INSTITUTE OF MARINE SCIENCE
University of Alaska
Fairbanks, Alaska 99701

COOK INLET
TIDAL STREAM ATLAS

J. C. H. Mungall

IMS Report R73-6
Sea Grant Report 73-17

D. W. Hood, Director
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D. W. Hood
Director

*Presently at Department of Oceanography, Texas A & M University, College Station, Texas 77843

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J. C. H. Mungall and J. B. Matthews, "Numerical Tidal Models with Unequal Grid Spacing," Report R73-2, Institute of Marine Science, University of Alaska, 1973, 213 pages.

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INTRODUCTION

The purpose of this tidal stream atlas is to provide oceanographers and engineers with a convenient means of estimating currents in Cook Inlet.

The currents were computed using a numerical tidal model whose original purpose was that of calculating the distribution of the amplitude and phase of the M_2 tide in Cook Inlet. The numerical model used as input the M_2 tide across the seaward entrance of Cook Inlet, and was adjusted so as to give the best possible agreement between the computed and actual amplitude and phase at Anchorage. As the differences between the computed and observed values throughout the rest of the inlet were small (in all cases less than 8% difference in amplitude and in phase) it was decided that the associated current amplitudes and phases would also be reasonably accurate, and, until something better became available, would provide information suitable for oceanographic or engineering use.

The assumption was made that the ratios between Neap tides and Spring tides to the M_2 tide amplitude (0.8 and 1.6 throughout much of Cook Inlet) would hold good also for the currents. Having computed the Neap and Spring currents throughout Cook Inlet using this assumption, it was then decided that the most convenient single reference point would be the effective daily tidal range at Anchorage as calculated from high and low water values taken from the tide tables. Another assumption was made that Neap currents would occur throughout the inlet when the effective tidal range at Anchorage was equal to its Neap value (approximately 20 ft.) and that Spring currents would be associated with an effective tidal range at Anchorage equal to its Spring value (approximately 31 ft.). Currents associated with any other effective daily tidal range would then be found by interpolation or extrapolation. (An obvious source of error is that at Anchorage the Spring range is only equal to about 1.5x the Neap range, and not 2x, as assumed for the rest of the inlet -- the difference probably being due to the distortion of the tide at Anchorage.)

As a result of the above assumptions and also as a result of the fact that the computed currents have not been compared with those actually occurring in Cook Inlet, it is felt that this tidal stream atlas should not be used for purposes of navigation.

INSTRUCTIONS FOR USE OF TIDAL STREAM ATLAS

To estimate the current at a given position at a particular time and date:

1) Locate in the Anchorage tide table the nearest high water to the time at which the current is to be predicted. Write down the time and the high water value.

2) Locate the nearest low water such that the prediction time lies between the times of low and high water. Subtract the low water value from the high water value so as to obtain the effective tidal range at Anchorage for that period.

3) Calculate the amount of time (to the nearest hour) by which the prediction time precedes or follows the time of high water at Anchorage. Select the figure (Figs. 1-13) of the tidal stream atlas that corresponds to this time; then, according to the position at which the current is to be predicted, estimate and write down the Neap and Spring current values. (The numbers correspond to a position midway along the arrow pointing to them.)

4) With the effective range and the Neap and Spring current values, turn to the prediction diagram (page 18). Locate the position of the first number in the left hand column of dots (corresponding to a Neap tide) and the position of the second (larger) number in the right hand column of dots (Spring tide). Place a straight-edge between these two points.

5) Locate the point of intersection of the vertical line corresponding to the effective range and the straight-edge. By running horizontally to the nearest current scale, obtain the predicted current in tenths of a knot.

EXAMPLE

Compute the current off Cape Ninilchik at 1000 hours given the following:

0300	26
0900	2
1600	28
2200	4

The effective tidal range is 26 ft., and the relevant page is that for 6 hours before H.W. Anchorage. The current values are 20,40. From the prediction diagram the current is 3.1 knots.

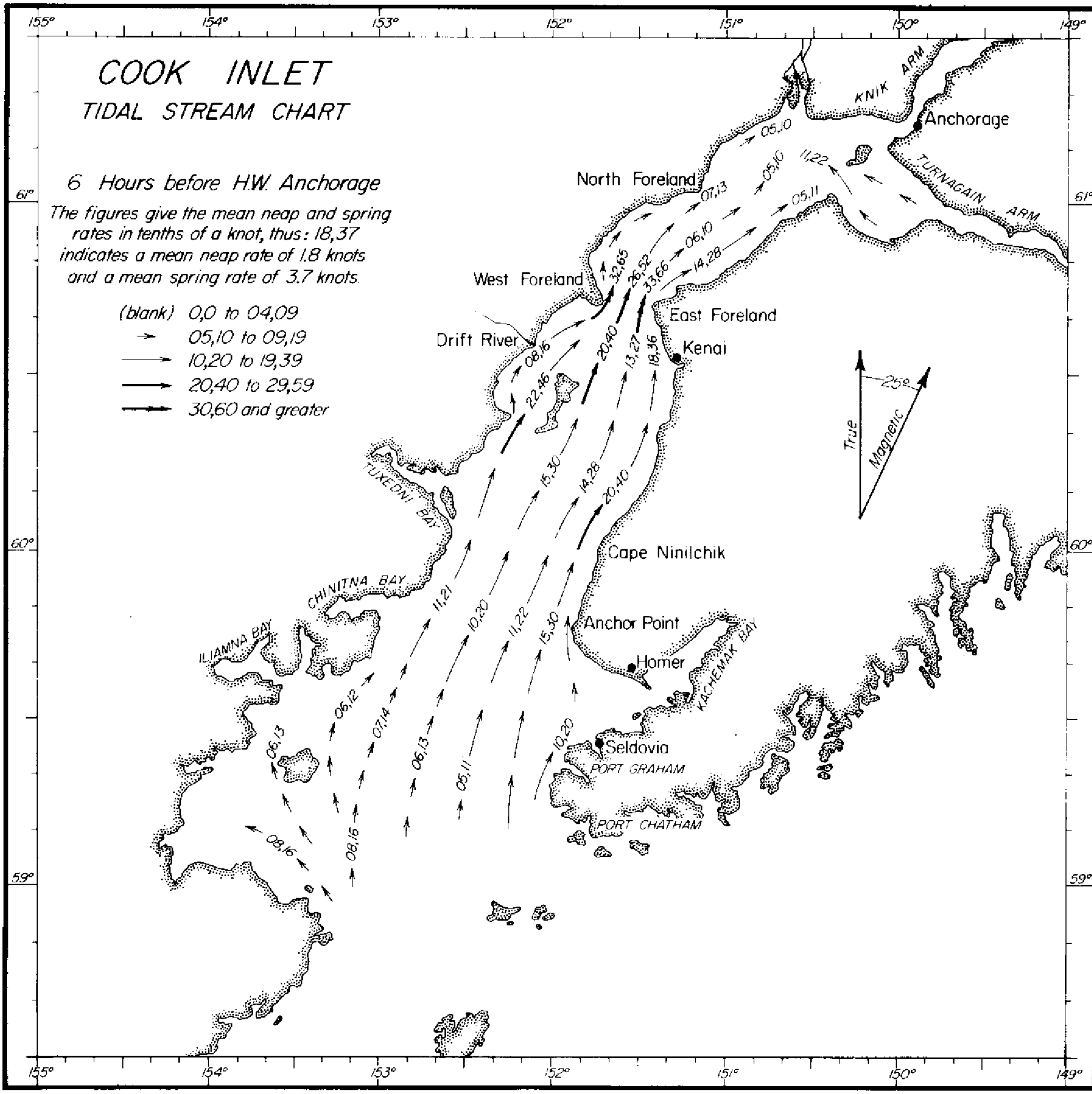

Figure 1. Tidal stream 6 hours before high water.

