FINAL REPORT

APPLICATION OF CLIMATOLOGICAL ANALYSIS TO MINIMIZE AIR POLLUTION IMPACTS IN CALIFORNIA

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Prepared for

California Air Resources Board
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SUMMARY

A summary of meteorological factors affecting air pollution potential in California has been prepared. The study utilized a data base from 1979-80 and included surface wind, temperature and humidity observations as well as available temperature soundings. Data were available from 47 surface stations and 17 sounding locations.

Distributions of temperature, wind speed and direction, humidity and mixing height were determined. The frequency of occurrence data are given in tables in the Appendix. Map representations of some of the data are included in the text.

The meteorological parameters or combinations of parameters have been used to obtain several alternative representations of air pollution potential. These include 850 mb temperature, maximum surface temperature, Holzworth potential, ventilation factors and a combination of low morning wind speeds and low afternoon mixing heights. The values of some of these parameters on a daily basis were correlated with maximum ozone concentration for the day. Highest and most consistent correlations were obtained using the two representations of temperature. Differences between the times of maximum ozone and maximum temperature were used to characterize source and receptor areas. An analysis of low wind speed occurrences during morning hours throughout the state indicated that the areas of Ukiah/Santa Rosa, parts of the Mojave Desert and the San Bernardino/March Field area experienced lowest morning wind speeds. These areas are particularly susceptible to the morning accumulation of pollutants.

A number of detailed meteorological factors which influence air pollution potential in the state are described. These include eddy structures, slope flows, layers aloft, convergence zones and marine air intrusions. The effect of these factors is to redistribute the pollutants both horizontally and vertically over wider areas than utilized in simple transport models. In the case of upslope flow and convergence zones, these also constitute effective mechanisms for removing pollutants from the surface mixed layer and delivering the material to higher altitudes where it may be transported away from the area. In addition, upslope flow delivers high

concentrations of pollutants to mountain areas. The western slopes of the Sierra Nevada and San Bernardino Mts. and the southern slopes of the San Gabriel Mts. experience high ozone concentrations in summer.

Interbasin transport of pollutants is a major factor in the state. Such transport has been documented between most of the primary source areas into adjacent air basins. Transport into low population, mountainous regions downwind of major source areas has also been shown.

The primary uncertainty in defining air pollution in the state from a meteorological standpoint relates to variations in mixing height characteristics, particularly in the coastal areas. Gradients in maximum surface temperatures in the coastal regions and the frequent afternoon intrusion of a marine layer complicate the characteristics of the mixing layer depth. Depths in these areas are not easily estimated from existing temperature soundings and may show considerable variation in space and time. Areas where additional mixing height data are needed include the Santa Rosa area, the south portion of the San Francisco Basin, the Salinas Valley, the San Bernardino/ Riverside area and the inland regions of the San Diego Air Basin.

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1.0 INTRODUCTION

Air quality concentrations are determined not only by emission patterns but are strongly dependent on meteorological factors. In many regions of the United States, emissions tend to be distributed in a very non-uniform spatial manner. High emission sources are usually isolated and distributed sources tend to be maximized in urban areas. In California, the meteorological factors are also very diversely distributed. Local terrain varies from below sea level to over 14,000 ft. within the state. The cooling and stabilizing effects of the ocean in summer contrast with the intense heating of the desert areas. The combination of terrain and ocean influences results in an unusually wide variety of meteorological factors affecting air quality concentrations in the state.

The objective of the present study has been to describe these meteorological factors from a climatological viewpoint. The end product of the study has been an attempt to map out the statewide distribution of those meteorological factors related to air pollution potential. The study has not been concerned with emission patterns or with specific meteorological/air quality interrelationships. Instead, the study attempts to describe the air pollution potential in the state primarily from a meteorological viewpoint.

The report begins with a statewide description of the individual meteorological parameters most closely associated with air pollution potential. These data are presented in map form in the text and in tabular form in the Appendix. This material is followed by several different combinations of parameters which have been used to quantify air pollution potential. Finally, a section of the report describes a number of meteorological events which result from ocean/terrain effects and which markedly influence the air pollution potential in California.

2.0 BACKGROUND

2.1 Literature

There have been a number of articles and reports which address the definition of meteorological air pollution potential. Some of these discuss the potential on a nation-wide basis while others relate to California alone. The significant discussions are summarized below in chronological order.

a. Bell (1958) - Bell produced a pioneering summary of California climatology at an early stage in the development of California air pollution history. Summaries were prepared of surface wind directions and speeds, regional circulation patterns, temperature variations, and upper air stability and inversion height parameters.

Two pollution indices were described although statistical distributions of the indices were not included. These indices were:

1. Smog Index:

$$S = \frac{10(T + 10)}{RW}\sqrt{\frac{I}{V}}$$

where T is the difference between the daily mean temperature and the normal mean temperature for that day in $^{\circ}F$, R is the relative humidity at noon in percent, W is the total 24-hr wind movement in miles, I is the inversion intensity and V is the visibility at noon in miles.

$$I = \frac{\Delta\theta^2}{3 + Z\Delta Z}$$

where θ is the temperature difference within the inversion of depth Z. Z is the inversion base height.

2. Leicester Index:

$$P = 0.552 + \frac{0.14}{\sqrt{u}}(25.5 + L)$$

where u is the mean wind speed in mph and L is the lapse rate in $^{\circ}F/3000$ ft.

The index was developed for Leicester, England and the parameters were determined from pollution measurements. Similar equations would need to be developed for each source area of interest.

b. Niemeyer (1960) - Niemeyer developed a system for forecasting air pollution potential utilizing the simultaneous occurrence of the following parameters:

1. Surface winds less than 8 knots (later changed to less than 5 knots average for 24 hrs),
2. No winds greater than 25 knots below 500 mb.,
3. Existence of subsidence below 600 mb.

This system was later evaluated in Miller and Niemeyer (1963) by comparison with particulate loadings.

c. Hosler (1961) - Hosler calculated the percentage of days nationwide with inversions or isothermal conditions below 500 ft.

d. Holzworth (1962) - Holzworth focused attention on low wind speed and low mixing depth as significant meteorological parameters contributing to high levels of air pollution. These conditions were associated with stagnating anticyclones in the western part of the U. S. Contours of mixing depth frequencies were presented for the region from the Rockies to the Pacific Coast. The behavior of wind speeds was presented as plots of the average number of days per month with average daily wind speeds of 5 mph or less at 48 locations.

e. Hosler (1964) - Hosler developed nation-wide climatological estimates of diffusion conditions in terms of the following parameters, presented individually:

1. Frequency of low wind speeds (average daily wind speed less than or equal to 5 mph).
2. Frequency of inversions less than or equal to 500 ft. (% of total hours per season).
3. Frequency of stagnation conditions (measured by light surface winds, persistent subsidence inversion and presence of clear skies).
4. Mixing depths (presented as mean maximum mixing depth).

f. Holzworth (1967, 1972) - Holzworth developed contour maps of mixing heights and average wind speeds in the mixed layer on a nation-wide basis. Using these parameters he formulated an urban dispersion model which was exercised for two city sizes (10 and 100 km). Results of the model calculations were presented as nation-wide maps of urban air pollution potential.

The wind speed and mixing height data were also used to determine the occurrence of episode pollution days. These days were defined in terms of persistent low values of the product of wind speed and mixing height.

g. Staff Report, CARB (1974) - The CARB staff utilized the Holzworth dispersion model to calculate urban air potential at selected locations in California. Data utilized were more extensive for California than were available to Holzworth. Morning mixing heights and wind speeds were used in the urban model calculations. Results of the calculations were presented as isopleth maps and frequency distributions.

h. Aron (1983) - In light of the common use of mixing height as a parameter in estimating air pollution potential, Aron investigated the relation between mixing height and ozone concentrations in several areas, including Los Angeles. The correlation between 12 PST mixing height and peak O_3 concentration in the Los Angeles area was found to be -0.56. Other meterological parameters such as 04 PST 850 mb temperature (.80) and 12 PST inversion top temperature (.83) were found to show better relationships to peak ozone.

i. Summary - Meteorological descriptions of air pollution potential have almost entirely focused on the primary parameters of wind speed and mixing height. As Aron (1983) points out, however, mixing height is a somewhat uncertain variable since it is estimated by making two critical assumptions concerning temperature lapse rate (Holzworth, 1972). These are 1) the morning mixing height is arbitrarily determined by adding 5° C to the minimum surface temperature. This leads to considerable uncertainty under some temperature lapse rate conditions and 2) the afternoon mixing height is determined by considering an adiabatic lapse rate from the maximum surface temperature to the existing sounding. In many areas, there is often a super-adiatic lapse rate in the lower levels during the afternoon. Use of the maximum surface temperature under these conditions can lead to an overestimate of the mixing height. Generally, distribution of the two parameters (wind speed and mixing height) have been treated separately. Holzworth combined the parameters in an analysis of episodes.

The primary attempt at construction of a quantitative pollution potential parameter was also provided by Holzworth who adapted a Gaussian dispersion model to an area source configuration of two different sizes. This model emphasizes the diffusion aspects of the air pollution potential. Evaluations of air pollution potential are consequently a function of urban size rather than having a unique value dependent on meteorology alone. From this standpoint the product of wind speed and mixing height (used by Holzworth to define episodes) is a better measure of meteorological air pollution potential.

2.2 Terrain

The terrain of California plays a very significant role in determining air pollution potential in the state. In particular, the combination of low inversion heights, high terrain and a strong diurnal heating cycle channel the summer flow patterns into a highly repeatable daily cycle. Since the source areas are largely fixed in location the receptor areas also tend to be similar each day but with minor fluctuations in wind speed and mixing height.

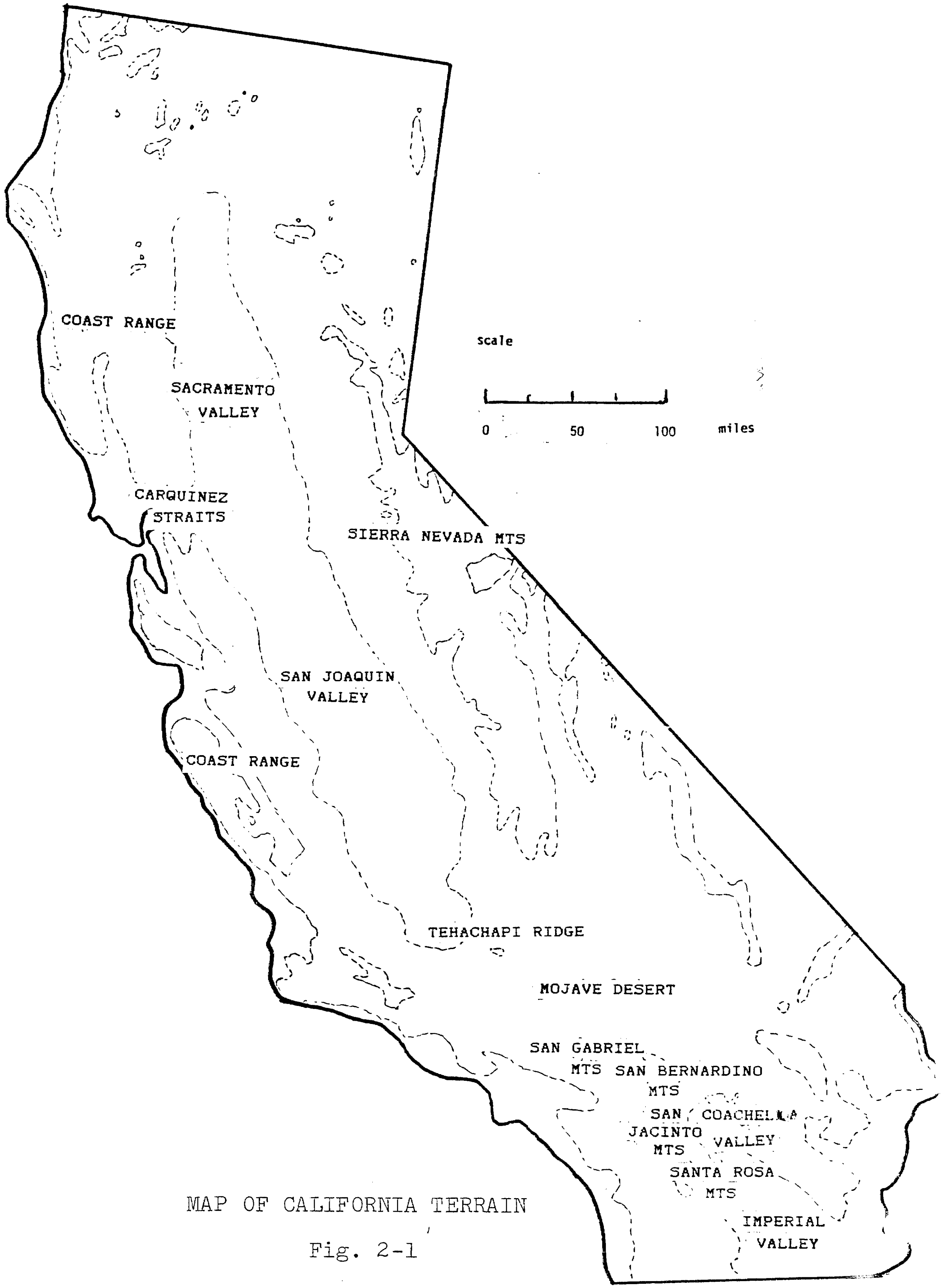
Fig. 2-1 shows a map of California including the principal terrain features which are of interest from an air pollution standpoint.

The Central Valley of California extends about 375 miles from north to south and includes the Sacramento Valley in the north and the San Joaquin Valley to the south. The valley averages 50-70 miles in width, depending on location. The valley is bordered on the east by the Sierra Nevada Mts. and on the west by the much lower coastal ranges. Principal entrance for air flow into the valley is the Carquinez Straits where the air flow is from the west 24 hours per day in summer. Principal exit zones are the western slopes of the Sierra Nevada Mts. and the Tehachapi Ridge to the southeast of Bakersfield.

In the south, the coastal plain which includes Los Angeles and San Diego is ringed to the east and north by the Santa Rosa Mts., San Jacinto Mts., San Bernardino Mts. and the San Gabriel Mts. To the east and north of these mountain ridges lies the Mojave Desert. The Coachella and Imperial Valleys are of particular interest since they represent the major populated areas in the desert.

There are three principal passes from the South Coast Air Basin into the Southeast Desert. These are Soledad Canyon, Cajon Pass and San Gorgonio Pass. The latter appears to be the most significant pollutant transport route into the desert. Air flow in the South Coast Basin during pollutant periods is strongly controlled on a diurnal basis by temperature differentials between the ocean and the inland areas. As a result, pollutants generated in the South Coast Basin are constantly transported from their source regions into the eastern part of the basin and frequently on into the desert.

More detailed descriptions of California flow patterns are given in later sections.



MAP OF CALIFORNIA TERRAIN

Fig. 2-1

2.3 Data Resources

Data used in the study were obtained from both surface and upper air sources.

Surface data were obtained from the National Climatic Center in the form of hourly observations from 47 airport locations in the state. A list of the stations is given in Table 2-1. Data from January, April, July and October for 1979 and 1980 were summarized. Attention was focused on observations at 08, 12 and 16 PST for each monthly summary. 08 PST represents the light wind period in the morning when peak urban traffic occurs. 12 and 16 PST indicate the transport patterns for the pollutants accumulated during the morning hours. Surface wind flow regimes at night are of less interest, particularly for ozone transport.

Sounding data were obtained on tape from CARB for the 1979-80 period. These data included NOAA and Defense Department radiosondes together with the aircraft soundings made frequently by CARB under contract in various areas. A list of the sounding locations in given in Table 2-2. All available data on the tape were processed for the study, regardless of time of day. The data were subsequently summarized into AM and PM groups.

Table 2-1

Surface Data Locations

North Coast Air Basin
- Arcata
- Ukiah

Sacramento Valley Air Basin
- Marysville
- Red Bluff
- Sacramento

San Francisco Bay Area Air Basin
- Alameda
- Concord
- Hayward
- San Francisco (Int'l Airport)
- San Jose
- Santa Rosa
- Travis AFB

San Joaquin Valley Air Basin
- Bakersfield
- Castle AFB
- Fresno
- Lemoore NAS
- Modesto
- Stockton

North Central Coast Air Basin
- Monterey
- Salinas

South Central Coast Air Basin
- Oxnard
- Paso Robles
- Pt. Mugu
- Santa Barbara
- Vandenberg AFB

South Coast Air Basin
- Burbank
- El Monte
- Los Angeles (LAX)
- March AFB
- Norton AFB
- Ontario
- San Nicolas Is
- Santa Ana (Orange County)

San Diego Air Basin
- Carlsbad
- Gillespie Field
- San Diego

Southeast Desert Air Basin
- Beaumont
- Blythe
- Daggett
- Edwards AFB
- George AFB
- Imperial
- Inyokern
- Lancaster
- Needles
- Palm Springs
- Thermal

Table 2-2

Sounding Data Locations

<u>North Coast Air Basin</u>
Ukiah

<u>Sacramento Valley Air Basin</u>
Red Bluff
Sacramento

<u>Lake Tahoe Air Basin</u>
Tahoe City

<u>San Francisco Bay Area Air Basin</u>
Oakland

<u>San Joaquin Valley Air Basin</u>
Fresno

<u>North Central Coast Air Basin</u>
Salinas

<u>South Central Coast Air Basin</u>
Vandenberg AFB
Pt. Mugu

<u>South Coast Air Basin</u>
El Monte
Los Angeles (LAX)
San Bernardino
San Nicolas Is.

<u>San Diego Air Basin</u>
San Diego

<u>Southeast Desert Air Basin</u>
China Lake
Edwards AFB
Thermal

Legend

1. Meteorological Parameters

   a. Percentile values are given as the percentage of data with values below the stated number.

   b. N is the number of data used to compute the percentiles.

2. Mixing Heights (see Holzworth, 1972)

   a. Morning mixing heights were computed from the morning temperature sounding as the intersection of a dry adiabat and the sounding assuming 1) minimum surface temperature plus 5° C (AM) and 2) maximum surface temperature (PM).

   b. All heights are agl (above ground level).

3. Ventilation Factors

Ventilation factors were computed as the product of the mixing height and the average wind speed in the mixed layer.

4. Holzworth Potential (see Holzworth, 1972)

Holzworth Air Pollution Potential was computed from the formulae given on p. 5-5 for 10 km and 100 km city sizes.

3.0 METEOROLOGICAL PARAMETER DISTRIBUTIONS

Distributions of temperature, relative humidity and wind speed at 08, 12 and 16 PST for the 47 surface stations have been summarized into 10 and 50 percentile values for January, April, July and October. The entire summary data set is given in Appendix A in tabular form. Selected data are shown in map form in this section.

Summary data are plotted on the maps for the specific station locations. Isopleths have been drawn using these data. The isopleths represent smoothed versions of the spatial distributions of the parameters. In regions such as California with very significant variations in terrain it is not possible to construct accurate, detailed isopleths of meteorological parameters which may vary greatly in a few miles distance. Consequently, the isopleths should be used only as guide lines to give the reader an overall perspective of the parameter distributions.

