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CONVERSION ALGORITHMS FOR THE CALCOFI STATION GRID

L.E. EBER
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Center
La Jolla, CA 92038

ROGER P. HEWITT
National Oceanic and Atmospheric Administration Corps
Southwest Fisheries Center
La Jolla, CA 92038

ABSTRACT

This note presents algorithms which may be used to convert station positions expressed in geographic coordinates (latitude and longitude) to the California Cooperative Oceanic Fisheries Investigations (CalCOFI) station grid coordinates and vice versa. Clarke's spheroid of 1866 is used as an estimate of the geoid off the west coast of North America.

INTRODUCTION

The CalCOFI station pattern (Figure 1) was designed orginally in the development of a systematic sampling program to determine the major spawning areas of the Pacific sardine off the coasts of the United States and Baja California, Mexico. Surveys were conducted along lines extending seaward approximately normal to the coast and spaced 120 miles apart from the Columbia River to Sebastian Vizcaino Bay. As the program progressed and spawning areas were delimited, additional lines of stations were added between the cardinal lines, and the surveys became concentrated off the coasts of California and Baja California.

The pattern was based on line 80 off Point Conception, California. Other lines were numbered using increments of 10, decreasing northwestward to line 10 off the U.S.-Canadian border, and increasing southeastward to line 157 off Cape San Lucas, Baja California (Kramer et al. 1972). It was originally intended that the 120-mile spacing would allow for additional lines to be plotted 12 miles apart between the cardinal lines and still be designated by whole numbers without resorting to fractions. However, when it was decided to insert additional lines, 40-mile intervals appeared to be sufficient. Thus the major pattern consists of cardinal lines in numbered multiples of 10 and ordinal lines whose numbers by convention end in 3's and 7's, having been rounded off from 3.333. . . . and 6.666. . . . .

The stations on the lines were laid out on the basis of a perpendicular to line 80, through a point designated Station 80.60. The original stations were plotted 40 miles apart and were numbered by increments of 10, which allowed additional stations between the 40-mile points to be plotted as close to 4 miles and still be designated by whole numbers.

CONVERSION OF CALCOFI GRID COORDINATES TO GEOGRAPHICAL COORDINATES

The primary reference point, Station 80.60, was located at 34°09'N, 121°09'W and is marked 0 in Figure 1. The perpendicular to line 80, through this point, was used to set all the other lines and will be referred to in the following discussion as the reference line.

As indicated before, unit line number increments represent 12 nautical miles and unit station number increments represent 4 nautical miles. Therefore, to locate a particular station, such as 50.120 (designated P in Figure 1), one would first proceed 360 nautical miles northwestward along the reference line from the reference point to Station 60 on line 50 (designated R in Figure 1), and then 240 nautical miles southwestward on line 50 to Station 120.

The CalCOFI station plan was originally laid out in this manner with the aid of navigation and plotting charts. CalCOFI station locations can also be computed numerically, using the Mercator transform based on Clarke's spheroid of 1866, as given by Bowditch (1958). The numerical procedure can be derived from the geometry of Figure 1, bearing in mind that distance along the *Y*-axis (north-south) on a Mercator chart must be measured in meridional units rather than in units of latitude.

Let PLA	=	Latitude of P
PLO	=	Longitude of P
PLN	=	Line number of P
PSN	=	Station number of P
RLA	=	Latitude of R
MCTR(LA)	=	Mercator transform

which expresses the distance from the equator to latitude LA and is defined by:

MCTR(LA) = (180/Π)*(LN(TAN(45 +LA/2)) −0.00678766*SIN(LA))

This is an approximation, accurate to within 3 seconds (in meridional units) south of 60°N. Recalling that the CalCOFI coordinates of the primary reference point are 80 (line number) and 60 (station number) and the geographical location of this point is 34°09'N, 121°09'W, the following sequence can be used to compute the location of P.

