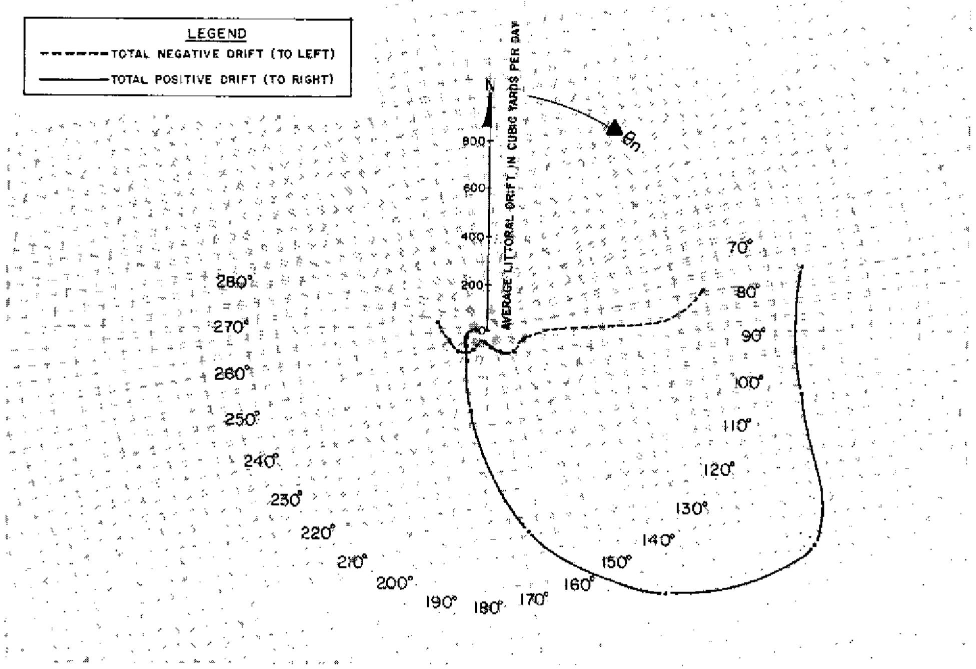


FIGURE A-218 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FLORIDA - OCTOBER

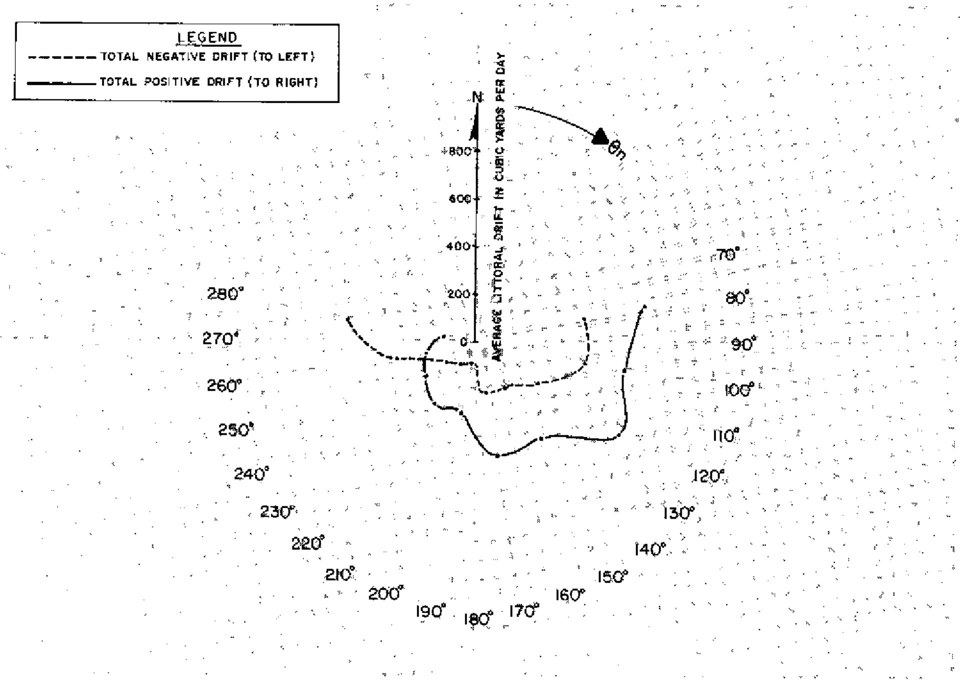


FIGURE A-219 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FLORIDA - NOVEMBER

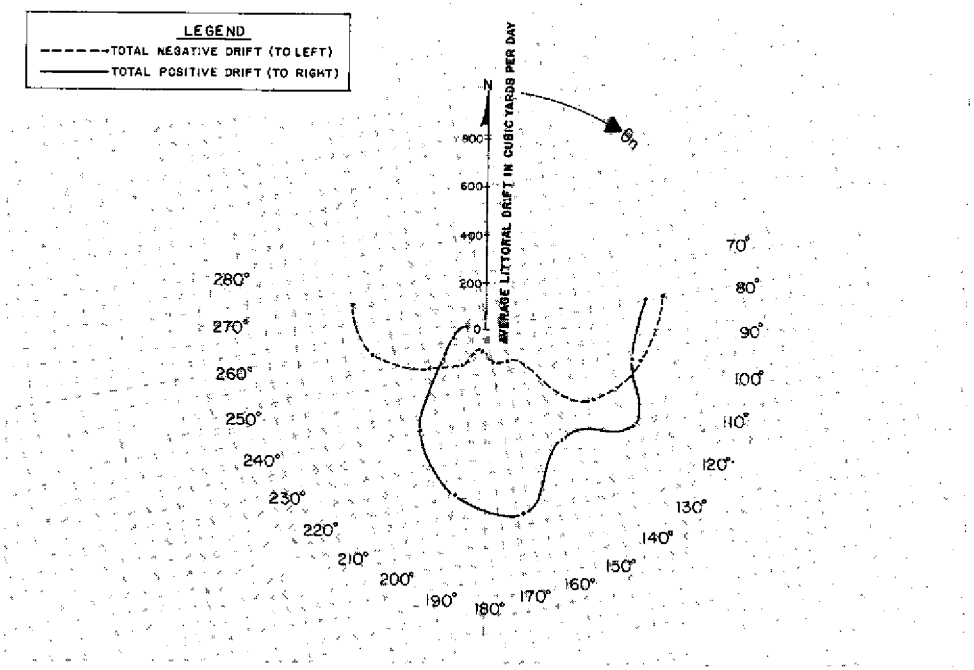


FIGURE A-220 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FL DA - DECEMBER

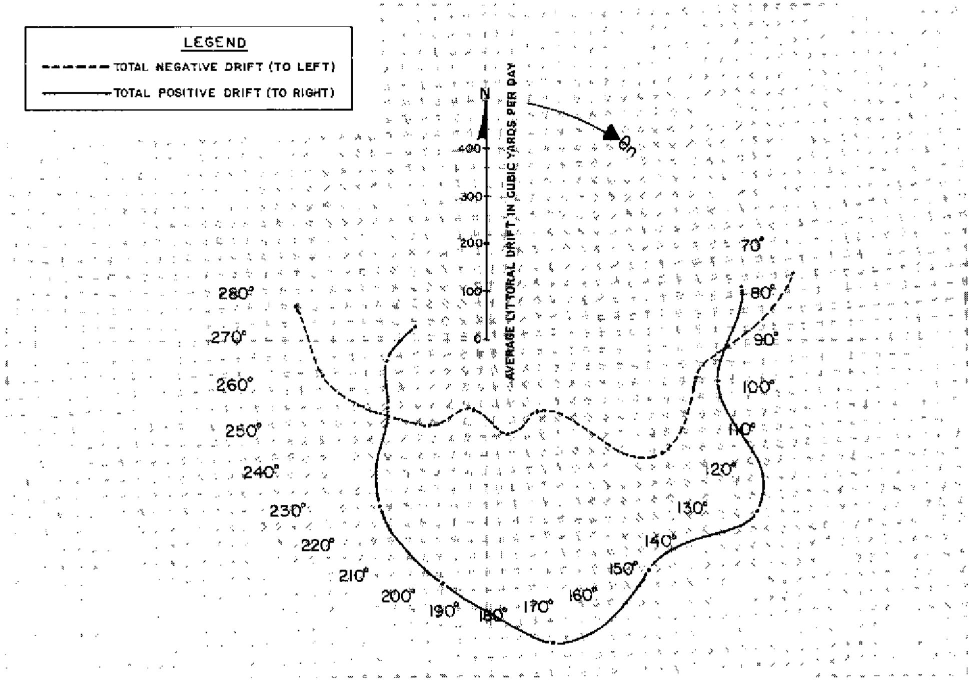


FIGURE A-221 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - LIGHTHOUSE POINT TO CAPE ST. GEORGE, FLORIDA

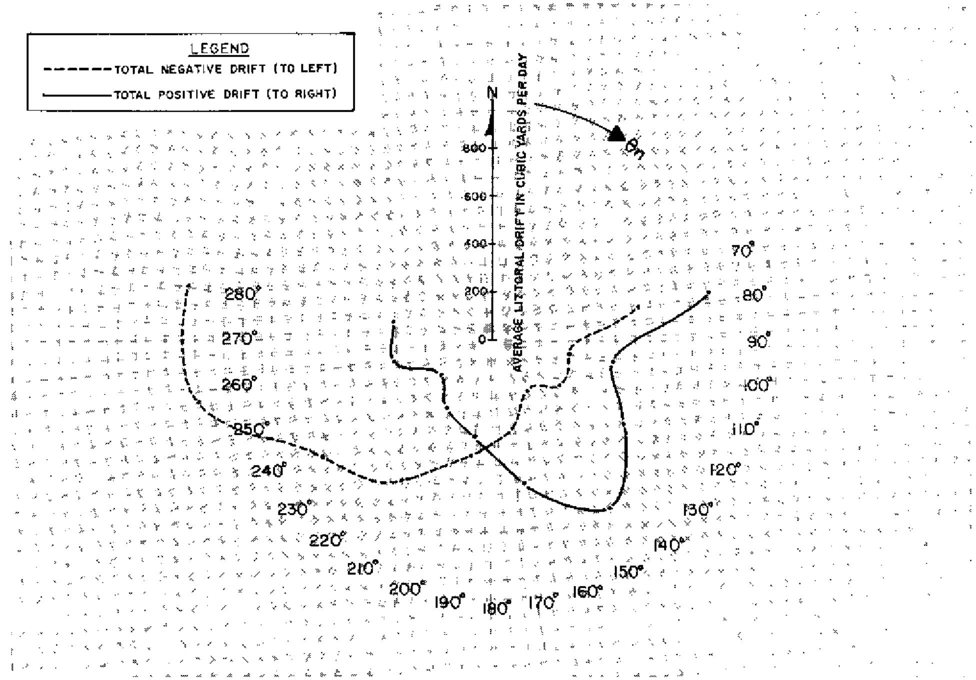


FIGURE A-222 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - JANUARY

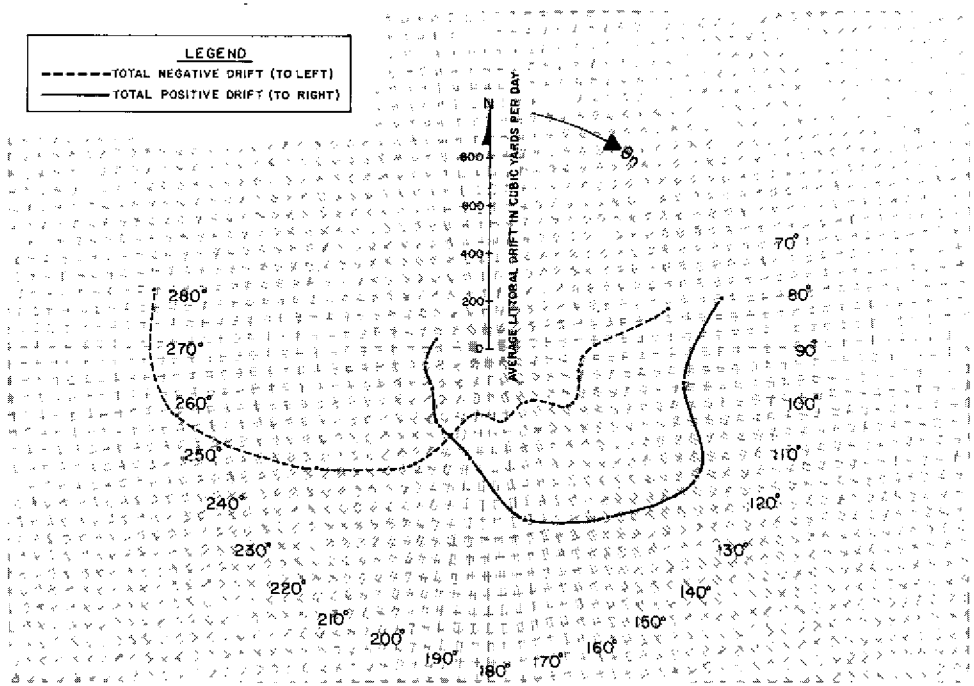


FIGURE A-223 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - FEBRUARY

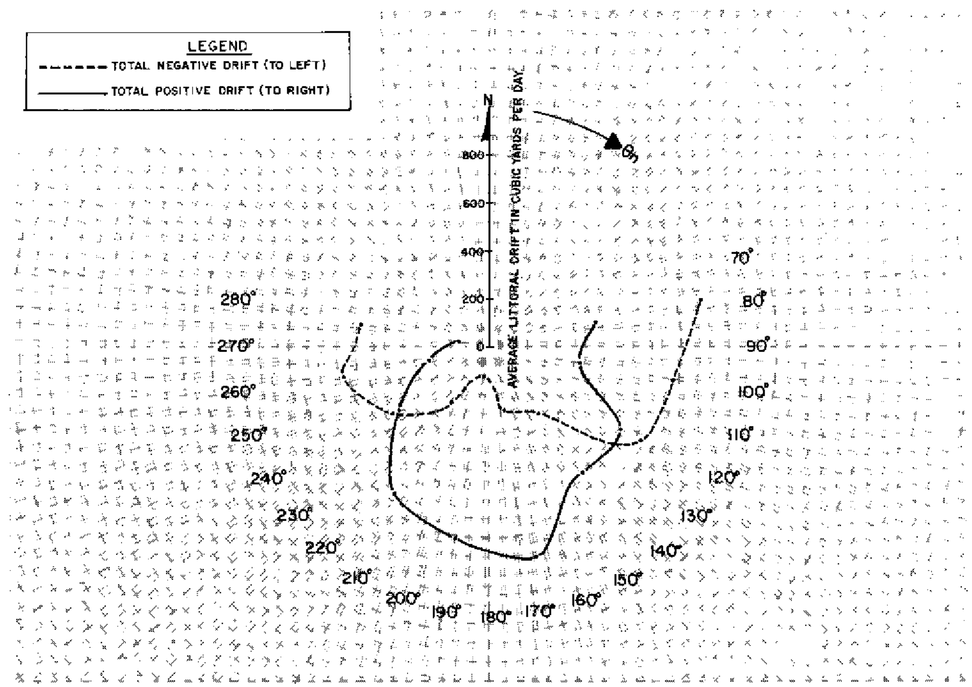


FIGURE A-224 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - MARCH

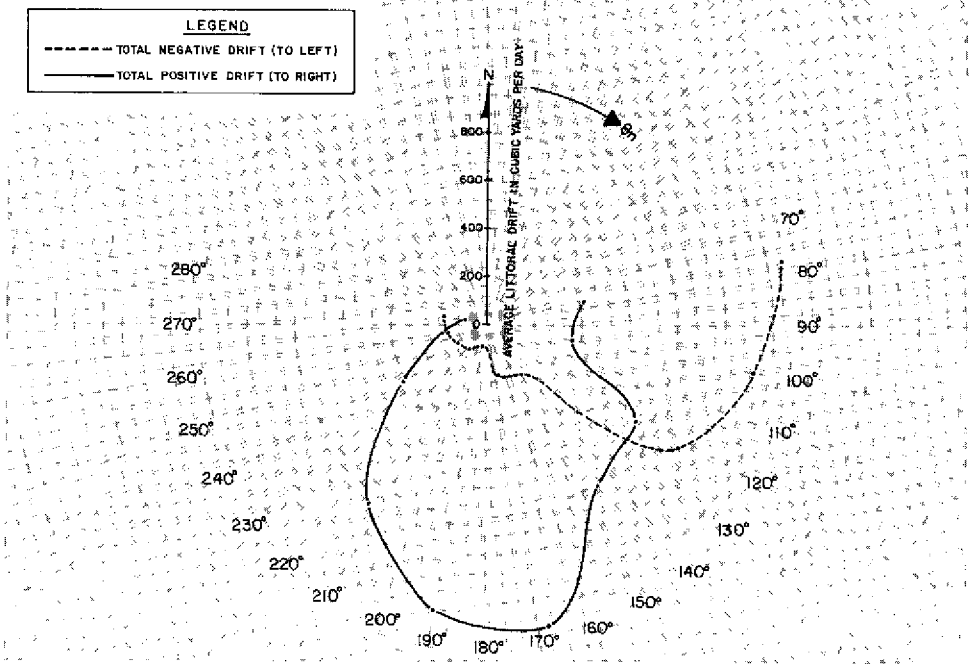


FIGURE A-225 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - APRIL

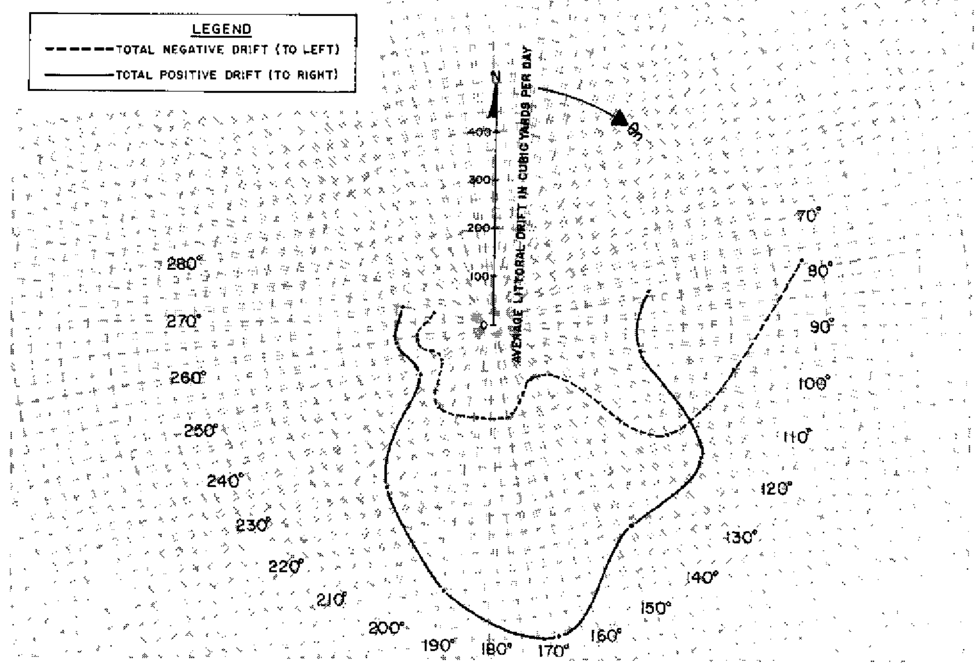


FIGURE A-226 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - MAY

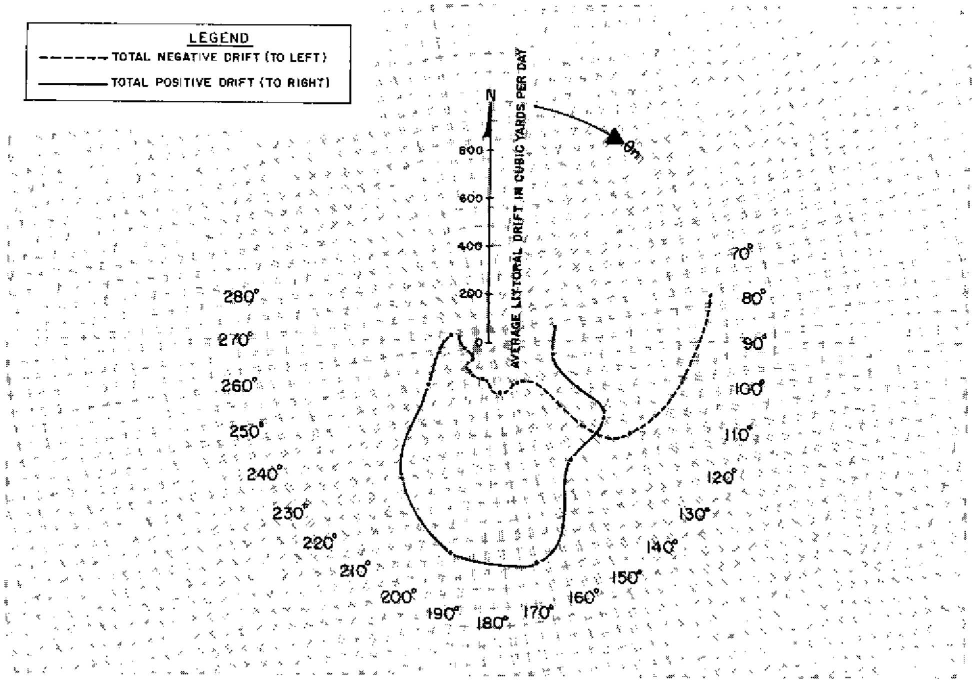


FIGURE A-227 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - JUN

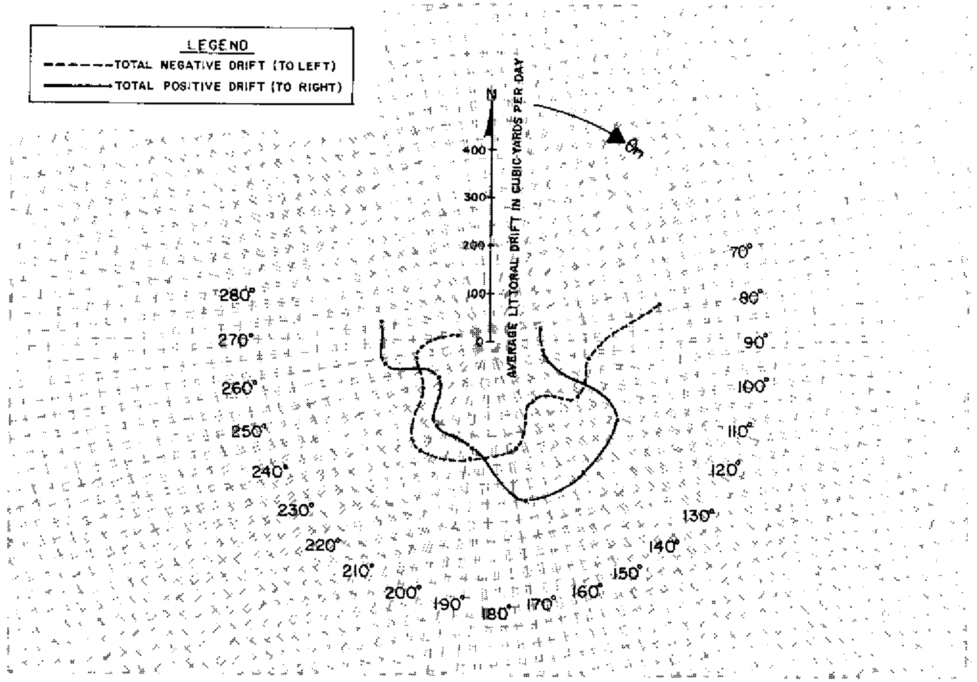


FIGURE A-228 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAP SAN BLAS, FLORIDA - JULY