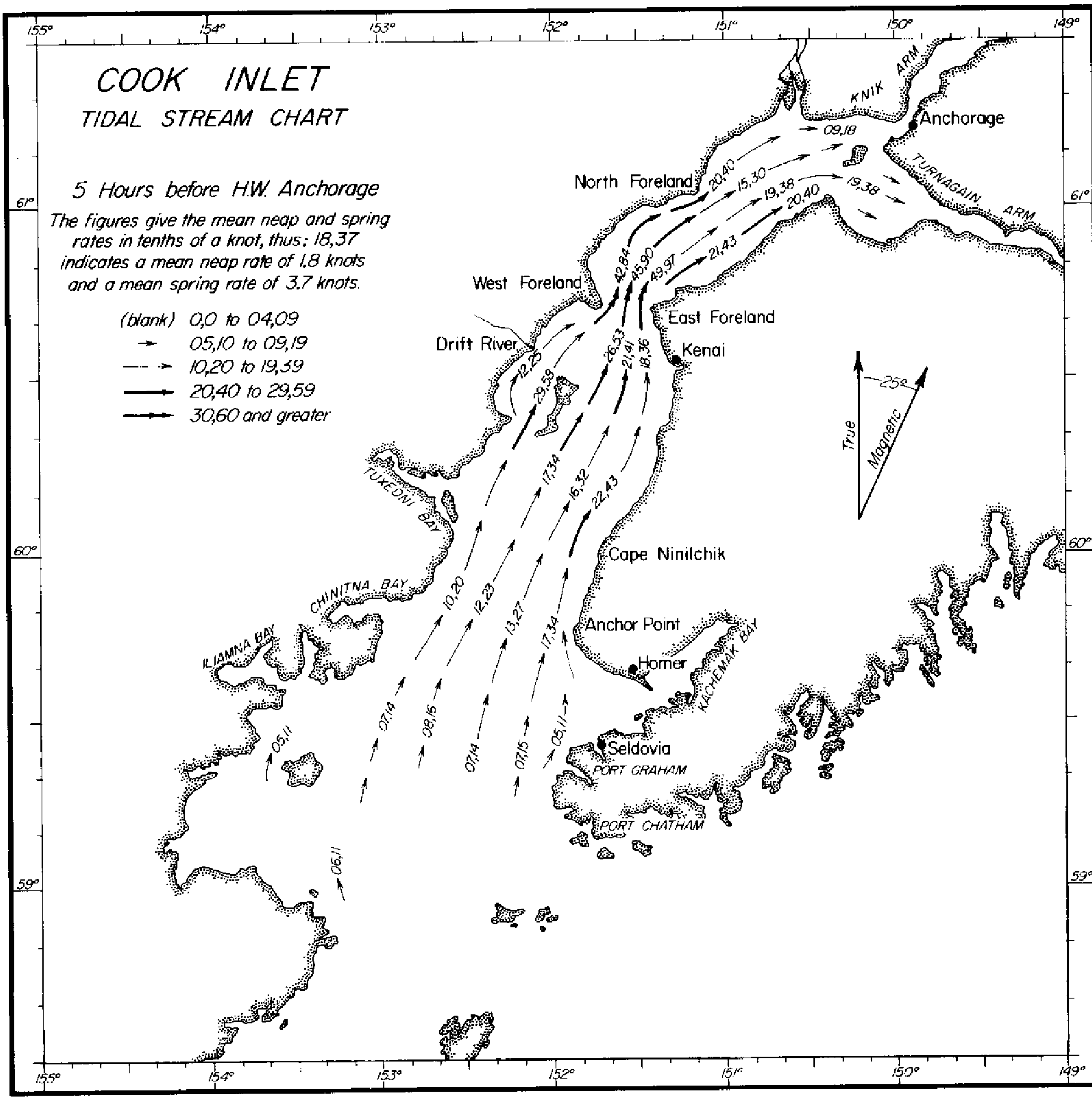

Figure 2. Tidal stream 5 hours before high water.

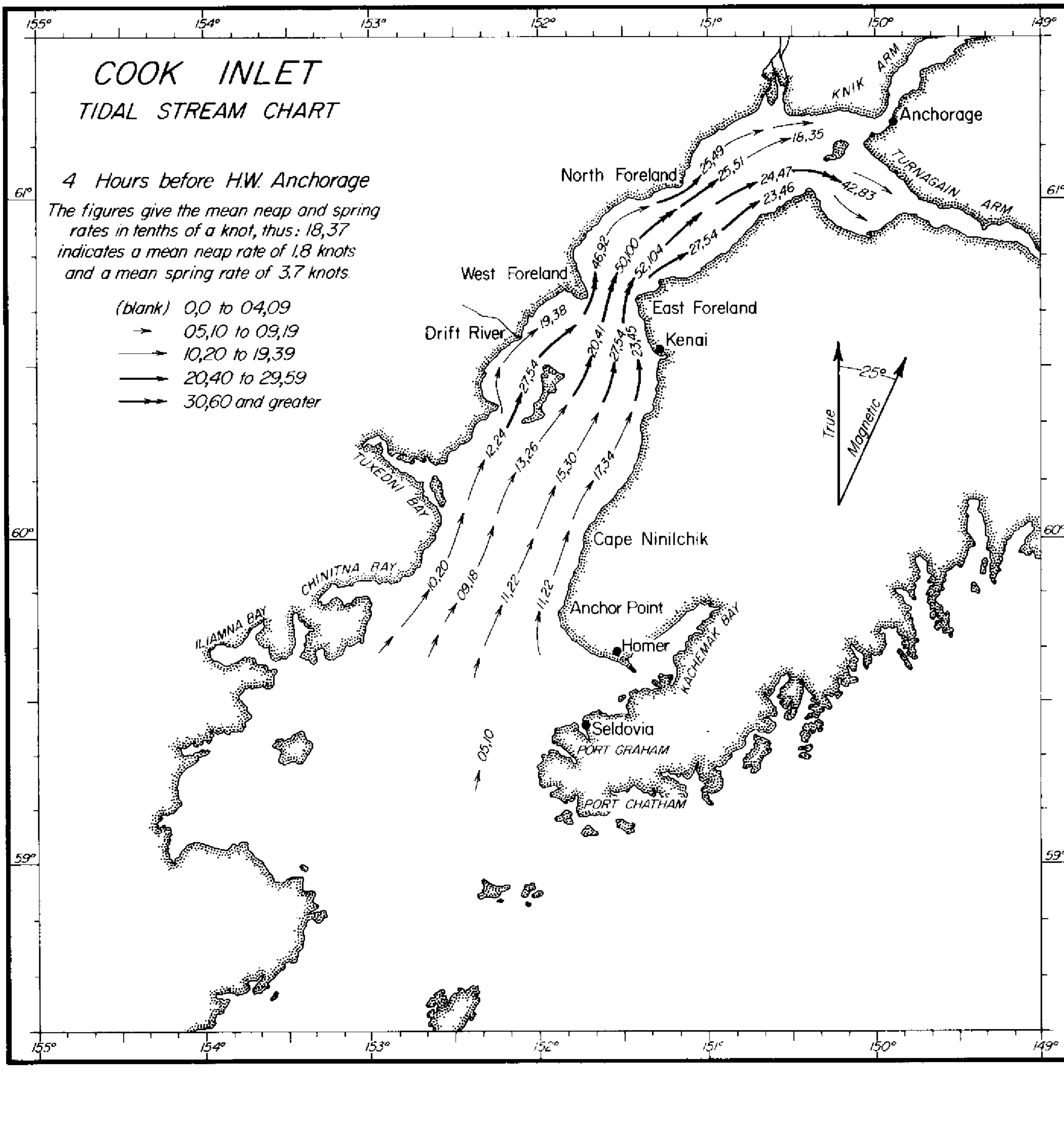

Figure 3. Tidal stream 4 hours before high water.

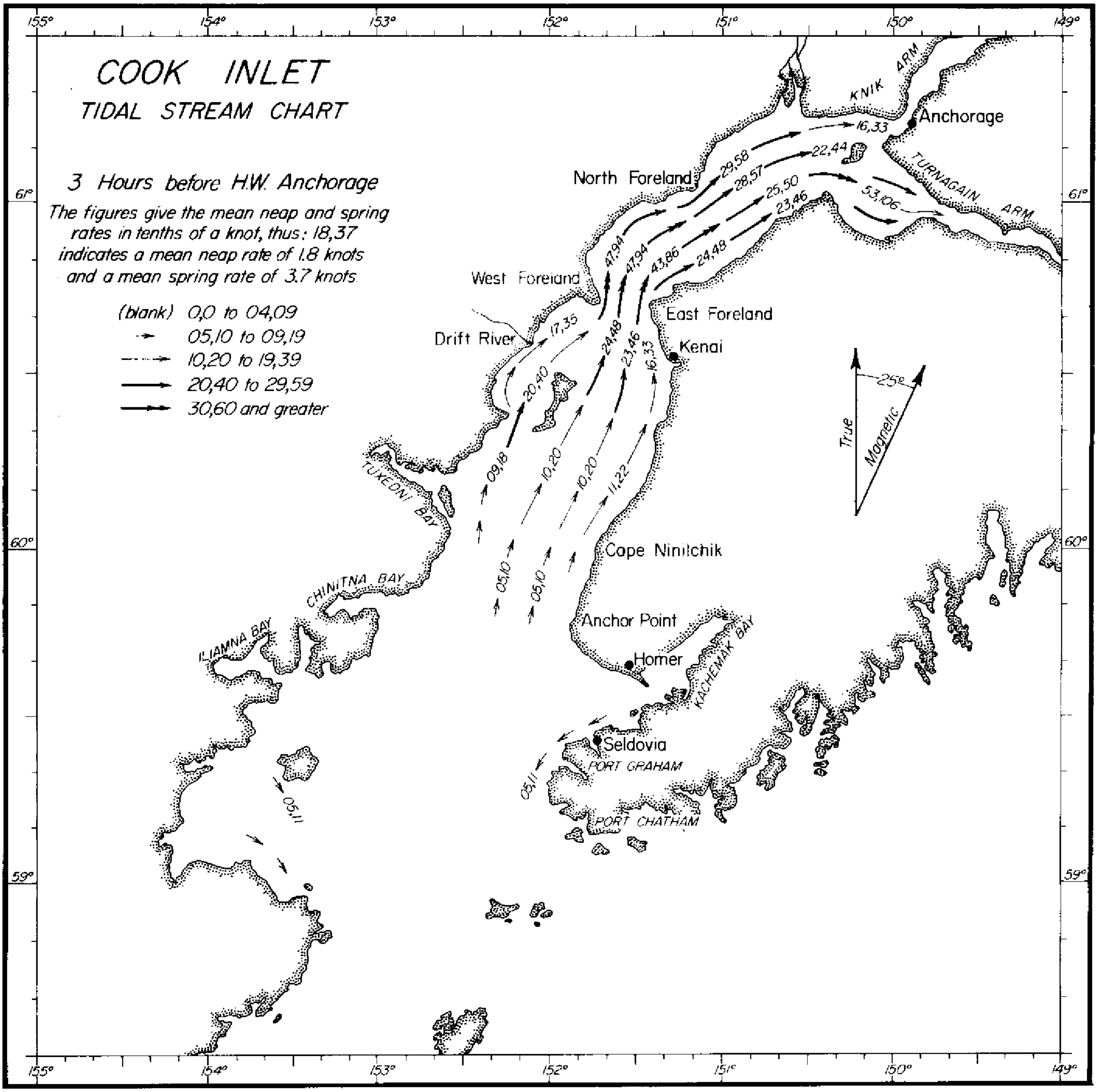

Figure 4. Tidal stream 3 hours before high water.