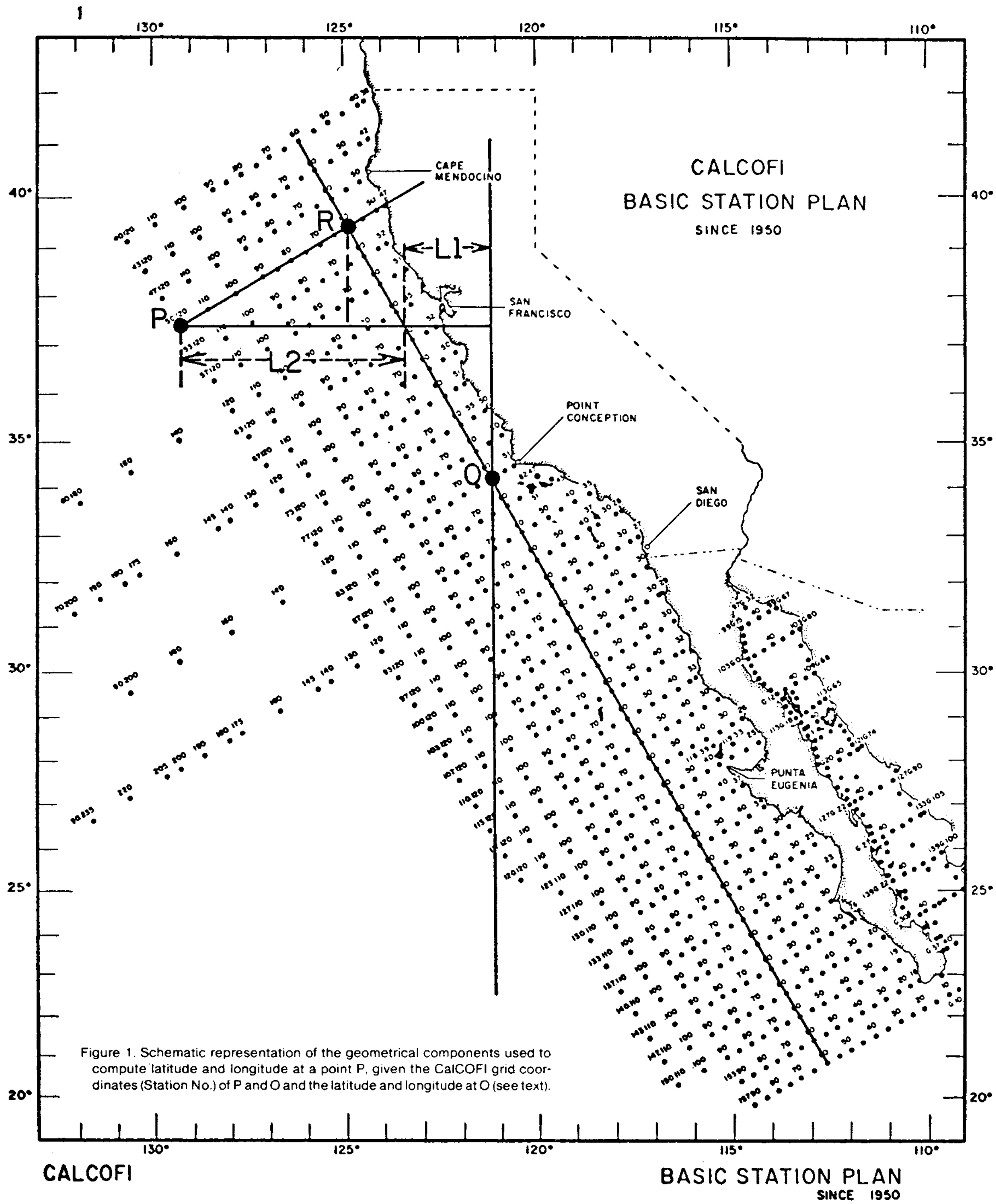

Figure 1. Schematic representation of the geometrical components used to compute latitude and longitude at a point P, given the CalCOFI grid coordinates (Station No.) of P and O and the latitude and longitude at O (see text).

1. RLA = 34.25 − 0.2*(PLN − 80)*COS(30)
2. PLA = RLA − (1/15)*(PSN −60)*SIN(30)
3. L1 = (MCTR(RLA)−MCTR(34.15))*TAN(30)
4. L2 = (MCTR(RLA)−MCTR(PLA))/ (COS(30)SIN(30))
5. PLO = L1 + L2 + 121.15

CONVERSION OF GEOGRAPHICAL COORDINATES TO CALCOFI COORDINATES

The computation of CalCOFI line and station numbers for a given location where latitude and longitude are given requires determination of a latitude when its Mercator transform is known, i.e. given MCTR(LA), find (LA). There is no simple algebraic solution to this problem; however, (LA) can be approximated with as much precision as desired with a simple iterative procedure in which MCTR(LA) is entered as the first approximation to (LA). The algorithm for the inverse Mercator transform is as follows:

1. Set I = 0
2. Set LA = MCTR(LA)
3. LA = 2*(ARCTAN(EXP(MCTR(LA)*Π/180 + 0.00676866*SIN(LA)))−45)
4. I = I + 1
5. IF I < 3 GO BACK TO STEP 3
6. STOP

The CalCOFI grid coordinates for a station at a given location can be computed with the following sequence:

1. L1 = (MCTR(PLA)−MCTR(34.15))*TAN(30)
2. L2 = PLO − L1 − 121.5
3. MCTR(RLA) = L2*COS(30)SIN(30) + MCTR(PLA)
4. RLA = INVERSE(MCTR(RLA))
5. PLN = 80 − (RLA − 34.15)*5/COS(30)
6. PSN = 60+ (RLA−PLA)*15/SIN(30)

DISCUSSION

The two conversion procedures presented here are mutually consistent in that when executed consecutively, using the output from one run as input for the next, the original coordinate values can be recovered with a precision of at least four decimal places. For example, Station 50.120 converts to 37° 20.7692'N, 129° 16.7727'W. With these values as input, the reciprocal conversion yields 50.0000 and 120.0000 for line and station, respectively. However, if the geographical coordinates are rounded to tenths of minutes, as is common in CalCOFI work, the conversion to line and station becomes 49.9969 and 120.0004.

We should point out that the correspondence between CalCOFI and geographical coordinates as computed from the numerical procedures is not in exact agreement with that given in the standard reference tables used by CalCOFI. The discrepancies are generally less than 2 minutes of latitude or longitude for given CalCOFI station numbers except out on the fringes of the pattern. They may possibly be due to accumulative errors incurred when laying out the station pattern on the navigational charts.

It should further be noted that even greater discrepancies are found when the computed locations for CalCOFI stations are compared with the actual locations occupied on individual cruises, as reported in the CalCOFI Physical and Chemical Data Reports. Deviation from standard station positions may have occurred during CalCOFI cruises to avoid navigational hazards or other reasons and nearby alternate locations accepted as representing the designated station. The conversion procedures can provide a convenient way to determine the CalCOFI coordinates of the actual locations occupied in such instances.

REFERENCES

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