Comments on the map presentations are:

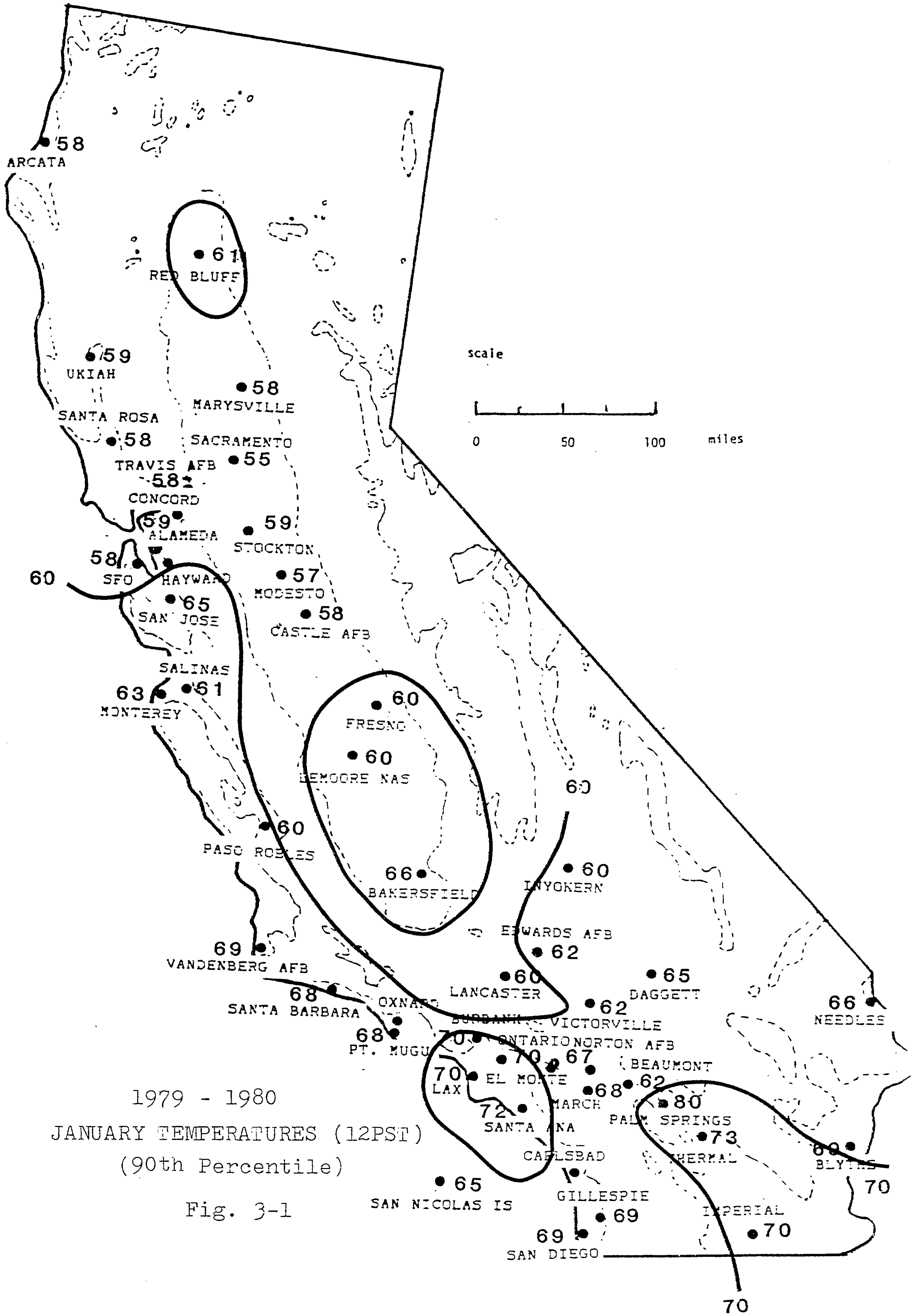
a. Temperature - Plotted data represent 12 PST (90 percentile) data, i.e. the temperature exceeds the value shown 10% of the time at 12 PST in the given month.

The principal interest in temperature from an air pollution standpoint deals with its influence on chemical reaction rates, particularly ozone. 12 PST is generally slightly before the maximum temperature peak but adequately represents the environmental conditions during the period of ozone formation. Ninetieth percentile data are given to include conditions during peak ozone periods.

Data on spatial temperature distributions are given in Figs. 3-1 through 3-4.

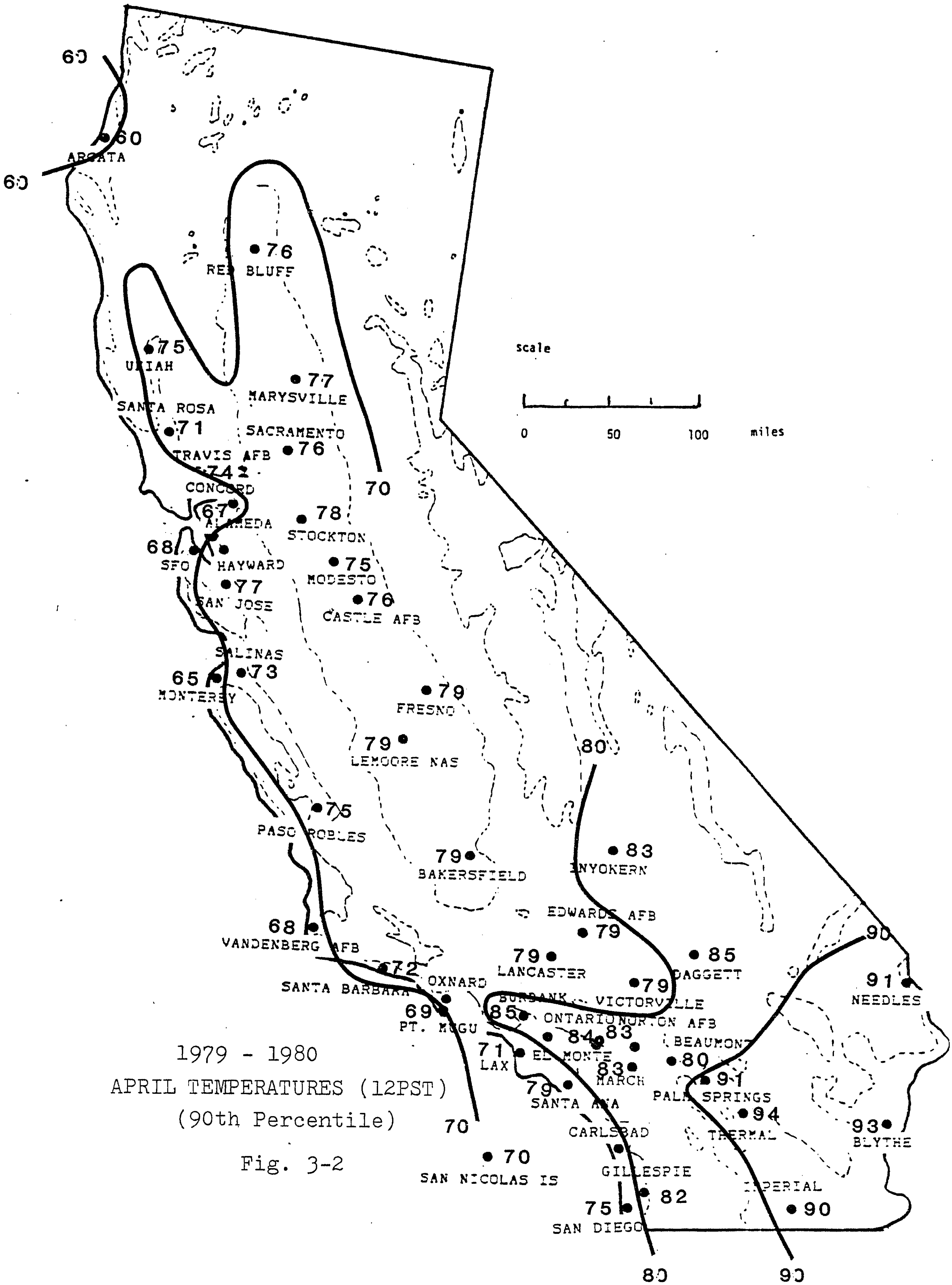
b. Relative Humidity - Relative humidity maps are also plotted in terms of 12 PST (90 percentile) values for January, April, July and October. The reason for this plotting selection is similar to the previous maps of temperature. High humidity affects chemical reaction rates and contributes to the growth of hygroscopic aerosols at about 70% RH or higher. 12 PST is again an important period during the day for chemical reactions and for aerosol effects on visibility. In some cases, e.g. Red Bluff in October, there may be a considerable difference between 90 percentile and 50 percentile values.

Relative humidity data are shown in Figs. 3-5 through 3-8.



1979 - 1980
JANUARY TEMPERATURES (12PST)
(90th Percentile)

Fig. 3-1

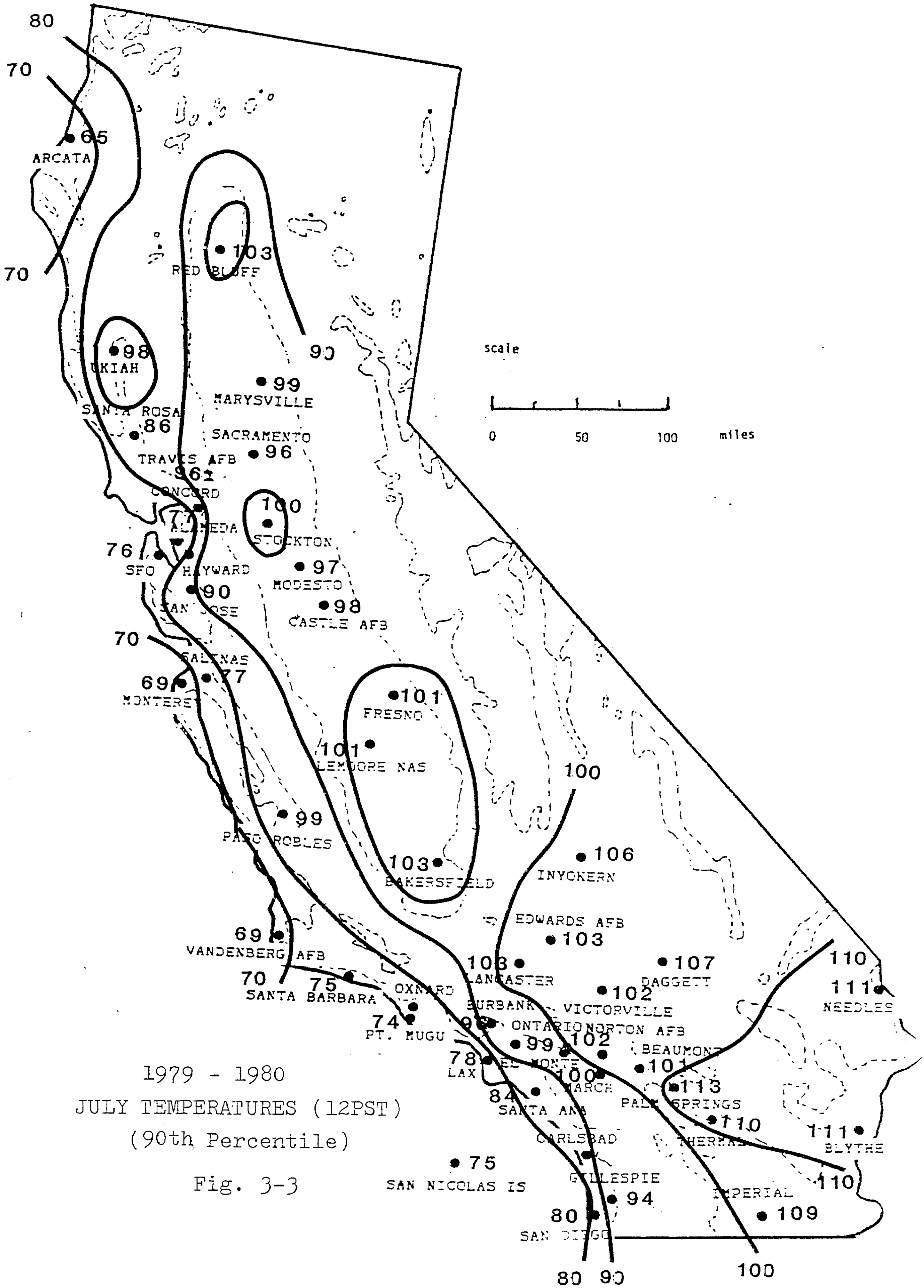


1979 - 1980

APRIL TEMPERATURES (12PST)

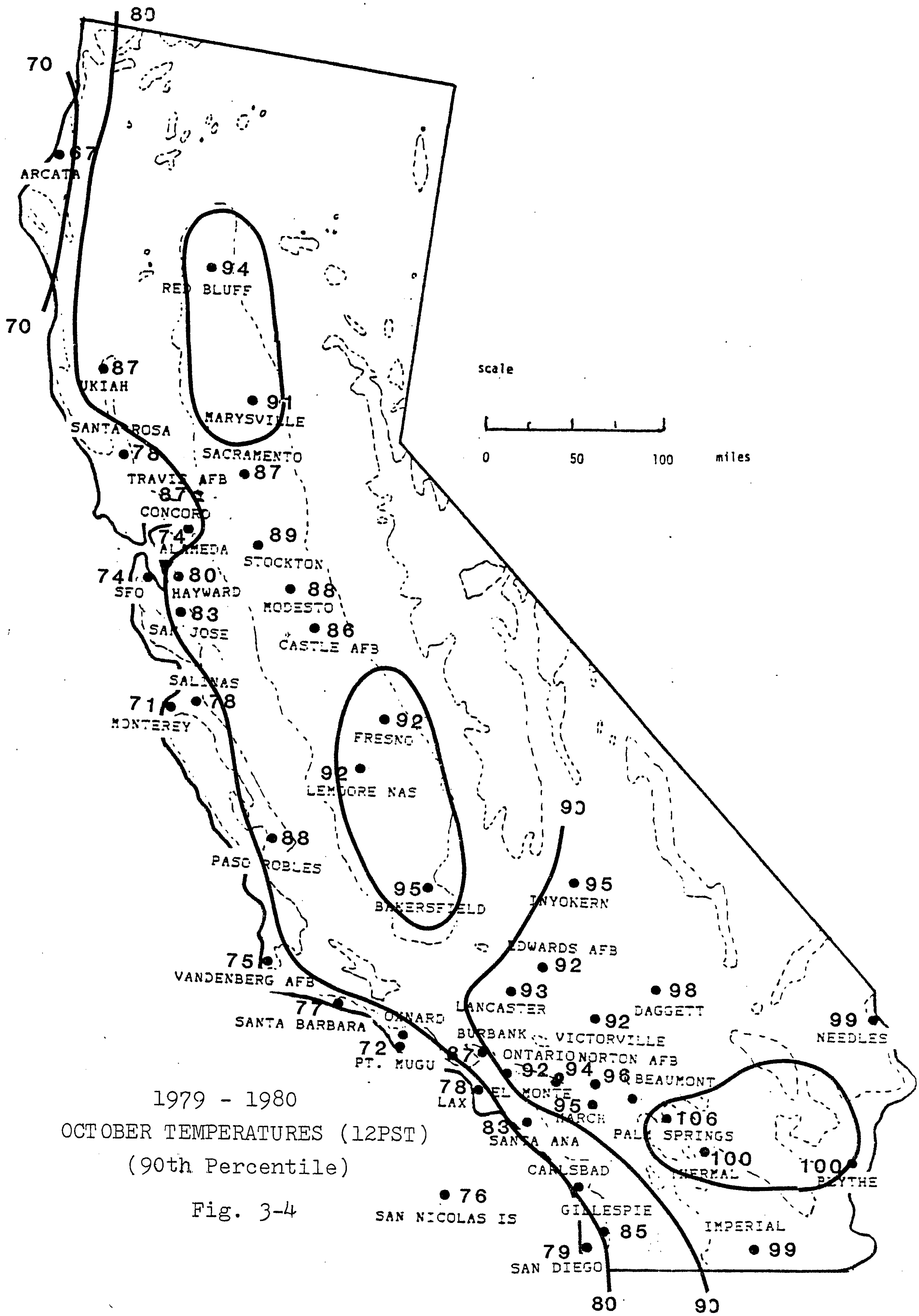
(90th Percentile)

Fig. 3-2



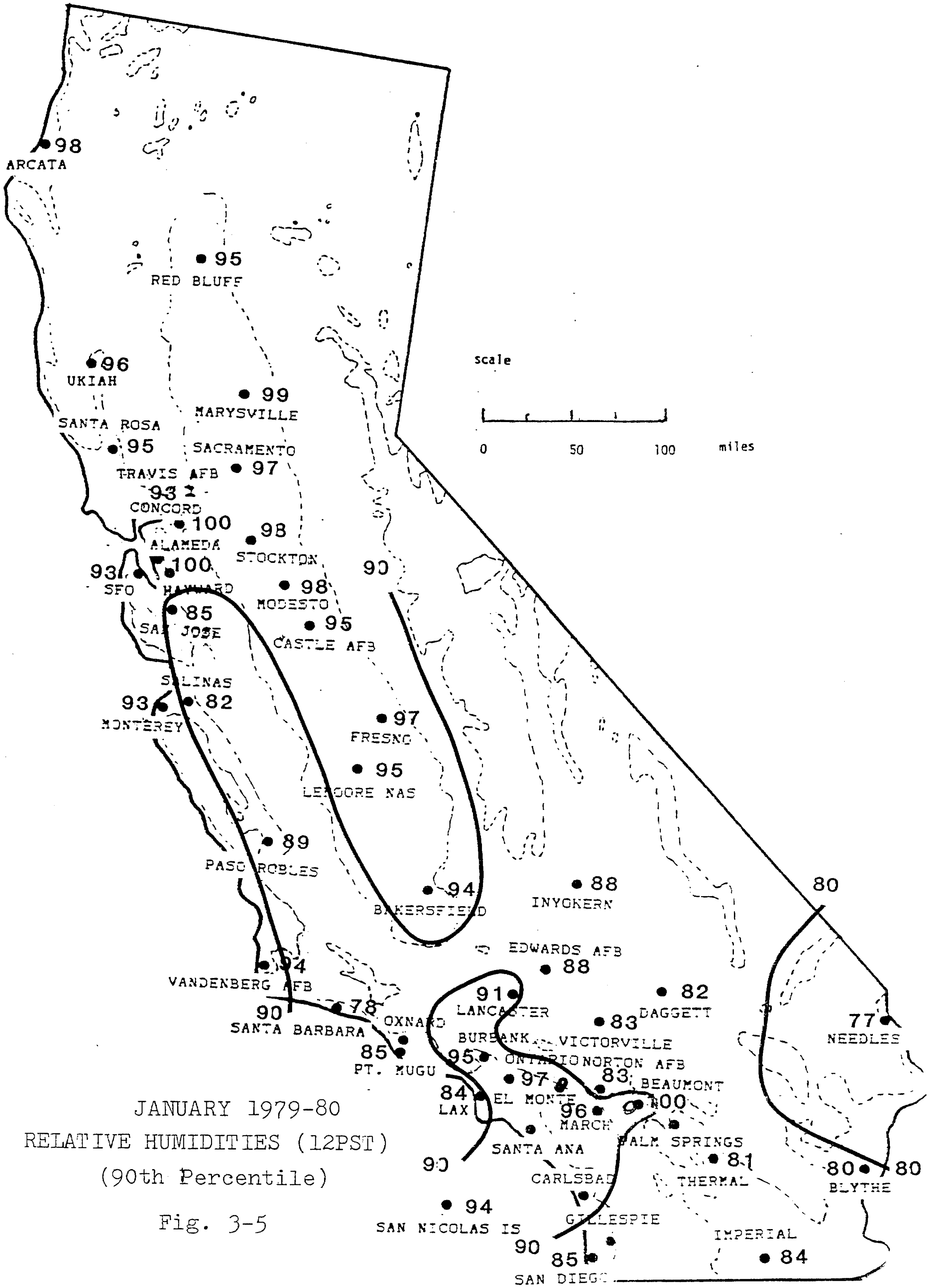
1979 - 1980
JULY TEMPERATURES (12PST)
(90th Percentile)