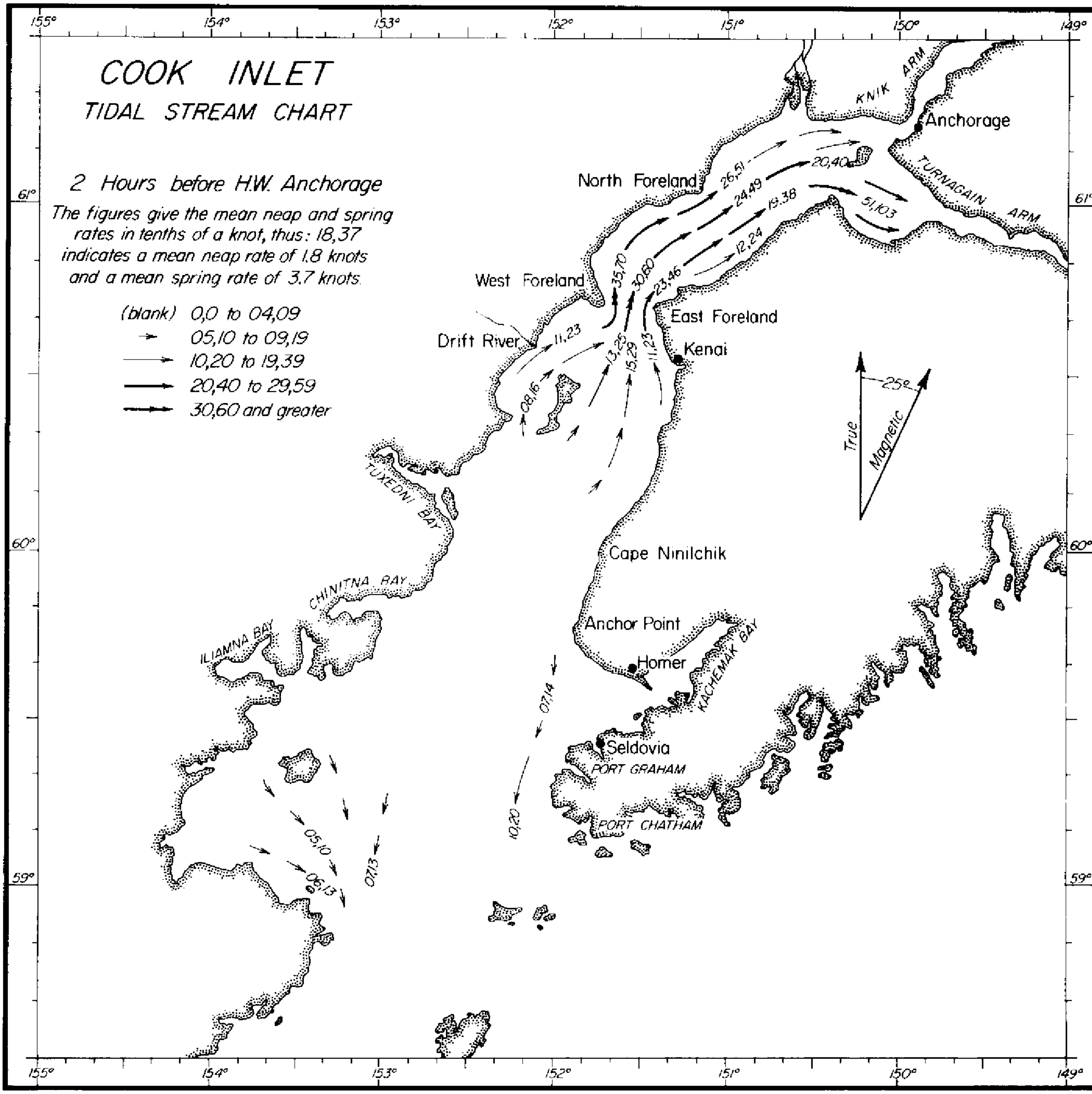

Figure 5. Tidal stream 2 hours before high water.

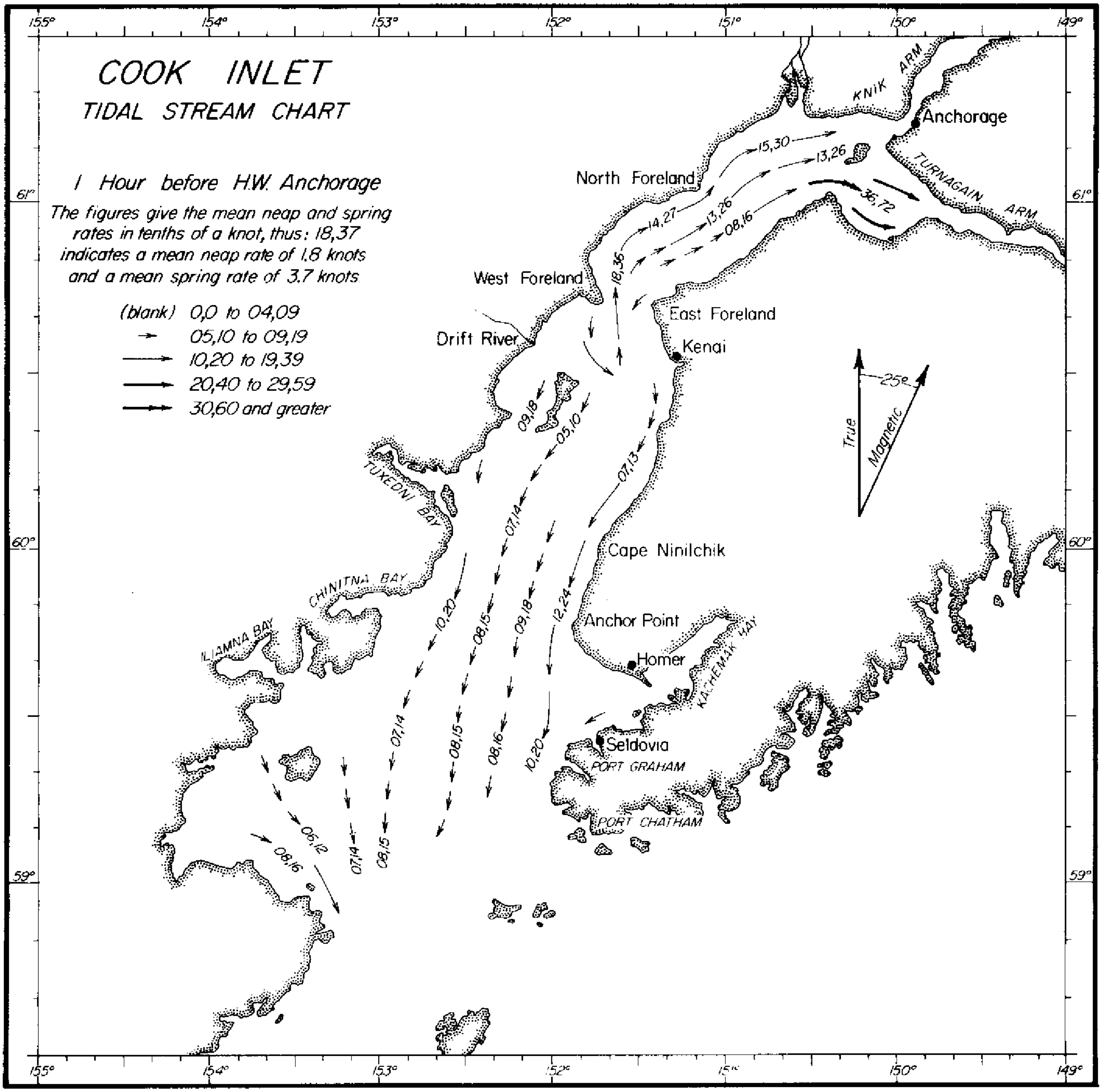

Figure 6. Tidal stream 1 hour before high water.

