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Central Archiving of Current Meter Data Summaries

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September 1982

Canadian Contractor Report of Hydrography and Ocean Sciences No. 7

*904 — 500 Laurier Avenue W., Ottawa, Ontario

Fisheries and Oceans / Pêches et Océans

Canada

Canadian Contractor Report of Hydrography and Ocean Sciences

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by

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This report was prepared by:

W.D. Forrester, Ottawa, Ontario under Fisheries and Oceans Contract FP802-1-2225.

Scientific Authority - P.A. Bolduc, MEDS.

Correct citation for this publication:

Forrester, W.D. 1982. Central archiving of current meter data summaries. Can. Contract. Rep. Hydrogr. Ocean Sci. 7:15 p.

Cat. No. Fs 97-17/7E ISSN 0711-6748

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ABSTRACT

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The proliferation of undigested or partially digested current meter data in scattered data banks that has resulted from improved current meter technology is discussed. It is suggested that most users' needs could be met from a central archive of current data summaries, and that the central archive could serve users with more particular needs as a directory of available Canadian current data and their sources. It is recommended that current data summaries should consist of:

(1) header information;

(2) frequency distribution of original data in velocity space;

(3) table of ten pairs of tidal harmonic constants;

(4) frequency distribution of non-tidal residues in velocity space.

The inclusion of a progressive vector diagram is discouraged because of the large storage requirement. The computational steps required to prepare the summary are given, and a sample summary is shown.

RÉSUMÉ

Forrester, W.D. 1982. Central archiving of current meter data summaries. Can. Contract. Rep. Hydrog. Ocean Sci. 7:15 p.

Ce rapport examine la prolifération rapide, par suite du perfectionnement de la technologie, des données non digérées ou en partie digérées recueillies à l'aide de courantomètres et inscrites dans des banques de données dispersées. On croit qu'un dépôt central contenant les résumés des données sur les courants pourrait satisfaire la plupart des besoins des usagers. Ce dépôt central pourrait mieux desservir les usagers avec des besoins précis, en tant que répertoire des données canadiennes sur les courants et de leurs sources. Il est recommandé que les résumés des données sur les courants comprennent:

(1) une en-tête;

(2) la répartition de la fréquence des données brutes en fonction du vecteur vitesse;

(3) un tableau de dix paires de constantes harmoniques de la marée;

(4) la répartition de la fréquence des courants non dus à la marée en fonction du vecteur vitesse.

On n'encourage pas l'inclusion d'un vectographe par étapes à cause du vaste espace d'entreposage nécessaire. Le rapport présente les étapes à suivre pour la préparation des résumés, ainsi qu'un modèle de résumé.

Background

Prior to the mid-1950's, the measurement of current at offshore locations was a laborious and time-consuming operation, involving either round-the-clock manual observation from a moored vessel or repeated tracking of drifting drogues. Consequently, current information was gathered sparingly, and, having been gathered, was usually fully exploited. This meant that the information could be made available to the public in data reports of manageable size, frequently published by the agency that gathered the data. Since the data were usually crucial to some investigation, analysis and interpretation of them could be expected in the open literature shortly after they were gathered. Data reports and published literature provided reasonable public access to the growing body of information on currents even in the 1960's, by which time self-contained moored current meters capable of recording unattended for a month or more were in general use. Most of the early moored current meters recorded rate and direction photographically by one process or another, and this demanded considerable manual effort in the processing of the records, which provided a control on the accumulation of data.

The 1970's saw the development of the moored current meter to the point where a moderately priced instrument could record unattended for many months, accumulating tens of thousands of data points. The points were by then mostly electronically recorded in a digital format that could be fed directly or through a translator to a computer for processing. The rapid advances in data gathering and data processing capabilities were occurring at a time when growing offshore exploration and marine activity were creating an ever-increasing demand for current information. As a result, a wealth of current information has been and continues to be accumulated in both private and governmental data banks across the country. Much of it has received only cursory examination and has not been interpreted or discussed in the open literature. Fortunately, electronic data storage and retrieval technology has kept pace with the proliferation of data.