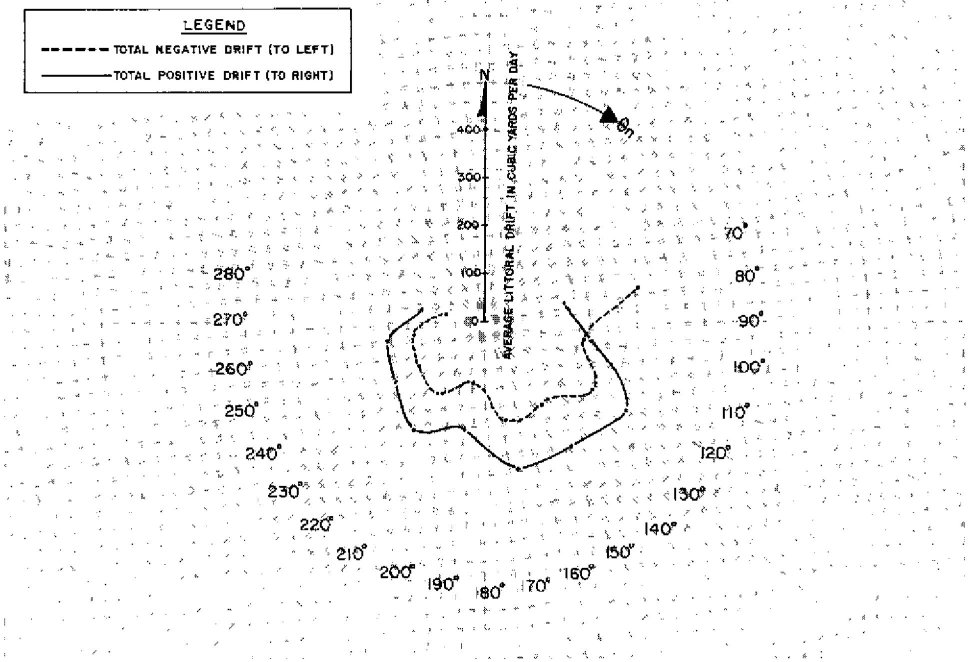


FIGURE A-229 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - AUGUST

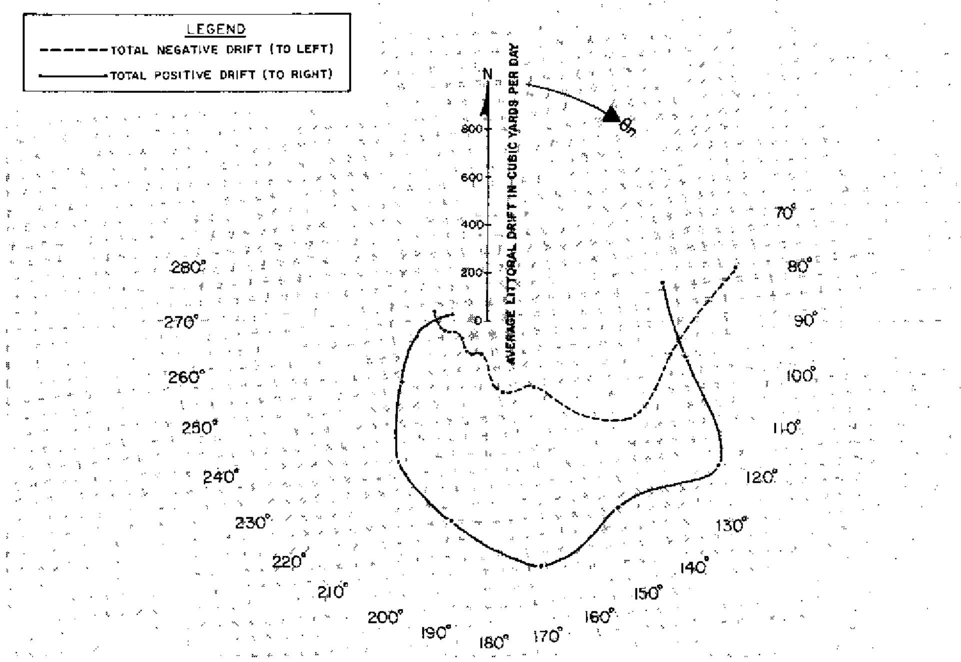


FIGURE A-230 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - SEPTEMBER

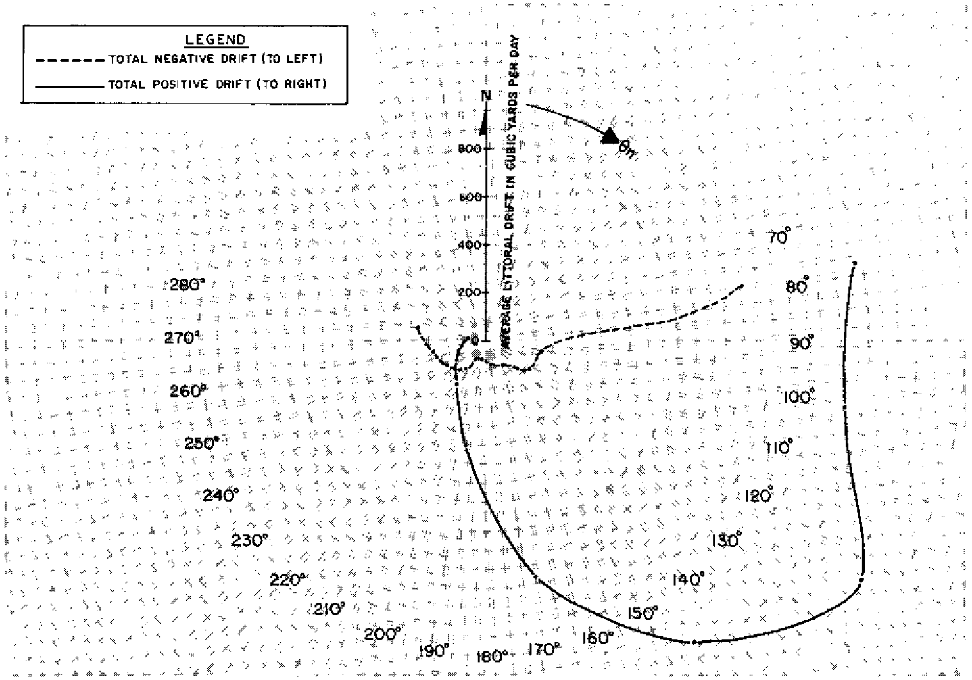


FIGURE A-231 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - OCTOBER

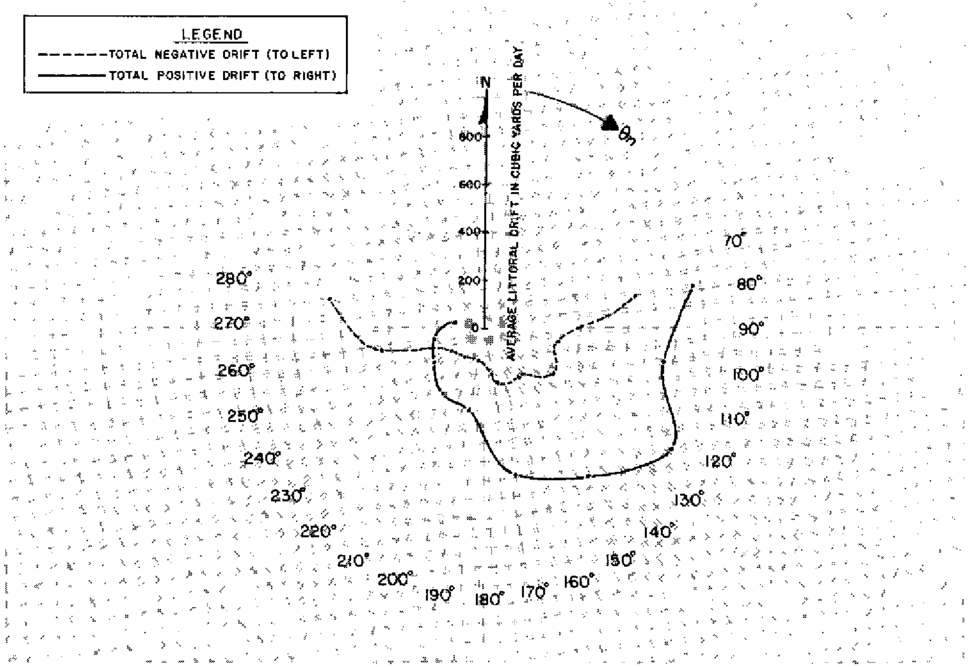


FIGURE A-232 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - NOVEMBER

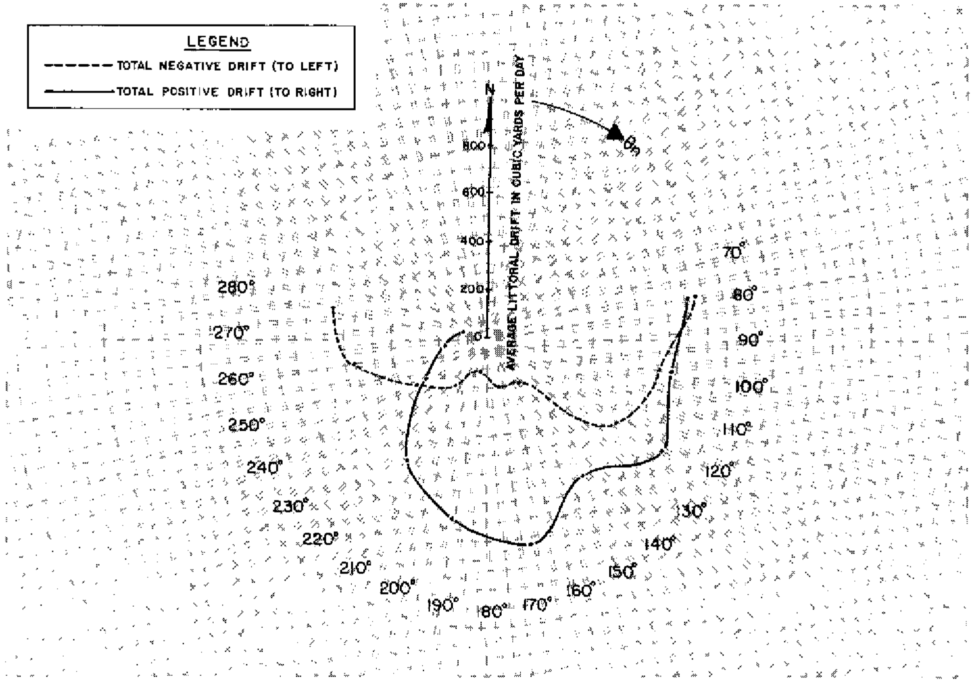


FIGURE A-233 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA - DECEMBER

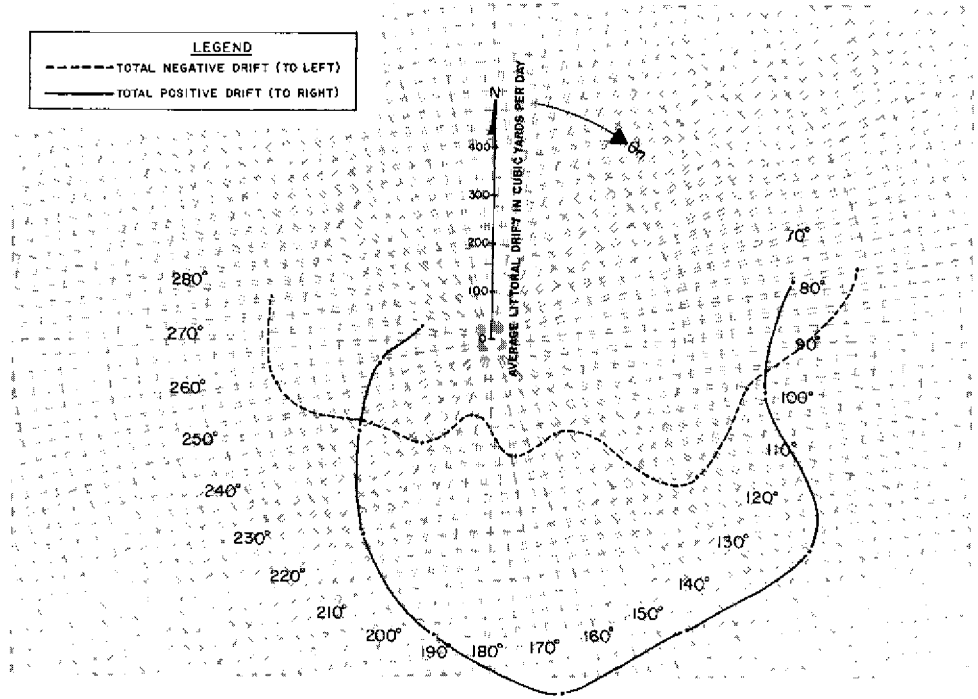


FIGURE A-234 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE ST. GEORGE TO CAPE SAN BLAS, FLORIDA

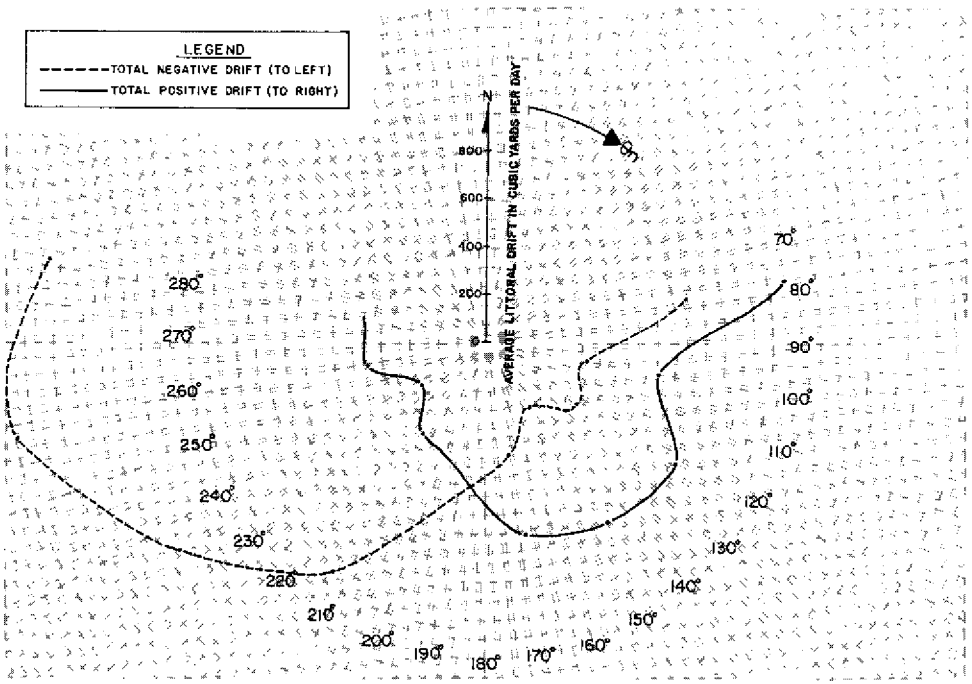


FIGURE A-235 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - JANUARY

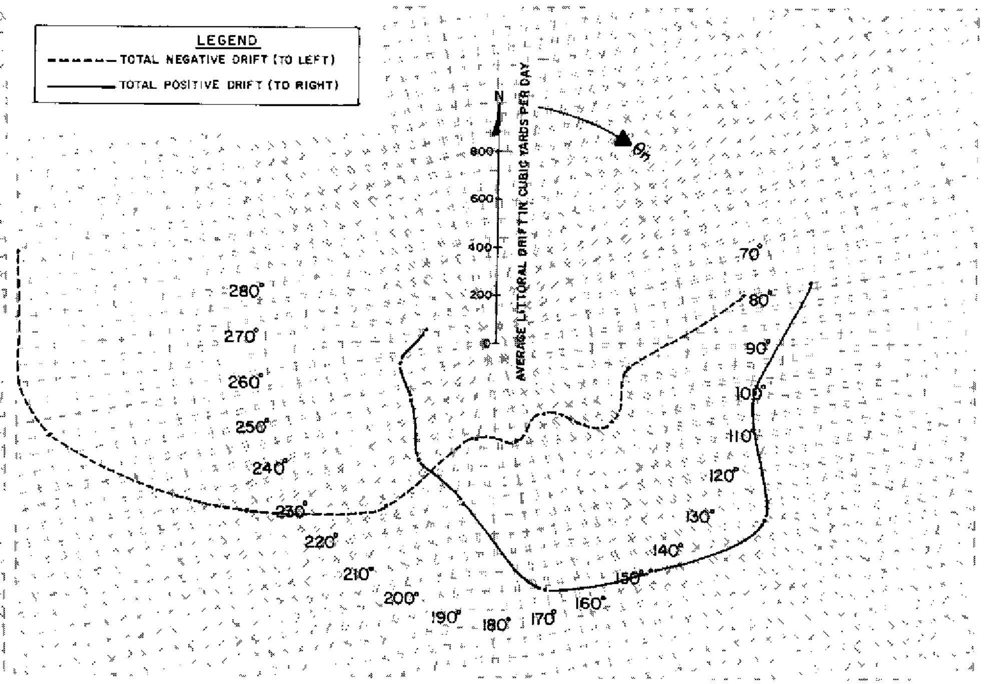


FIGURE A-236 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - FEBRUARY

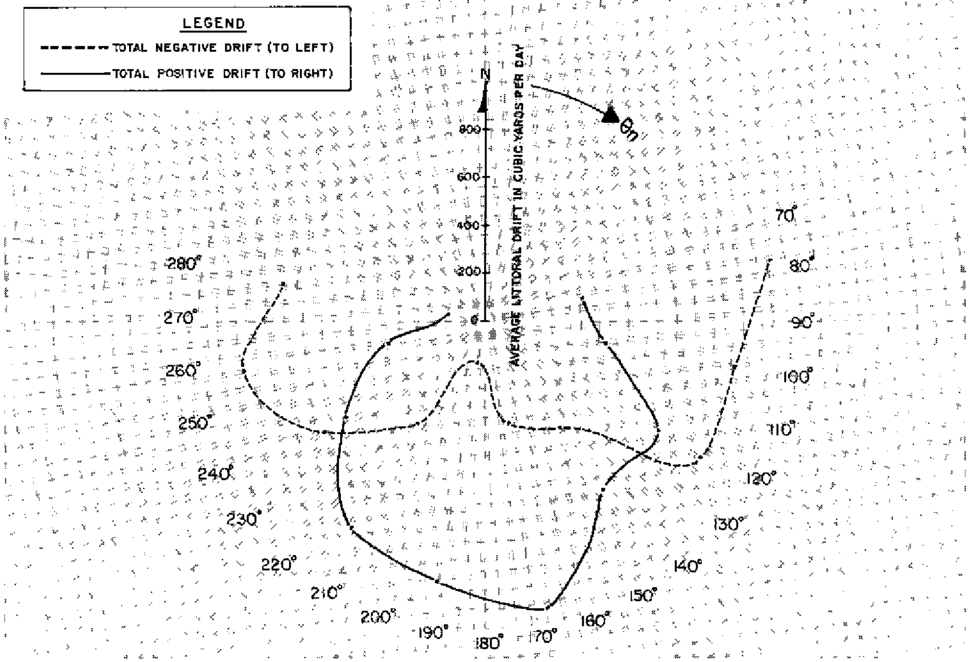


FIGURE A-237 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - MARCH

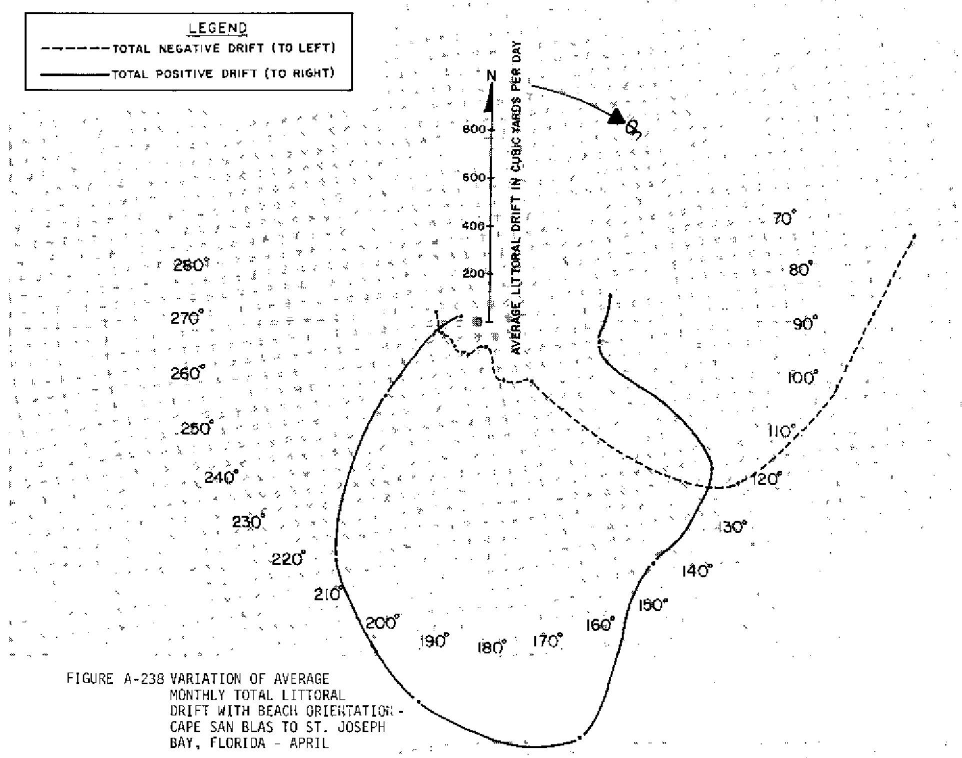


FIGURE A-238 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - APRIL

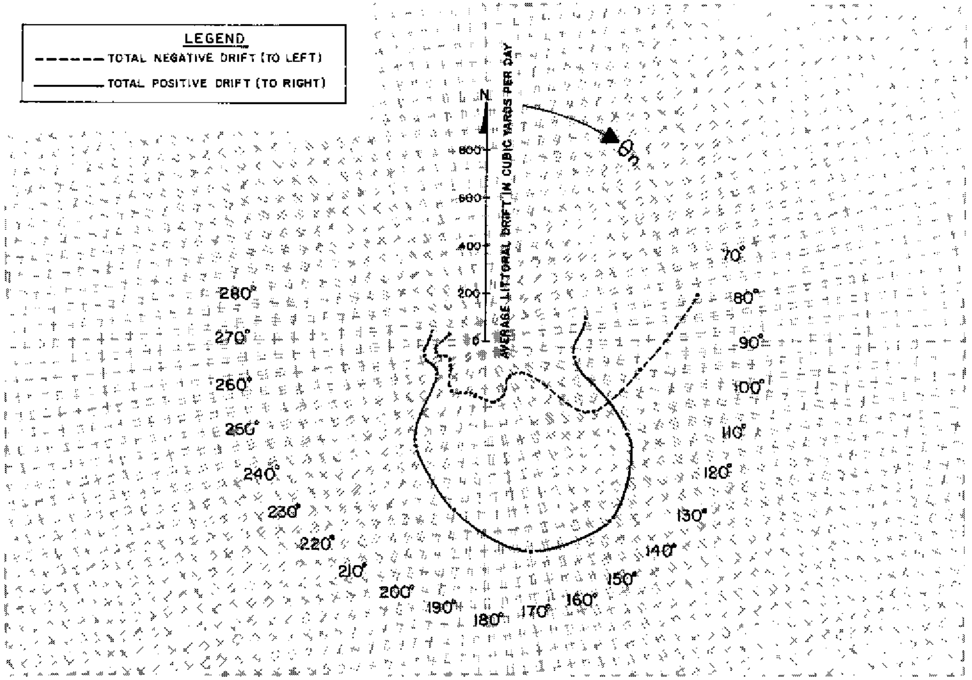


FIGURE A-239 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - MAY

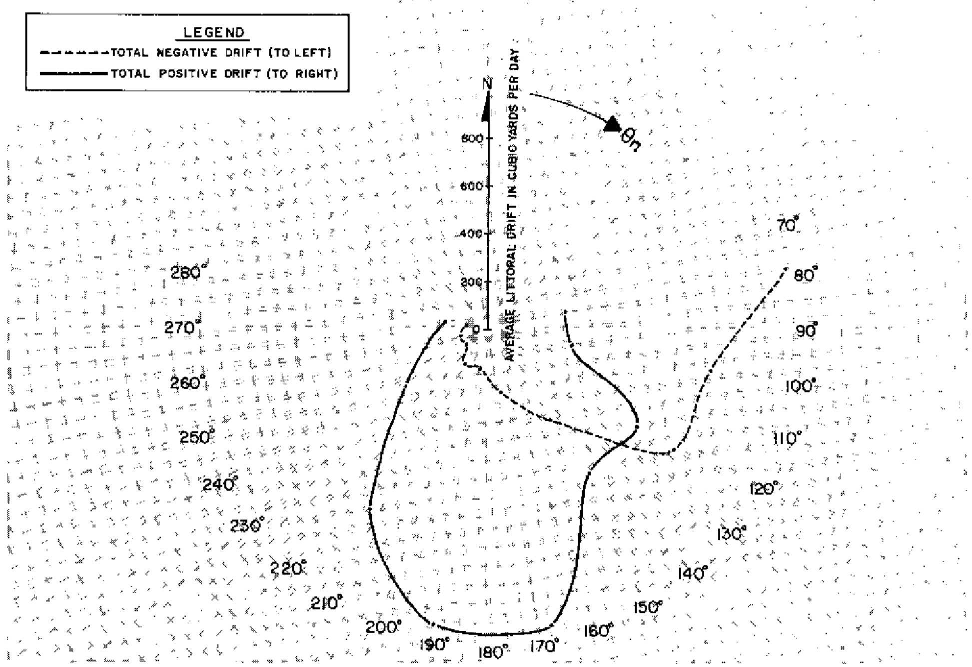


FIGURE A-240 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - JUNE