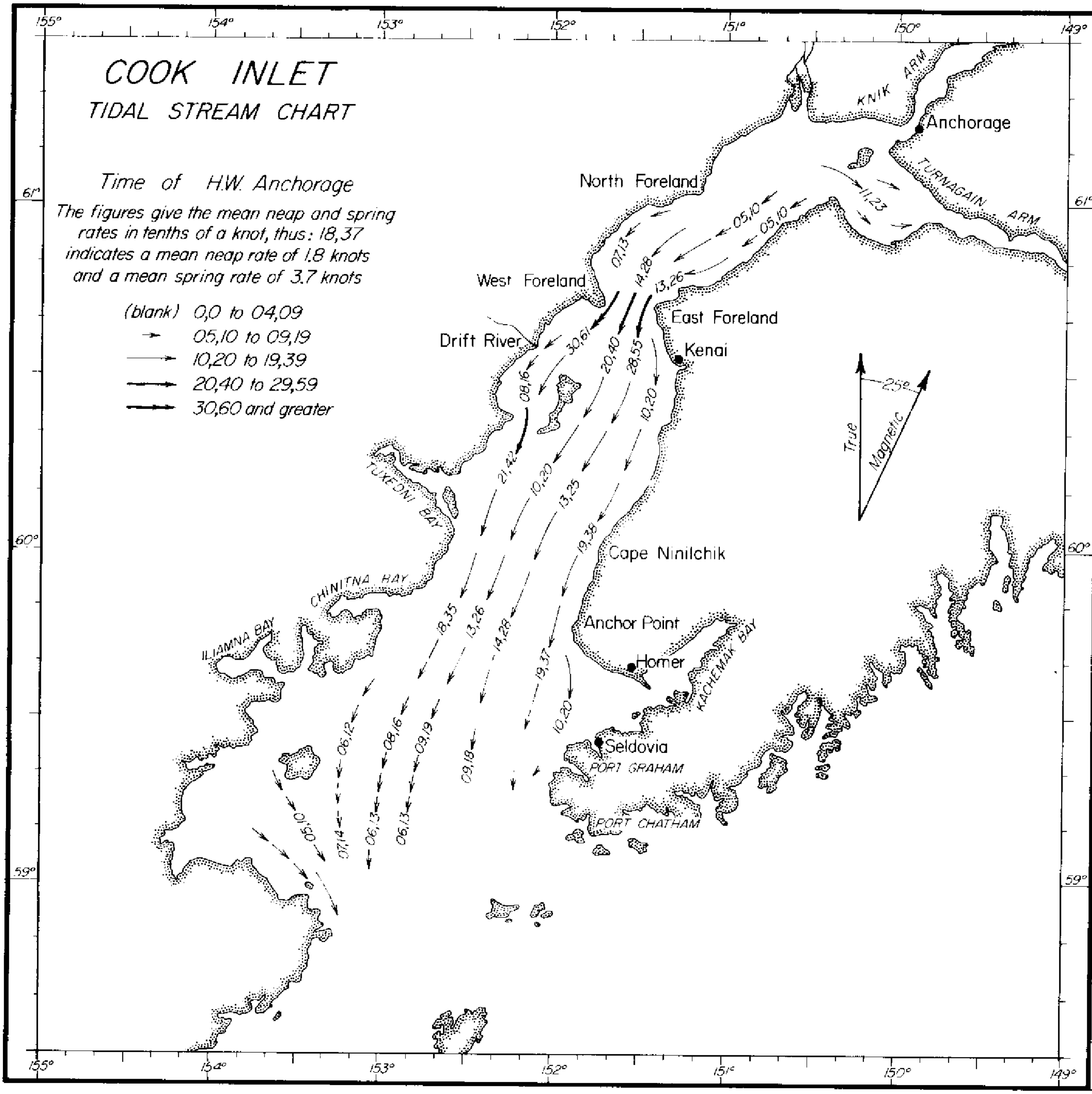

Figure 7. Tidal stream at time of high water.

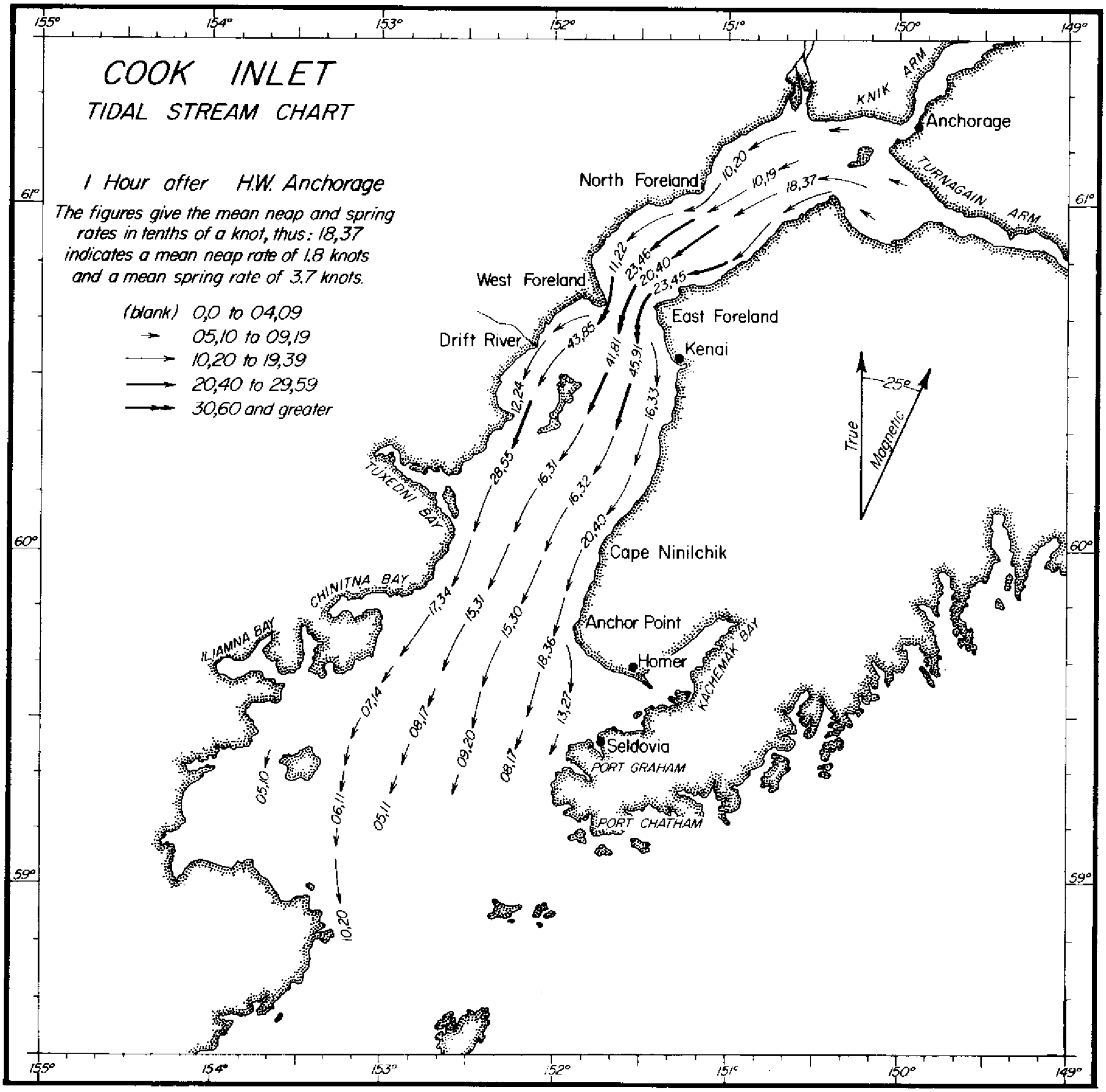

Figure 8. Tidal stream 1 hour after high water.