Requirement for central archiving of data summaries

For the most part, the current meter data in the various banks can be made available to the general public upon request. The problems faced by the average user today, however, are to know

(1) what type and vintage of data exists in a region;

(2) if the data is available, and if so, from what agency;

(3) how to sort out and understand the mass of undigested data that may be regurgitated by a well-fed computer bank.

The requirements of the vast majority of users could be conveniently and efficiently serviced from a central archive containing simple summaries in graphical and tabular form, prepared from the records of all current meters operated in areas of Canadian interest. The summaries would be generated by specified computer routines, with no subjective interpretation of the data permitted. Included in the general information would be the source and storage location of the original data, so that the bank could also be used as a directory from which to locate the current data for a study, even when the simple summaries might themselves be insufficient. The few users requiring complete data sets instead of summaries are, in fact, probably better served by a central directory than by a central bank of complete data. This is because going to the source of the original data may put them in touch with investigators with similar interests, and who might offer advice on interpretation of the data.

Proposed contents of current meter data summaries

(1) General information

This section should be capable of being listed separately from the data summaries when the bank is being used as a directory or catalogue of available data. It would contain, among other things, all the parameters on which retrieval could be based: recommended retrieval parameters are station number, latitude and longitude, depth, body of water, and source agency. It should be possible to use combined retrieval criteria, e.g., all stations in given latitude, longitude, and depth range. A "station" is understood to be a current meter location, so three meters on a single string constitute three stations. The station number would be assigned by the central bank, the recommended system being a twelve-digit number formatted

1 - 4: latitude degrees and minutes,

5 - 9: longitude degrees and minutes,

10: digit to identify up to ten meters on same string,

11: digit to identify up to ten moorings in same 1-minute square,

12: digit to identify up to ten occupations of same site.

The following information is recommended for inclusion in the general information header:

Station number---Latitude---Longitude---Body of water---Depth of meter---Total depth of water---Start time and date of record---Length of record---Sampling interval---Type of meter---Type of platform (e.g., moored vessel, drifting vessel, subsurface float, surface float, drilling platform, bottom stand, etc.)---Source agency for original data---Storage location of complete data record---Mean current (rate and direction) over period of record.

(2) Frequency distribution plot of original data

The coordinate space for this plot would be current vector space, with axes north and east, and with length scale proportional to current speed. The coordinate origin is the origin for the current vectors, and a point on the diagram represents a current vector joining the origin to the point. Each observed current vector from the original record could be plotted as a point on the diagram, to give a frequency distribution in the form of a "scatter diagram". Scatter diagrams with large numbers of points, however, can be confusing, and the following more quantitative presentation is recommended: with the vector space partitioned into grid squares, print in each square the number of occurrences of a vector terminating in that square (preferably normalized on 1,000; i.e., in units of 0.1%). The origin should always appear in the plot, but the only two grid lines required are the north and east axes. Since the space allotted to the plot would be constant for all stations, the speed scale would have to be adjusted to accommodate the origin and the extreme data points (excluding wild points) within the diagram. A reasonable number of grid squares would be 400 (20 x 20). The origin for the plot should be adjusted for each station in order to make best use of the allotted space.

(3) Tabulation of tidal harmonic constants

The tidal character of the current at a station can be most efficiently described in terms of the tidal harmonic constants in two perpendicular horizontal component directions. There is some precedent for presenting this information as a set of tidal ellipses, one for each tidal constituent, but it is not recommended here, being somewhat esoteric and open to misinterpretation. The two component directions in which the observations are to be resolved and harmonically analysed might be chosen in relation to some local feature (e.g., channel or coast-line direction), and this is probably desirable when a study is restricted to a local area. For inclusion in a central archive, however, it is better to have the axes the same for all stations. It is recommended here that the component directions be taken as north and east, the same as the axes of the frequency distribution diagram of (2) above.

Tidal streams are usually much more variable than are surface tides, particularly in off-shore regions. This is because they may vary in direction as well as magnitude and phase, because they may vary in depth (with internal tides), and because they may vary seasonally (as the internal modes change with the stratification). Consequently, retention of tidal constants for a large number of harmonic constituents is not justified, even when the record may be long enough to permit their separation. It is recommended that only the ten largest constituents (excluding Z_0) or a specified set of ten constituents be retained for each station in the bank. A possible fixed set of constituents is one containing M_2, S_2, N_2, K_2, K_1, O_1, P_1, M_4, MS_4, and M_f. Of course, if a record were too short to resolve all ten constituents, some entries would have to be left blank. (Note: it must be assured that zeros do not appear when a field is blank.) Constituent phaselags should be quoted for the Greenwich Standard Time Zone, since it is desirable to have uniformity in a central bank, and because "local time" has little meaning at locations far off shore. Constituent amplitudes should be rounded to the nearest unit in cm/sec.