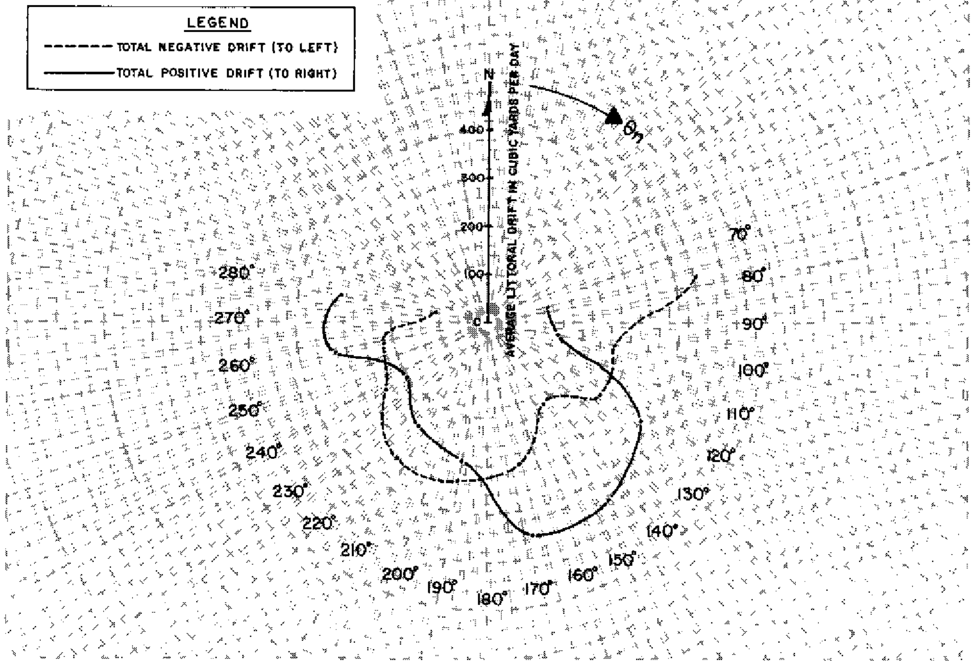


FIGURE A-241 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - JULY

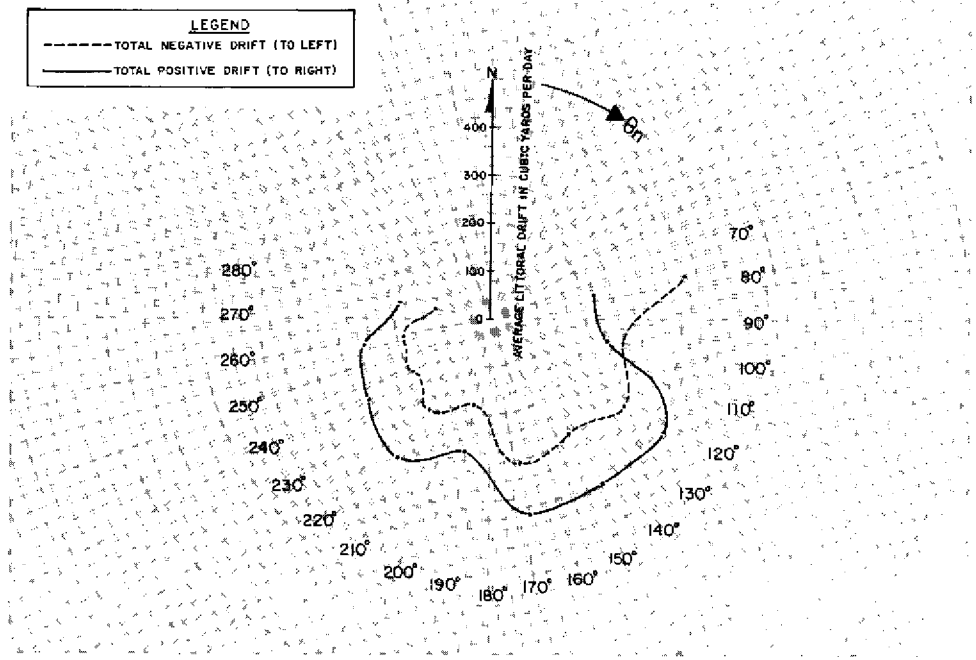


FIGURE A-242 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - AUGUST

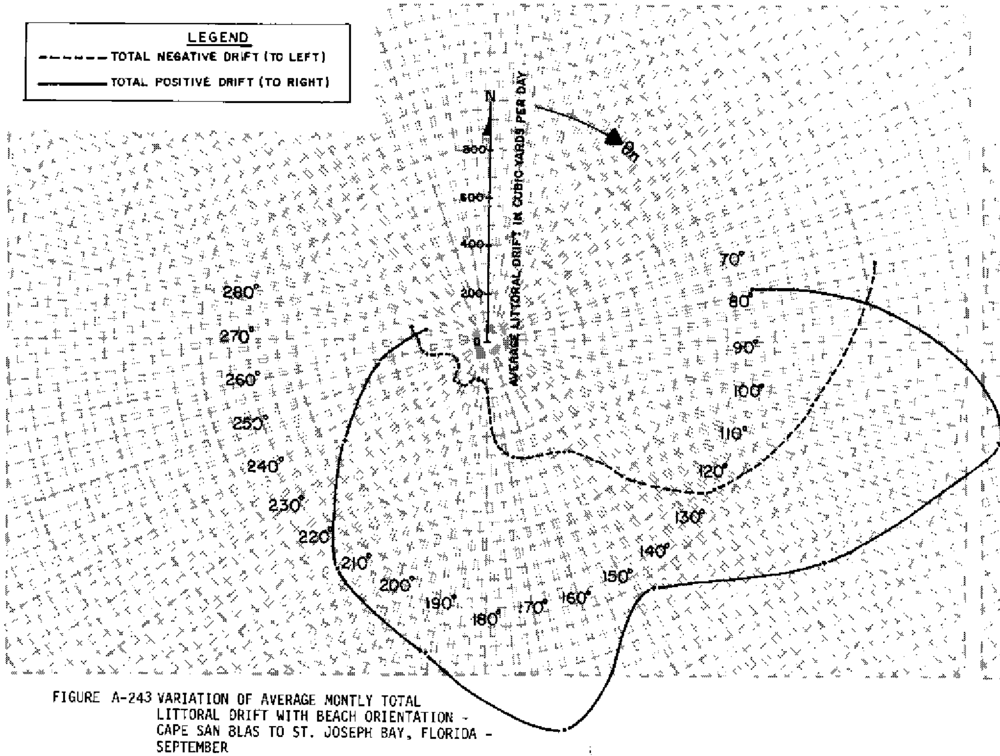


FIGURE A-243 VARIATION OF AVERAGE MONTLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - SEPTEMBER

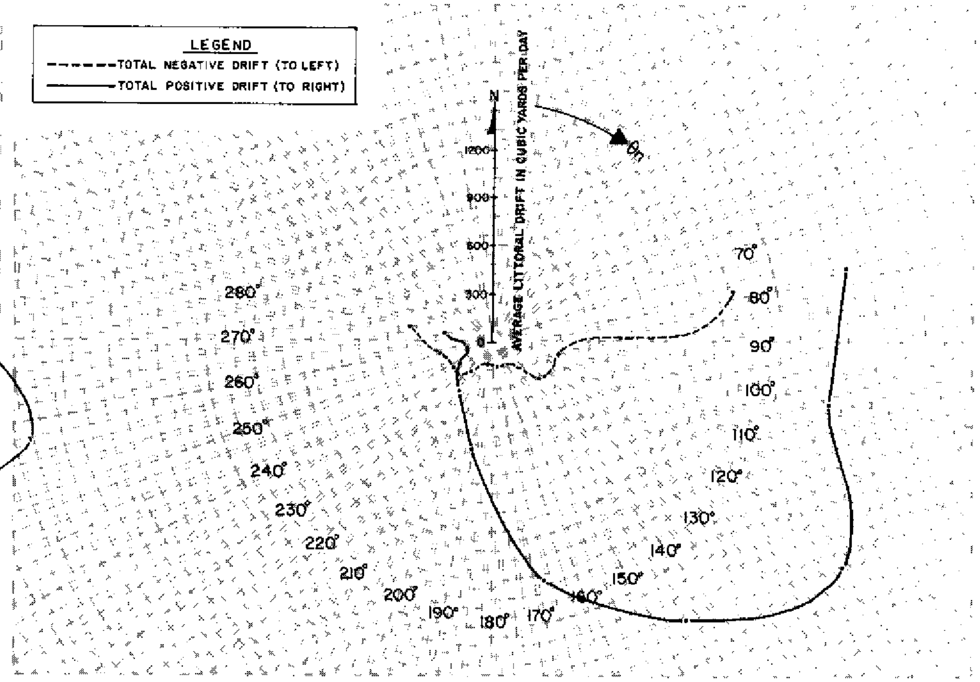


FIGURE A-244 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST JOSEPH BAY, FLORIDA - OCTOBER

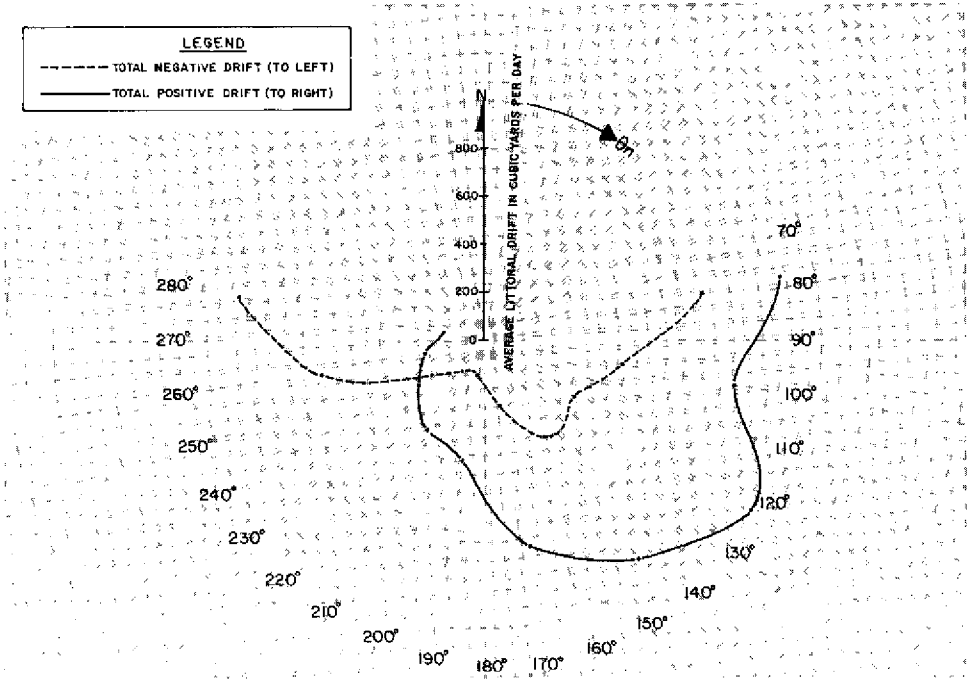


FIGURE A-245 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - NOVEMBER

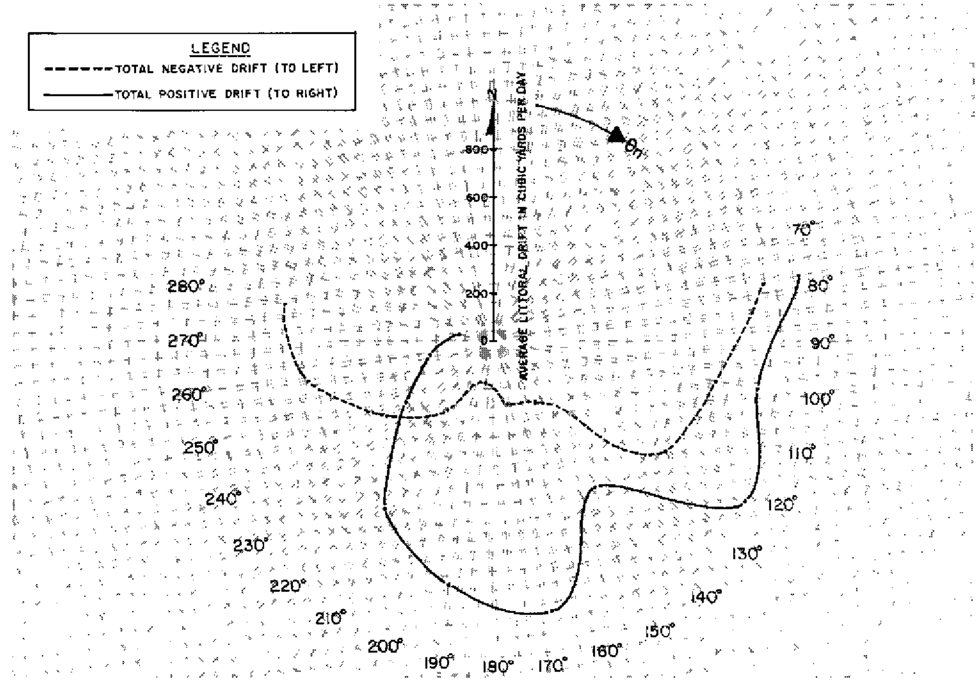


FIGURE A-246 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA - DECEMBER

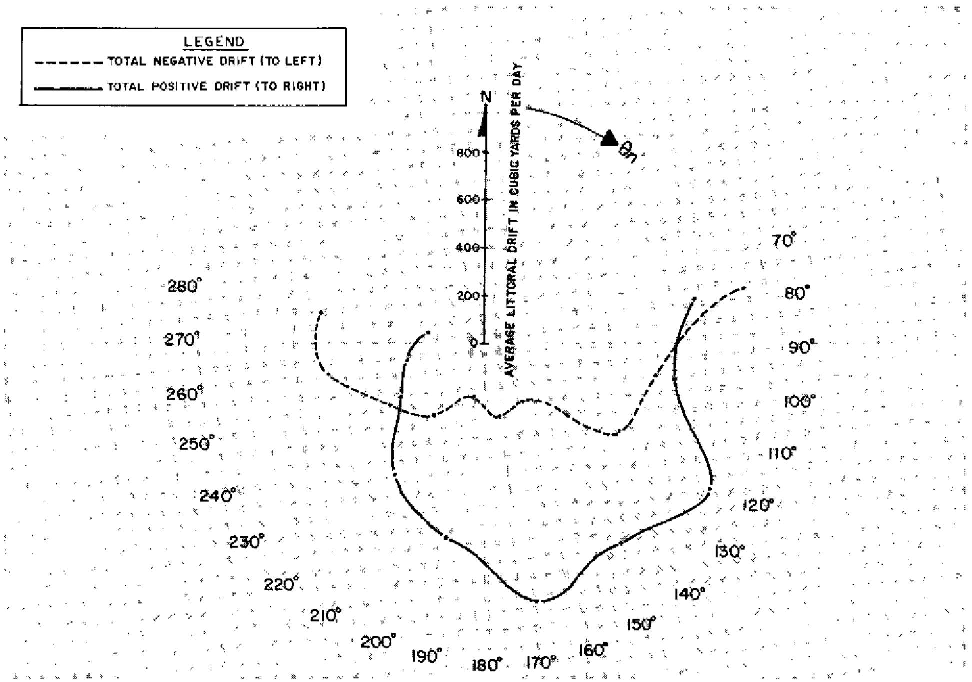


FIGURE A-247 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CAPE SAN BLAS TO ST. JOSEPH BAY, FLORIDA

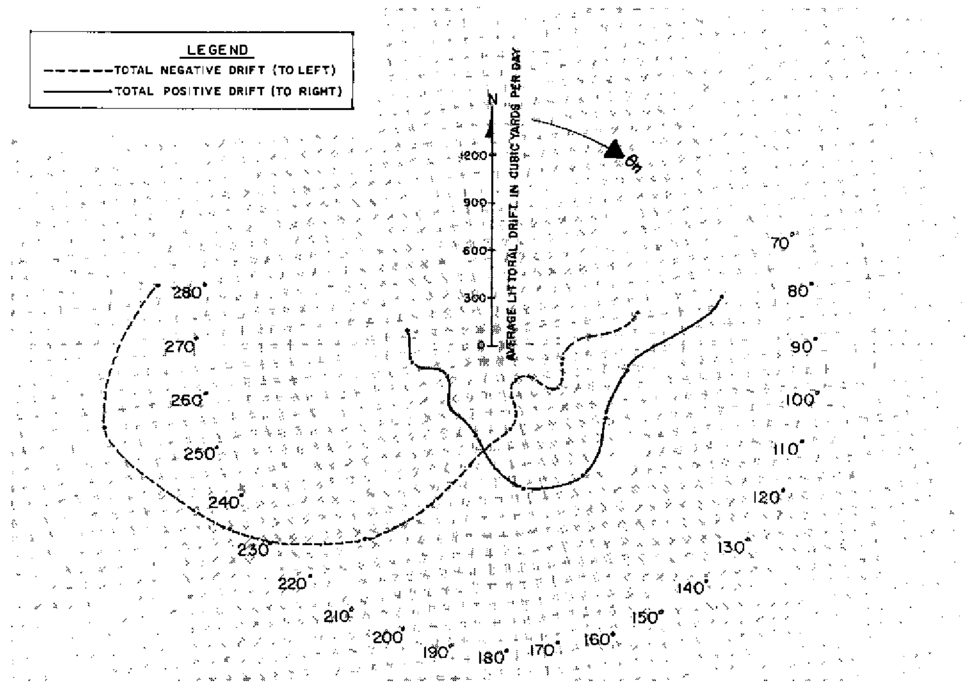


FIGURE A-248 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - JANUARY

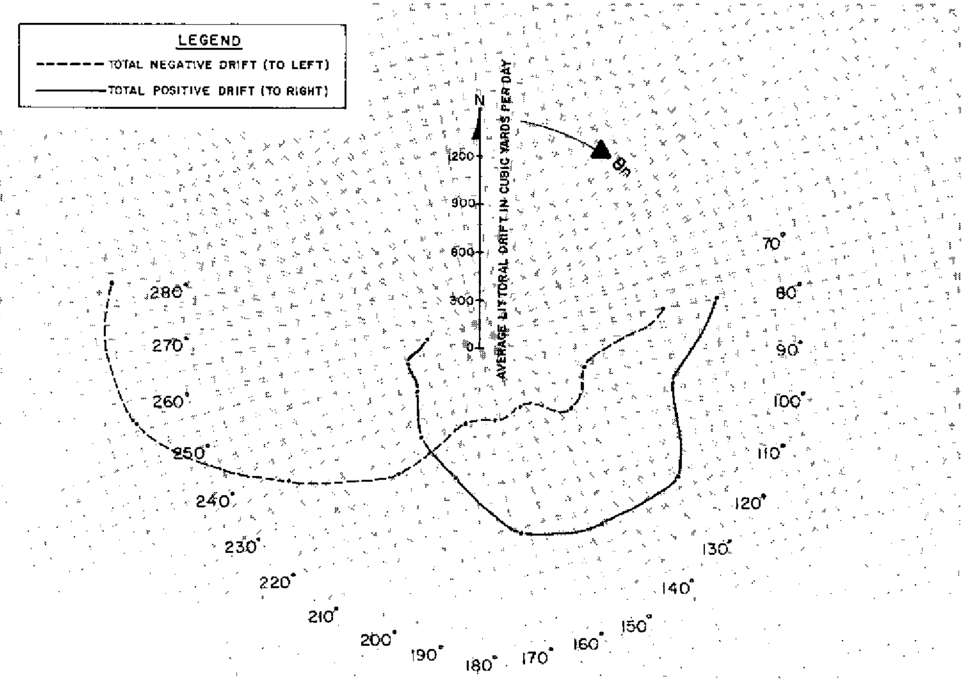


FIGURE A-249 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - FEBRUARY

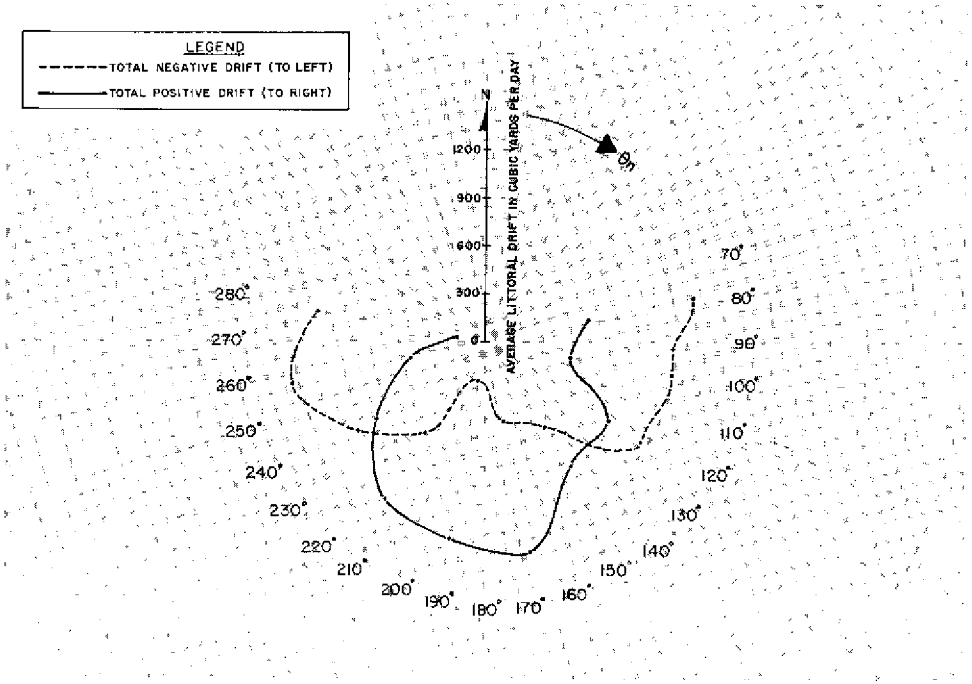


FIGURE A-250 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - MARCH

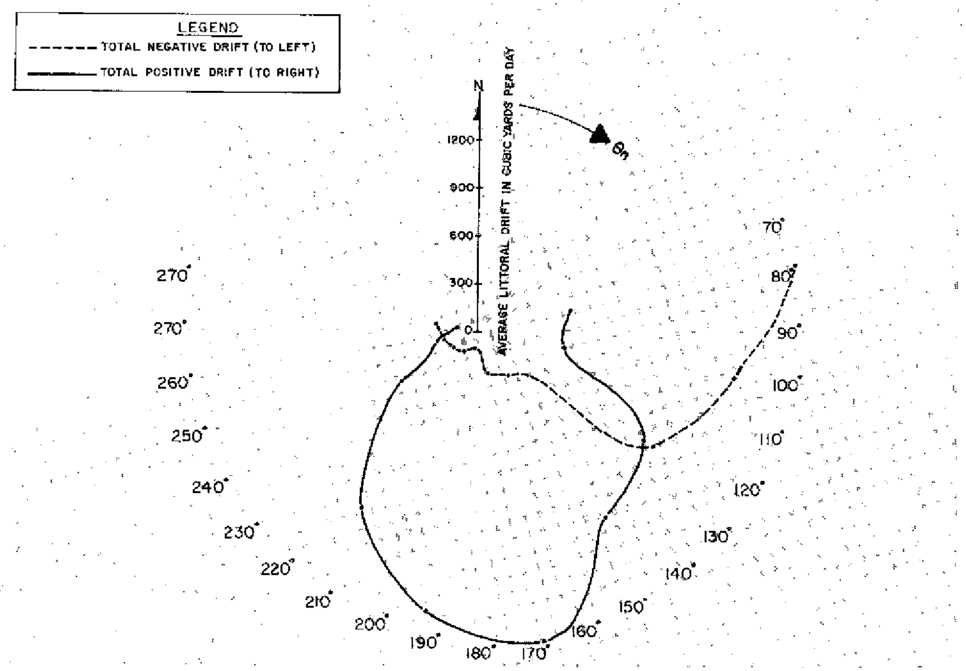


FIGURE A-251 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - [illegible]IL