Fig. 3-3



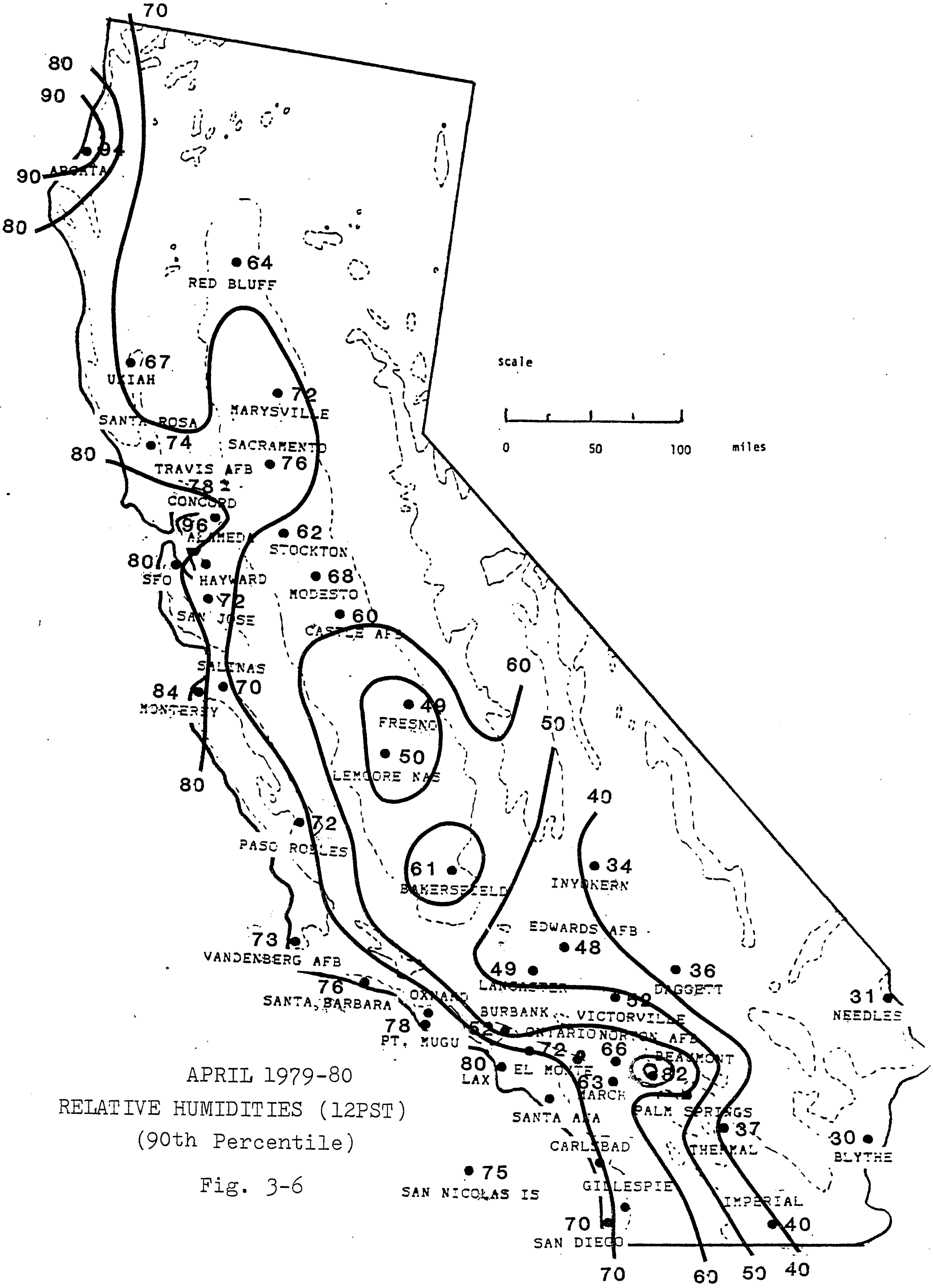
1979 - 1980
OCTOBER TEMPERATURES (12PST)
(90th Percentile)

Fig. 3-4



JANUARY 1979-80
RELATIVE HUMIDITIES (12PST)
(90th Percentile)

Fig. 3-5

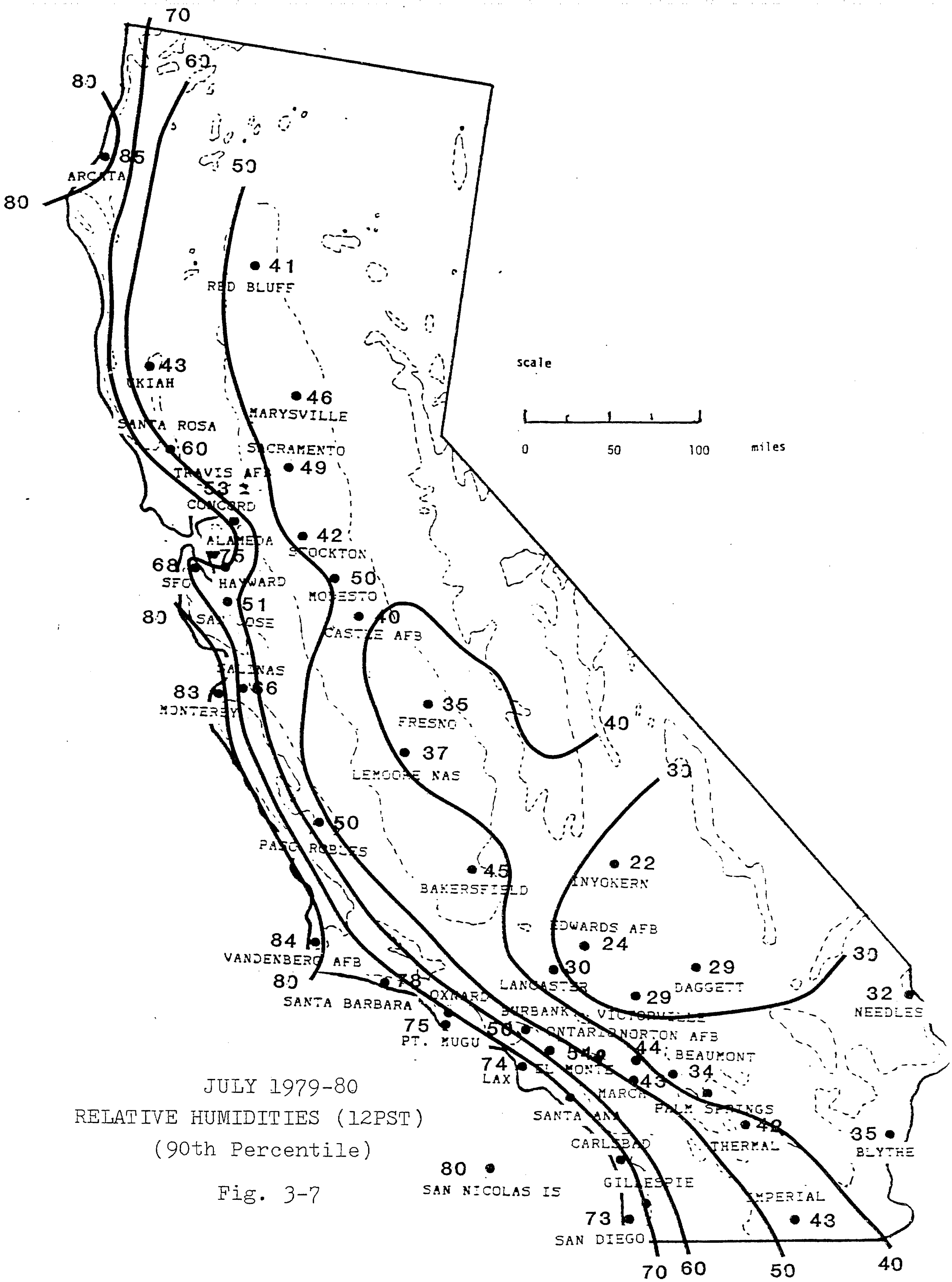


APRIL 1979-80

RELATIVE HUMIDITIES (12PST)

(90th Percentile)

Fig. 3-6

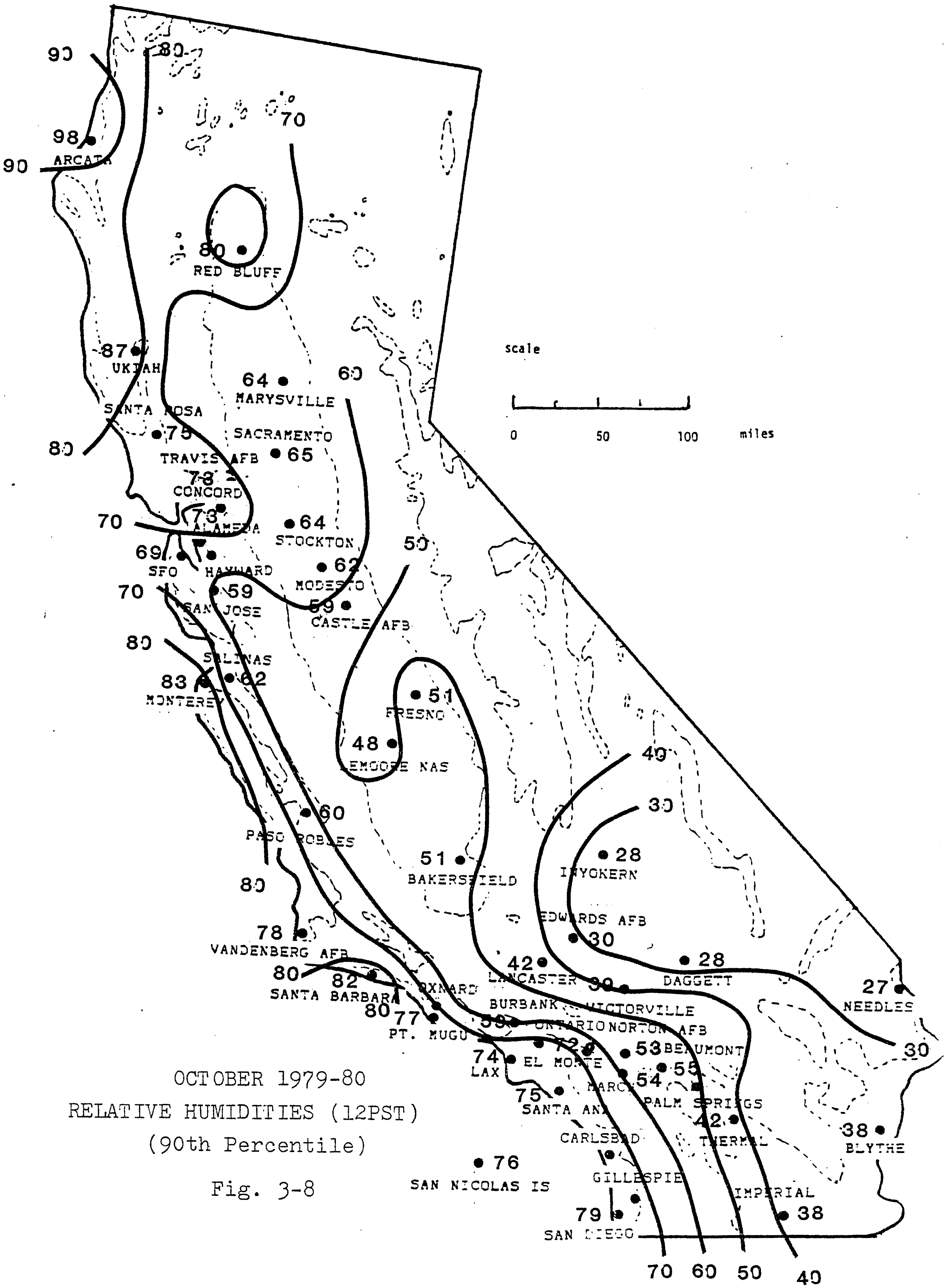


JULY 1979-80

RELATIVE HUMIDITIES (12PST)

(90th Percentile)

Fig. 3-7



OCTOBER 1979-80
RELATIVE HUMIDITIES (12PST)
(90th Percentile)

Fig. 3-8

c. Wind Speed - Wind speed has an important effect on area ventilation and dilution of concentrations from individual source areas. Light winds occurring in conjunction with important emission sources lead to an accumulation of pollutants which may move downwind later in the day. This phenomenon is particularly noticeable in the forenoon in the Los Angeles area and in the morning commuter hours in the San Jose/Sunnyvale area.

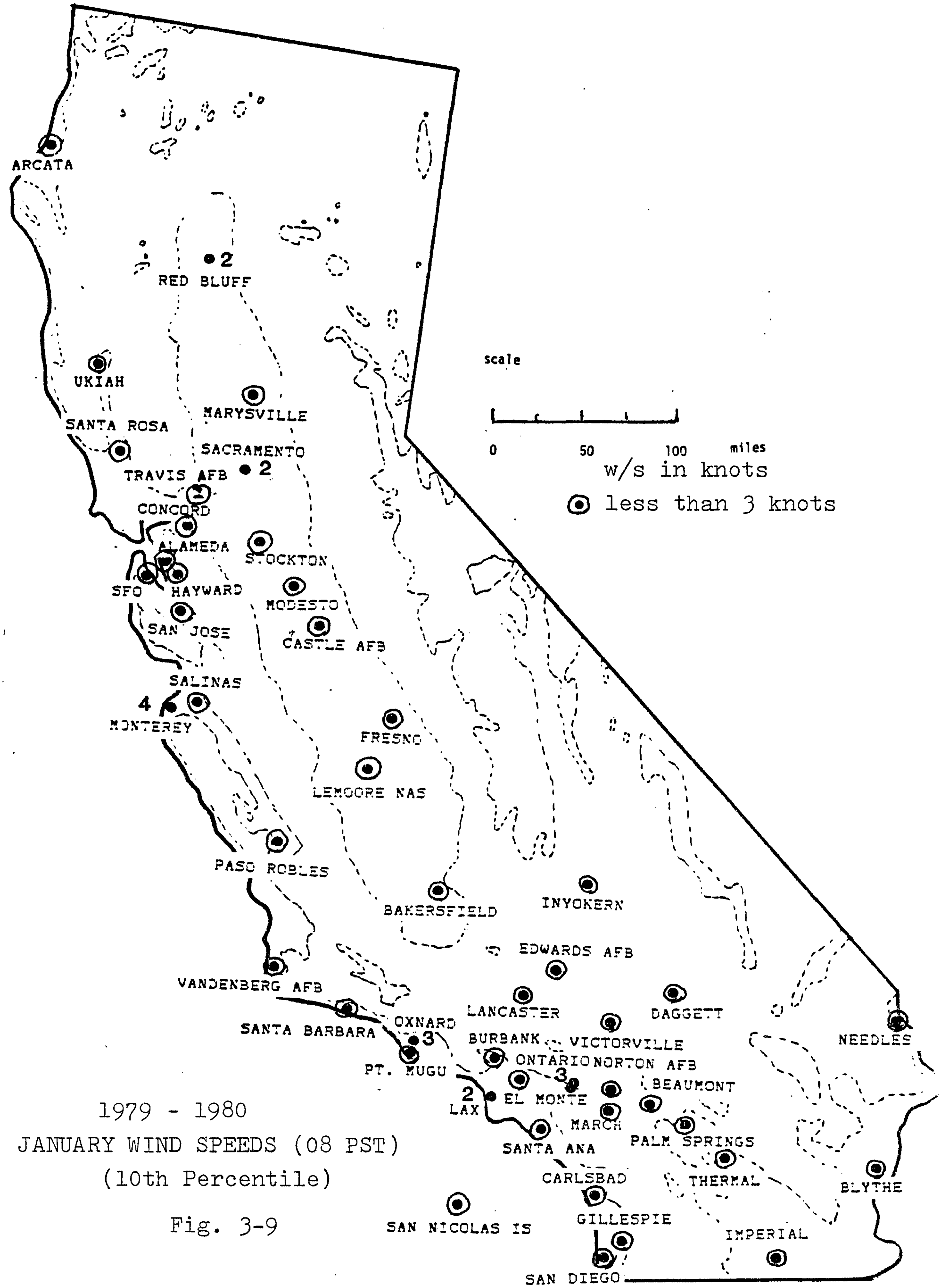
Wind speed data are presented in map form in terms of the lightest (tenth percentile) winds occurring at the location at the given hour and season. In view of the importance of wind speeds throughout the day, data for three hours (08, 12 and 16 PST) are presented for all four months.

Notable in the maps is the frequent occurrence of calms in the tenth percentile data, particularly at 08 PST. Largest numbers of calms occur in fall and winter. "Calm" wind speeds may be somewhat misleading, however. Most anemometers do not measure wind speed accurately below 3 knots and provide an underestimate of the wind speed in this range. The "calm" wind data therefore signify wind speeds less than 3 knots.

The plotted data on wind speeds are given in Figs. 3-9 through 3-20. Data on the 50th percentile are given in Figs. 3-21 through 3-32 and in the Appendix. Tables 3-1 through 3-12 show the rank order of 10 and 50 percentile wind speeds for the stations used in the figures. A further discussion of the statewide distribution of light winds and the impact on air pollution is included in Section 5.