(4) Progressive vector or frequency distribution plot of non-tidal residues

It is usually the non-tidal current that is of most interest in the study of the transport and spreading of pollution, since the tidal streams tend only to move things round and round and back and forth within the same general region. To display the non-tidal aspect of the current, it is recommended that the tidal streams be predicted and subtracted from the observed currents to produce time series of non-tidal residues. This can be done separately for the north and east components, since the progressive vector plot or the frequency distribution plot is most easily constructed from the residues in component form. A progressive vector plot shows the path that would be followed by a particle if its velocity were always identical to that at the fixed current station. Where the current regime is fairly uniform over a large area (far from boundaries and irregular bathymetry), the progressive vector plot may represent fairly well the drift of water properties, pollutants, etc. Near shore, where the current regime may be irregular, interpretation of the plot as a particle path may not be valid, but it still displays the variability or the constancy of the non-tidal residues at the current meter site.

Preparation of the progressive vector plot requires computation of the running sum of the east component times the time interval between values, to give the x-coordinate for the plot, and the simultaneous running sum of the north component times the time interval between values, to give the y-coordinate. To optimize use of the space allotted for the plot, the scale should be adjusted for each station, to accommodate comfortably the extrema in the two running sums. As discussed later, the large storage required to archive the progressive vector plot may make the alternative presentation in the form of a frequency distribution plot of the residues more attractive.

Steps in preparing current meter data summary

(a) Enter all the header information (see (1) above), except Z_0.

(b) Resolve all current observations into north and east components.

(c) Define a 20 x 20 square grid to include the maximum and minimum east component and zero in the x-coordinate range, and the maximum and minimum north component and zero in the y-coordinate range. (Note: the grid spacing must be the same in both x and y coordinates.)

(d) Count for each grid square the number of observations whose north and east components fall within the square. Normalize these values by dividing by the total number of observations and multiplying by 1,000 to give the frequency in units of 0.1%.

(e) Plot the north and east axes, the normalized frequencies (centred in each grid square), the velocity scale, and appropriate labels. The frequencies should be rounded to the nearest unit, and zero values either left blank or indicated by a dot. No grid lines other than the axes should be plotted. Since the grid is always to be plotted the same size, the velocity scale is determined in step (c). Recommended velocity unit is cm/sec, to avoid decimals.

(f) Perform tidal harmonic analyses separately on the time series of the north and east velocity components from step (b). Tabulate constituent name, frequency (cpd), amplitude (cm/sec) and phaselag (GMT) of constituent in north component and in east component, for M_2, S_2, N_2, K_2, K_1, O_1, P_1, M_4, MS_4, and M_f. Enter Z_0 in header. If all these constituents are not available, the missing ones should either be omitted entirely, or the entries opposite them should be left blank or filled with dots or dashes; zeros must not be permitted in blank fields.

(g) Predict the tidal streams for the length of record, one series for the north and one for the east component directions, using all the tidal constituents from the harmonic analysis, not just the ones to be tabulated in the summary. Subtract the tidal stream component from the components of the observed current, to create the components of the non-tidal residues to be used in the next step.

(h) Form the running sums of $\frac{1}{2}\Delta t \sum_{i=0}^{i=n} (u_i + u_{i+1}) = x_n$, and

$$\frac{1}{2}\Delta t \sum_{i=0}^{i=n} (v_i + v_{i+1}) = y_n.$$

Δt is the sampling interval, the u_i and v_i are the east and north velocity components respectively, and the x_n and y_n are the east and north coordinates for the progressive vector plot at time corresponding to $i = n$.

(i) Choose a distance scale for the progressive vector plot that will accommodate the maxima and minima of both x_n and y_n within the space allotted for the plot in the format.

Locate the origin for the plot such that the extrema of the x_n and y_n fall comfortably within the boundaries.