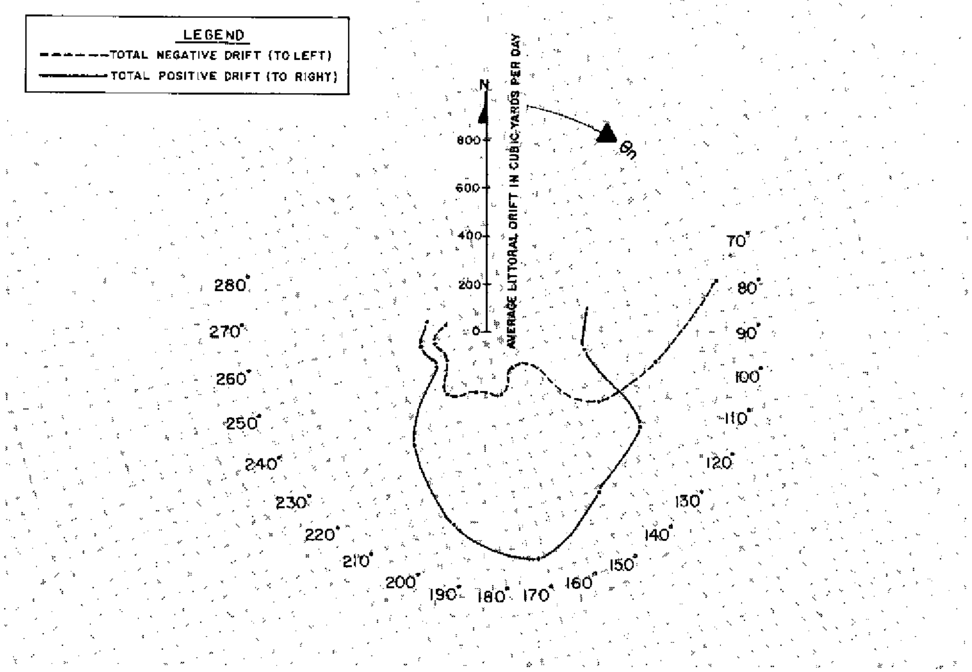


FIGURE A-252 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT W[illegible] BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - MAY