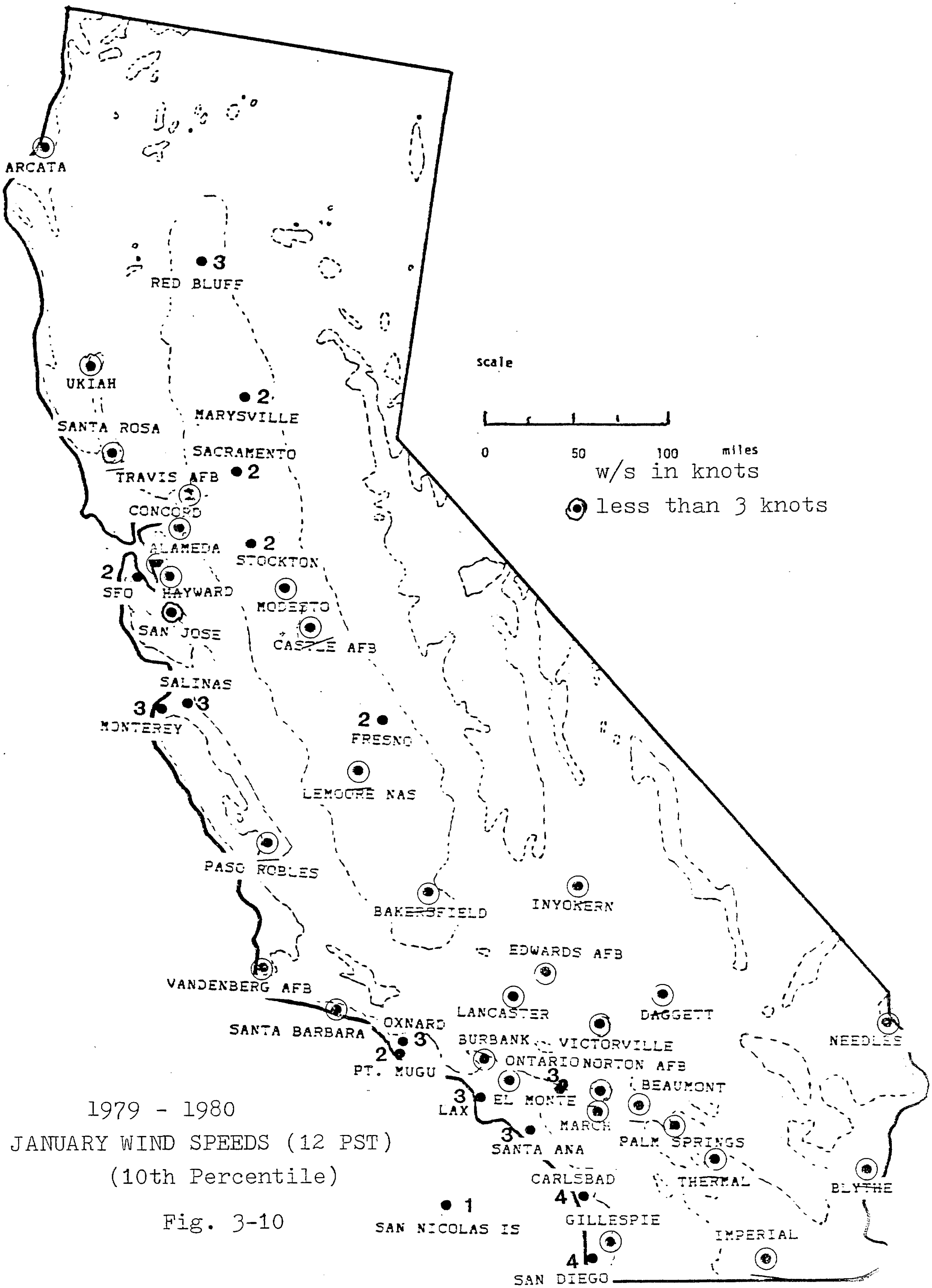
d. Mixing Heights - Mixing height data were estimated by the method suggested by Holzworth (1972). During the afternoon the maximum surface temperature was used with the measured sounding to construct a dry adiabatic lapse rate which intersected the sounding at the maximum mixing height for the day. The morning mixing height was estimated by increasing the minimum temperature by 5^{o} C and determining the intersection of an adiabatic lapse rate with the measured sounding. Both techniques probably lead to slight overestimates of the mixing height.

In addition to the difficulties with the estimating techniques there were notable gaps in the available data set. CARB aircraft flights do not occur each day and in some months there were relatively few data at some locations. As a consequence the results of the



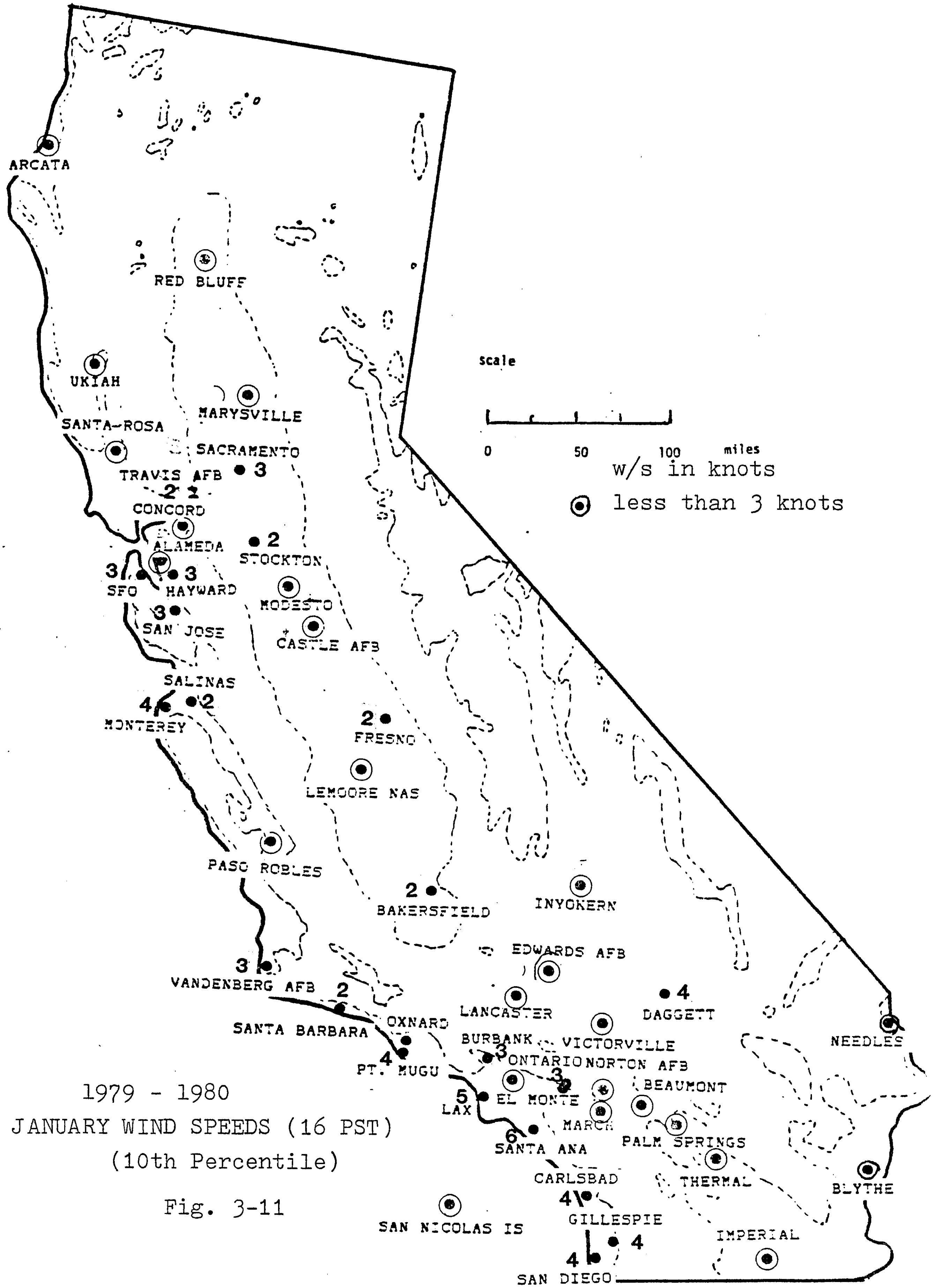
1979 - 1980
JANUARY WIND SPEEDS (08 PST)
(10th Percentile)

Fig. 3-9



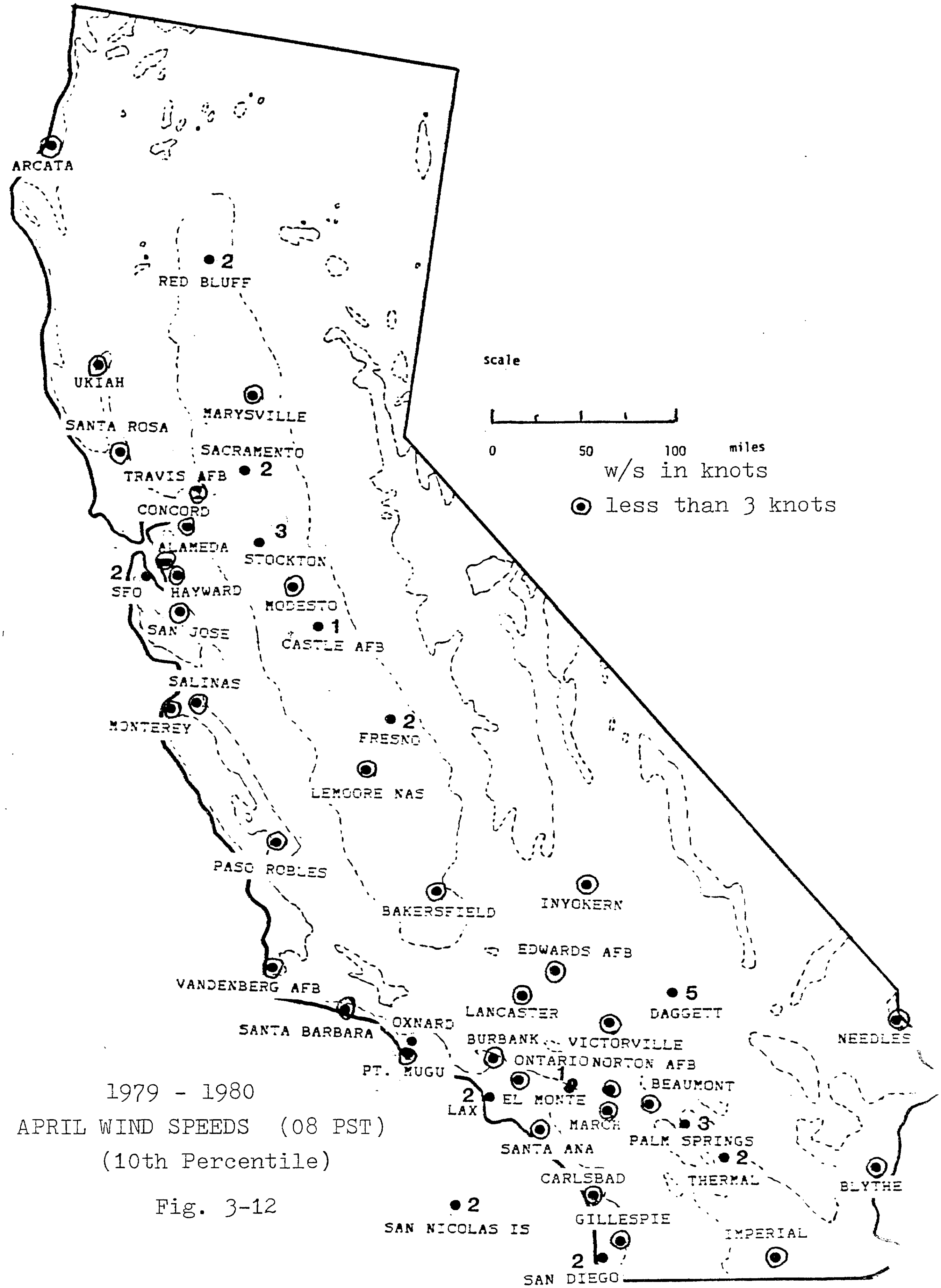
1979 - 1980
JANUARY WIND SPEEDS (12 PST)
(10th Percentile)

Fig. 3-10



1979 - 1980
JANUARY WIND SPEEDS (16 PST)
(10th Percentile)

Fig. 3-11

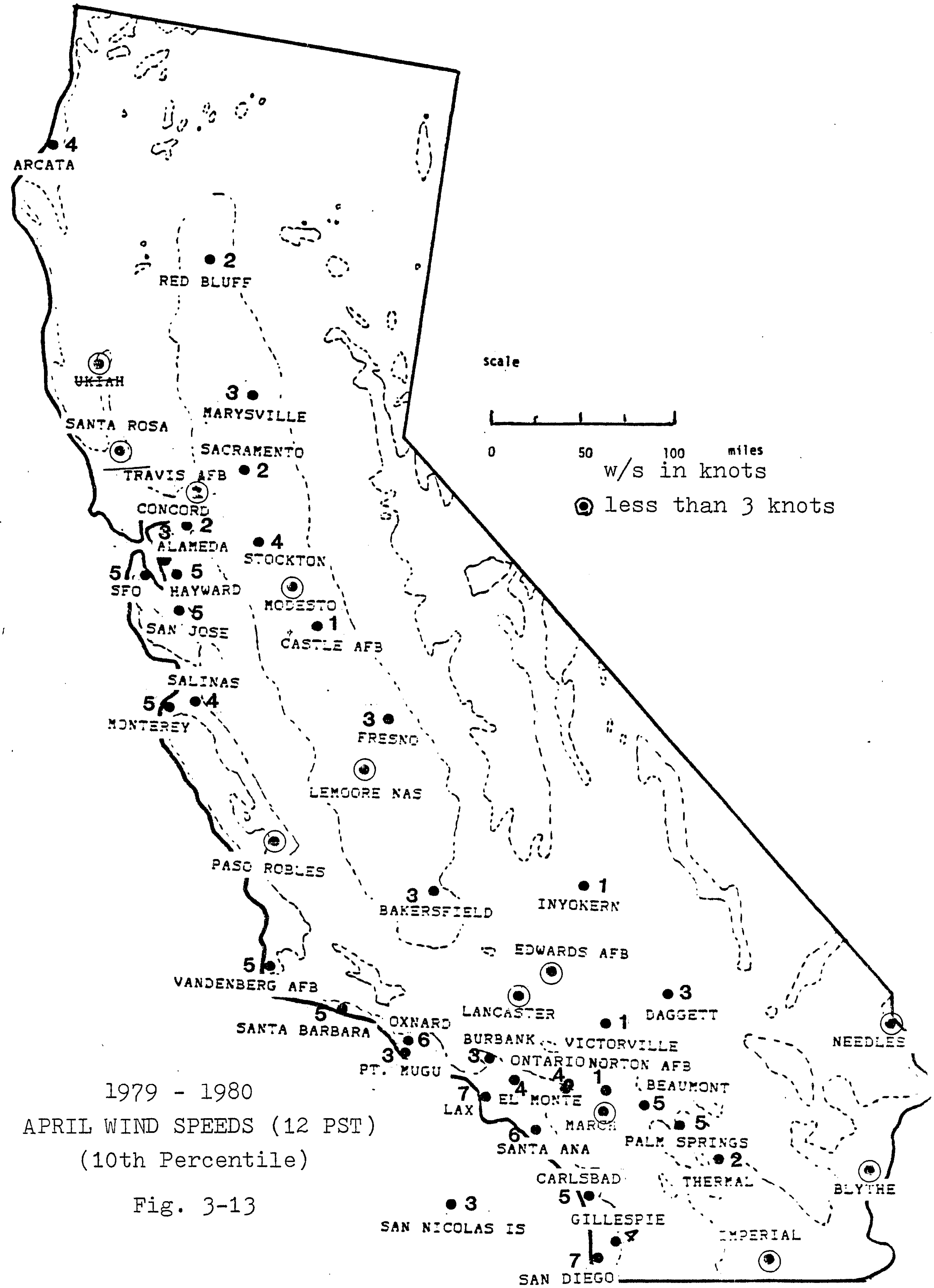


1979 - 1980

APRIL WIND SPEEDS (08 PST)

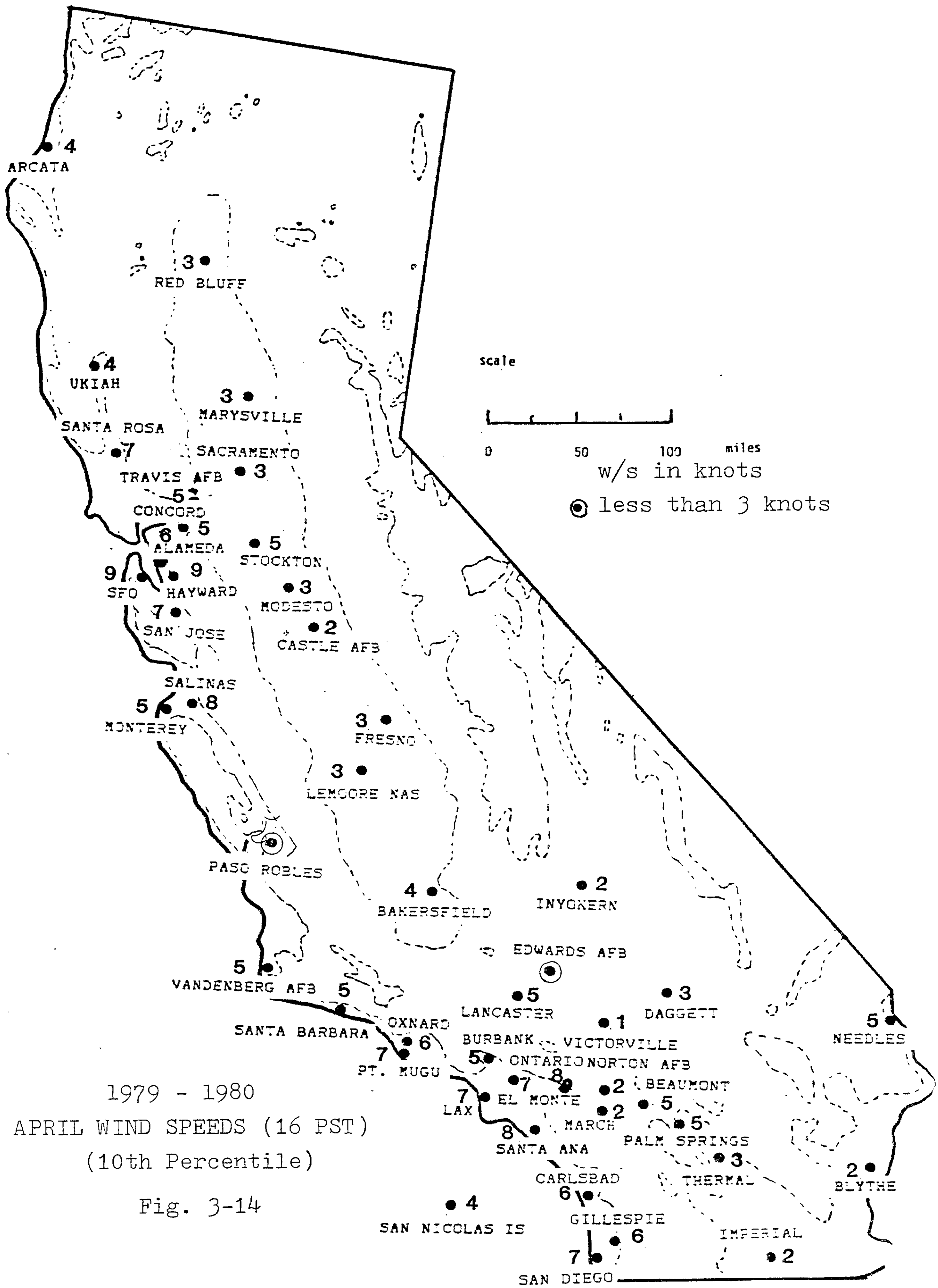
(10th Percentile)