(j) Plot the north and east axes to intersect at the origin. Commencing at the origin, plot a continuous line to pass through all points with coordinates (x_n, y_n) for all values of n to the end of the record.

A symbol (e.g. a cross) should be marked on the progressive vector trace at the zero hour of each day. Label and title the plot appropriately, including scale, starting and ending time, etc.

Storage requirement

Two options are available:

(1) To store the original data sets, and to generate the plots and tables (steps (a) to (i) above) from scratch for each request.

(2) To generate the values necessary for the plots and tables from the original data, and store only these values.

The second option has the advantage of requiring less computer time to produce current summaries on request, but has little, if any saving in storage space. This is because the series of coordinates generated in step (g), above, for the progressive vector plot contains as many numbers as did the original data. Only by decimating this series to, say, one set of coordinates per hour could the storage space be kept from exceeding that of the original data. The storage space requirement of the progressive vector plot coordinates makes its use questionable, and prompts the alternative proposal given below.

Alternative proposal

To reduce the data storage requirement, the progressive vector diagram proposed above could be replaced by a frequency distribution plot of the non-tidal residues, prepared in the same manner as the frequency distribution plot of the original data (steps (c) to (e), but using the series of non-tidal residues, generated in step (g), as input. Steps (h) to (j) would be replaced by the repetition of steps (c) to (e). Actually, a frequency distribution plot contains, in a more compact form, all the useful information about the non-tidal current that a progressive vector diagram does. The vector plot shows the residues in the sequence in which they were observed, but the sequence is not expected to repeat itself regularly, and is not important statistically. The data storage requirement for this alternative proposal is approximately 822 values, plus header information; i.e., one 20 x 20 matrix for each of the two frequency distribution diagrams, and ten pairs of tidal harmonic constants, plus two scale factors for the diagrams. The conventions for component directions (E and N) and time zone (GMT) are uniform, and need not be stored with each summary.

Discussion and recommendations

It is the intent of the above two alternative proposals to assemble in one central archive data summaries of all current measurements taken in Canadian waters or waters of Canadian interest. It is not the intent to replace the originating agencies, or their data services, as a source of the original data. Indeed, it is recommended that the original data not be stored in the central archive after the summary information is extracted. This policy might forestall possible proprietary concerns about the original data. It would also encourage researchers needing the original data for detailed study to discuss it with the originator. It is intended that the central bank should satisfy about 90% of requests with the data summaries alone, and should act as a directory of current data sources for the remaining 10% of requests that may require copies of original data sets.

The proposed summaries provide a complete statistical record of the observed current in the mean value and the frequency distribution diagram plotted in velocity space, a tidal stream summary in the table of tidal harmonic constants, and a summary of the non-tidal residues in either the progressive vector plot or the frequency distribution in velocity space.

It is recommended that the second alternative proposal be adopted, in which the summary would consist of the following:

Header information,

Frequency distribution of original data in velocity space,

Table of ten pairs of tidal harmonic constants,

Frequency distribution of non-tidal residues in velocity space.

Permanent storage for each station should include only the approximately 850 values required to reproduce the summary, and should not include the original data.

Sample summary

St'n no. 433406506000 Lat. 43 34 43 Long. 065 06 18

Body of water: Northwest Atlantic Inst. depth: 59 m.