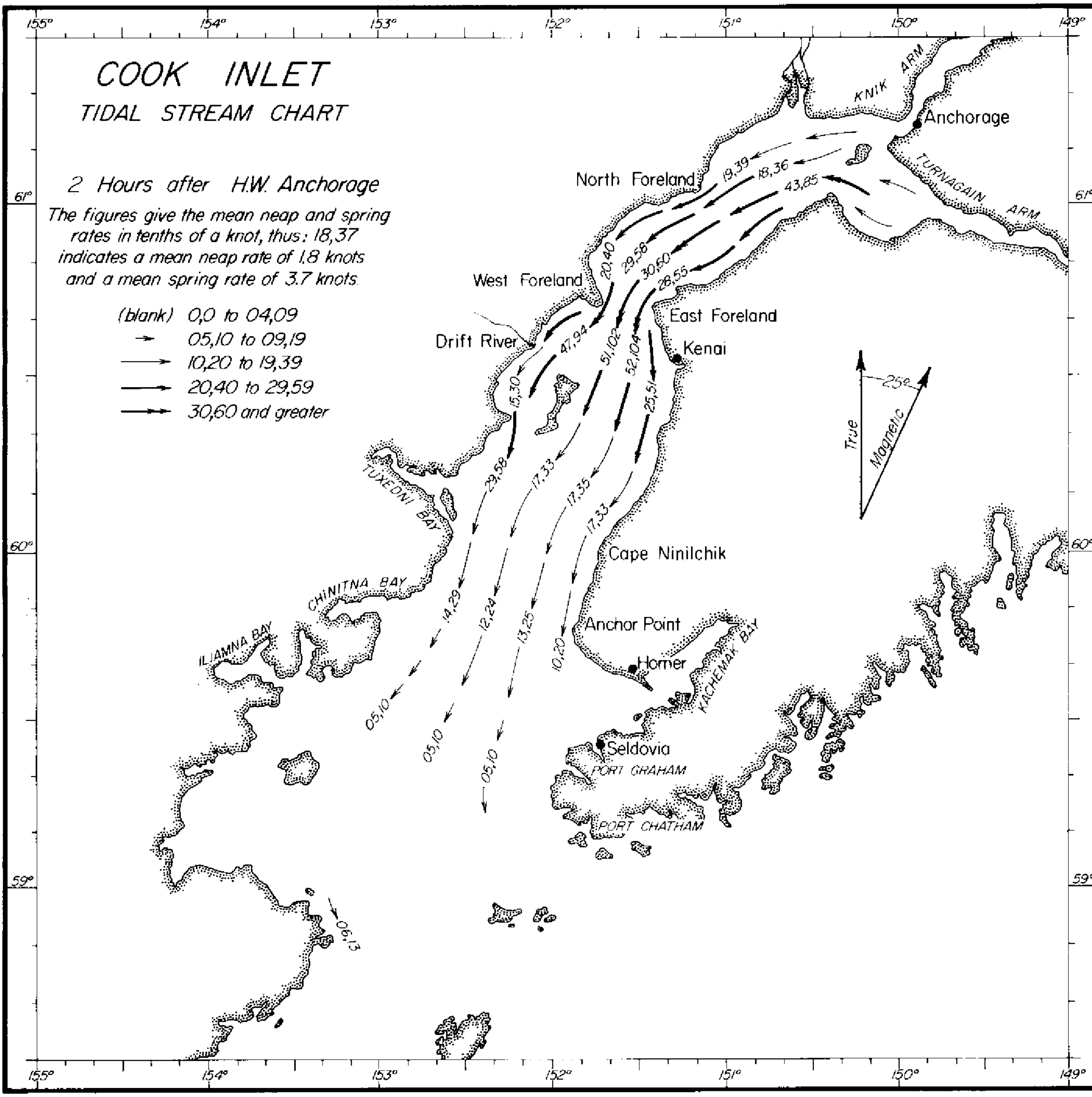

Figure 9. Tidal stream 2 hours after high water.

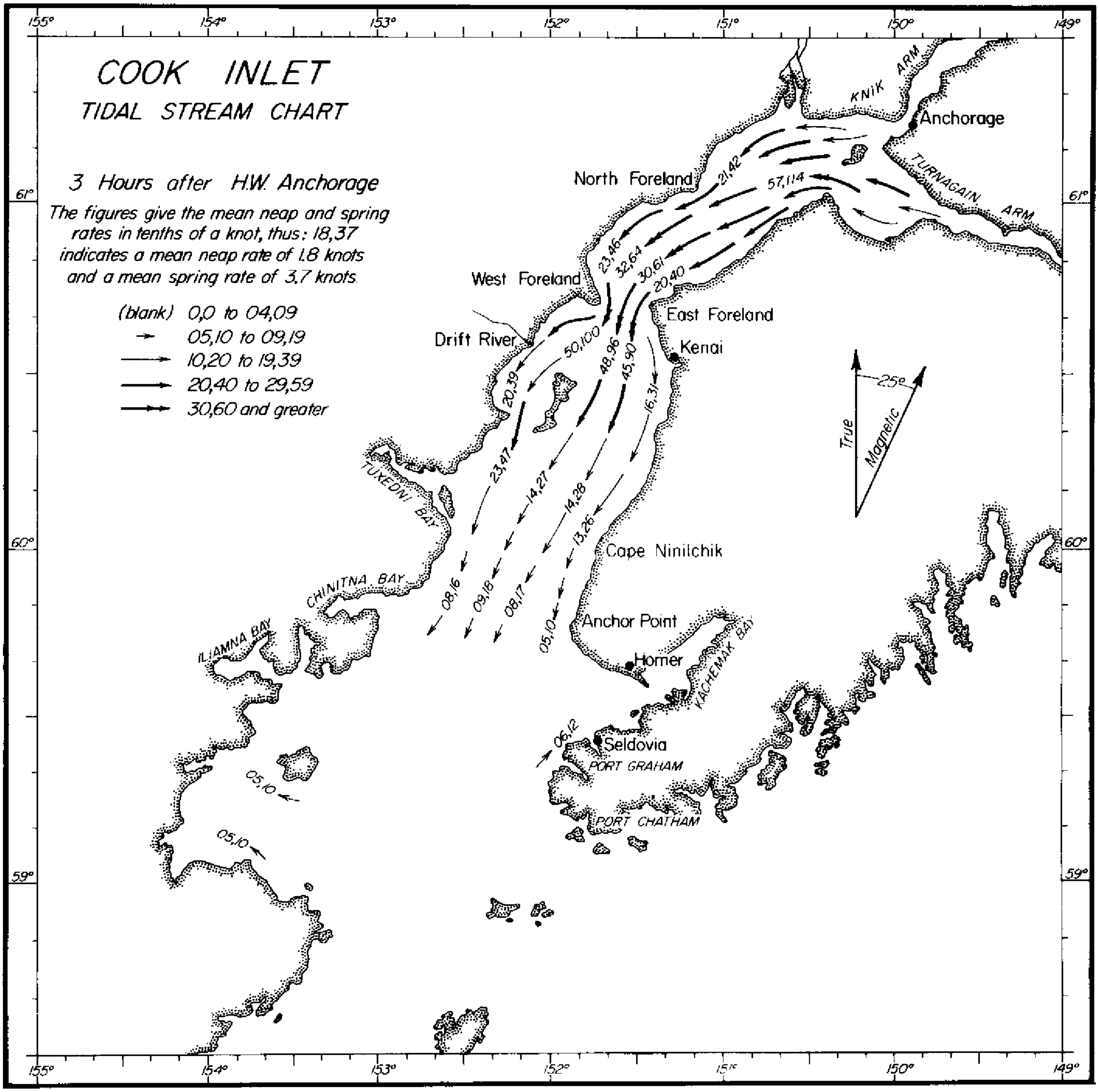

Figure 10. Tidal stream 3 hours after high water.

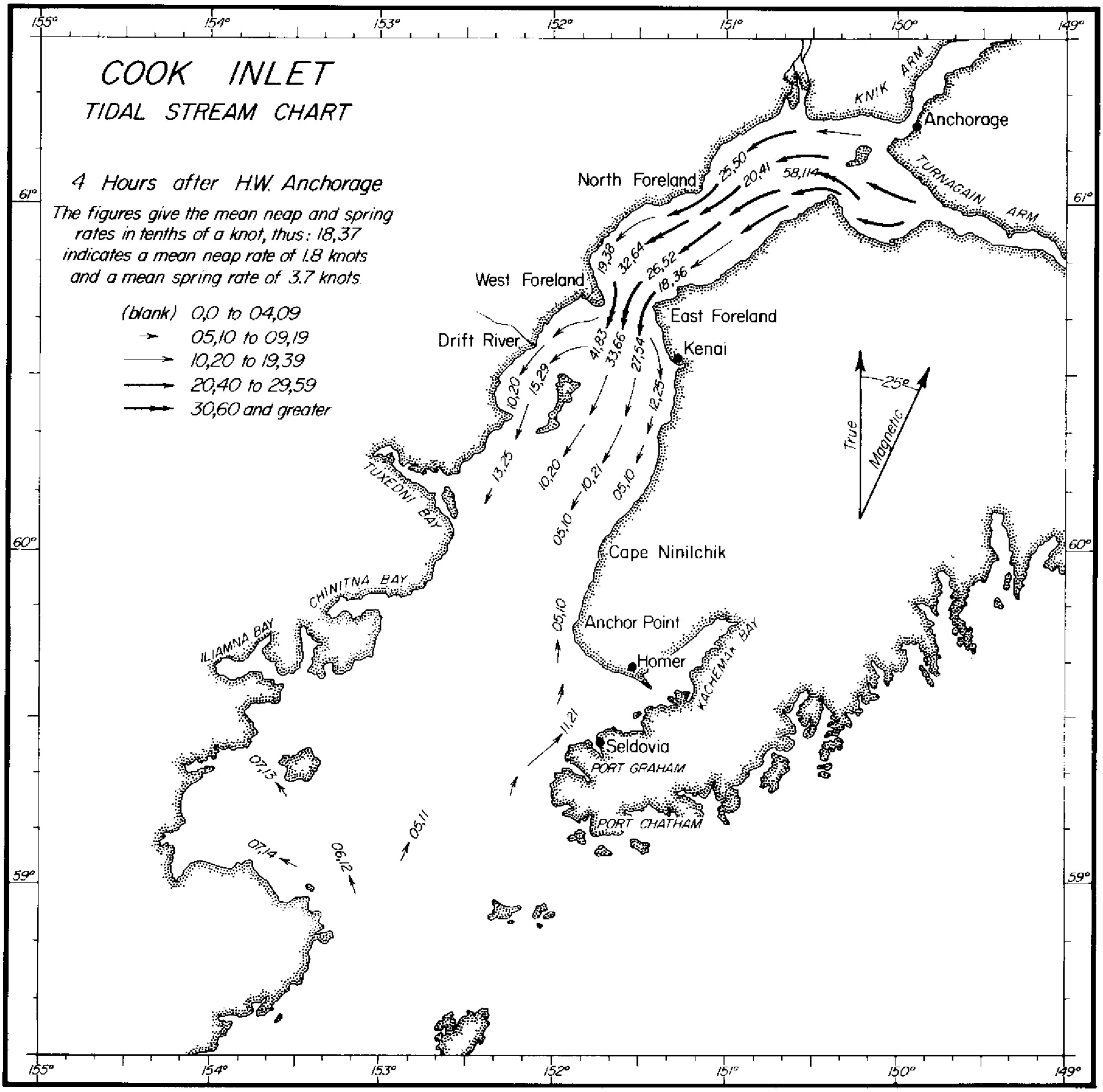

Figure 11. Tidal stream 4 hours after high water.