Fig. 3-12



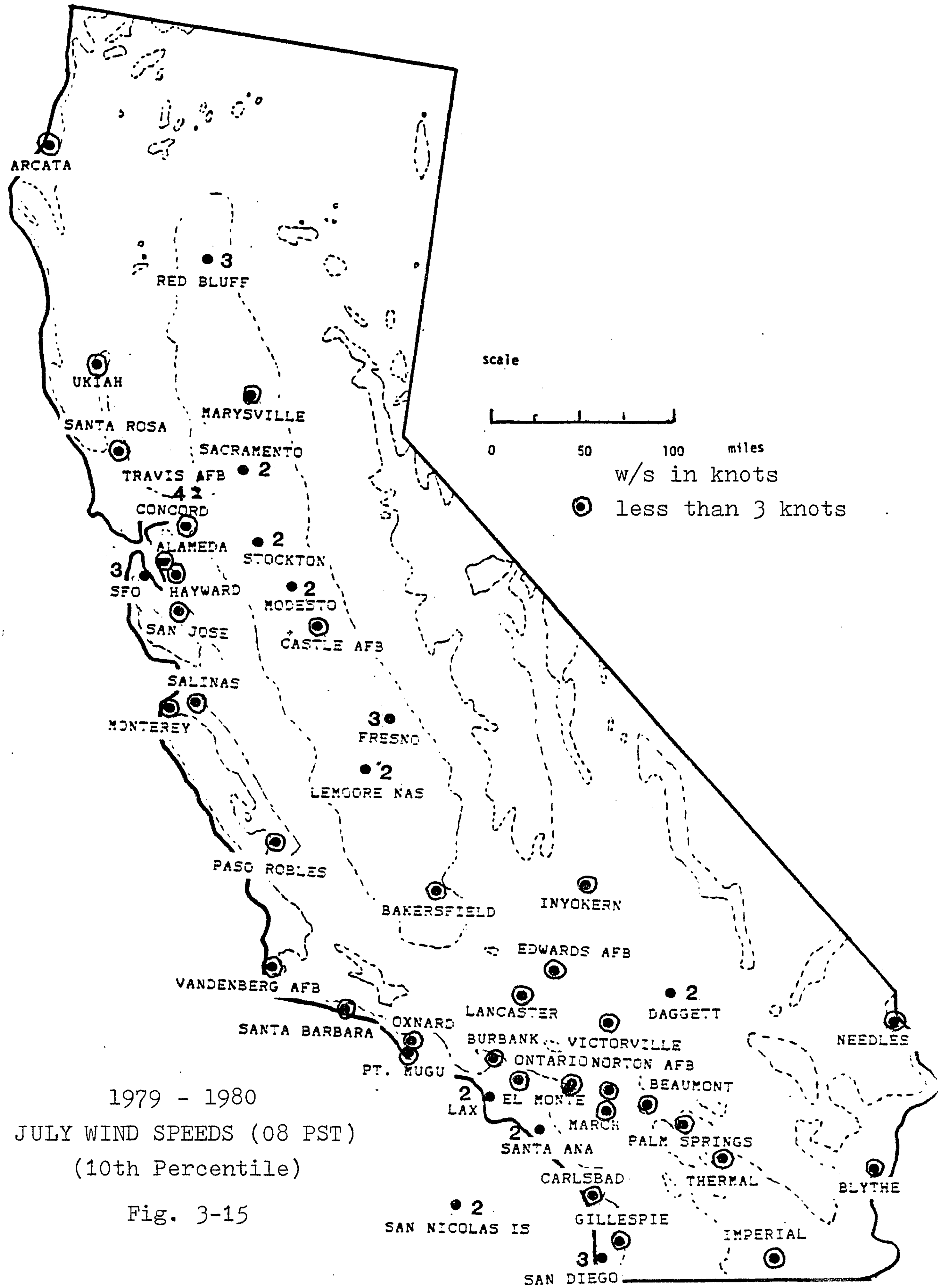
1979 - 1980
APRIL WIND SPEEDS (12 PST)
(10th Percentile)

Fig. 3-13



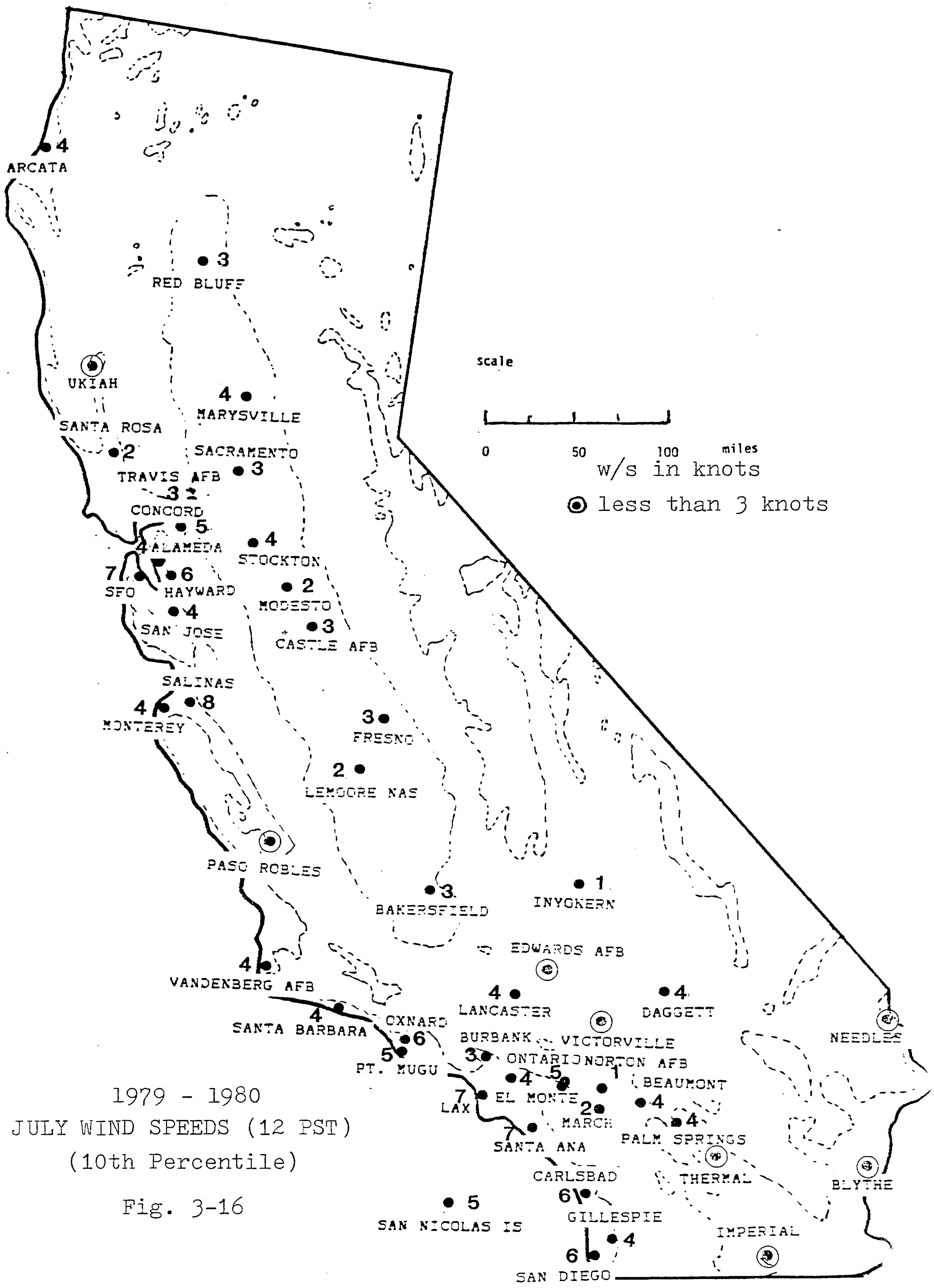
1979 - 1980
APRIL WIND SPEEDS (16 PST)
(10th Percentile)

Fig. 3-14



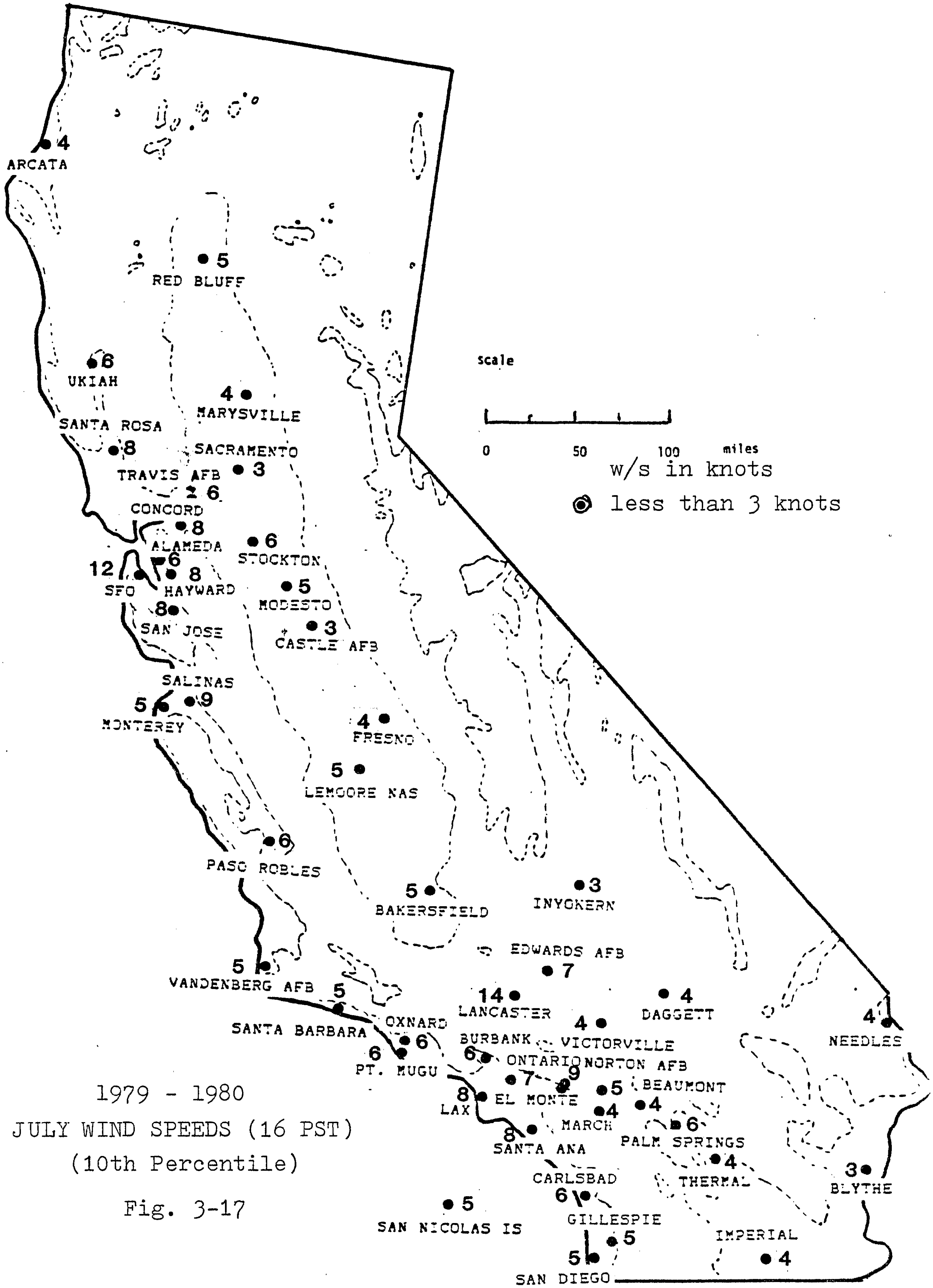
1979 - 1980
JULY WIND SPEEDS (08 PST)
(10th Percentile)

Fig. 3-15



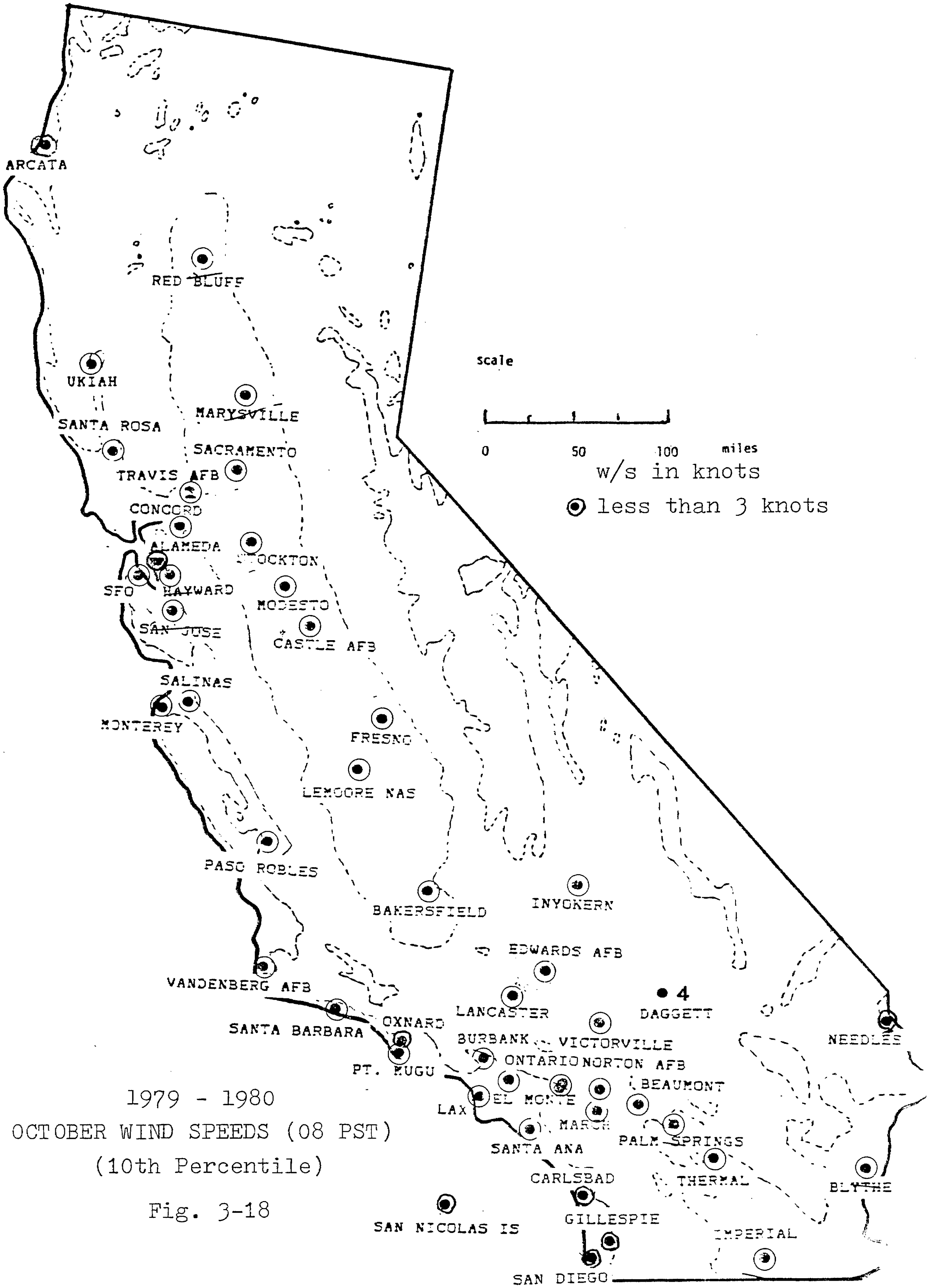
1979 - 1980
JULY WIND SPEEDS (12 PST)
(10th Percentile)

Fig. 3-16



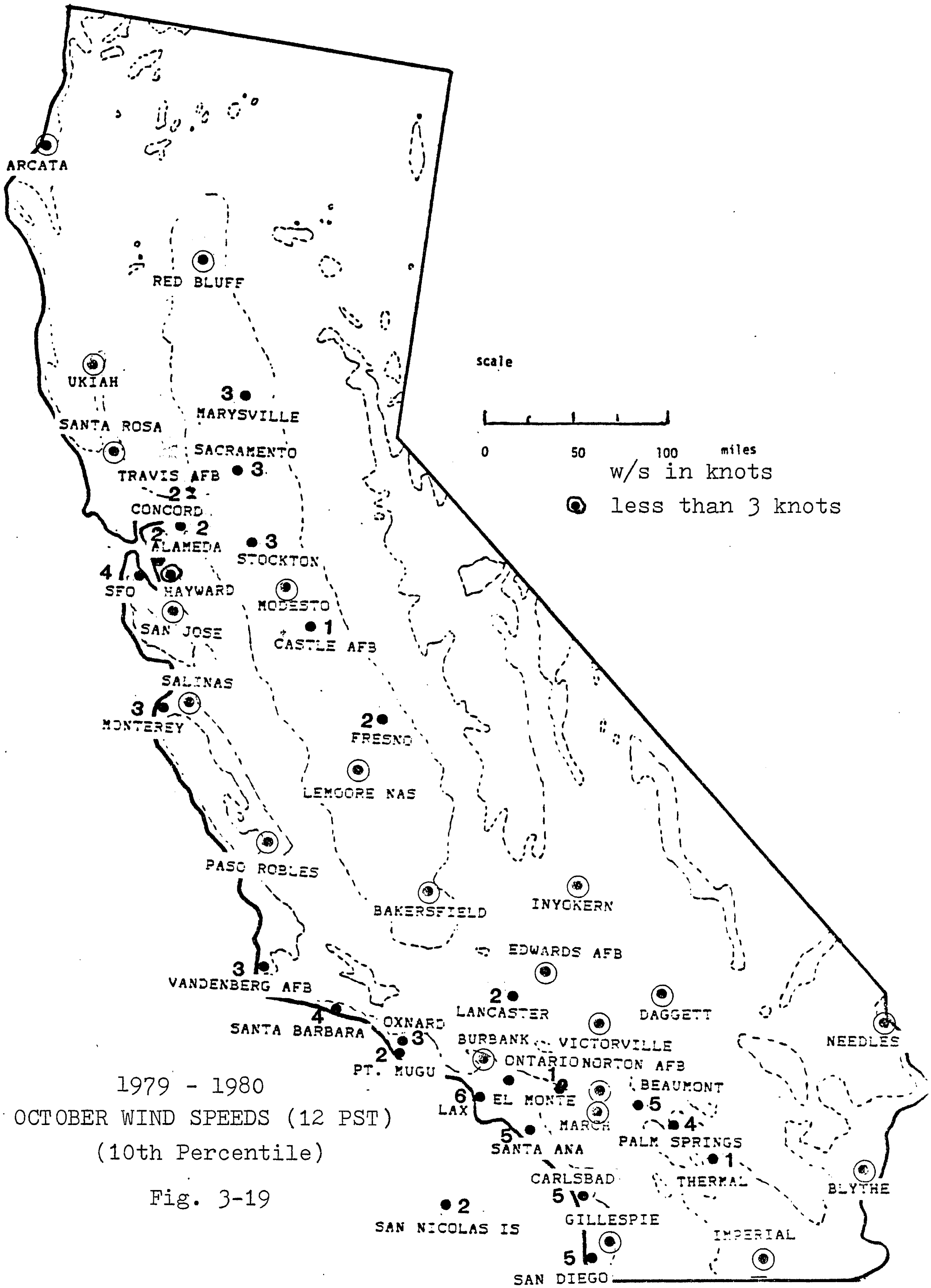
1979 - 1980
JULY WIND SPEEDS (16 PST)
(10th Percentile)