Water depth: 59 m. Start time (GMT): 2230 day 289 year 1979

Record length: 250 hours Sample interval: 1 hour

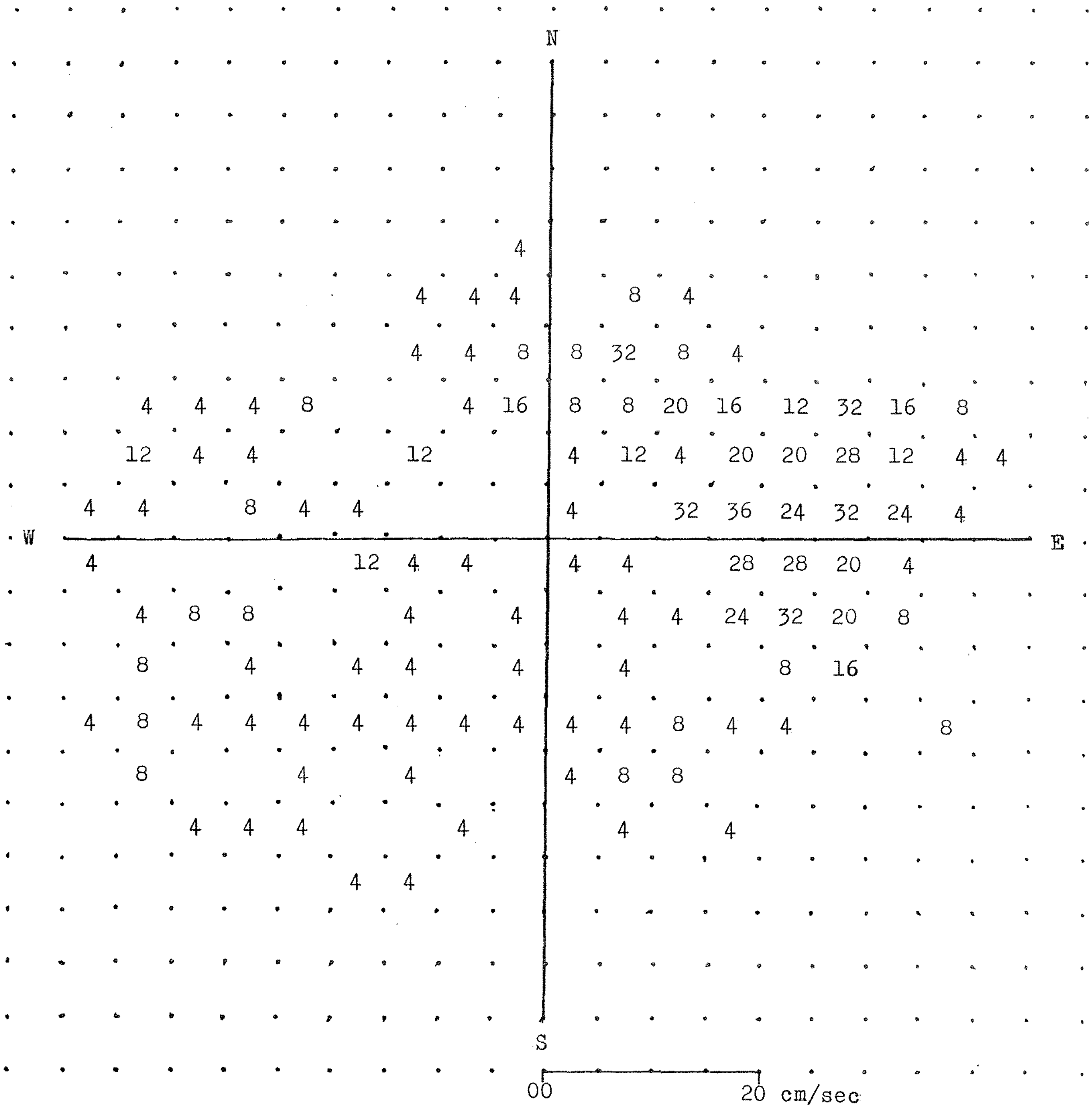
Inst. Aanderaa RCM Platform: subsurface float

Observed by: AOL, BIO Stored at: AOL, BIO

Mean current: east 7.2, north 4.1 cm/sec (or 8.3 cm/sec, 060°T)

Harmonic Constituents (GMT)