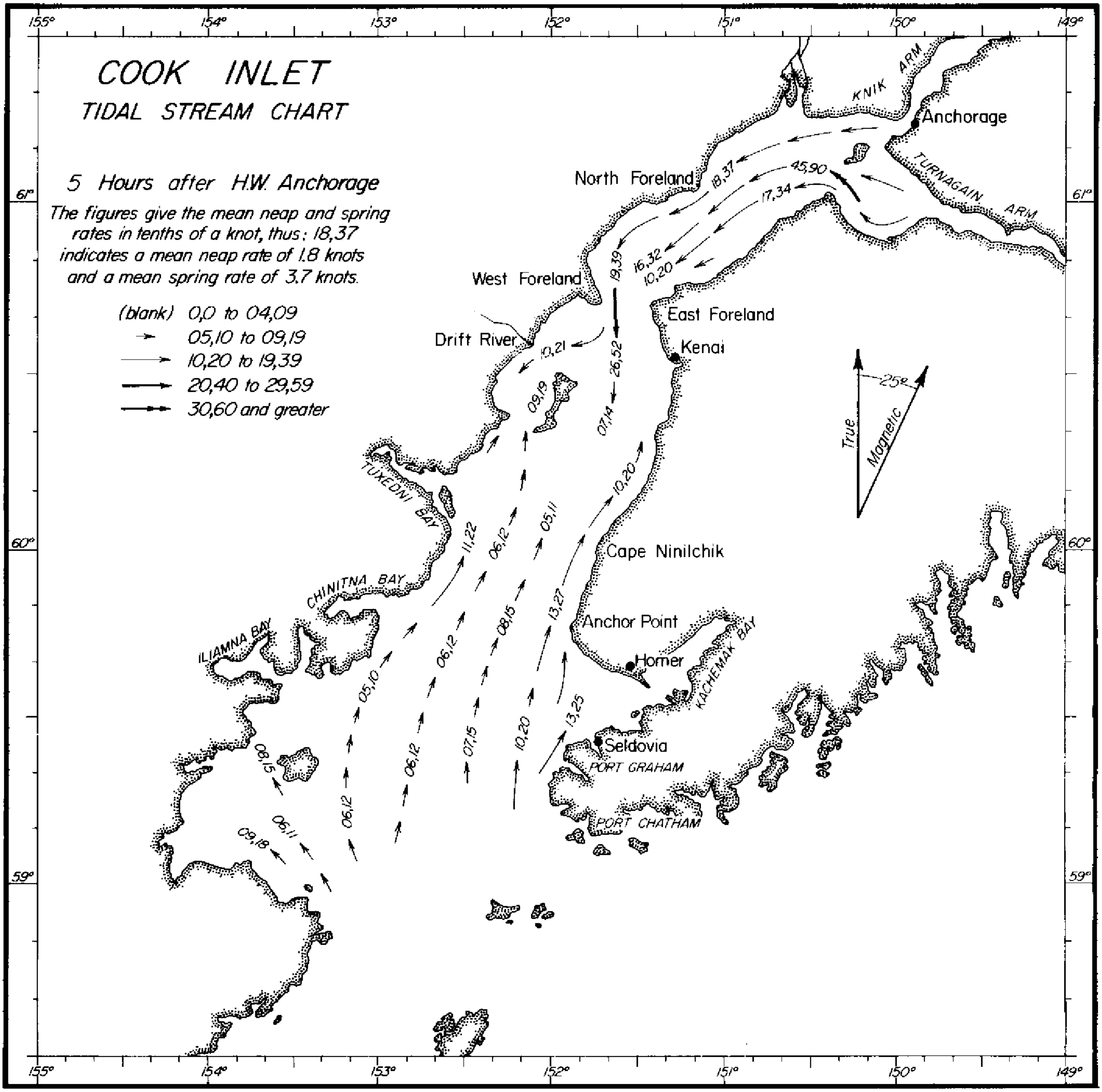

Figure 12. Tidal stream 5 hours after high water.

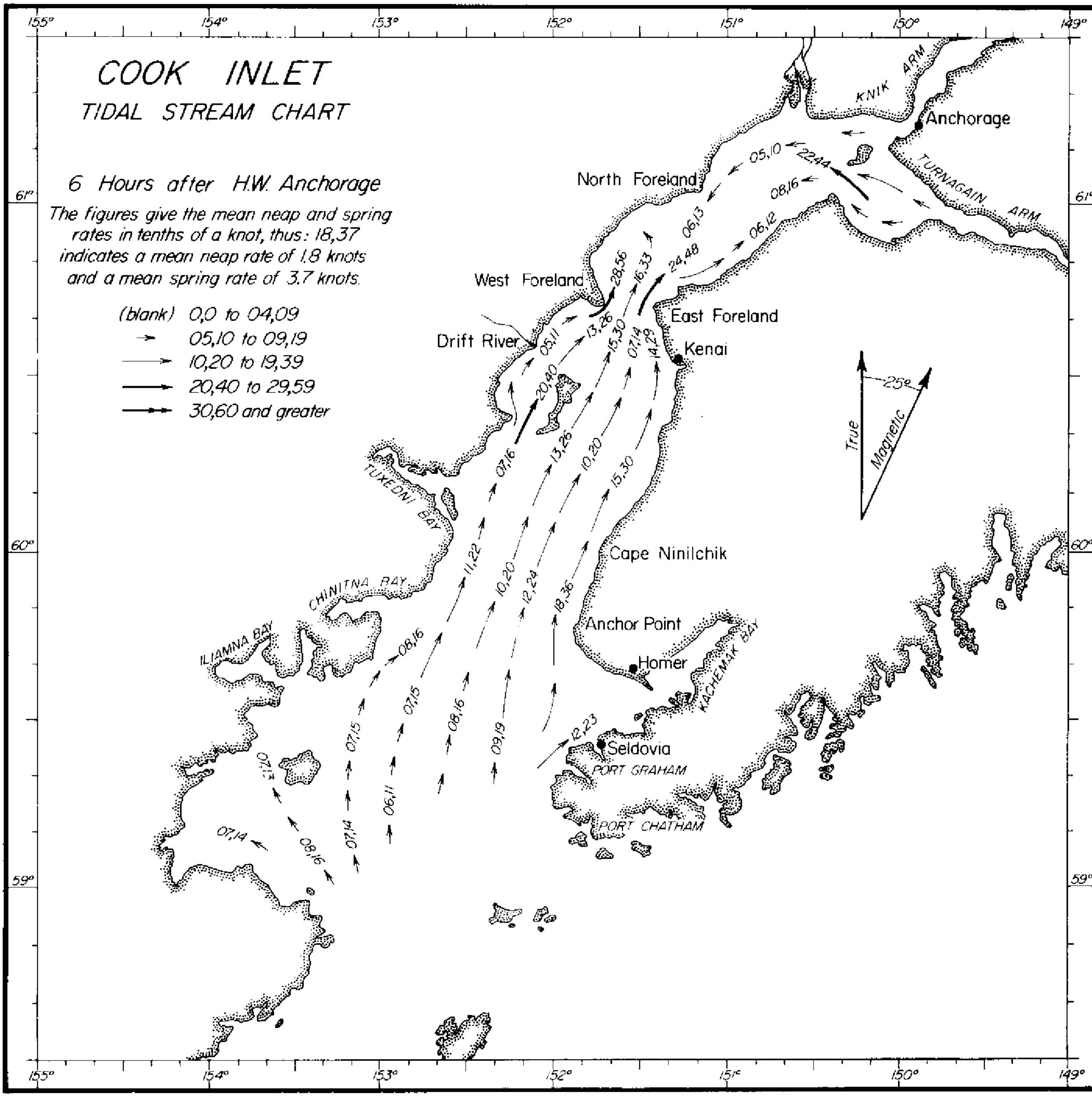

Figure 13. Tidal stream 6 hours after high water.