Fig. 3-17



1979 - 1980
OCTOBER WIND SPEEDS (08 PST)
(10th Percentile)

Fig. 3-18

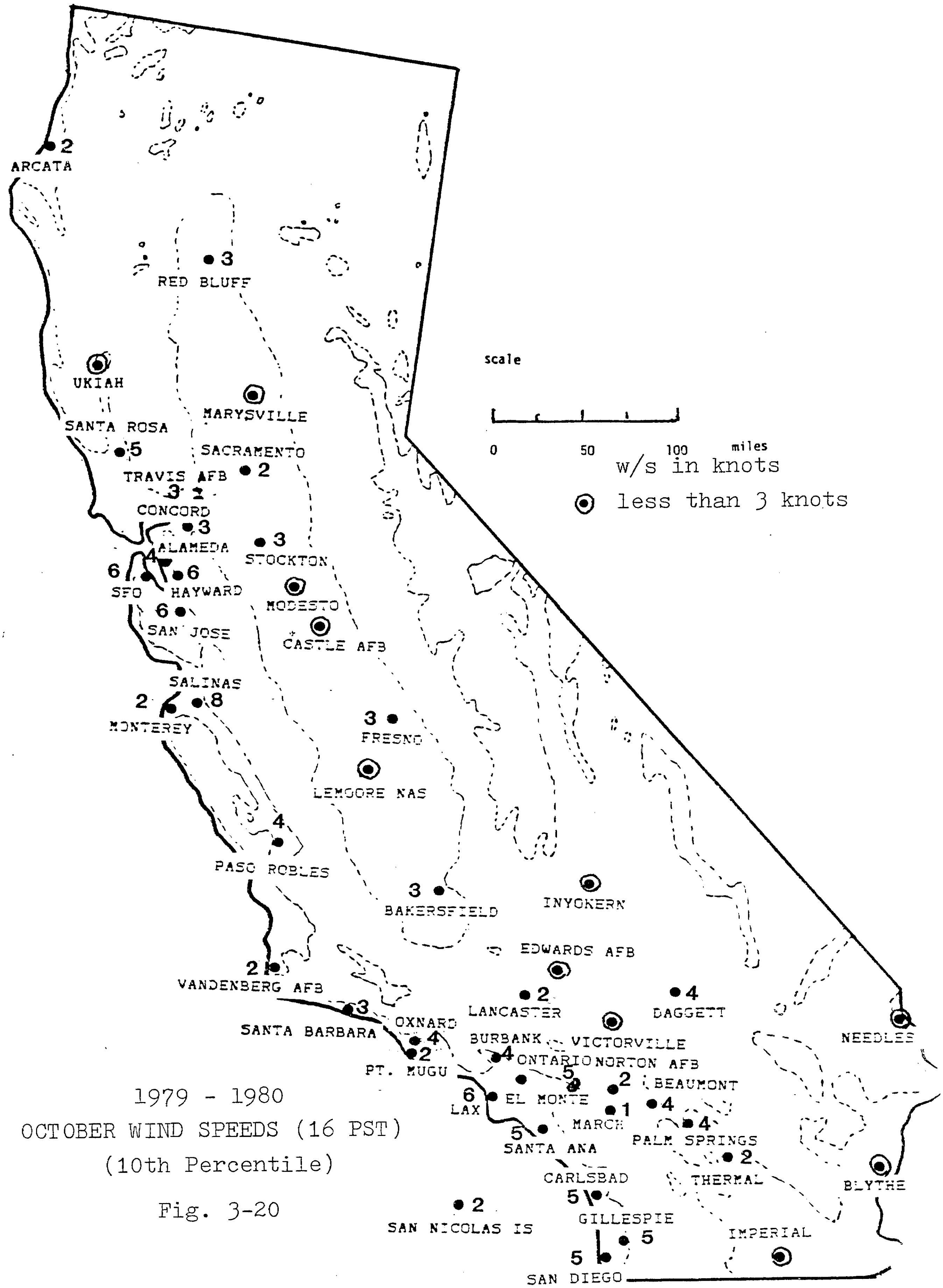


1979 - 1980

OCTOBER WIND SPEEDS (12 PST)

(10th Percentile)

Fig. 3-19

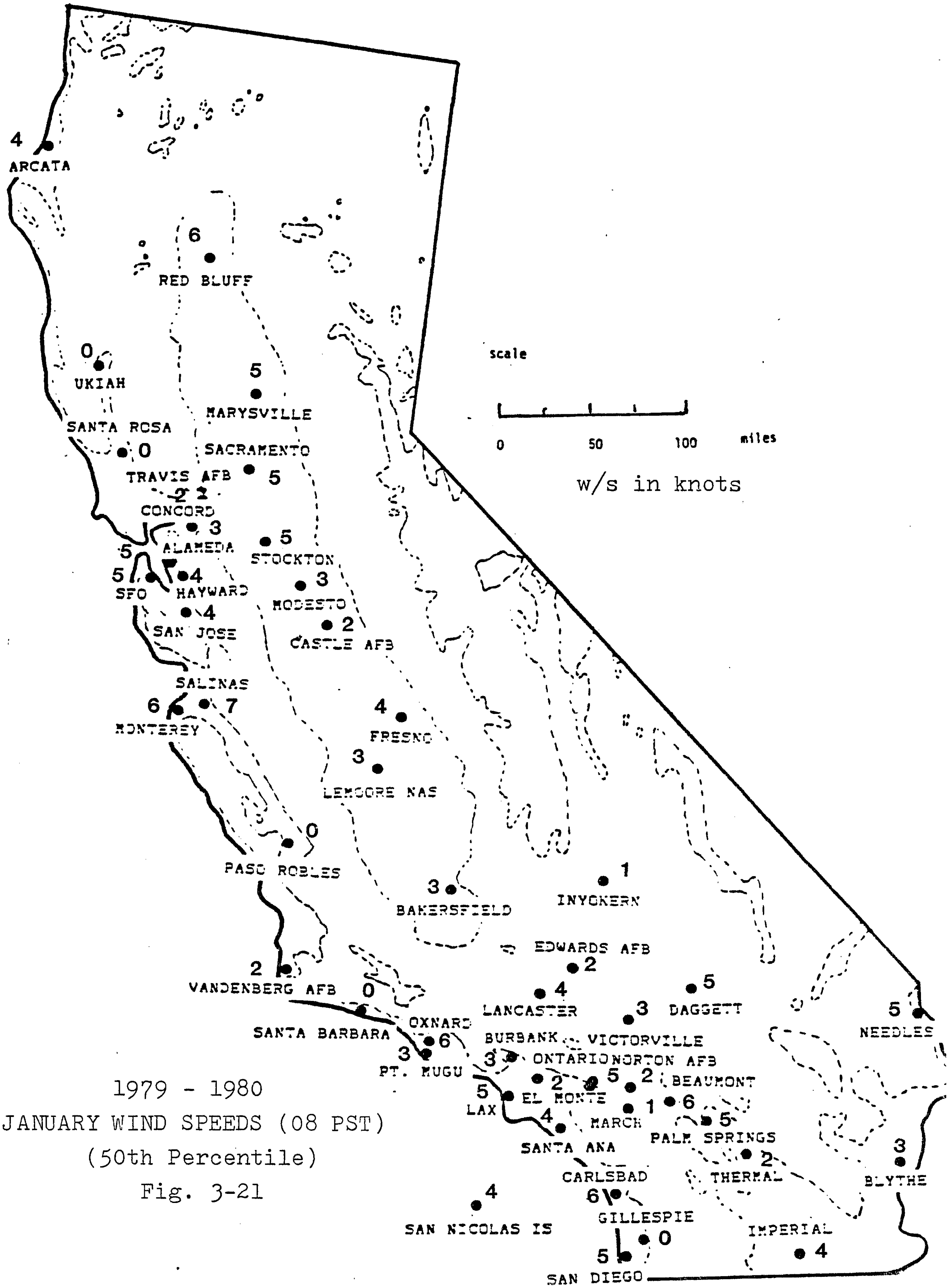


1979 - 1980

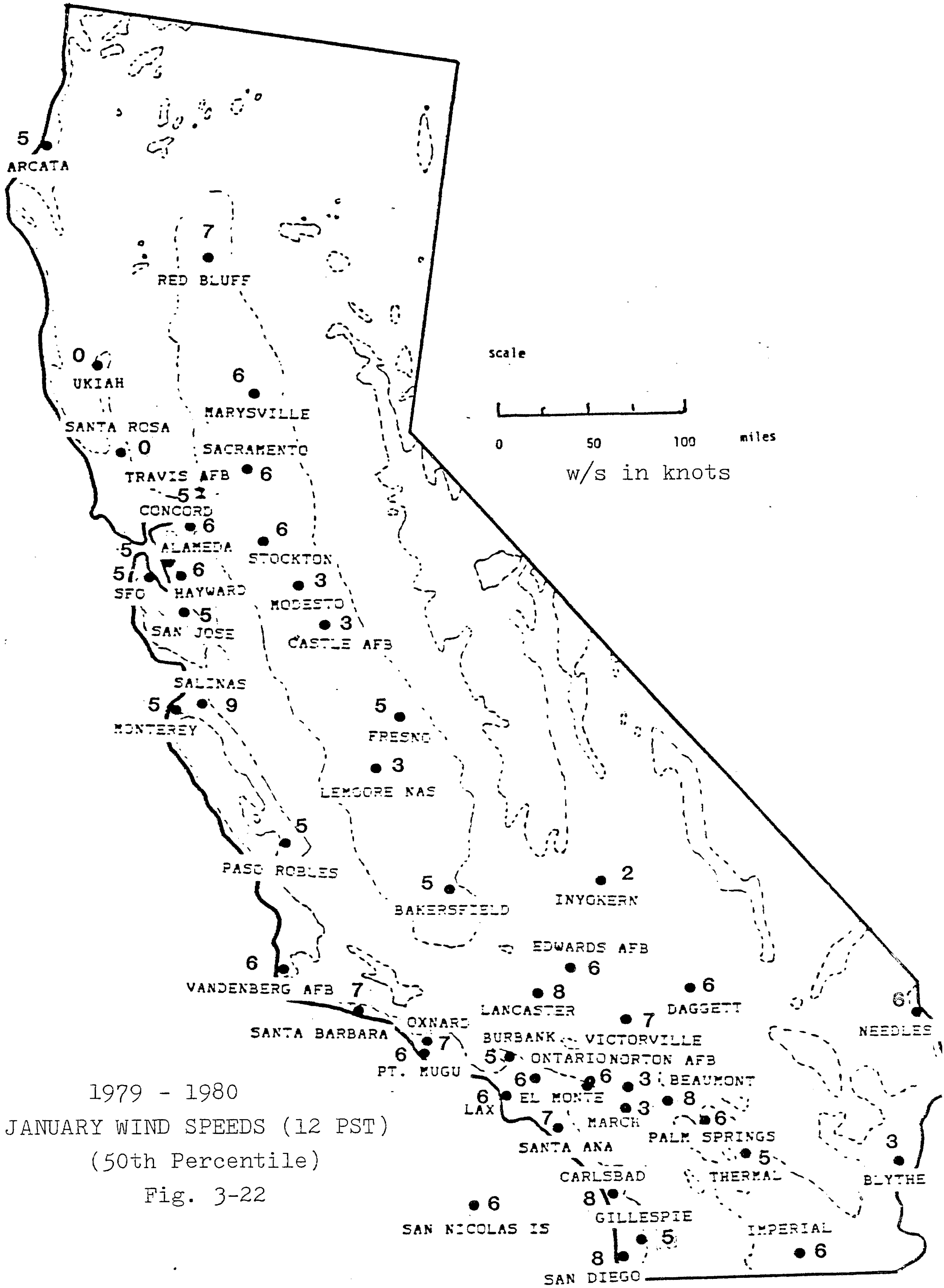
OCTOBER WIND SPEEDS (16 PST)

(10th Percentile)

Fig. 3-20



1979 - 1980
JANUARY WIND SPEEDS (08 PST)
(50th Percentile)
Fig. 3-21

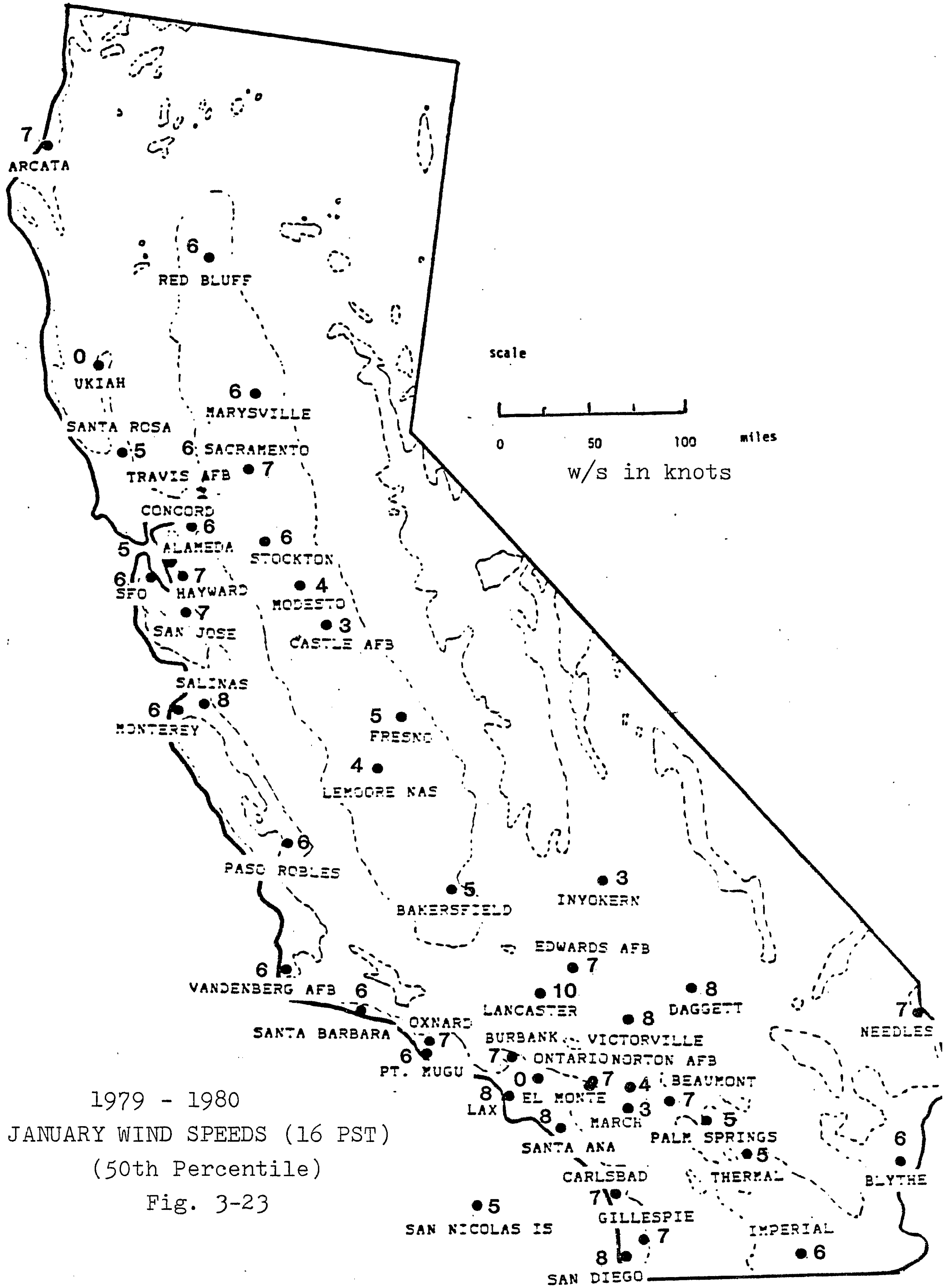


1979 - 1980

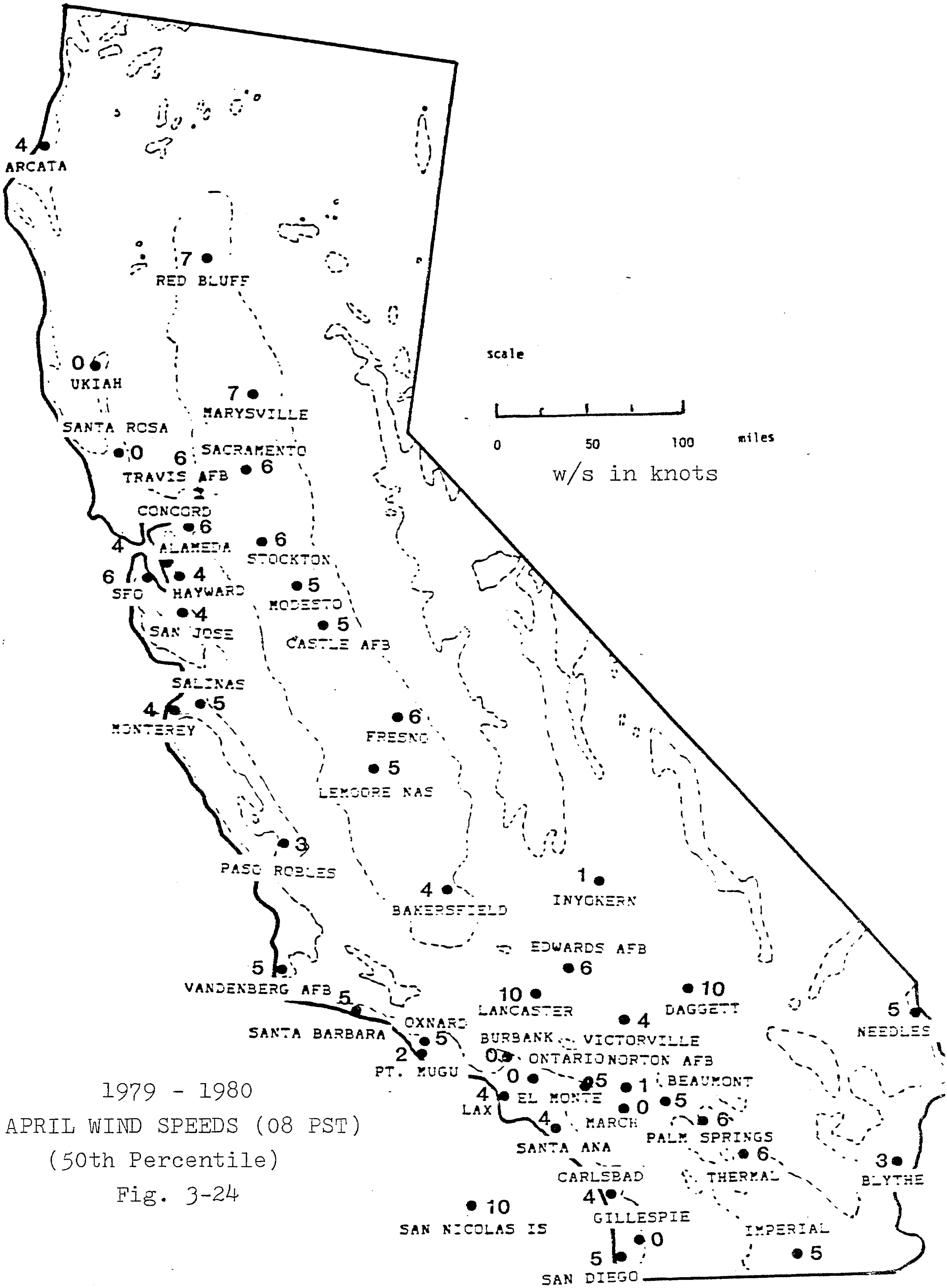
JANUARY WIND SPEEDS (12 PST)