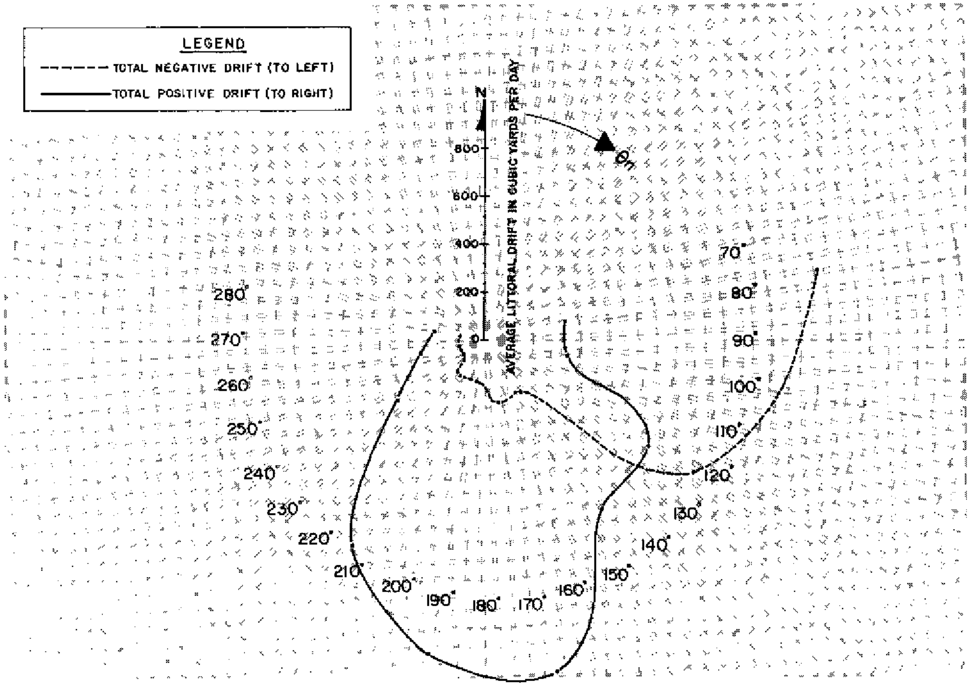


FIGURE A-253 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - JUNE

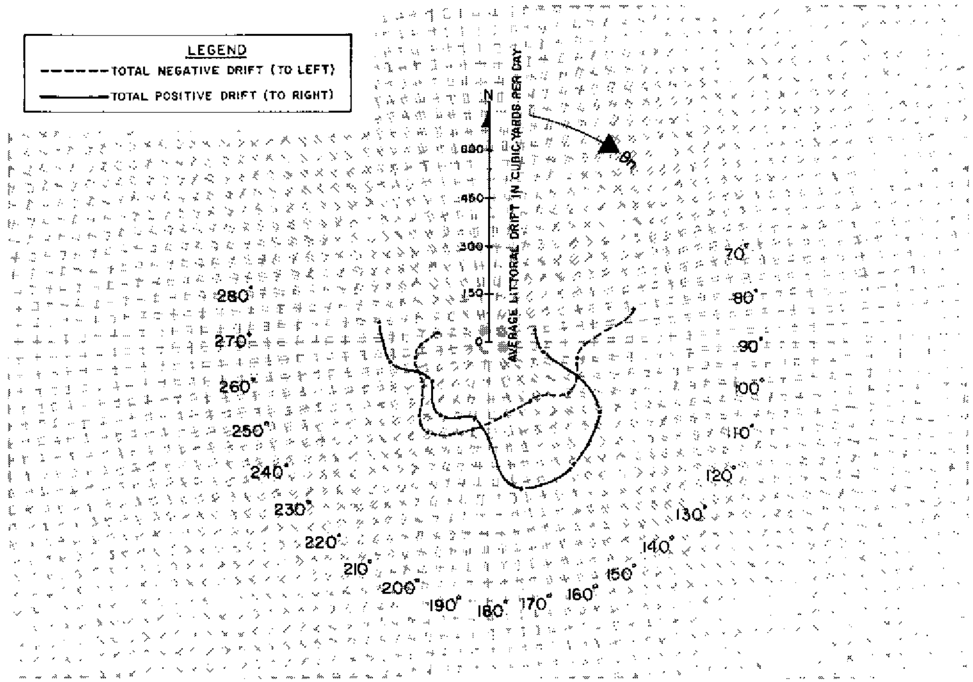


FIGURE A-254 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - JULY

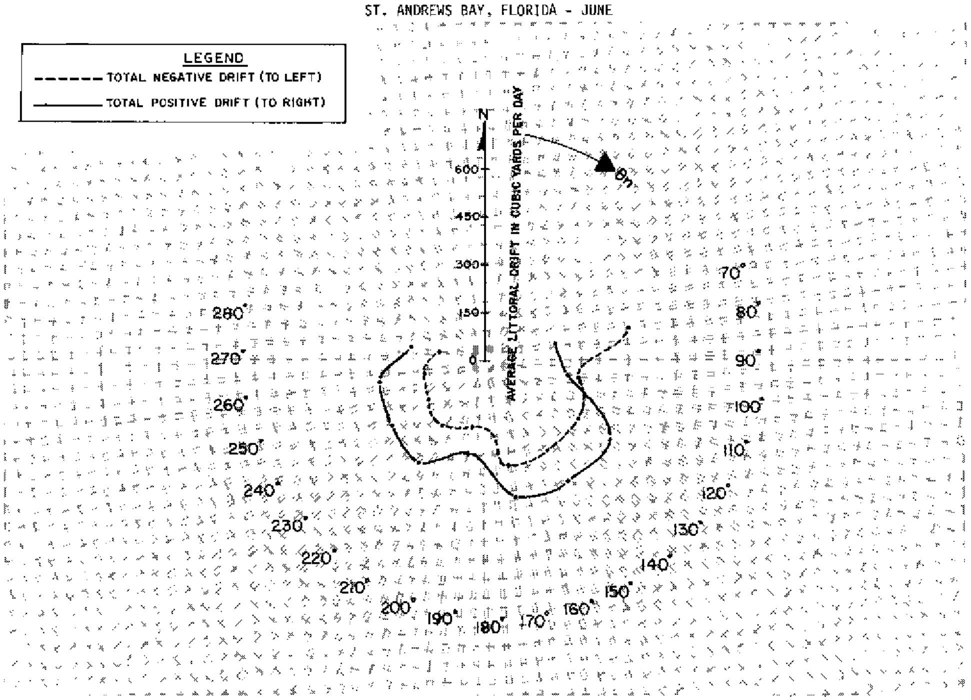


FIGURE A-255 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - AUGUST

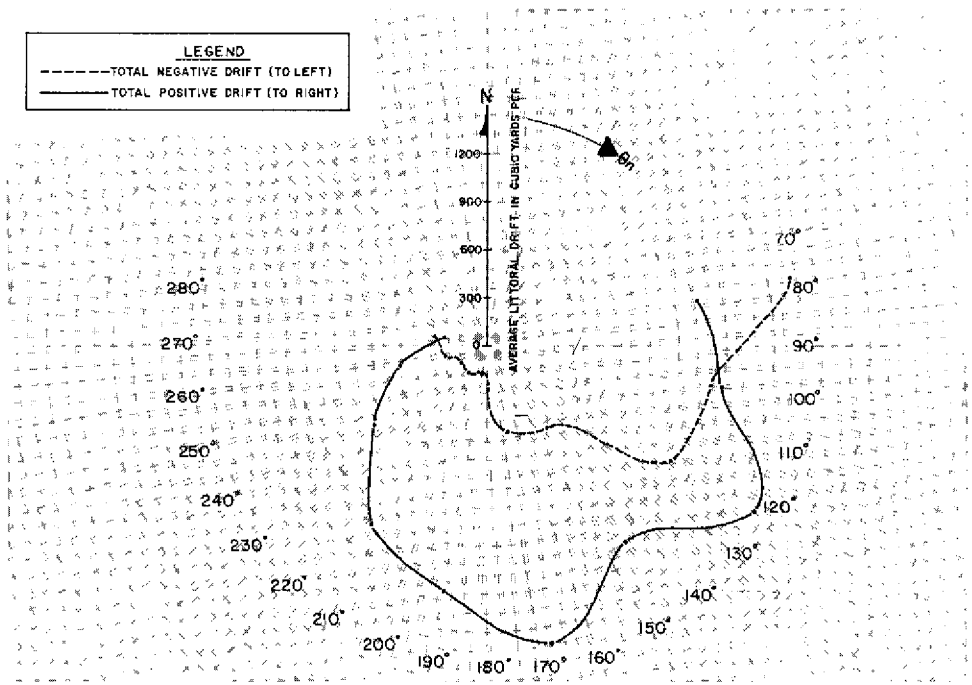


FIGURE A-256 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - SEPTEMBER

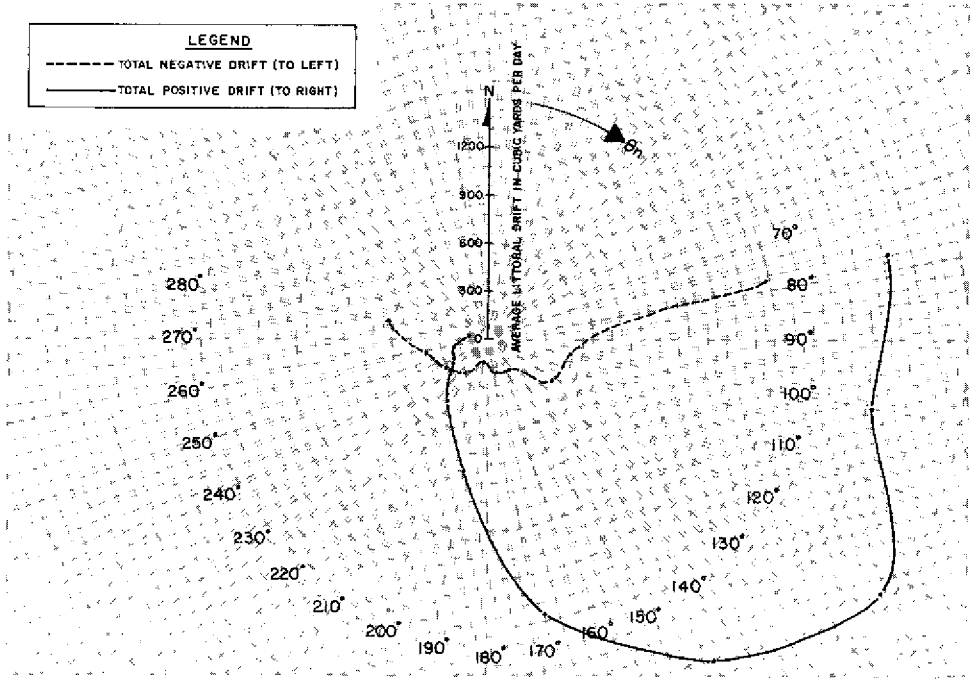


FIGURE A-257 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - OCTOBER

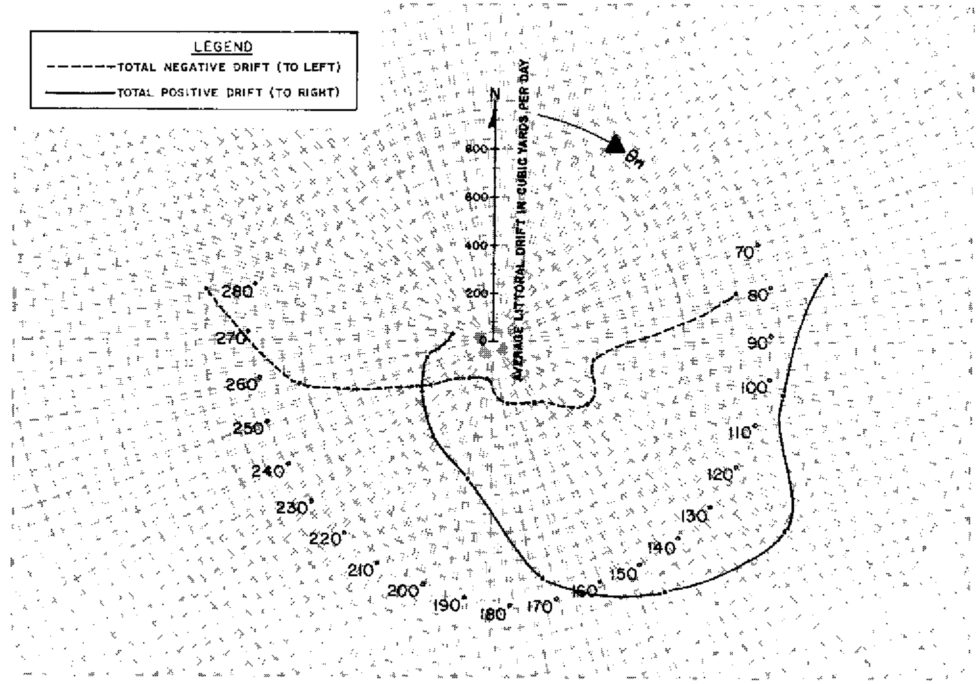


FIGURE A-258 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - NOVEMBER

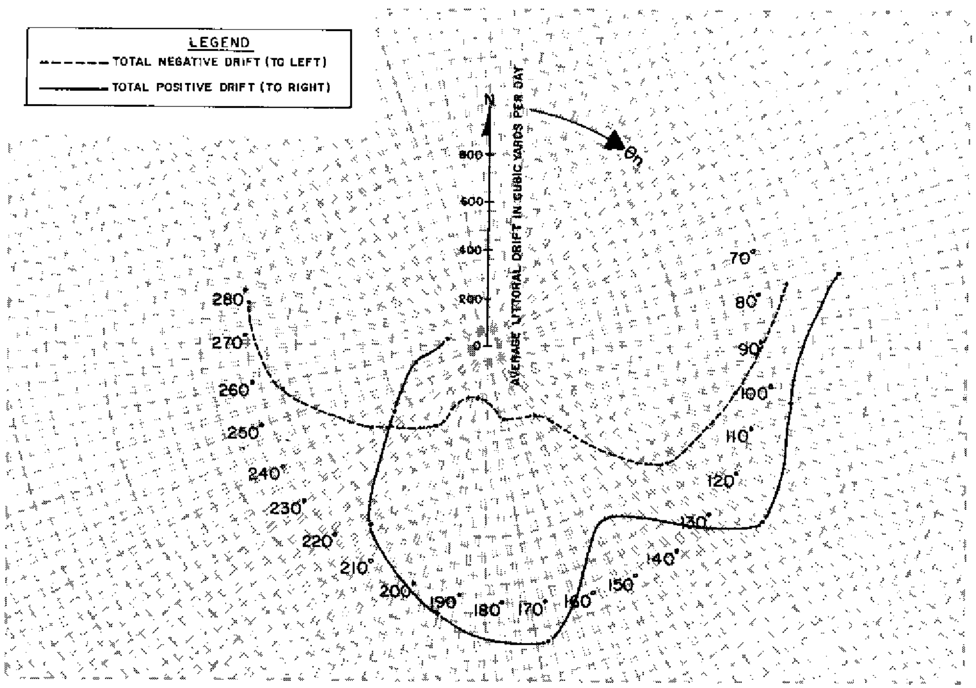


FIGURE A-259 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA - DECEMBER

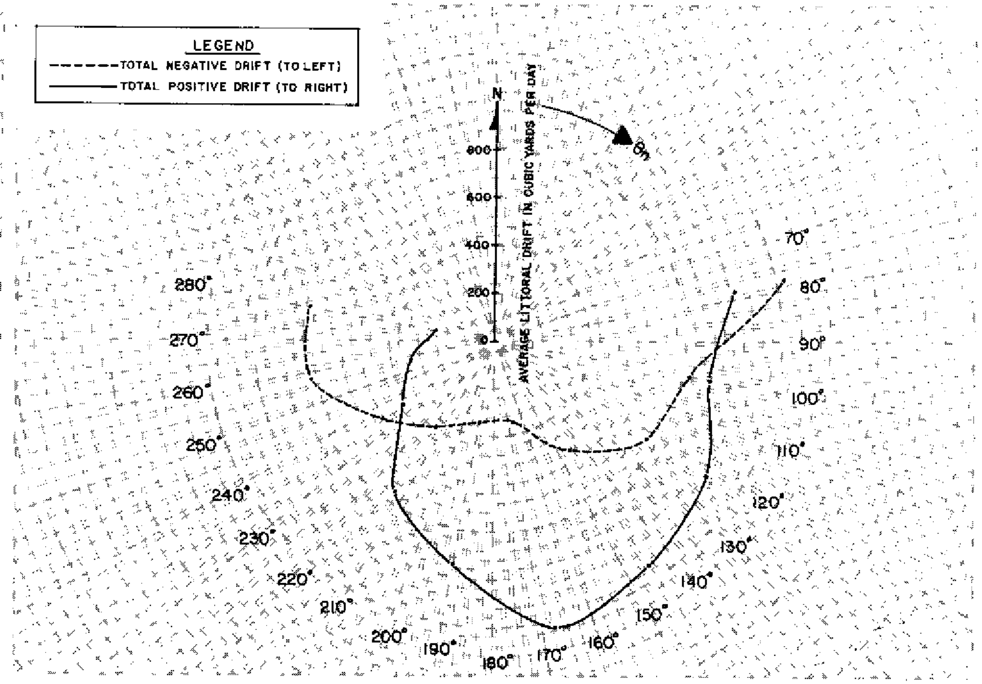


FIGURE A-260 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. JOSEPH BAY TO ST. ANDREWS BAY, FLORIDA

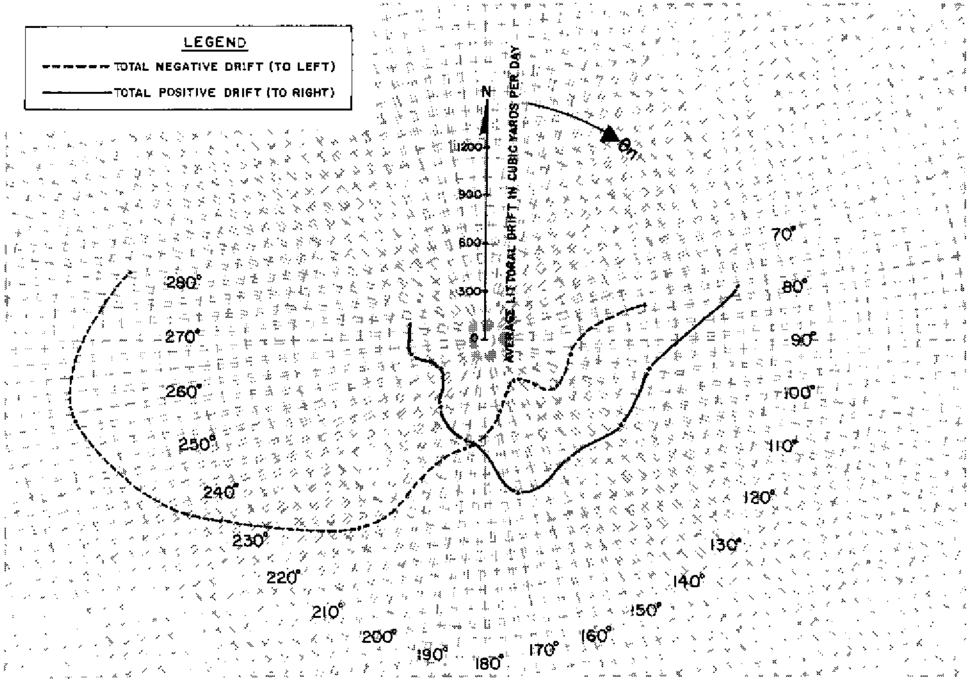


FIGURE A-261 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - JANUARY

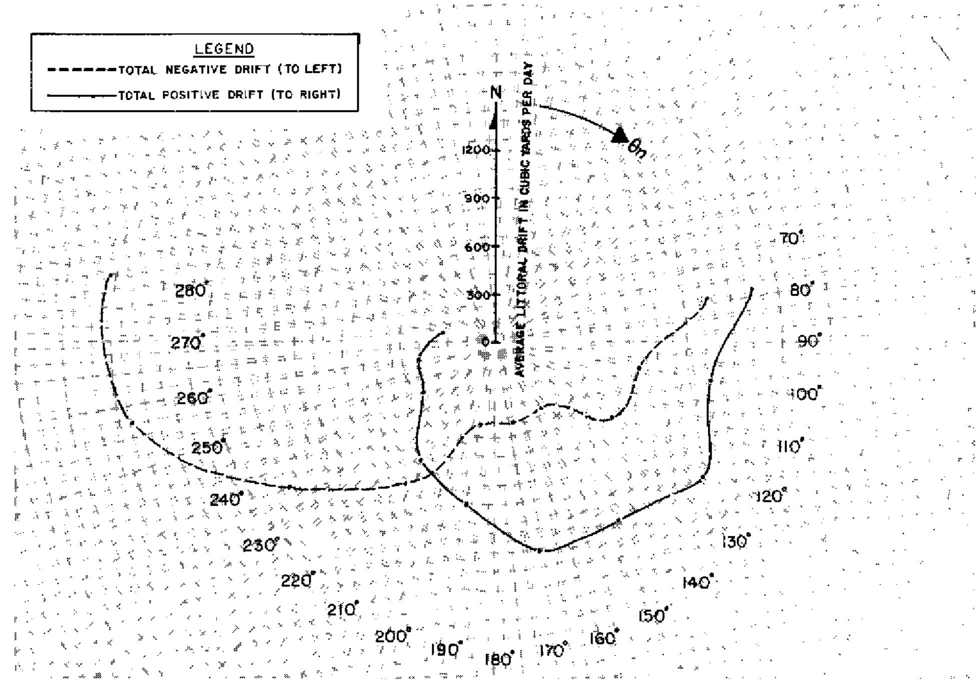


FIGURE A-262 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - FEBRUARY

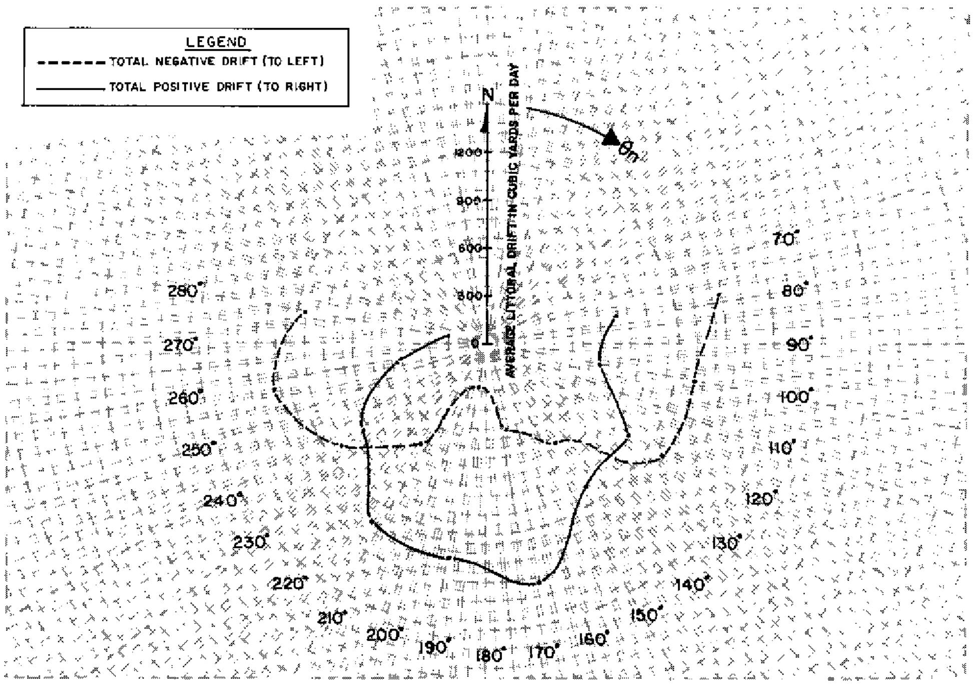


FIGURE A-263 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - MARCH

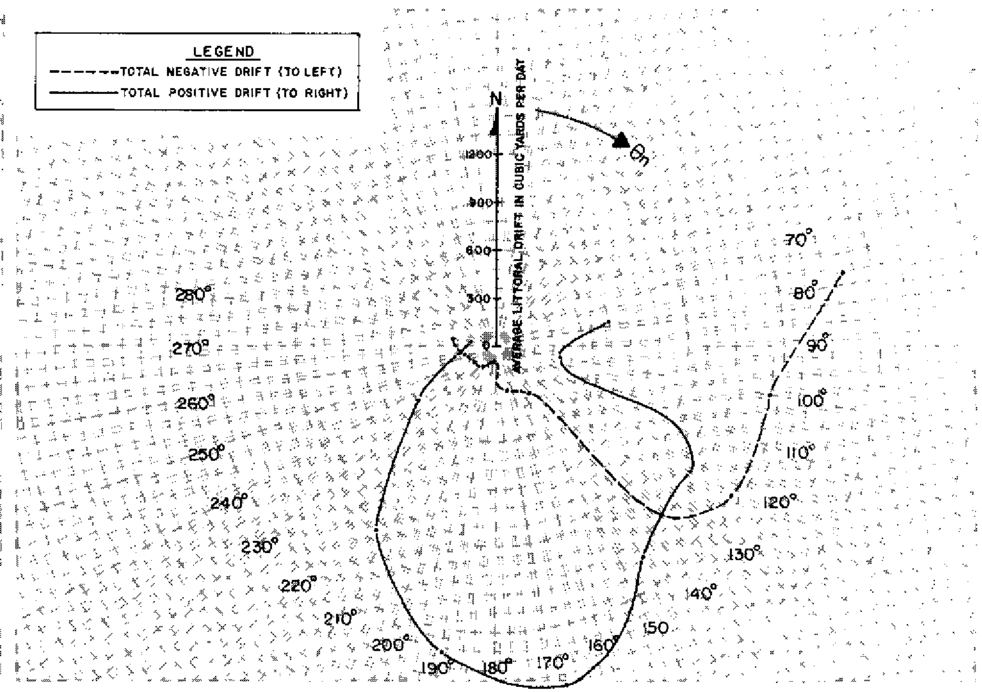


FIGURE A-264 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - APRIL

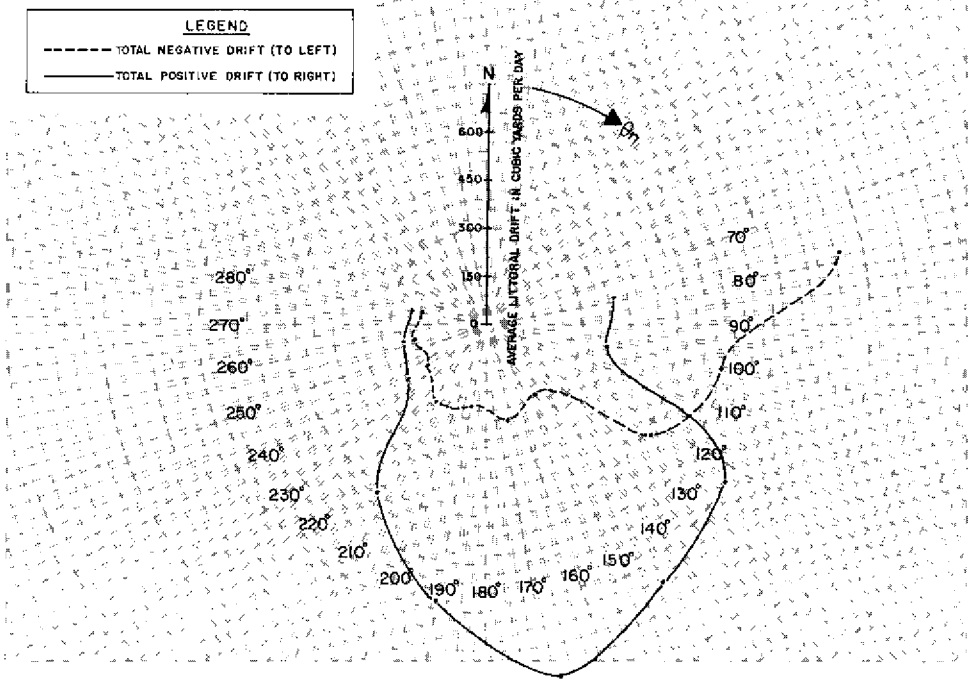


FIGURE A-265 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - MAY

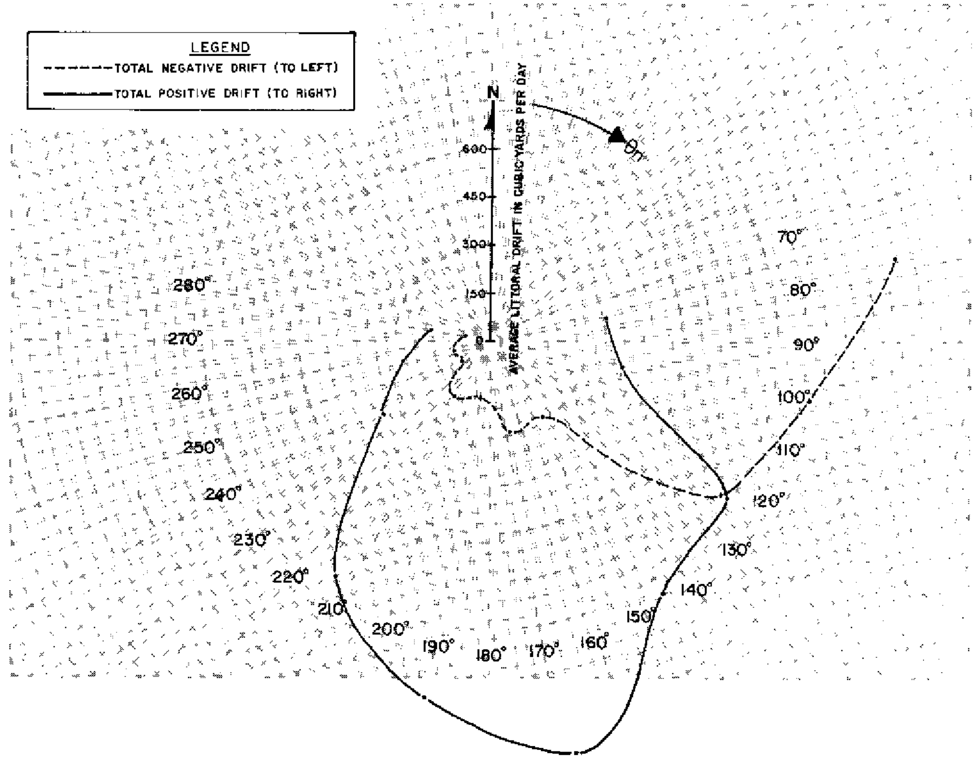


FIGURE A-266 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - JUNE

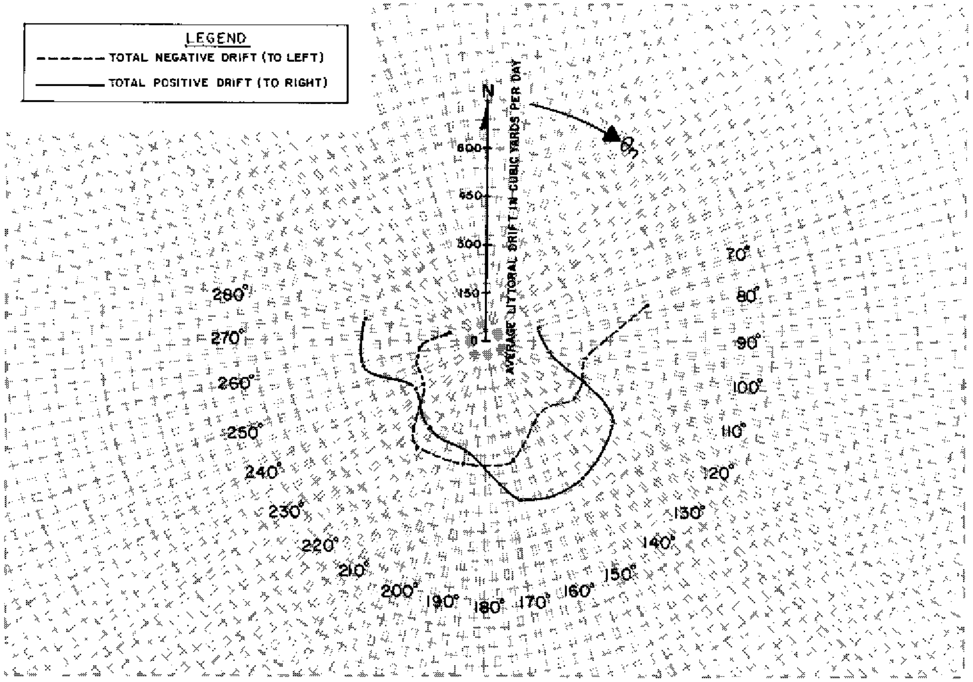


FIGURE A-267 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - ILY

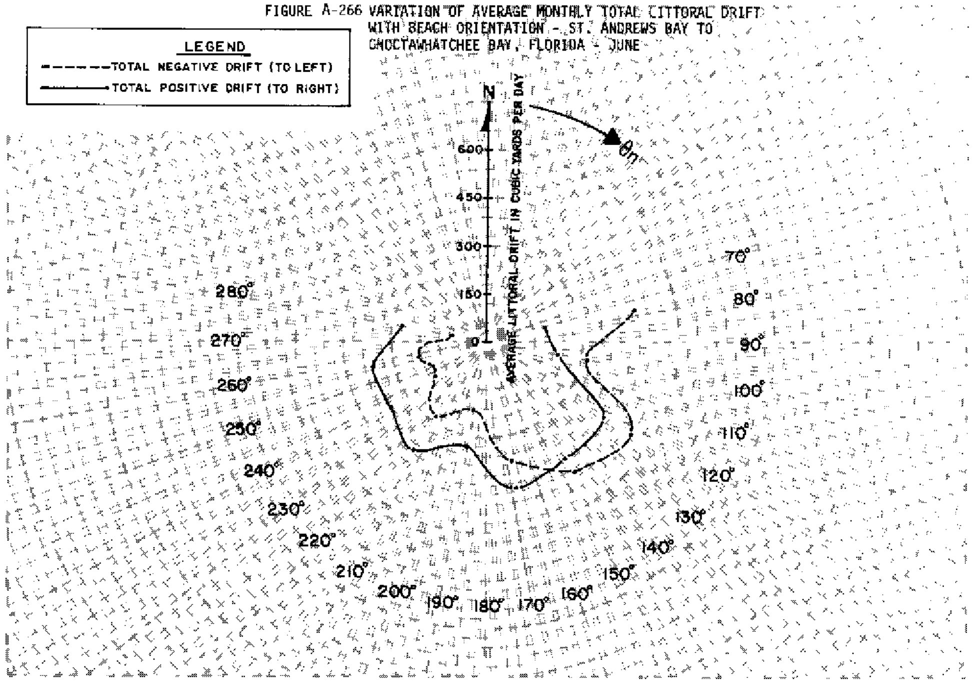


FIGURE A-268 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOC HATCHEE BAY, FLORIDA - AUGUST