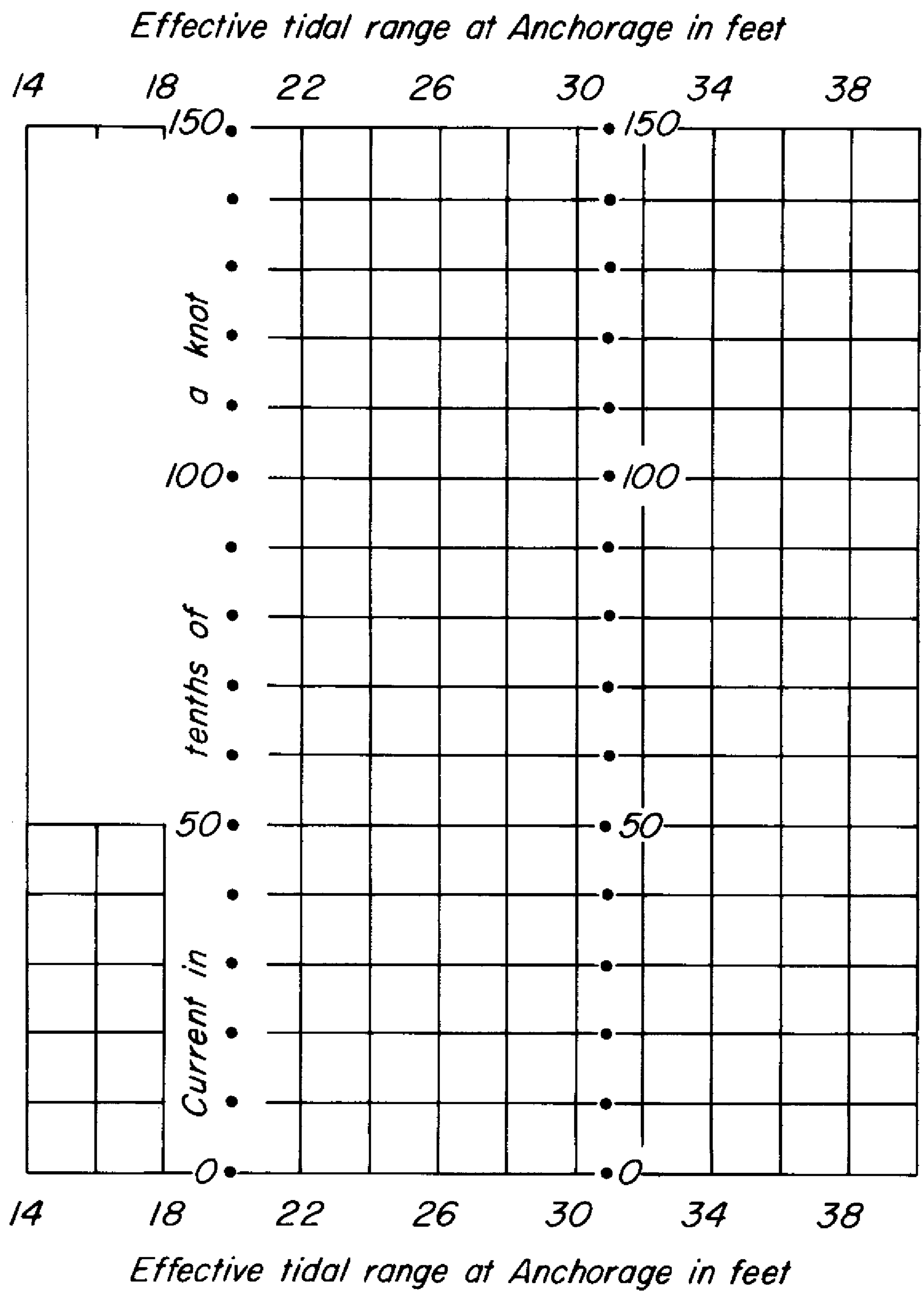

Figure 14. Current Prediction Diagram of Cook Inlet.

A SUMMARY OF THE COOK INLET M_2 TIDE CALCULATIONS

Introduction. - For the sake of completeness some additional information concerning the M_2 tide of Cook Inlet will be included here. The results are in the form of amplitudes and phases for the M_2 tide height and current and were obtained as follows. A numerical model (whose boundaries are shown in each figure) was used to compute heights and currents at a large number of grid points throughout the inlet. The model was driven by a sinusoidal tide height specified at the seaward entrance, the amplitudes and phases of which were obtained from interpolated M_2 tide data. Four hundred time steps were used per tidal cycle (12.42 hours), and when the model settled down to a quasi-periodic state a complete tidal cycle was analysed in order to obtain the M_2 constituents of the tide height and the currents (the latter being computed in the form of components at right angles to each other). These current constituents were then combined so as to produce current ellipses and thus maximum currents along with their times of occurrence.

Tide Heights. - The M_2 tide height amplitudes are shown in Figure 15. The dashed lines are lines along which the amplitude (expressed in centimeters) is constant, and the solid lines are lines along which the phase in degrees (referred to 150° west longitude) is constant. To obtain the local epoch use the formula $K_{local} = K_{150} - 2$ (west longitude - 150).

The amplitudes approximately double in magnitude as one goes up the inlet, from about 175 cm at the entrance to 350 cm at Anchorage. In the same distance the phase increases from 22° at the entrance to 173° at Anchorage, thus indicating a delay of 5 lunar hours (5 solar hours and 10 minutes) between high water at the entrance and at Anchorage.

A notable feature of the amplitudes south of the Forelands region is that the co-amplitude lines run parallel to the axis of the inlet, there being a difference in amplitude across the inlet of approximately 40 cm. North of the Forelands region the co-amplitude

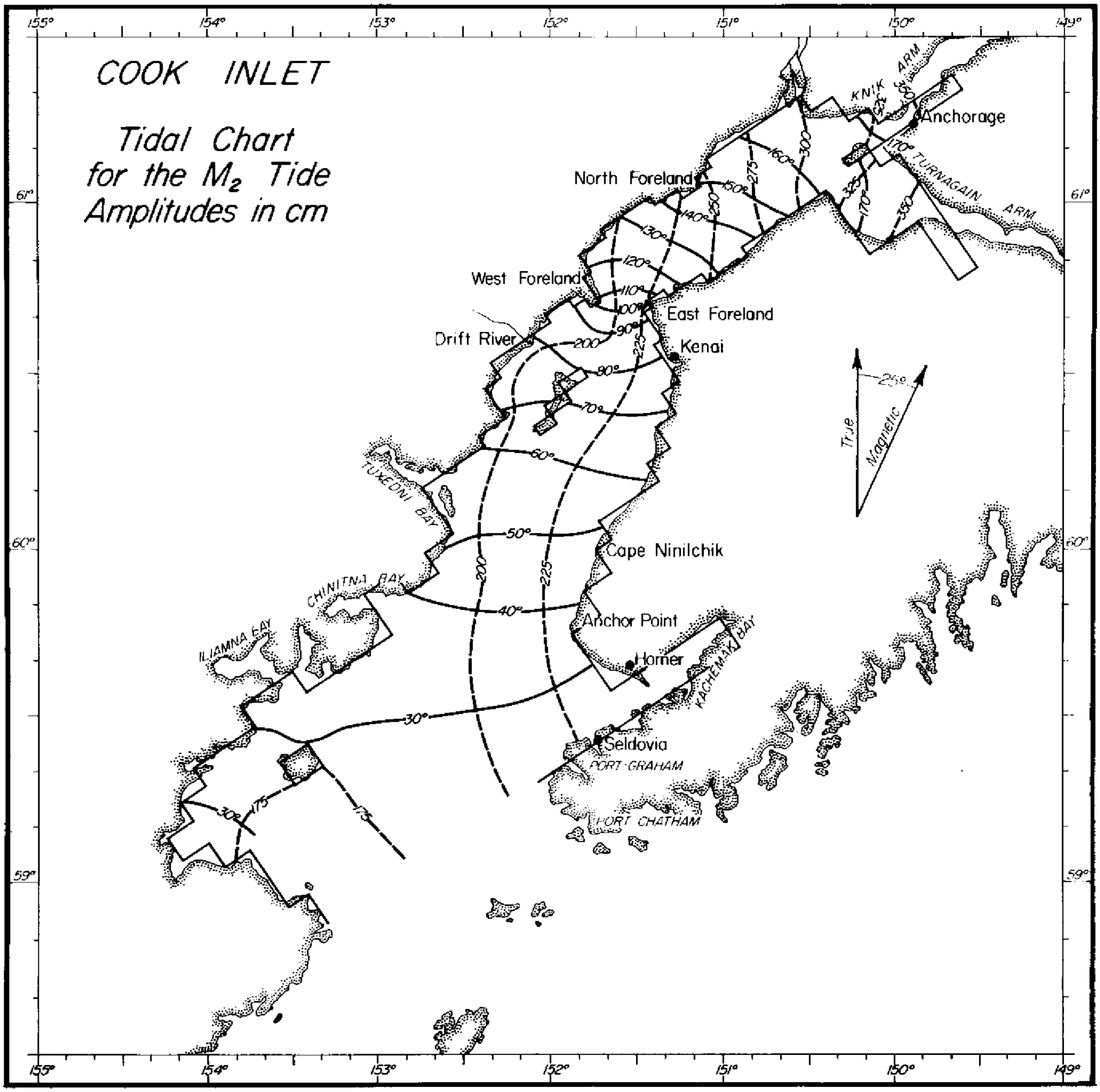

Figure 15. Co-amplitude lines (in cm) and co-phase lines (in degrees) for the M_2 tide of Cook Inlet, Alaska.

lines tend to become oriented across the inlet. The reason for this behavior will be explained later.

Currents. - The information concerning the M_2 currents is presented in a slightly different fashion from that above. Current amplitudes are shown separately in Figure 16. As can clearly be seen, the two regions of maximum current are between the Forelands (up to 335 cm/sec) and south-west of Fire Island (up to 365 cm/sec). The latter value may not be very reliable due to inadequate grid resolution in that part of the model. Furthermore one should bear in mind the extreme variability that can occur in currents over a short distance; this, coupled with the fact that the original model included neither convective acceleration terms nor flooding boundaries, indicates that the computed currents should be used with caution.

Phases are shown in Figure 17 in the form of the lead in lunar hours of the maximum inward current over the time of high water at Anchorage (12 lunar hours are equivalent to 12 solar hours and 25 minutes). It is interesting to note that the time difference between maximum inward currents at the entrance and at Anchorage lies between 3 and 4 lunar hours. (That for the times of high water was 5 lunar hours.) Also, maximum inward currents on the western side of the inlet can occur up to one hour earlier than those on the eastern side.

Comments of a Theoretical Nature. - Although the tides of Cook Inlet are complex, it is possible to make some generalizations concerning their form. Three features play an important part: the increase in amplitude due to topography; friction; and the Coriolis force. In the absence of friction the tides would resemble a standing wave – high water would occur simultaneously throughout the inlet, and currents would reach their inward maxima 3 lunar hours before high water. The tide height amplitude would remain essentially constant between the entrance and the Forelands, and would then steadily increase, until at Anchorage the amplitude would be about twice that at the entrance. As there would be zero current at the time of high water, there would be little change in amplitude across the inlet due to the Coriolis force.