(50th Percentile)

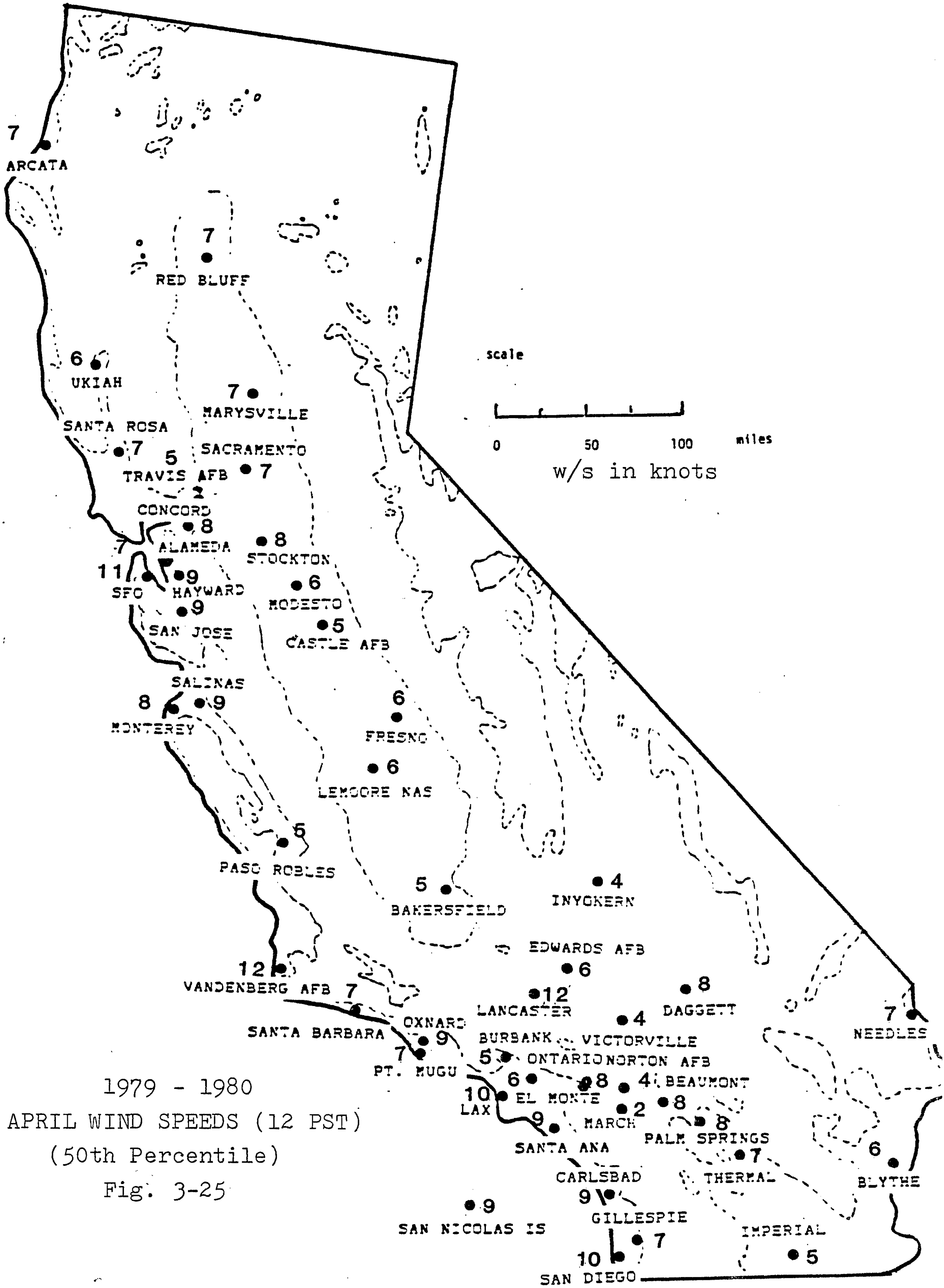
Fig. 3-22



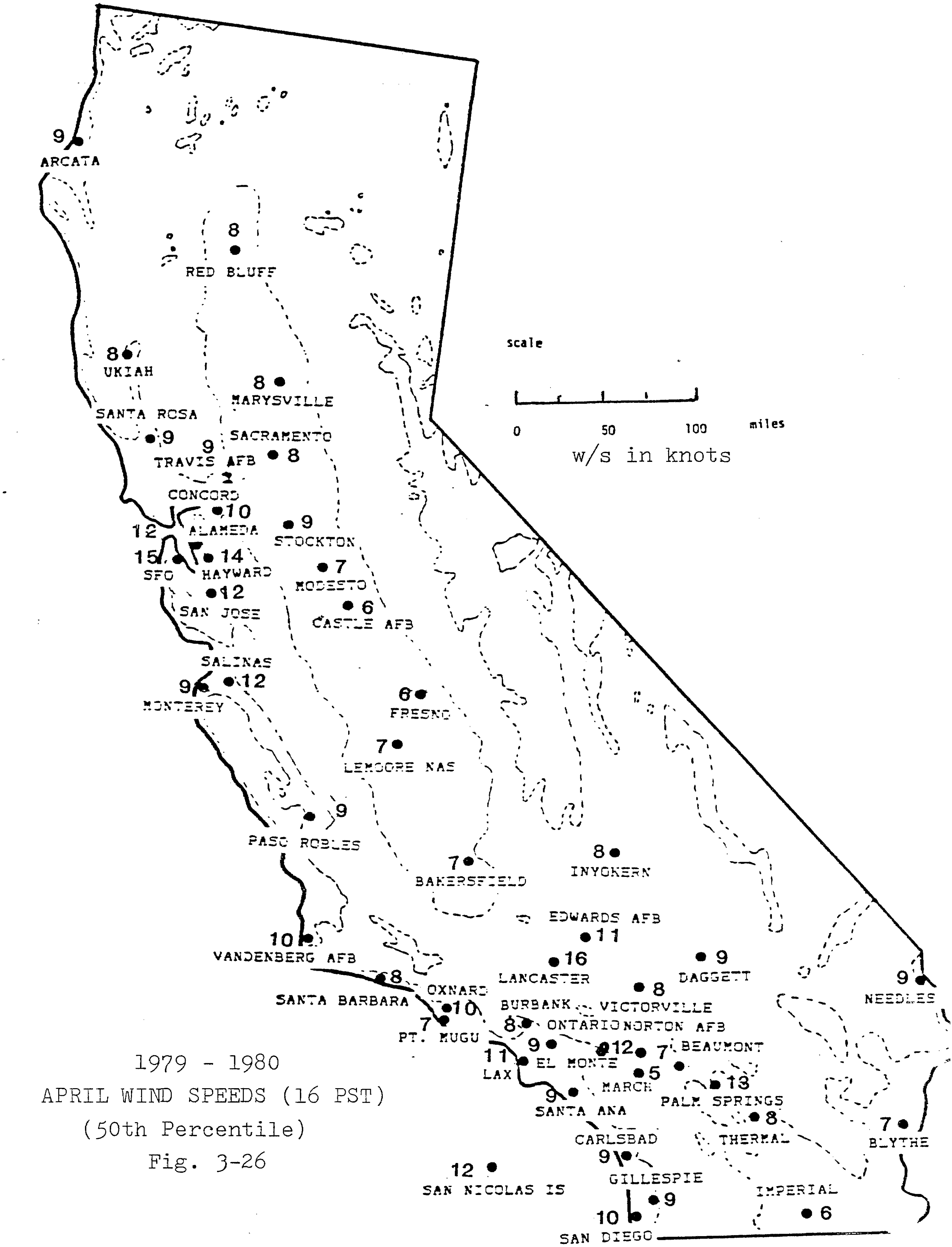
1979 - 1980
JANUARY WIND SPEEDS (16 PST)
(50th Percentile)
Fig. 3-23



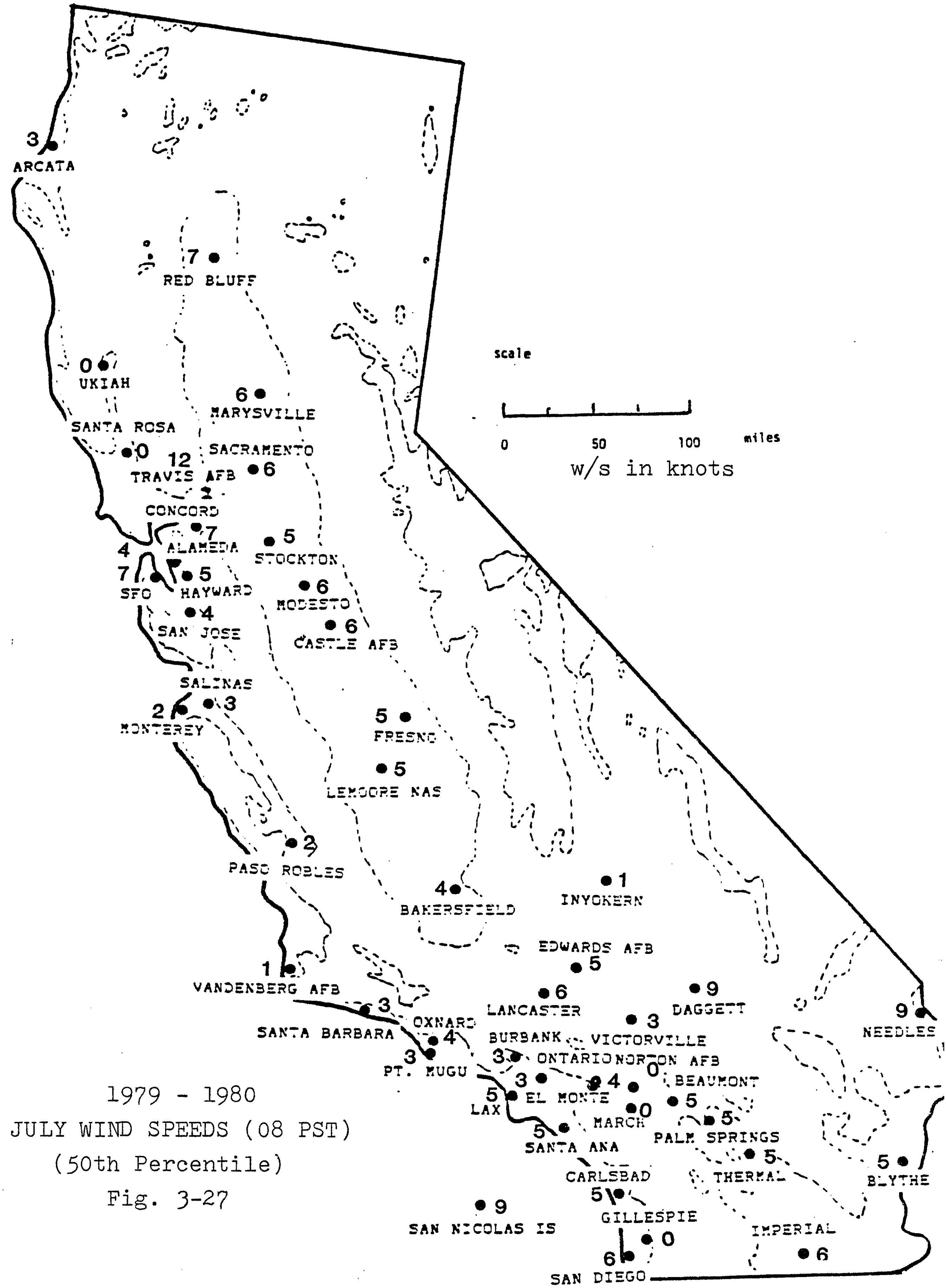
1979 - 1980
APRIL WIND SPEEDS (08 PST)
(50th Percentile)
Fig. 3-24



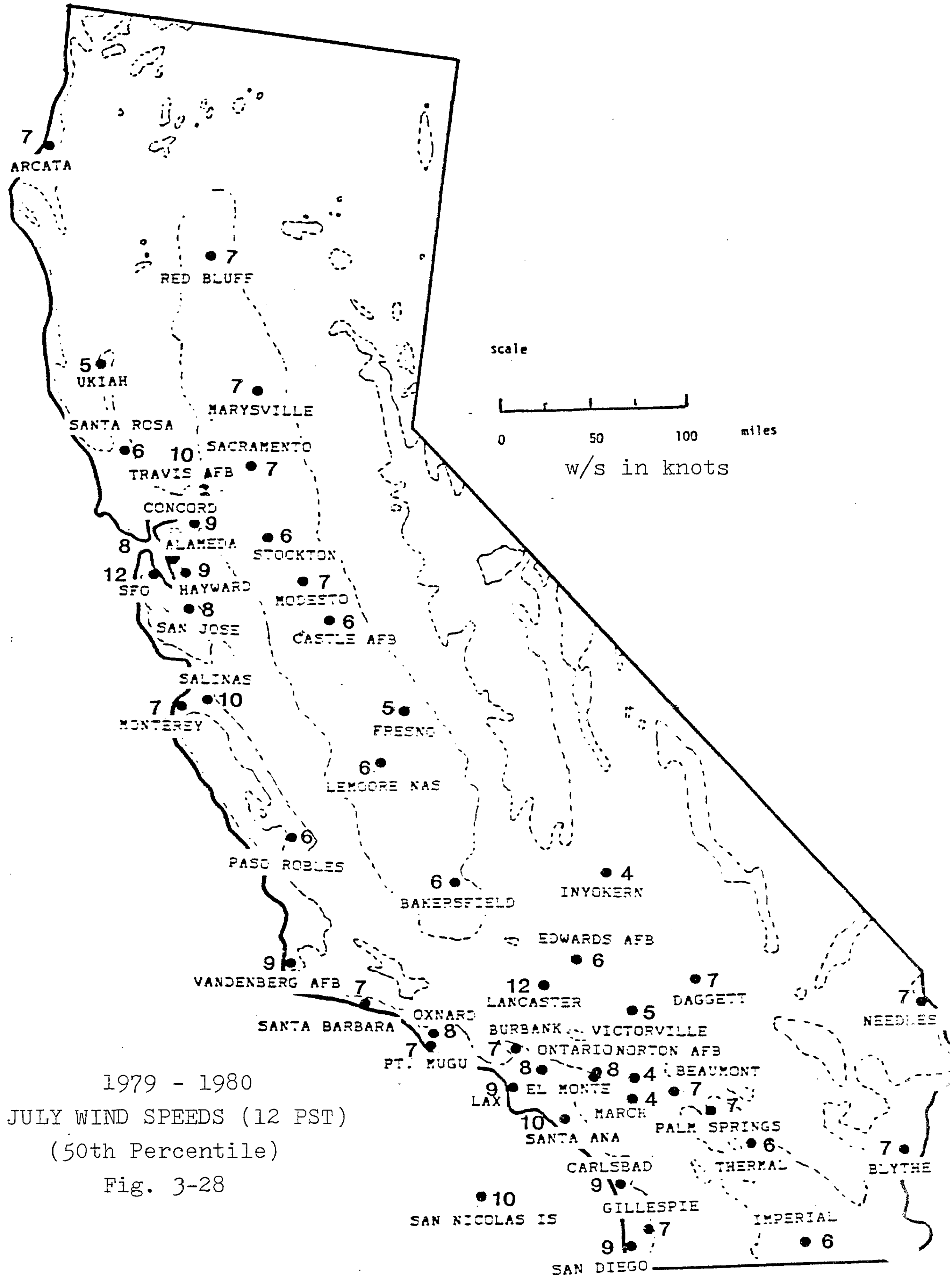
1979 - 1980
APRIL WIND SPEEDS (12 PST)
(50th Percentile)
Fig. 3-25



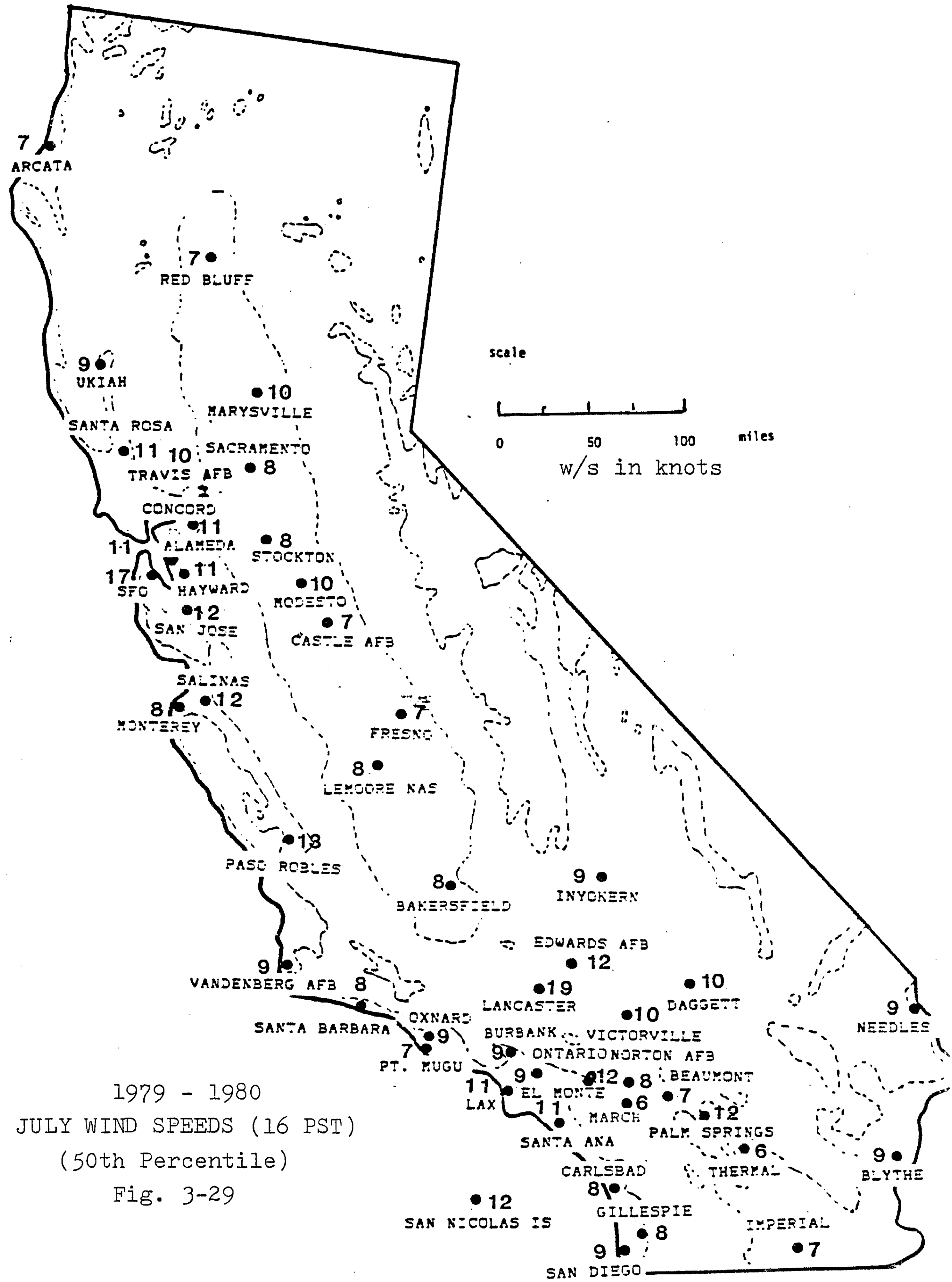
1979 - 1980
APRIL WIND SPEEDS (16 PST)
(50th Percentile)
Fig. 3-26