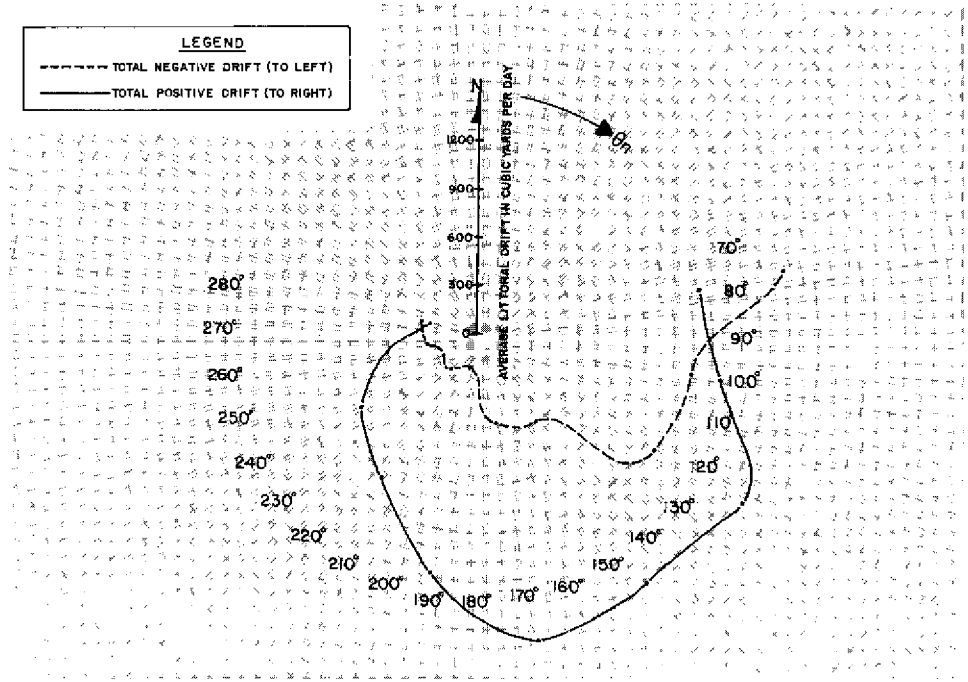


FIGURE A-269 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - SEPTEMBER

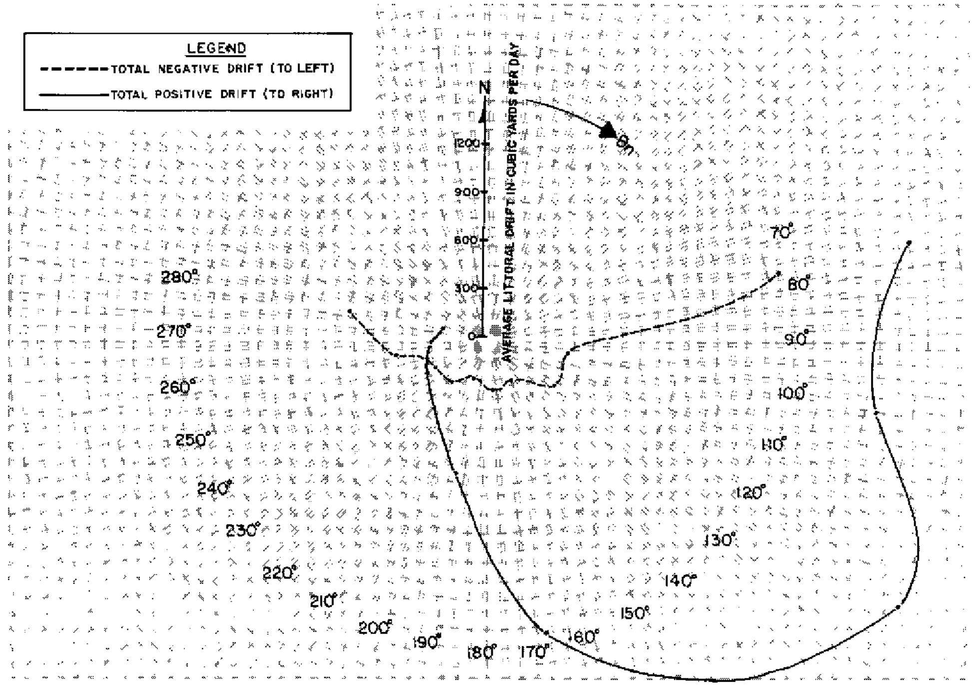


FIGURE A-270 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - OCTOBER

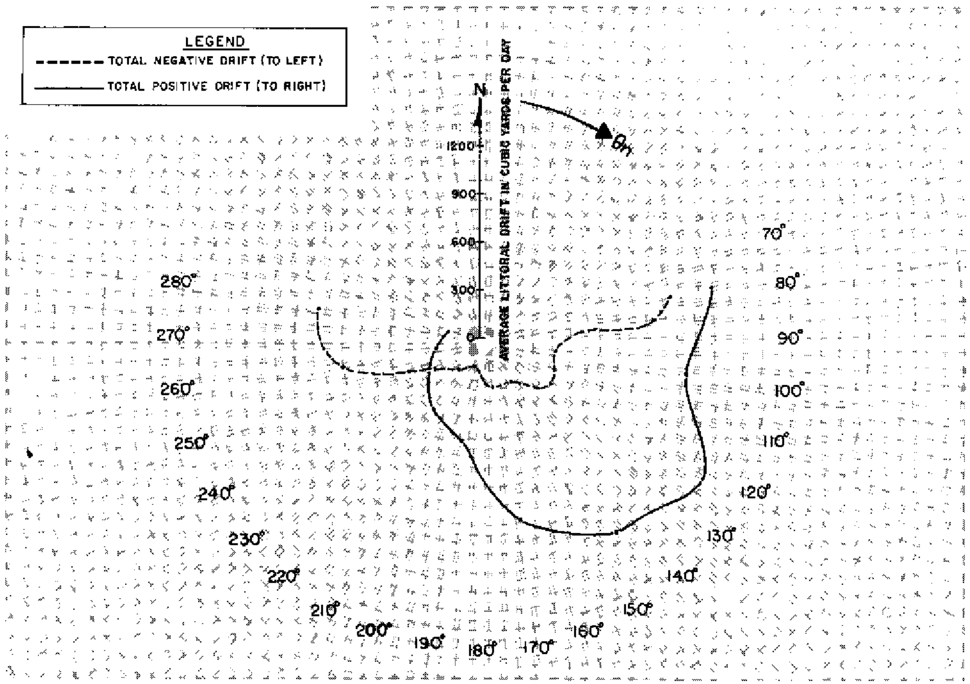


FIGURE A-271 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - NOVEMBER

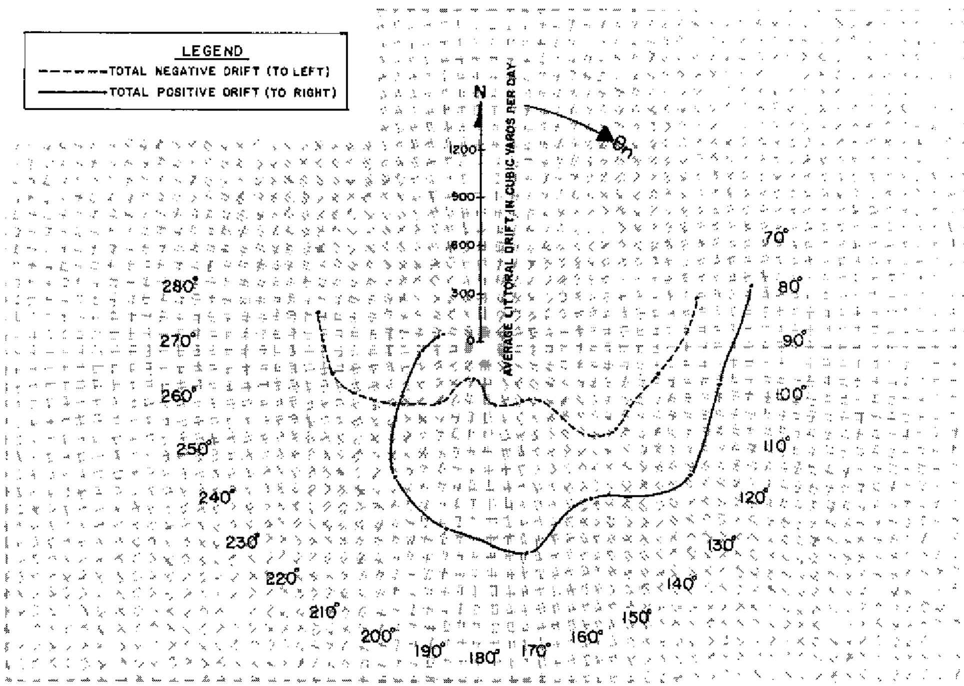


FIGURE A-272 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA - DECEMBER

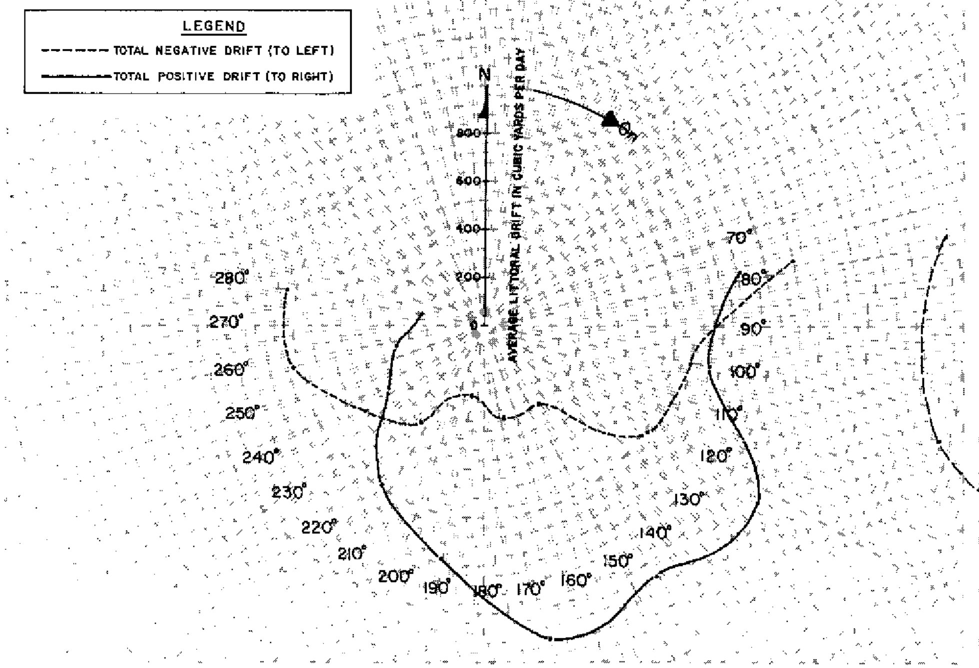


FIGURE A-273 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - ST. ANDREWS BAY TO CHOCTAWHATCHEE BAY, FLORIDA

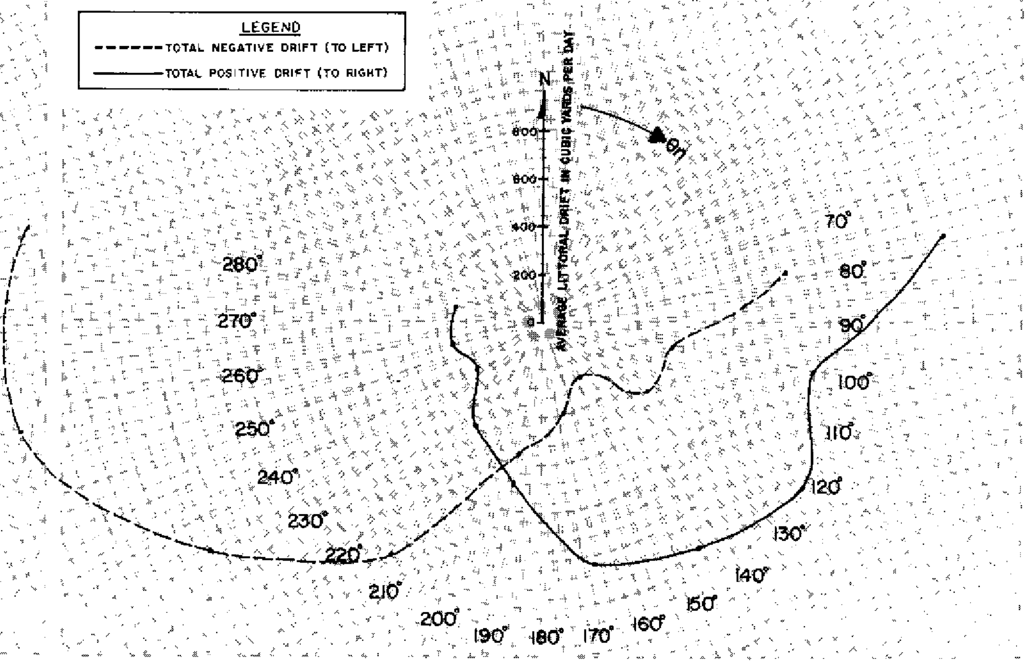


FIGURE A-274 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - JANUARY

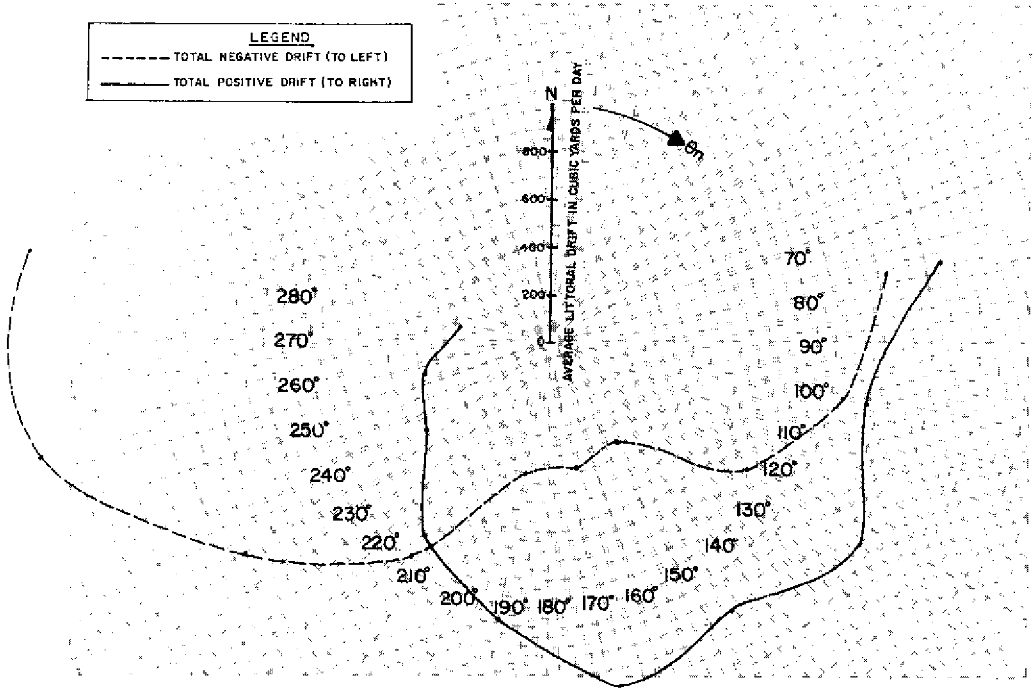


FIGURE A-275 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - FEBRUARY

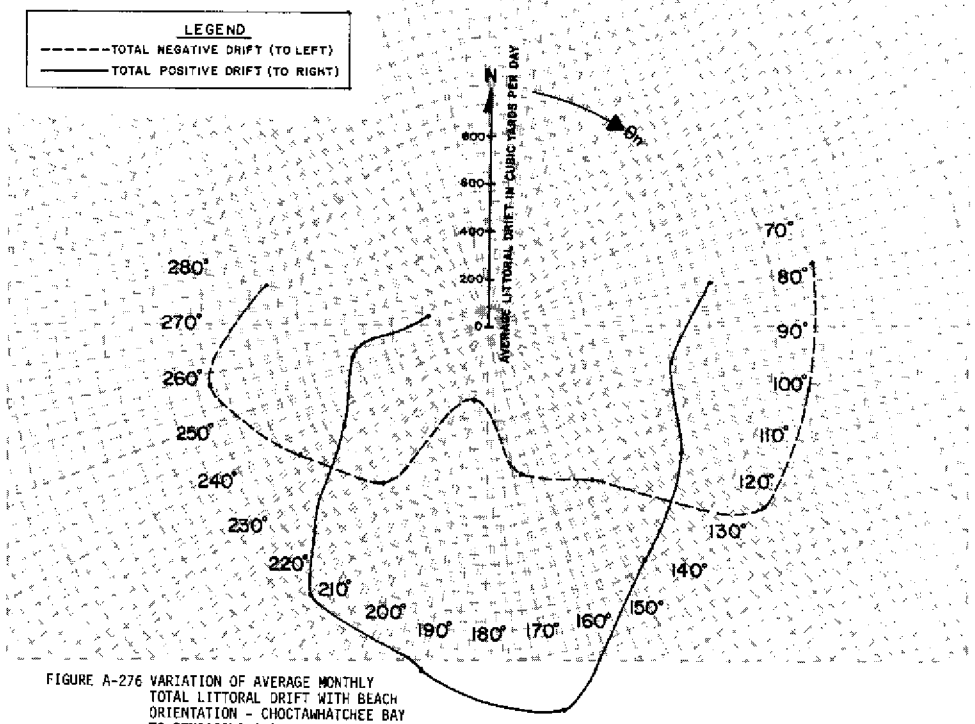


FIGURE A-276 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - MARCH

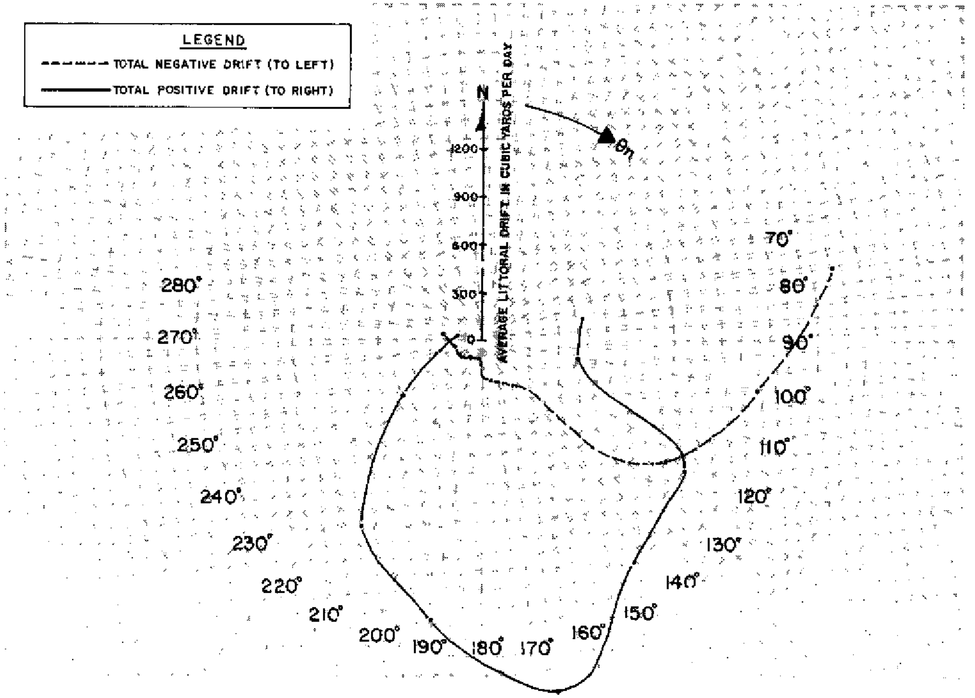


FIGURE A-277 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - APRIL

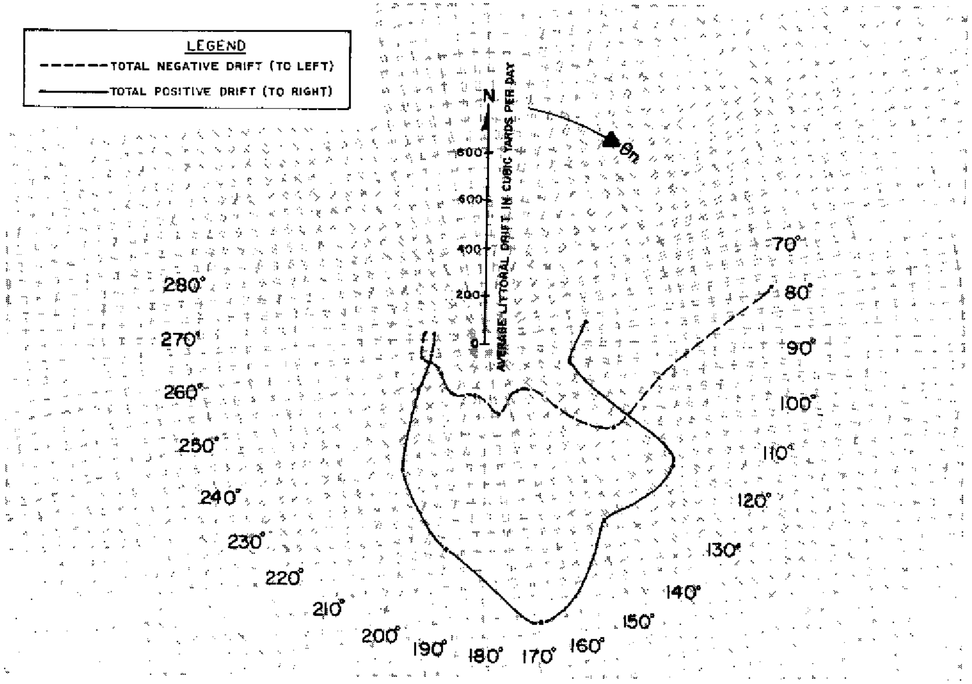


FIGURE A-278 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - MAY

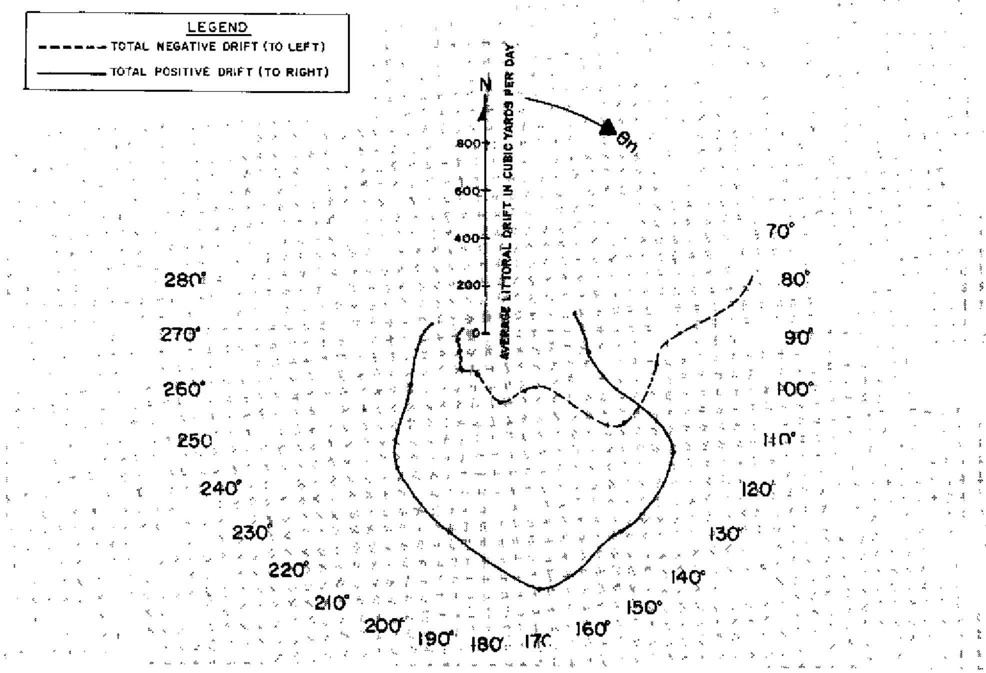


FIGURE A-279 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - JUNE

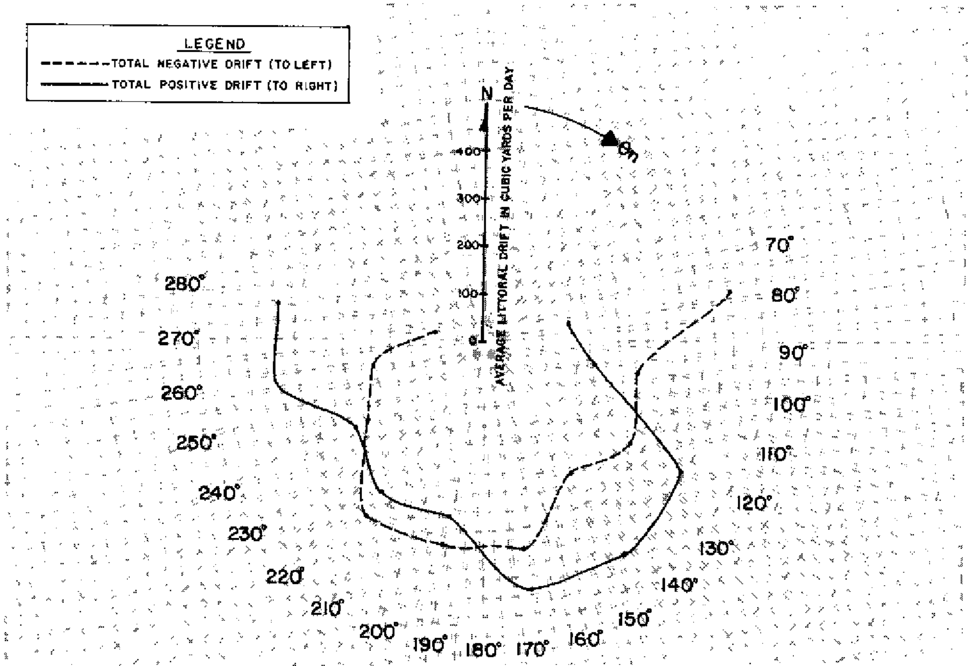


FIGURE A-280 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - JULY

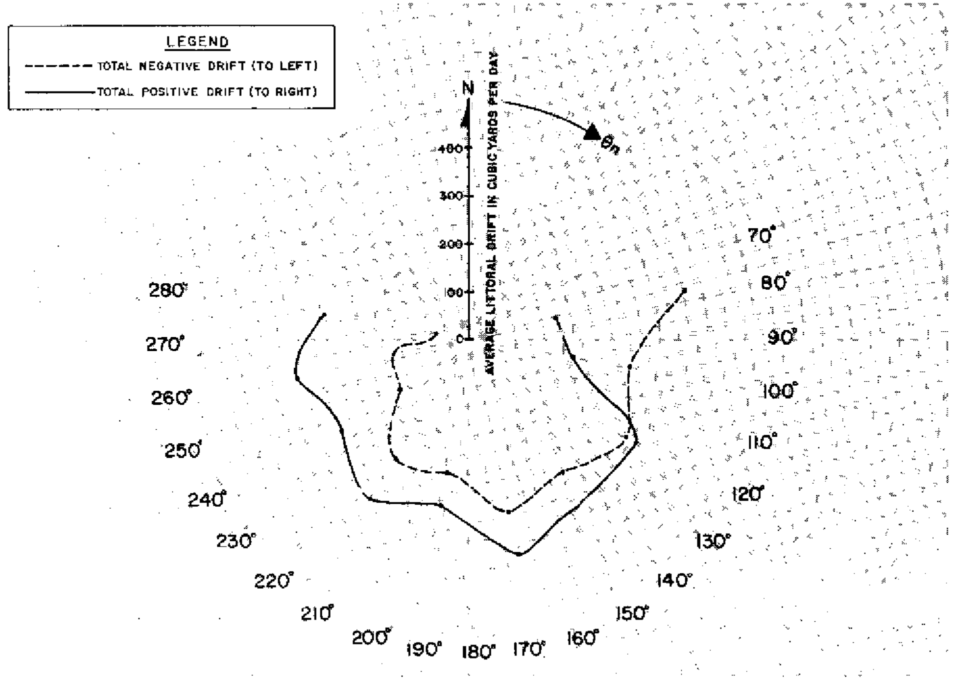


FIGURE A-281 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - AUGUST

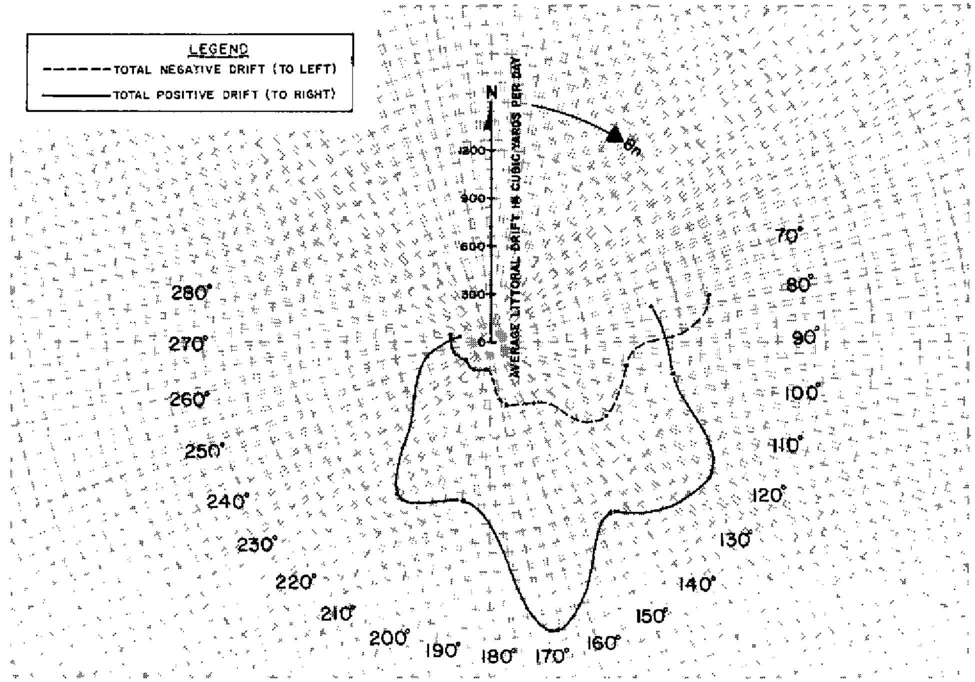


FIGURE A-282 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - SEPTEMBER

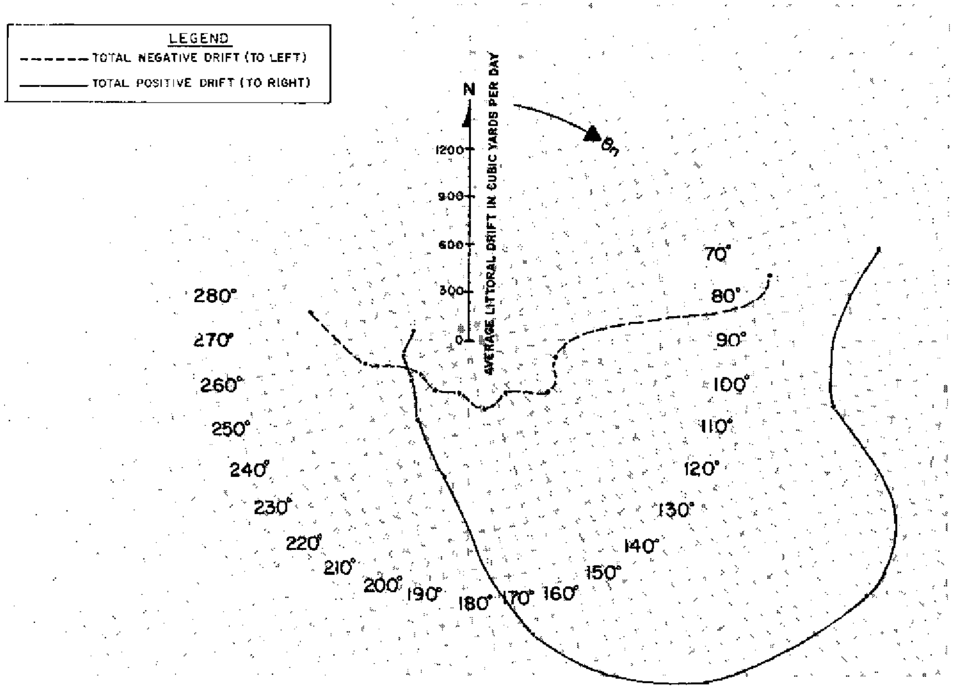


FIGURE A-283 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - OCTO.