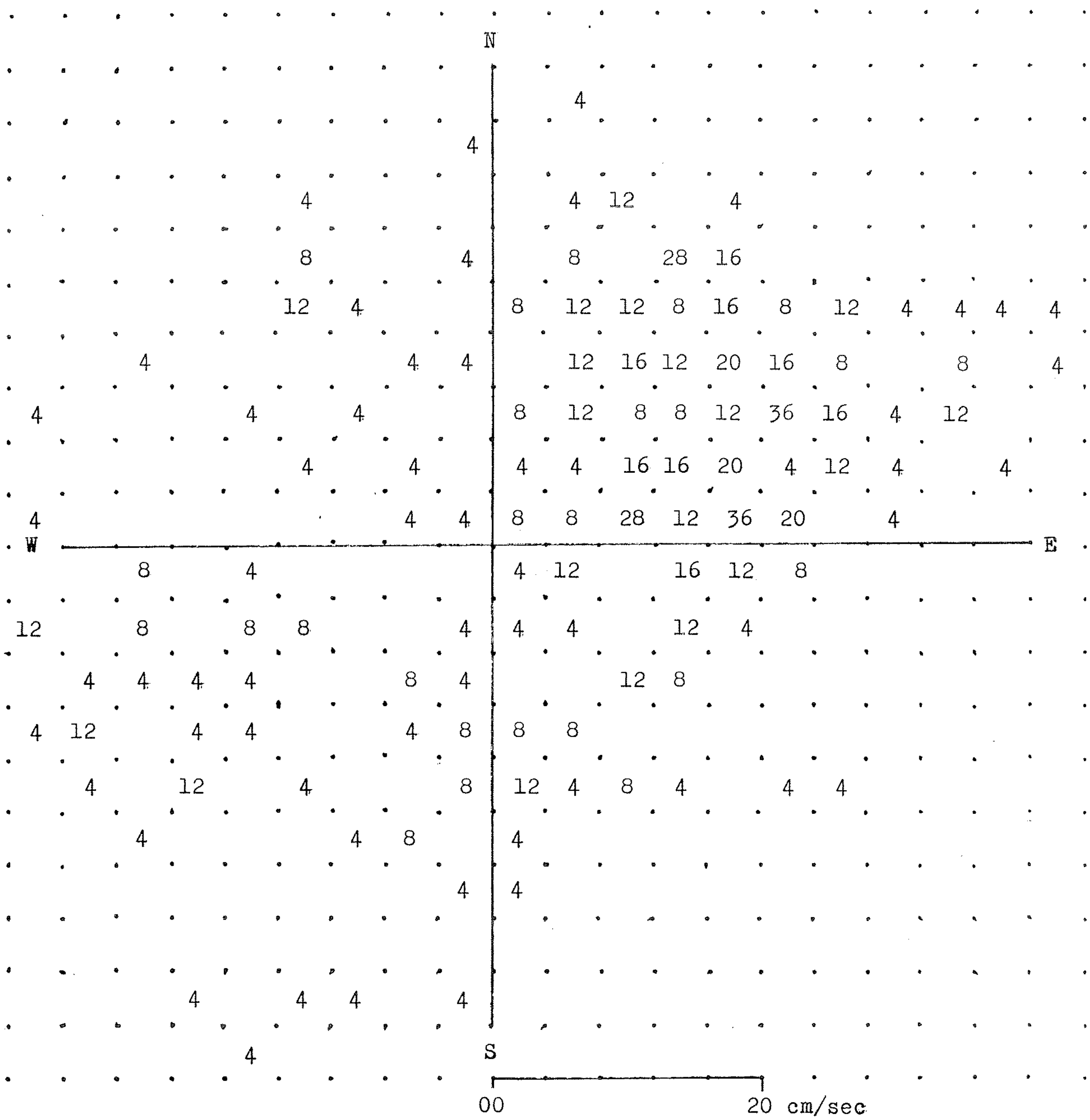
Constituent Name	East Amplitude	East Phaselag	North Amplitude	North Phaselag
Z_0	7.2 cm/sec		4.1 cm/sec	
K_1	4.4 cm/sec	330°	3.8 cm/sec	120°
O_1	3.7 cm/sec	274°	3.9 cm/sec	071°
M_2	12.7 cm/sec	124°	7.2 cm/sec	314°
S_2	2.0 cm/sec	187°	0.9 cm/sec	055°
N_2	1.8 cm/sec	129°	2.0 cm/sec	311°
M_4	0.6 cm/sec	202°	0.7 cm/sec	009°
MS_4	0.3 cm/sec	164°	0.3 cm/sec	110°
M_f	5.1 cm/sec	079°	1.4 cm/sec	269°



Frequency distribution of current observations in velocity space.

Station No. 433406506000. Start 1979, 289, 2230 GMT.