As a result of friction, however, energy is lost, and there has to be a net inwards transport of energy through the entrance to replace this loss. This can only be achieved if

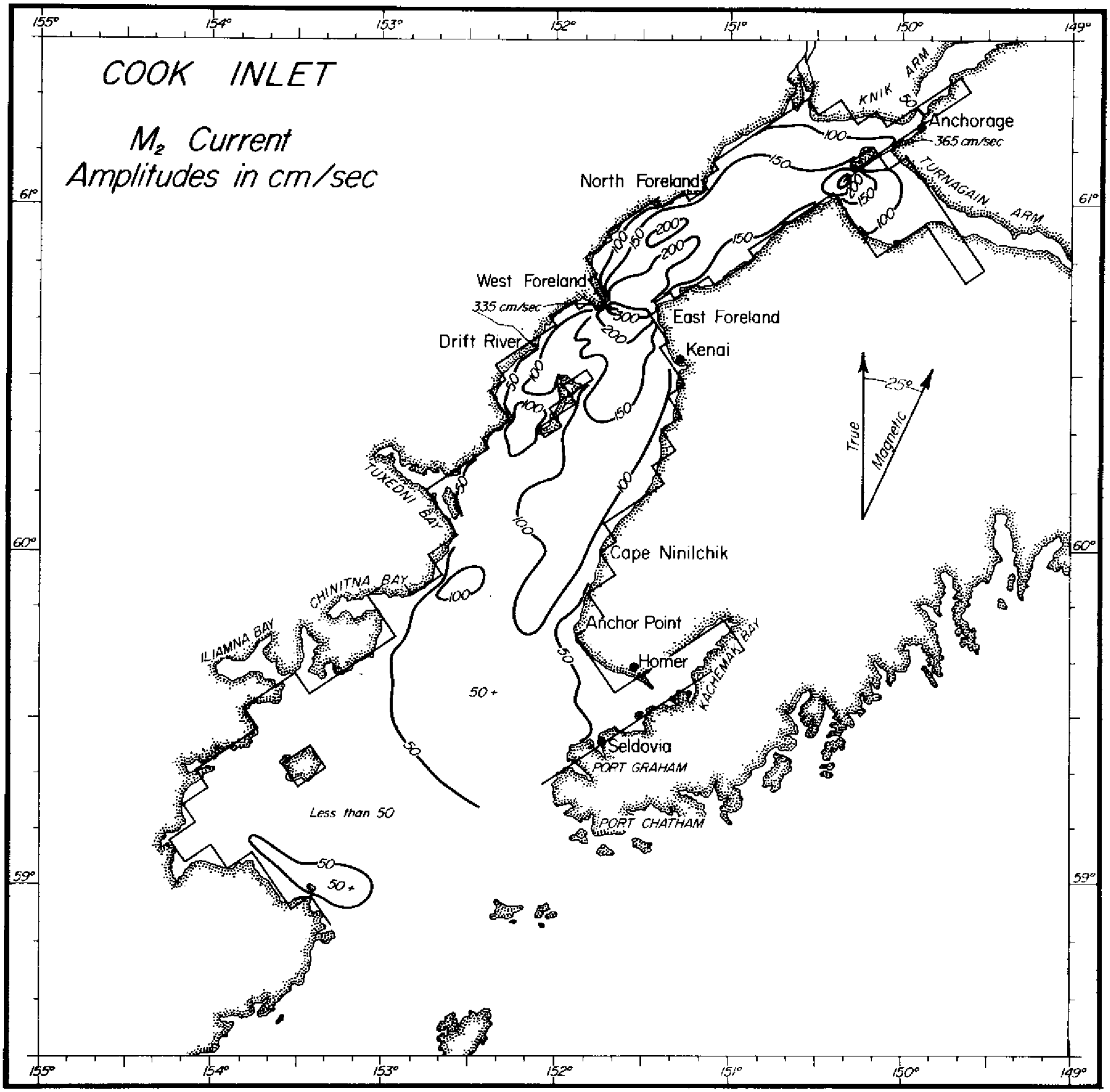

Figure 16. Current amplitues (in cm/sec) for the M_2 tide of Cook Inlet, Alaska.

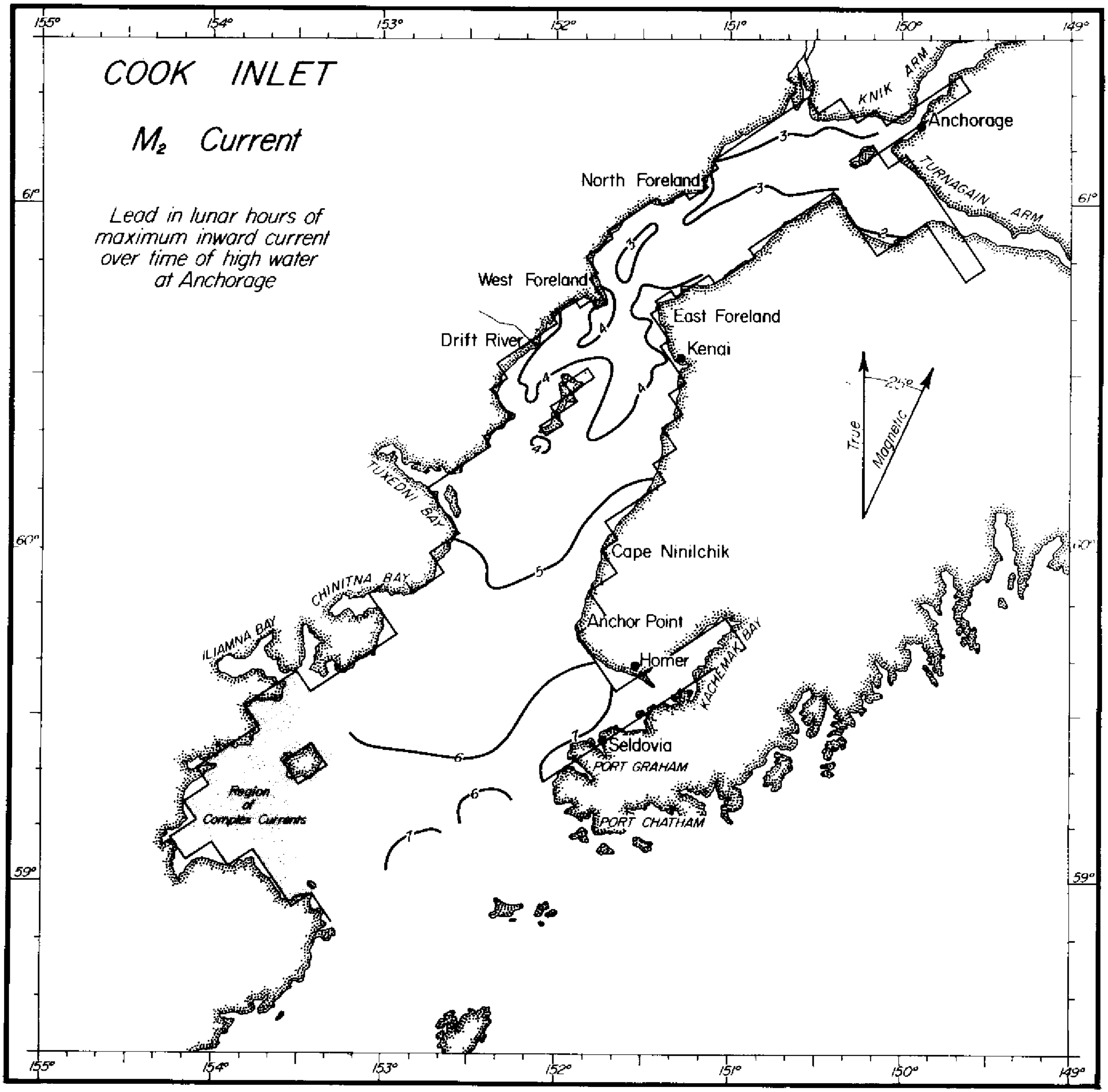

Figure 17. Lead (in lunar hours) of the time of maximum inward current over the time of high water at Anchorage for the M_2 tide of Cook Inlet, Alaska.

the form of the wave at the entrance and throughout much of the inlet is partly progressive – maximum currents will occur less than 3 lunar hours before local high water. The smaller this time difference is, the larger the currents will be at the time of local high water, and hence the greater the Coriolis effect. The result is to cause the tide amplitude to be greater on the east of the inlet than on the west.

Throughout the lower part of the inlet maximum inward currents occur about 1½ hours before local high water, while in the upper part they occur between 1½ to 3 hours before local high water. At Anchorage the figure is three hours, so that conditions there are essentially those of a standing wave. The effects described above cause an amplitude difference of about 40 cm across the lower part of the inlet (not enough to cause an amphidromic region, however, since amplitudes in the center of the inlet are of the order of 200 cm). As there is little change of amplitude along the axis of this part of Cook Inlet the co-amplitude lines tend to lie parallel to the inlet axis and conditions resemble a Kelvin wave of progressive character. In the upper part of the inlet conditions approach those of a standing wave; there is little change in amplitude across the inlet. However, because there is a considerable increase in the amplitude along the inlet axis, the co-amplitude lines will tend to become perpendicular to the axis as one approaches Anchorage.