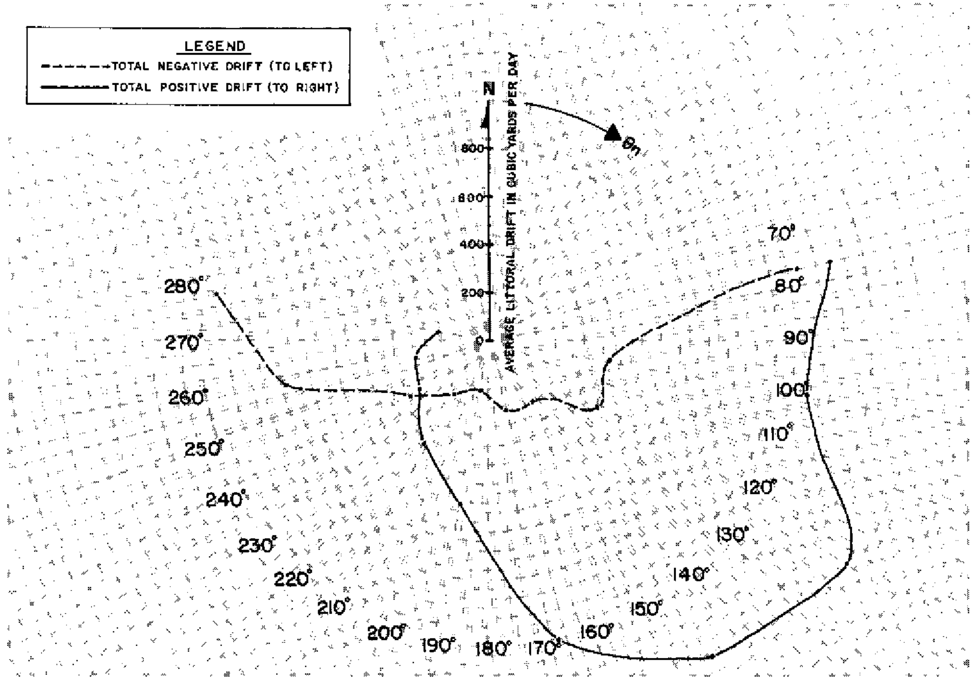


FIGURE A-284 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BE^^H ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACC CHANNEL, FLORIDA - NOVEMBER

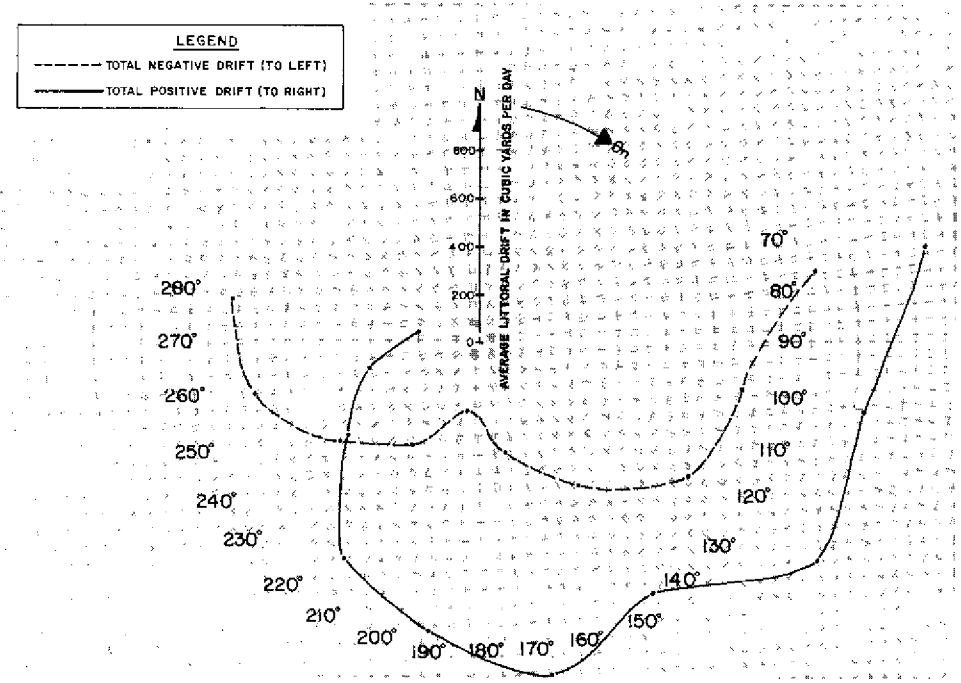


FIGURE A-285 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA - DECEMBER

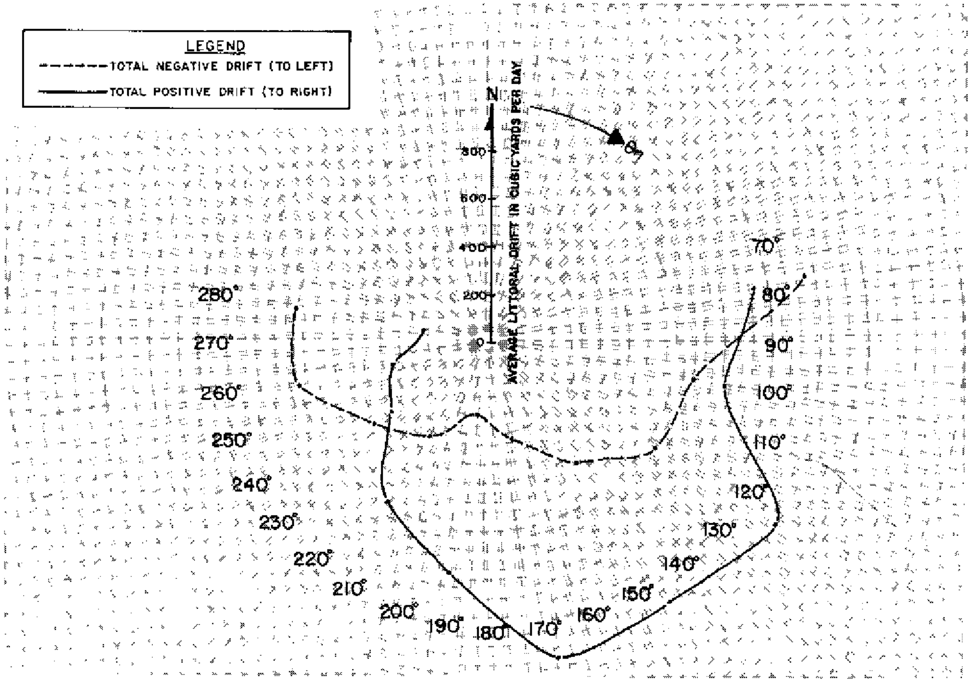


FIGURE A-286 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - CHOCTAWHATCHEE BAY TO PENSACOLA CHANNEL, FLORIDA

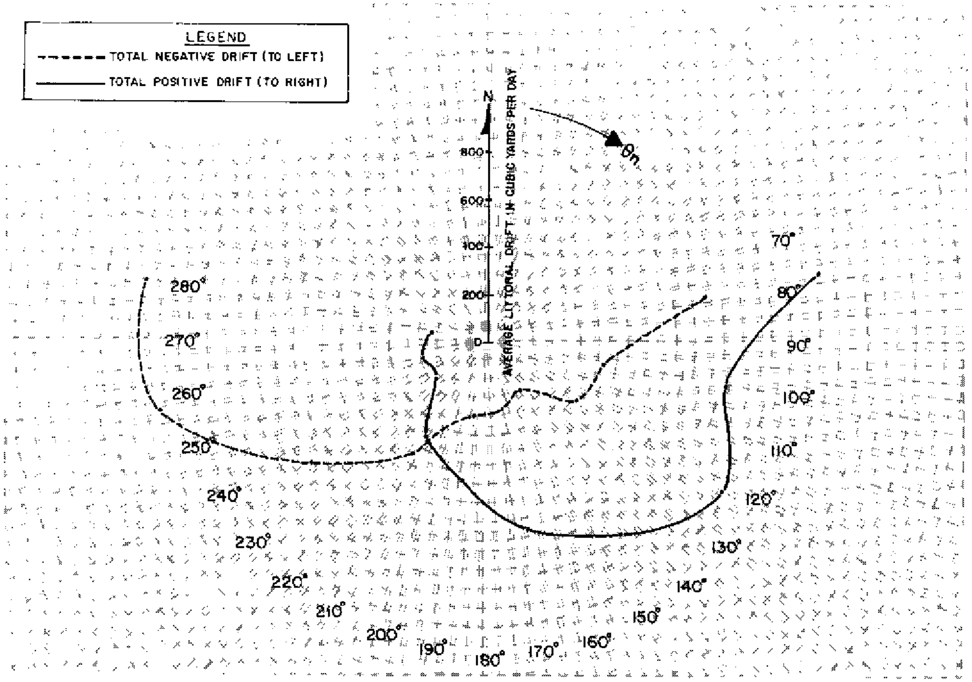


FIGURE A-287 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - JANUARY

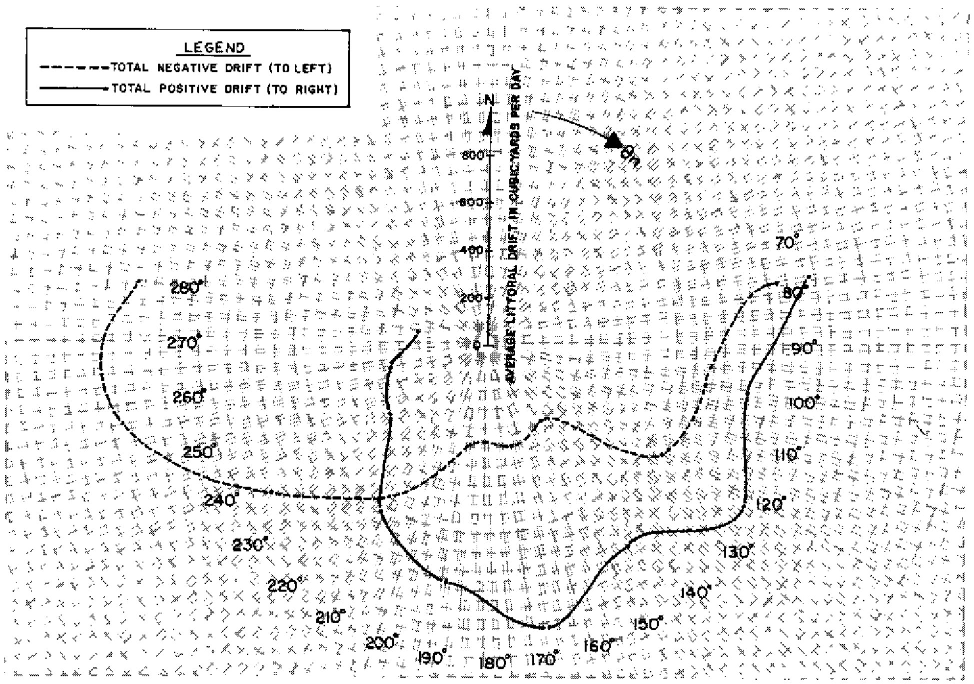


FIGURE A-288 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - FEBRUARY

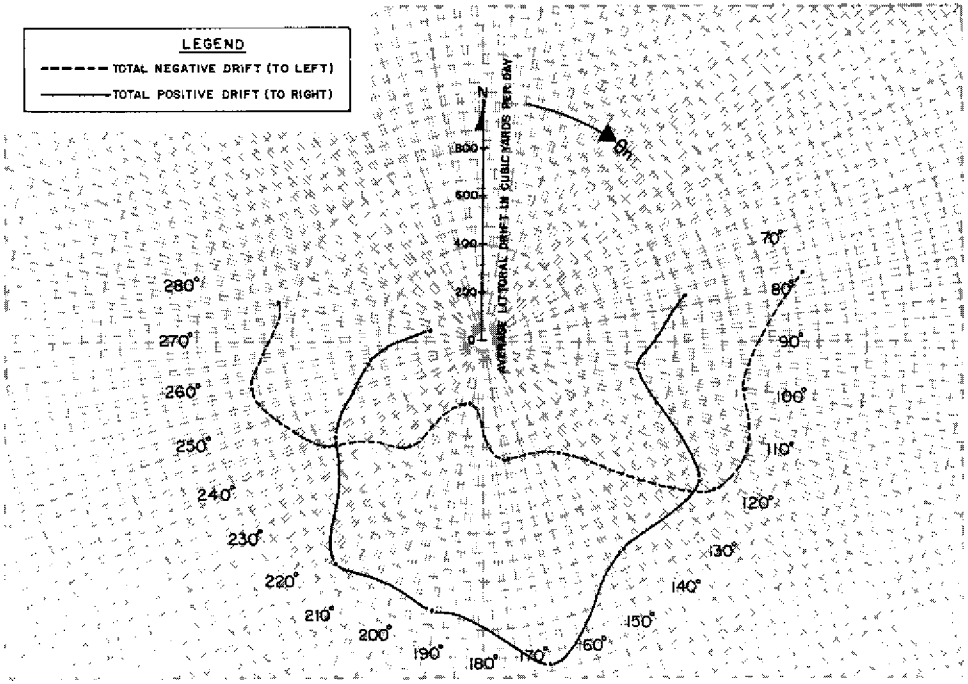


FIGURE A-289 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - MARCH

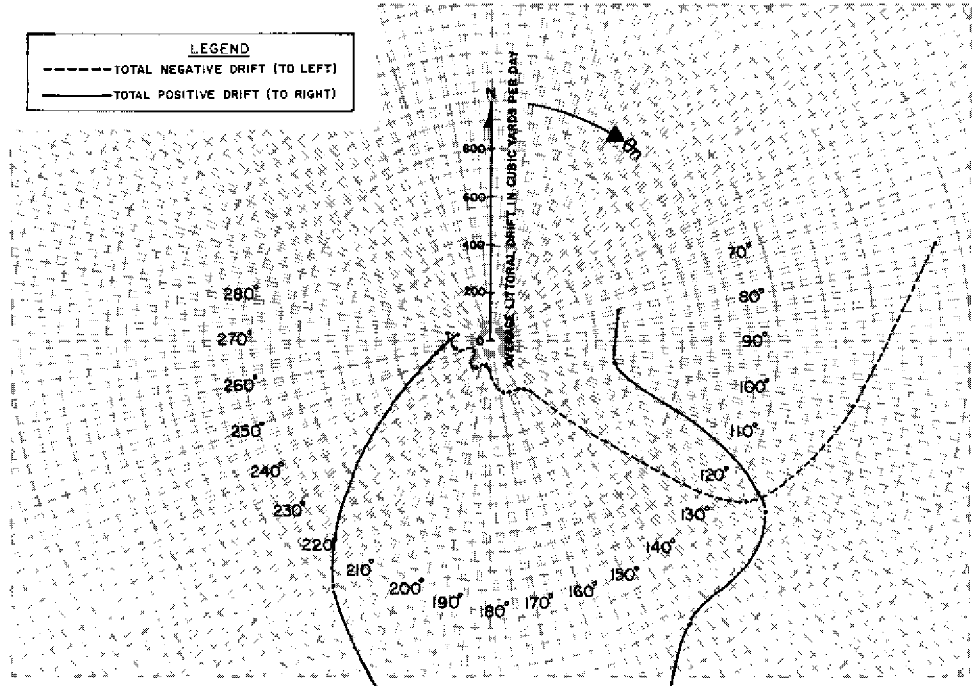


FIGURE A-290 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - APRIL

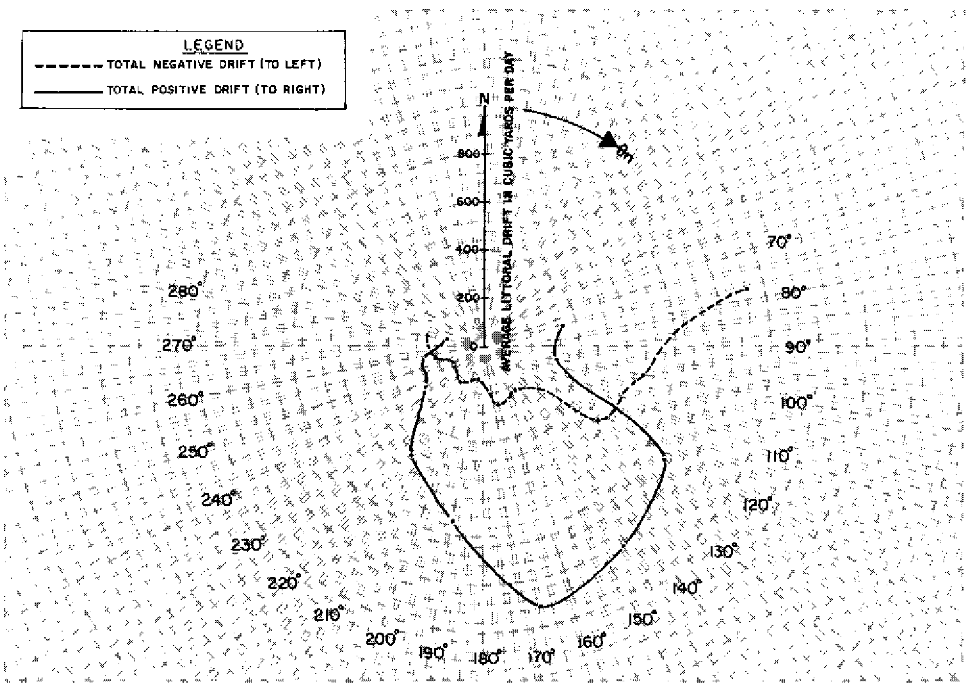


FIGURE A-291 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - MAY

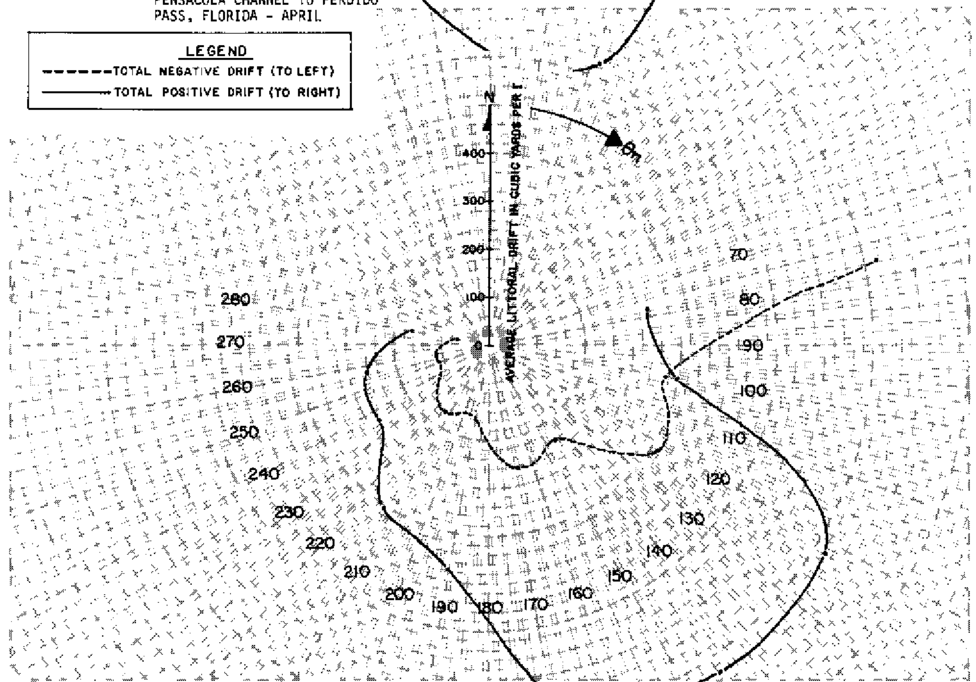


FIGURE A-292 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS. FLORIDA - JUNE