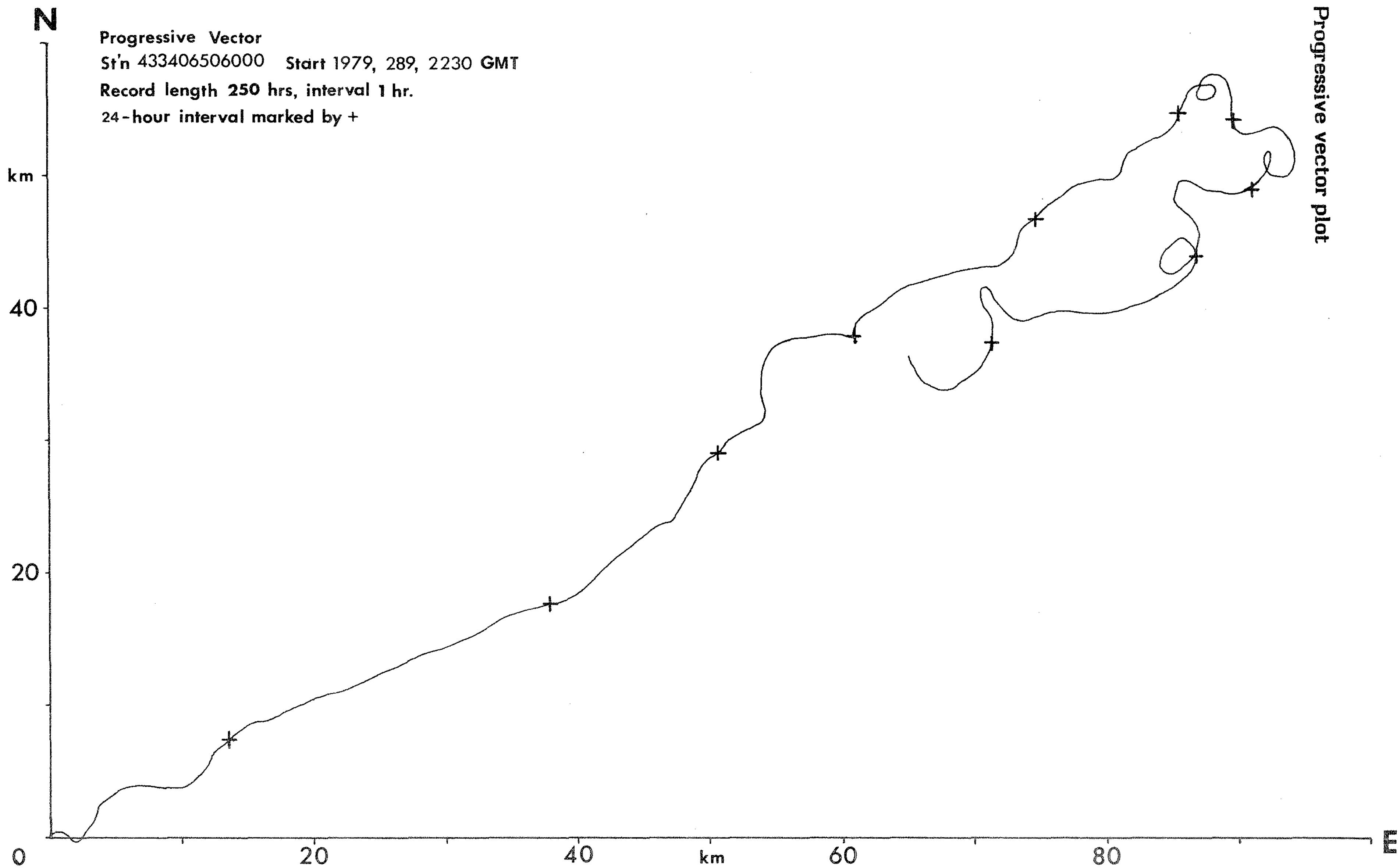
Record length 250 hours, Interval 1 hour, Frequency unit 0.1%.



Frequency distribution of current residues in velocity space.

Station No. 433406506000. Start 1979, 289, 2230 GMT.

Record length 250 hours, Interval 1 hour, Frequency unit 0.1%.


N
Progressive Vector
St'n 433406506000 Start 1979, 289, 2230 GMT
Record length 250 hrs, interval 1 hr.
24-hour interval marked by +
km
40
20
0
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km
60
80
E
Progressive vector plot