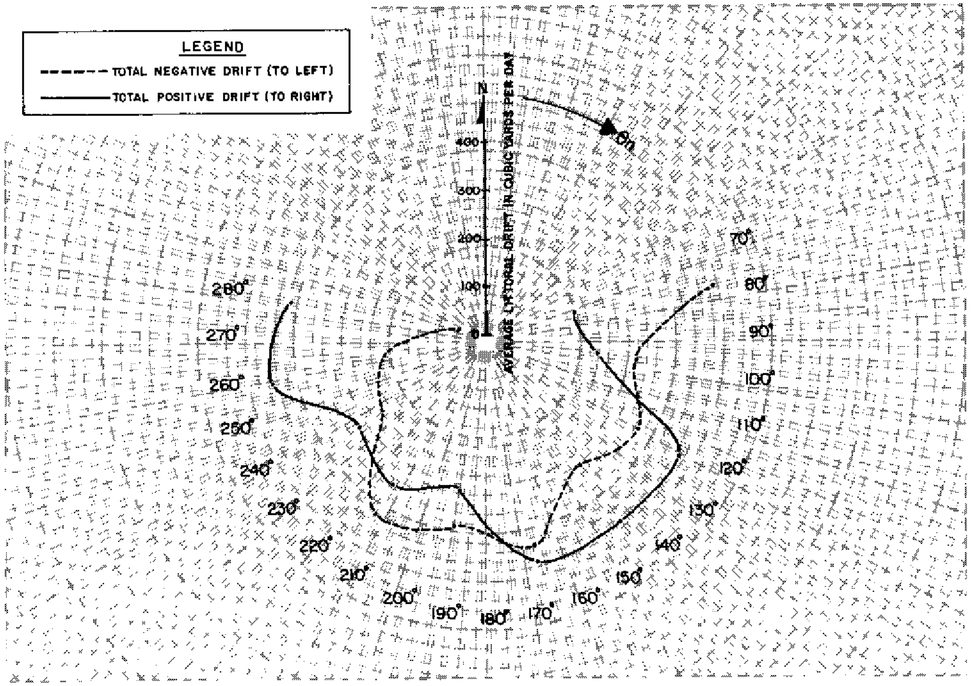


FIGURE A-293 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - JULY

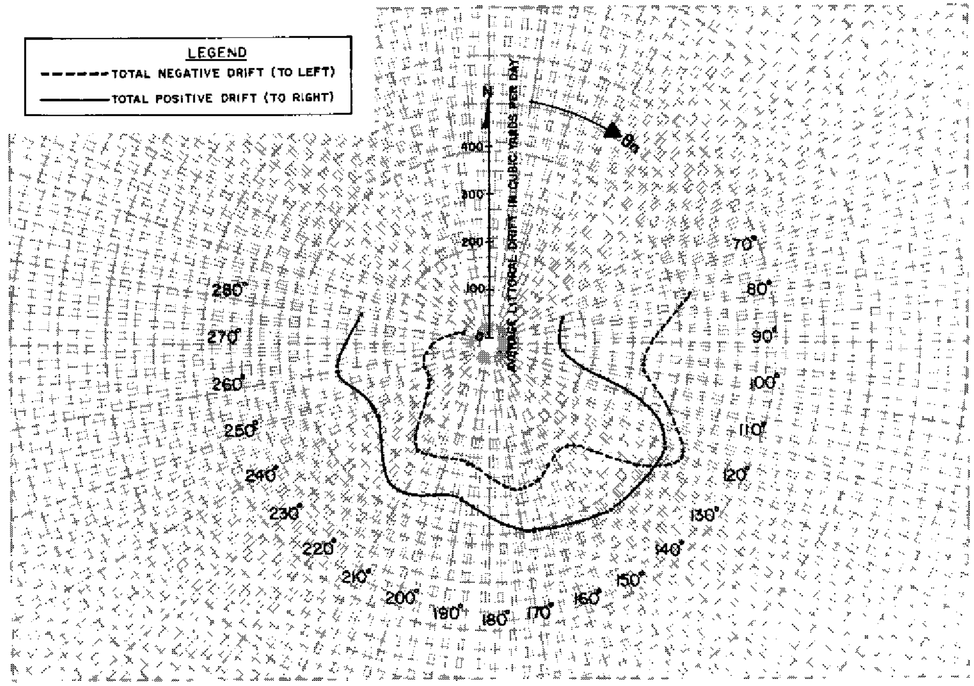


FIGURE A-294 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - AUGUST

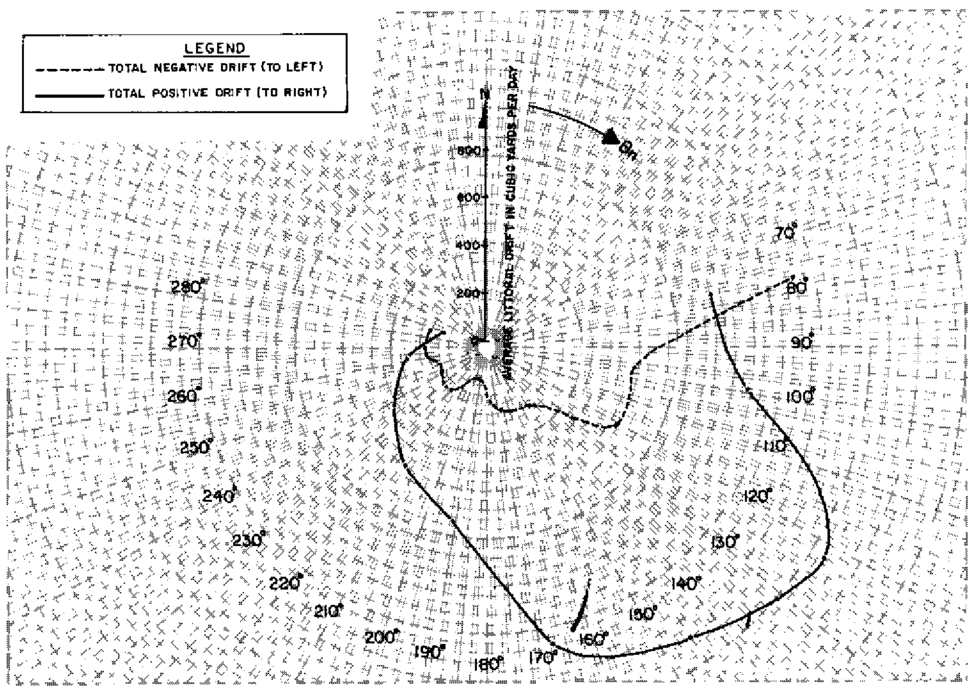


FIGURE A-295 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - SEPTEMBER

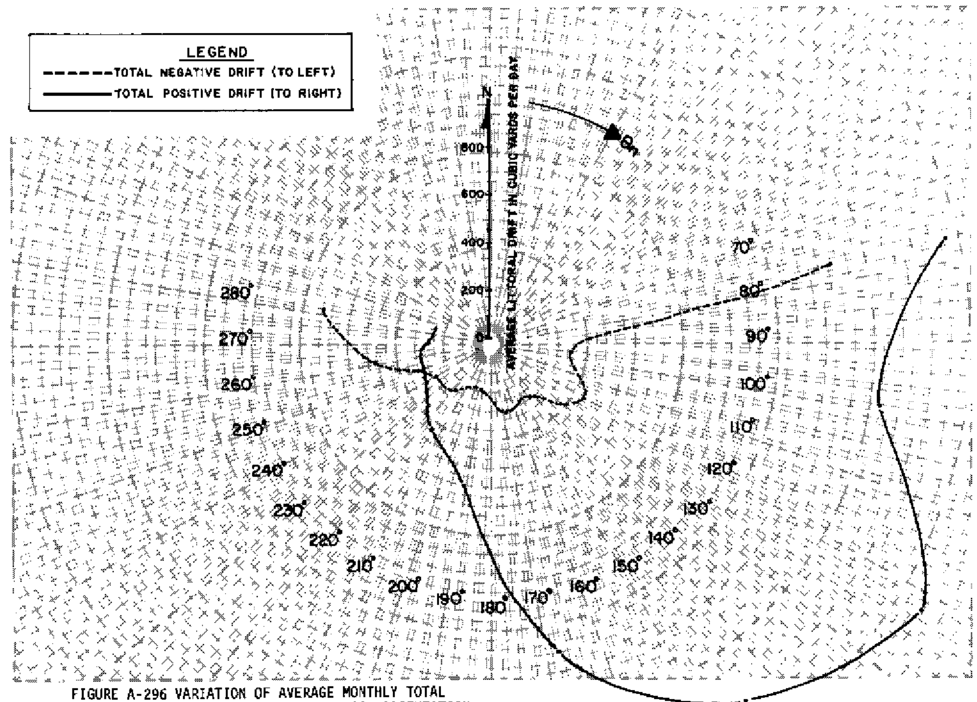


FIGURE A-296 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - OCTOBER

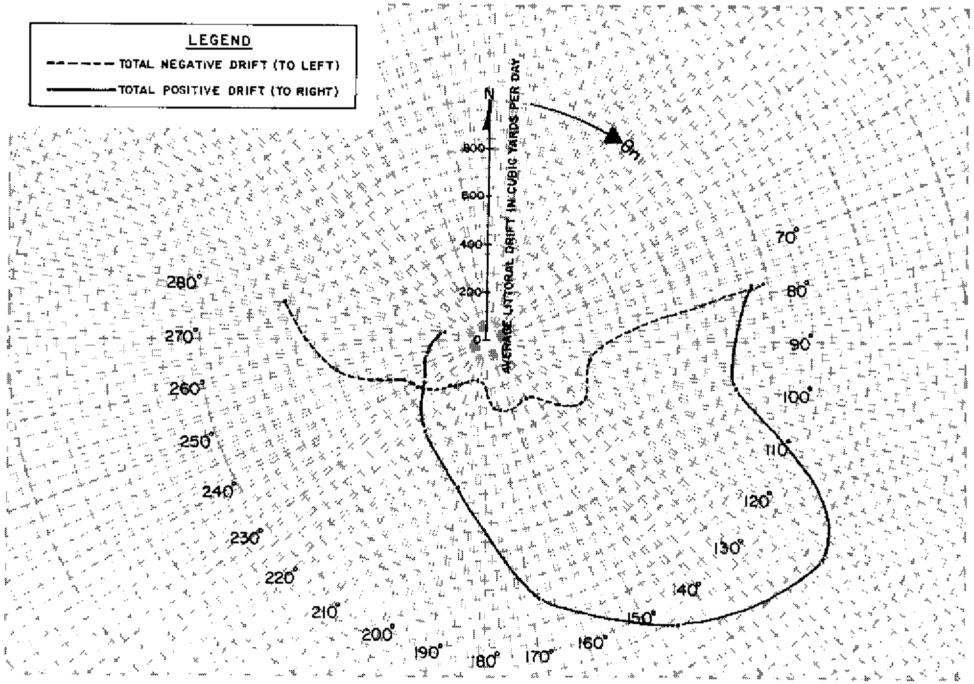


FIGURE A-297 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - NOVEMBER

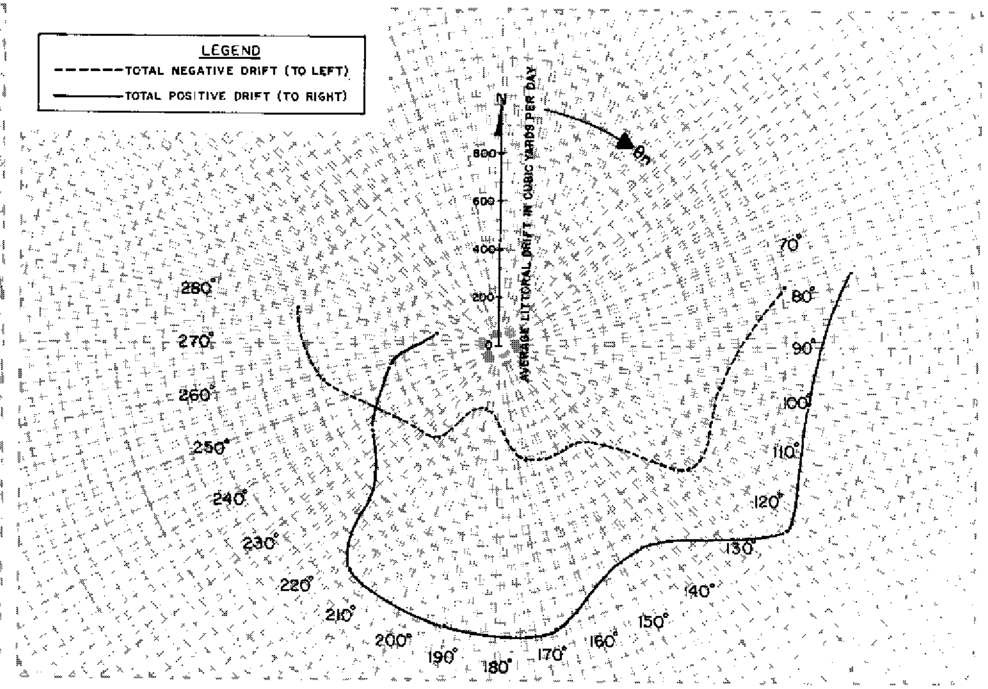


FIGURE A-298 VARIATION OF AVERAGE MONTHLY TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA - DECEMBER

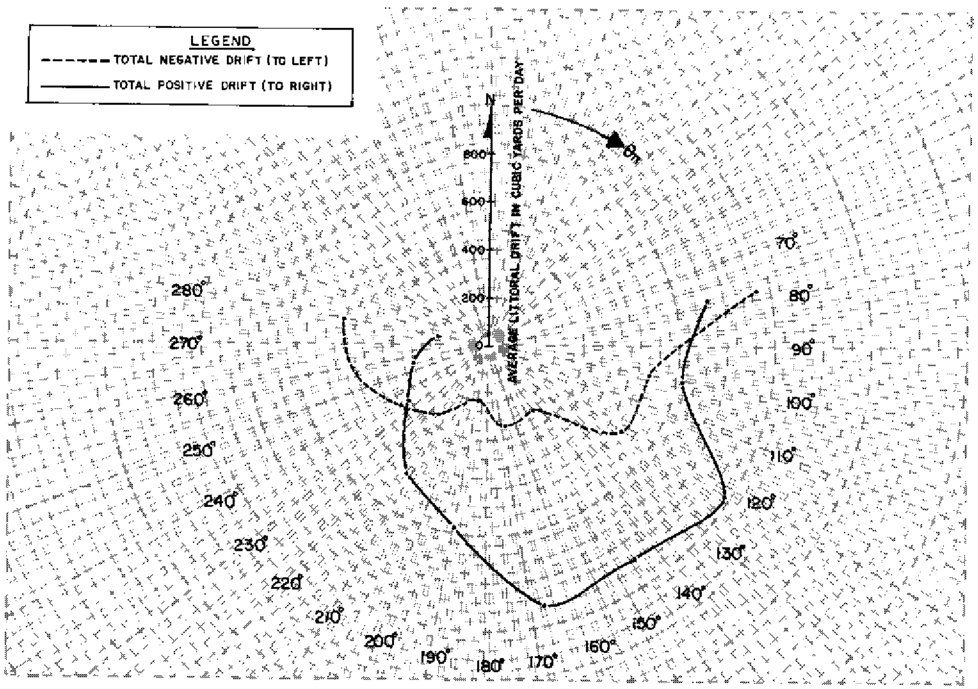
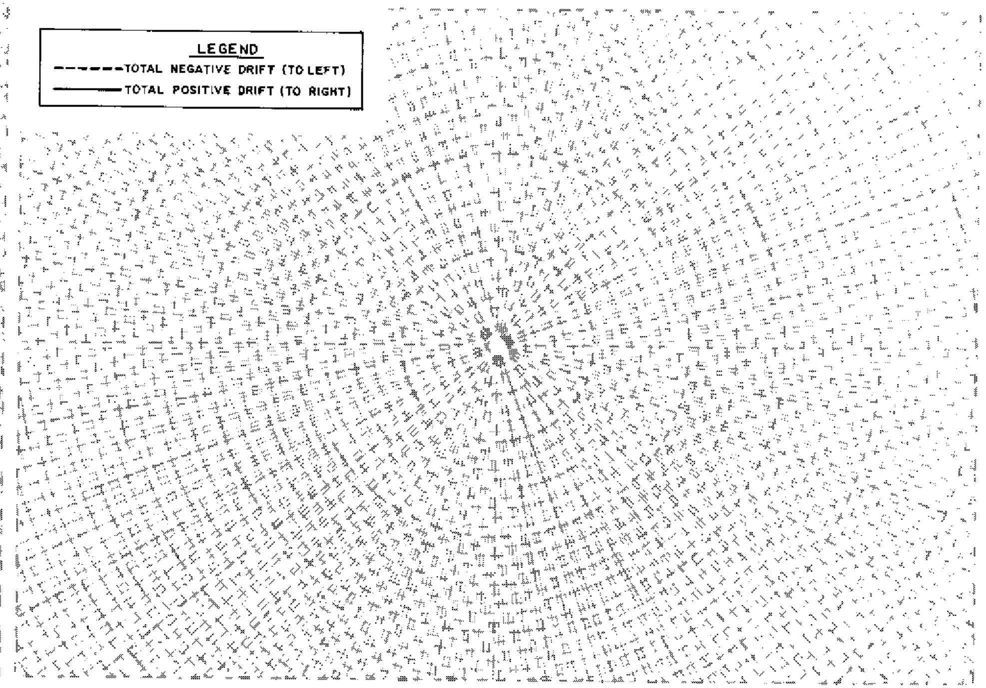


FIGURE A-299 VARIATION OF AVERAGE ANNUAL TOTAL LITTORAL DRIFT WITH BEACH ORIENTATION - PENSACOLA CHANNEL TO PERDIDO PASS, FLORIDA



APPENDIX B

The following summary of the estimated quantity of net littoral drift in the vicinity of Perdido Pass is taken from Appendix A, House Document No. 274, 84th Congress, 2nd Session, titled: Perdido Pass (Alabama Point), Alabama Beach Erosion Control Study, September 21, 1955.

1. The average annual rate of shoaling or deposition resulting from littoral drift along the shore in the vicinity of Perdido Pass has been estimated by determining the quantity of material deposited in the area as indicated by hydrographic surveys made in 1934, 1948 and 1953, respectively. In 1934 the channel of Perdido Pass followed a course generally south by 25° east from a point inside the pass to the outer edge of the bar. From 1934 to 1948 the channel had swung to the west at its outer end, its inner end remaining relatively stationary at the point inside the pass referred to above discloses that there is considerable deposition of sand along the beach immediately east of Perdido Pass, and accretion at Florida Point is extending that peninsula gradually westward.

2. In determining the extent of deposition which had occurred between successive surveys, it was assumed that the area or segment through which the channel had migrated had been scoured by erosive action of the channel to the average channel depth throughout, after which it filled or shoaled to the extent indicated by the later survey. In other words, the volume of sand in the area between successive channel alinements above the elevation of average channel depth represents the total deposition from littoral drift during the period considered. Deposition in the adjacent area east of the channel was determined by comparison of contours developed from two successive surveys.

3. The average annual rate of shoaling at Perdido Pass, determined by the above method, was 150,000 cubic yards for the period 1934 to 1948, and

211,000 cubic yards for the period 1948 to 1953, or about 165,000 cubic yards annually for the 19-year period of record. A study conducted in 1930 of sand movement and beach erosion at the entrance to Pensacola Harbor indicated that an average volume of 162,000 cubic yards of sand was deposited annually at the western end of Santa Rosa Island and on the Middle Ground Bar as a result of littoral drift. Estimates were based on surveys of the area made between 1856 and 1930, and on records of quantities removed by dredging, the total for the 74-year record being 11,965,000 cubic yards. Between 1931 and 1953, a total of 7,134,000 cubic yards was removed from the entrance channel. The indicated average annual rate, based on the 97-year record, is therefore 197,000 or, rounded, 200,000 cubic yards. Design of plans of improvements herein are based on that estimate. The predominant direction, as indicated by the westerly growth of Florida Point and the western end of Santa Rosa Island and by observation of the effect of experimental groins constructed in connection with the study of Pensacola Harbor referred to above, is from east to west. There is little evidence of reversal in direction.

The following summary of the estimated quantity of net littoral drift in the vicinity of Palm Beach Inlet is taken from Page 15, Paragraph 38, House Document No. 772, 80th Congress, 2nd Session, titled: Palm Beach County, Beach Erosion Study, December 29, 1948.

38. Littoral drift. - The existing jetties at Lake Worth Inlet and at South Lake Worth Inlet have caused changes in the adjacent shore lines similar to those at a number of other inlets along the east coast of Florida where jetties have been constructed; namely, accretion north of the north jetty, erosion south of the south jetty. The prevailing summer winds, usually moderate, create waves which cause littoral drift from south to north, which tends to build up the beaches on the south side of such structures. This tendency is more than offset, however, by the rapid movement of beach material from north to south during the more violent, but less frequent, wave action caused by winds from the northeast, the prevailing direction in winter. The predominant littoral drift is, therefore, from north to south. The Gulf Stream, which lies relatively close to shore, flows northward with a maximum surface velocity of 3½ knots. A low velocity counter-current generally flows southward between the Gulf Stream and the Florida shore. This current is accelerated or reversed by alongshore winds.

39. The present quantity and rate of movement of littoral drift along Palm Beach cannot be determined from available data. Historical surveys are inadequate to provide a basis for accurate estimates of the rate at which material has been impounded by the north jetty at Lake Worth Inlet, but a number of rough estimates have been made, utilizing available information. These estimates, although rough, indicate the range between the limits of which the true value probably lies. They indicate that during the 14-

year period immediately following completion of the inlet and jetties, material was impounded at a rate averaging 150,000 to 225,000 cubic yards per year, and that during the past 7 years the rate has approximated 130,000 cubic yards per year. On the other hand, observations south of South Lake Worth Inlet over the 4-year period 1937-41 indicated that the beach drifting forces at that point were incapable of moving as much as the average of 50,000 cubic yards per year deposited on the beach. The difference in indicated beach drifting capacity north of Lake Worth Inlet and that south of South Lake Worth Inlet is undoubtedly accounted for by the resistance to the movement of littoral material offered by the existing groins along the shore in the vicinity of South Lake Worth Inlet.

APPENDIX C

CALCULATION OF LITTORAL DRIFT FROM LEO DATA

The calculation of littoral drift is based upon the longshore energy flux versus littoral drift relationship expressed in Reference (5), Equations (1) and (2) which can be modified (see Reference (3)) to read:

$$Q_\ell = C \frac{\gamma H_b^{\,2}}{8} \cdot C_{gb} \frac{\sin 2\alpha_b}{2} \cdot \frac{24(3600)}{10^6}$$

where Q_ℓ = littoral drift rate (in cubic yards per day),

H_b = breaking wave height (in feet),

C_{gb} = breaking wave celerity (in feet per second),

α_b = angle the wave makes with the shoreline at breaking (in degrees),

γ = specific weight of water = 64 lbs./ft.^{3},

C = a constant: In these calculations the constant used was 125 from Reference (5).

From the theory of Longuet-Higgins, Reference (13), an equation for the longshore current is as follows:

$$V_b = \frac{0.694\Gamma}{2\beta\ f} \cdot m\sqrt{gH_b} \cdot \sin 2a_b$$

where

Γ = a mixing coefficient = 0.2 as recommended in Reference (7),

β = water depth to wave height ratio at breaking = 1.28,

f = friction factor = .01,

m = beach slope = $\frac{-dh}{dx}$,

H_b = defined in previous equation,

α_b = defined in previous equation,

V_b = longshore current at breaking zone.

Noting that $\sqrt{gH_b} = C_{gb} / \sqrt{1.28}$ from linear theory, we find that

$$C_{gb} \sin 2\alpha_b \cong \frac{V_b}{4.79m} \quad \text{and that}$$

$$Q_\ell = C \times \frac{\gamma}{16} \cdot \frac{24(3600)}{10^6} \cdot \frac{H_b^{\,2}\, V_b}{4.79m}$$

$$= \frac{125(64)\ (24)\ (3600)}{16\ (10^6)\ 4.79} \quad \frac{H_b^{\,2}\, V_b}{m} \quad = \quad \frac{9.02\ H_b^{\,2}\, V_b}{m}$$

finally:

$$Q_\ell = \frac{9.02\ H_b^{\,2}\, V_b}{m}$$

Q_ℓ = (in cubic yards per day),

H_b = (in feet),

V_b = (in feet per second),

m = (dimensionless average beach slope to breaker depth).

UNCALIBRATED VALUES OF LITTORAL DRIFT COMPUTED FROM

LEO DATA AVERAGED ON A MONTHLY BASIS

NAVARRE BEACH 1969 - 1970

		Q_ℓ+	Q_ℓ-	$Q_\ell$net	Number of Observations
September	1969	-	-	-	-
October	"	4206	0	4206	15
November	"	282	-557	-275	31
December	"	286	-362	-76	26
January	1970	331	-3	328	29
February	"	40	-119	-79	23
March	"	778	-757	21	28
April	"	1701	-41	1660	30
May	"	4379	-1598	2781	30
June	"	2790	-1488	1302	29
July	"	580	-105	475	28
August	"	836	-884	-48	31

Q_ℓ in Cubic Yards Per Day (+ = Westward, - = Eastward)

CRYSTAL PIER 1969 - 1970

	$Q_\ell+$	$Q_\ell-$	$Q_\ell$net	Number of Observations
September 1969	445	-11	434	30
October "	993	-485	508	30
November "	422	-233	189	28
December "	1384	-983	401	29
January 1970	519	-120	399	31
February "	260	-293	33	28
March "	1469	-432	1037	31
April "	912	-289	623	30
May "	1114	-108	1006	31
June "	696	-577	121	30
July "	341	-598	-257	31
August "	1373	-481	892	20

Q_ℓ in Cubic Yards Per Day (+ = Westward, - = Eastward)

GRAYTON BEACH 1969 - 1970

	$Q_\ell +$	$Q_\ell -$	Q_ℓ net	Number of Observations
September 1969	413	-46	367	26
October "	388	-240	148	31
November "	165	-189	-24	30
December "	356	-586	-230	31
January 1970	284	-43	241	31
February "	631	-159	472	28
March "	647	-105	542	31
April "	388	-3	385	30
May "	365	-7	358	31
June "	218	-137	81	30
July "	363	-222	61	30
August "	707	-118	589	31

Q_ℓ in Cubic Yards Per Day (+ = Westward, - = Eastward)

ST. ANDREWS STATE PARK 1969 - 1970

	Q_ℓ+	Q_ℓ-	$Q_\ell$net	Number of Observations
September 1969	176	0	176	25
October "	152	-210	-58	30
November "	79	-109	-30	28
December "	442	-203	239	29
January 1970	14	-57	-43	31
February "	130	-232	-102	28
March "	289	-128	161	31
April "	360	-65	295	31
May "	364	-72	292	26
June "	218	-154	64	23
July "	294	-357	-63	29
August "	326	-423	-97	30

Q_ℓ in Cubic Yards Per Day (+ = Westward, - = Eastward)

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8/1M/76