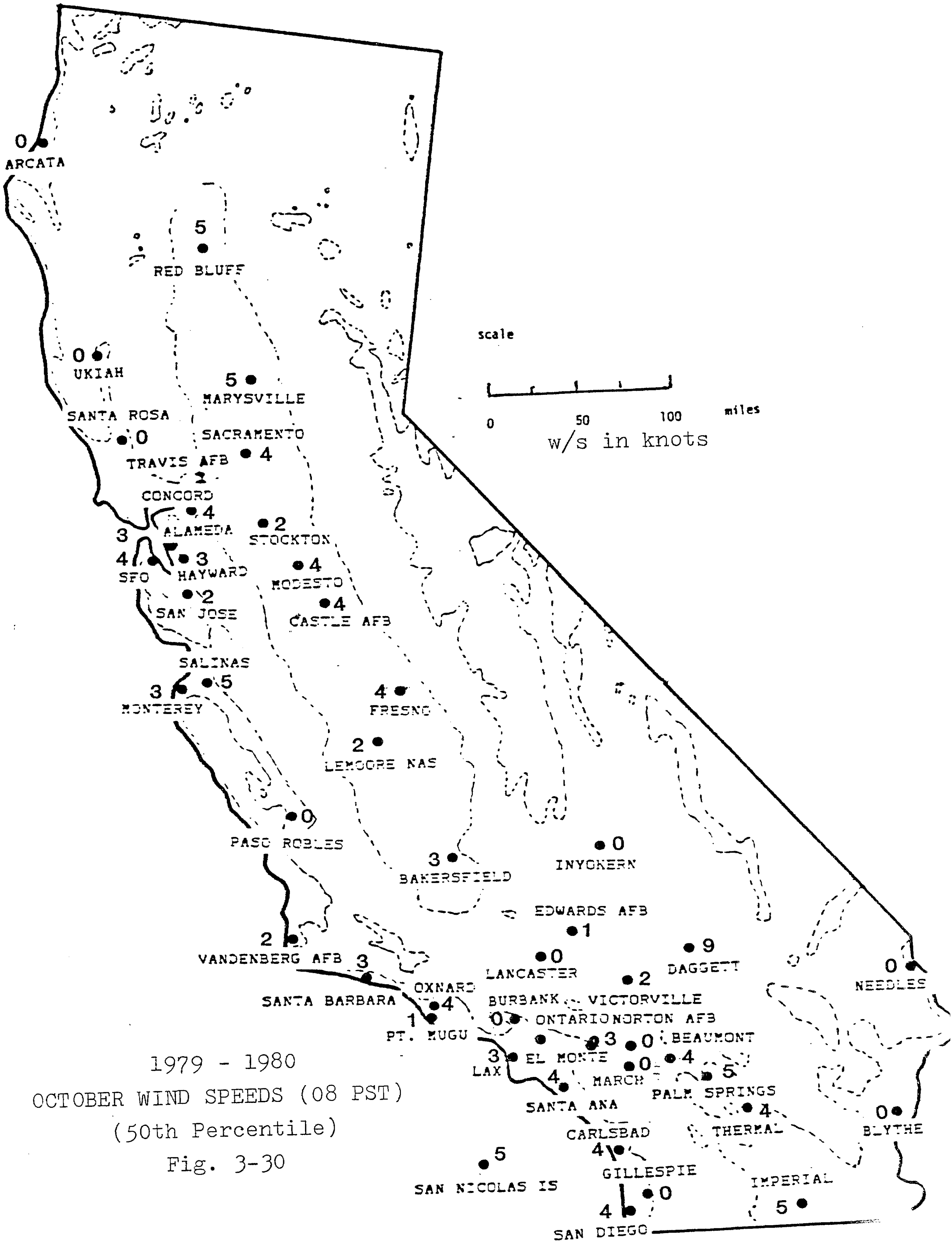
1979 - 1980
JULY WIND SPEEDS (08 PST)
(50th Percentile)
Fig. 3-27



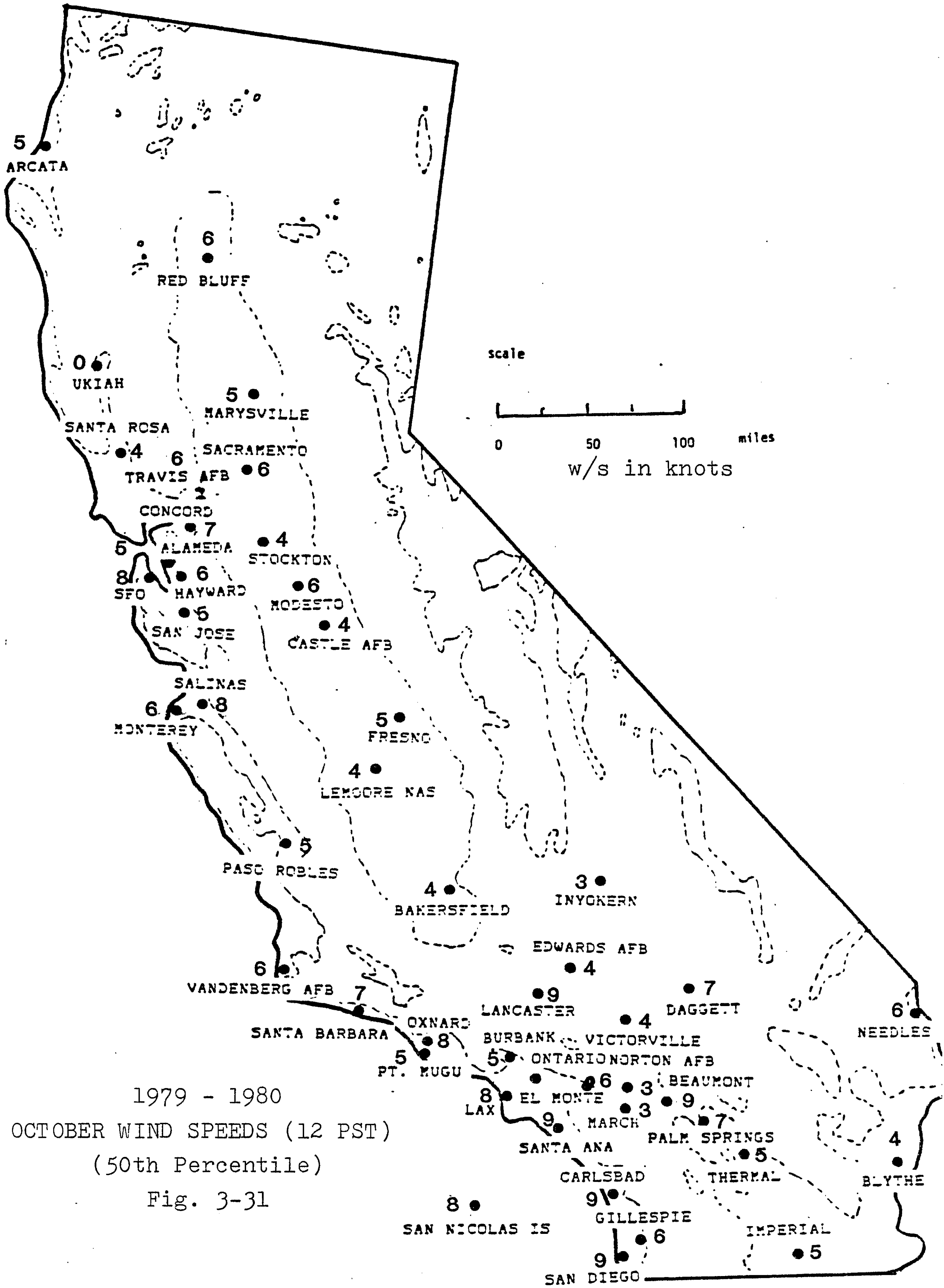
1979 - 1980
JULY WIND SPEEDS (12 PST)
(50th Percentile)
Fig. 3-28



1979 - 1980
JULY WIND SPEEDS (16 PST)
(50th Percentile)
Fig. 3-29



1979 - 1980
OCTOBER WIND SPEEDS (08 PST)
(50th Percentile)
Fig. 3-30

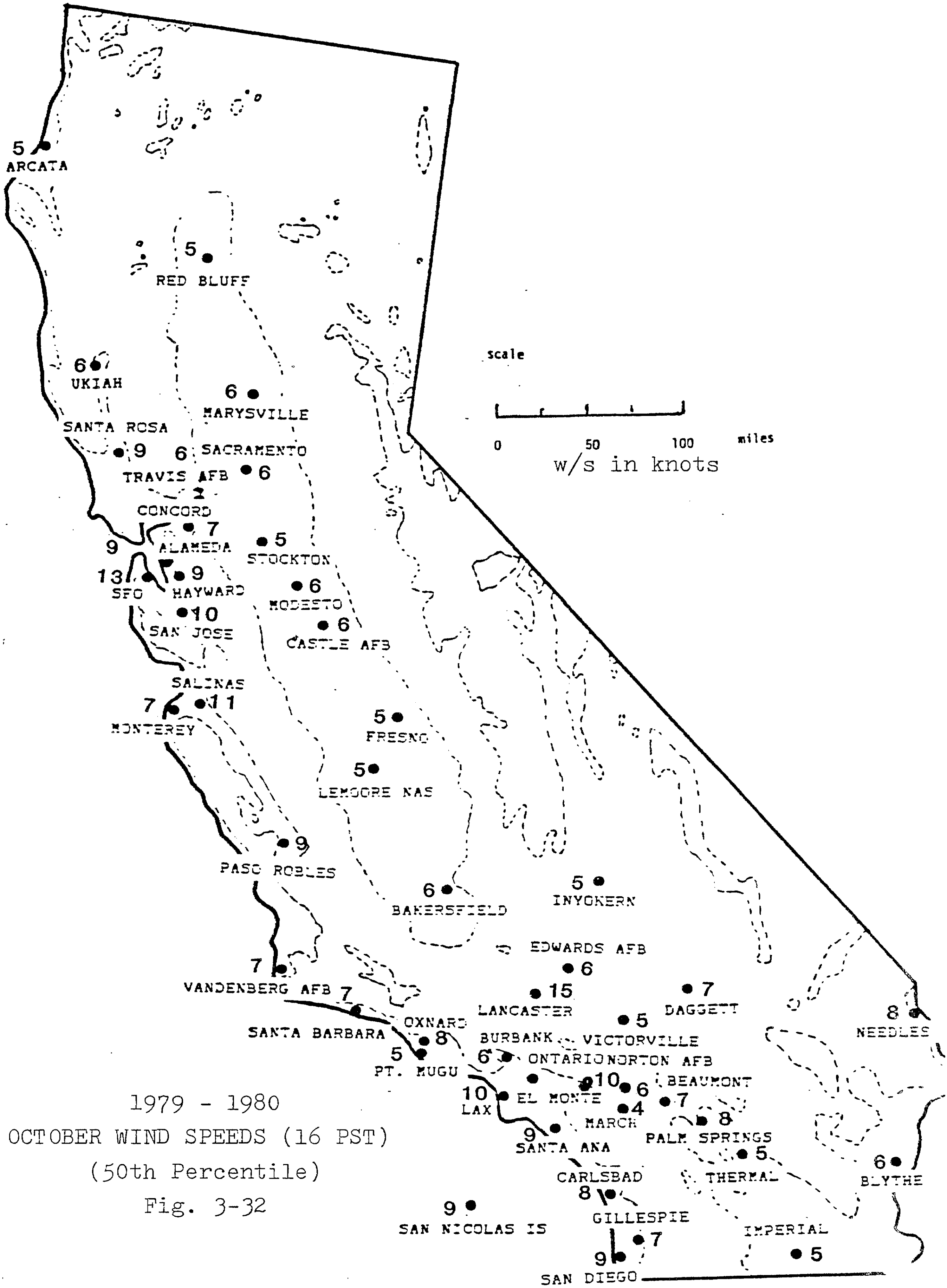


1979 - 1980

OCTOBER WIND SPEEDS (12 PST)

(50th Percentile)

Fig. 3-31



1979 - 1980

OCTOBER WIND SPEEDS (16 PST)

(50th Percentile)

Fig. 3-32

Table 3-1

Rank Order of Wind Speeds

January (08 PST)
1979-80

Rank		Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Alameda	0*	5
	Arcata	0	4
	Bakersfield	0	3
	Beaumont	0	2
	Blythe	0	3
	Burbank	0	3
	Carlsbad	0	6
	Castle AFB	0	2
	Concord	0	3
	Daggett	0	5
	Edwards AFB	0	2
	El Monte	0	2
	Fresno	0	4
	Gillespie Field	0	0
	Hayward	0	4
	Imperial	0	2
	Inyokern	0	1
	Lancaster	0	4
	Lemoore NAS	0	3
	March AFB	0	1
	Marysville	0	5
	Modesto	0	3
	Needles	0	5
	Norton AFB	0	2
	Palm Springs	0*	5
	Paso Robles	0	0
	Pt. Mugu	0	3
	Salinas	0	7
	San Diego	0	5
	San Francisco AP	0	5
	San Jose	0	4
	San Nicolas Is.	0	4
	Santa Ana	0	4
	Santa Barbara	0	0
	Santa Rosa	0	0
	Stockton	0	5
	Thermal	0	2
	Travis AFB	0	2
	Ukiah	0	0
	Vandenberg AFB	0	2
	Victorville	0	3
2.	LAX	2	5
	Red Bluff	2	6
	Sacramento	2	5
3.	Ontario	3	5
	Oxnard	3	6
4.	Monterey	4	6

* Less than 3 knots

Table 3-2

Rank Order of Wind Speeds

January (12 PST)
1979-80

Rank		Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Alameda	0*	5
	Arcata	0	5
	Bakersfield	0	5
	Beaumont	0	8
	Blythe	0	3
	Burbank	0	5
	Castle AFB	0	3
	Concord	0	6
	Daggett	0	6
	Edwards AFB	0	6
	El Monte	0	6
	Gillespie Field	0	5
	Hayward	0	6
	Imperial	0	6
	Inyokern	0	2
	Lancaster	0	8
	Lemoore NAS	0	3
	March AFB	0	3
	Modesto	0	3
	Needles	0	6
	Norton AFB	0	3
	Palm Springs	0	6
	Paso Robles	0	5
	San Jose	0	5
	Santa Barbara	0*	7
	Santa Rosa	0	0
	Thermal	0	5
	Travis AFB	0	5
	Ukiah	0	0
	Vandenberg AFB	0	6
	Victorville	0	7
2.	San Nicolas Is.	1	6
3.	Fresno	2	5
	Marysville	2	6
	Pt. Mugu	2	6
	Sacramento	2	6
	San Francisco AP	2	5
	Stockton	2	6
4.	LAX	3	6
	Monterey	3	5
	Ontario	3	6
	Oxnard	3	7
	Red Bluff	3	7
	Salinas	3	9
	Santa Ana	3	7
5.	Carlsbad	4	8
	San Diego	4	8

*Less than 3 knots

Table 3-3

Rank Order of Wind Speeds

January (16 PST)
1979-80

	Rank	Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Alameda	0*	5
	Arcata	0	7
	Beaumont	0	7
	Blythe	0	6
	Castle AFB	0	3
	Concord	0	6
	Edwards AFB	0	7
	El Monte	0	0
	Imperial	0	6
	Inyokern	0	3
	Lancaster	0	10
	Lemoore NAS	0	4
	March AFB	0	3
	Marysville	0	6
	Modesto	0	4
	Needles	0	7
	Norton AFB	0	4
	Palm Springs	0	5
	Paso Robles	0	6
	Red Bluff	0	6
	San Nicolas Is.	0	5
	Santa Rosa	0	5
	Thermal	0	5
	Ukiah	0	0
	Victorville	0	8
2.	Bakersfield	2	5
	Fresno	2	5
	Salinas	2	8
	Santa Barbara	2	6
	Stockton	2	6
	Travis AFB	2	6
3.	Burbank	3	7
	Hayward	3	7
	Ontario	3	7
	Sacramento	3	7
	San Francisco AP	3	6
	San Jose	3	7
	Vandenberg	3	6
4.	Carlsbad	4	7
	Daggett	4	8
	Gillespie Field	4	7
	Monterey	4	6
	Pt. Mugu	4	6
	San Diego	4	8
5.	LAX	5	8
6.	Santa Ana	6	8

* Less than 3 knots

Table 3-4

Rank Order of Wind Speeds

April (08 PST)
1979-80

Rank		Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Alameda	0*	4
	Arcata	0	4
	Bakersfield	0	4
	Beaumont	0	5
	Blythe	0	3
	Burbank	0	0
	Carlsbad	0	4
	Concord	0	6
	El Monte	0	0
	Edwards AFB	0	6
	Gillespie Field	0	4
	Hayward	0	4
	Imperial	0	5
	Inyokern	0	1
	Lancaster	0	10
	Lemoore NAS	0	5
	March AFB	0	0
	Marysville	0	7
	Modesto	0	5
	Monterey	0	4
	Needles	0	5
	Norton AFB	0	1
	Paso Robles	0	3
	Pt. Mugu	0*	2
	Salinas	0	5
	San Jose	0	4
	Santa Ana	0	4
	Santa Barbara	0	5
	Santa Rosa	0	0
	Travis AFB	0	6
	Ukiah	0	0
	Vandenberg AFB	0	5
	Victorville	0	4
2.	Castle AFB	1	5
	Ontario	1	5
3.	Fresno	2	6
	LAX	2	4
	Red Bluff	2	7
	Sacramento	2	6
	San Diego	2	5
	San Francisco AP	2	6
	San Nicolas Is.	2	10
	Thermal	2	6
4.	Palm Springs	3	6
	Stockton	3	6
5.	Daggett	5	10

* Less than 3 knots

Table 3-5

Rank Order of Wind Speeds

April (12 PST)
1979-80

Rank		Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Blythe	0*	5
	Edwards AFB	0	6
	Imperial	0	5
	Lancaster	0	12
	Lemoore NAS	0	6
	March AFB	0	2
	Modesto	0	6
	Needles	0	7
	Paso Robles	0	5
	Santa Rosa	0	7
	Travis AFB	0	5
	Ukiah	0	6
2.	Castle AFB	1	5
	Inyokern	1	4
	Norton AFB	1	4
	Victorville	1	4
3.	Concord	2	8
	Red Bluff	2	7
	Sacramento	2	7
	Thermal	2	7
4.	Alameda	3	7
	Bakersfield	3	5
	Burbank	3	5
	Daggett	3	8
	Fresno	3	6
	Marysville	3	7
	Pt. Mugu	3	7
	San Nicolas Is.	3	9
5.	Arcata	4	7
	El Monte	4	6
	Gillespie Field	4	7
	Ontario	4	8
	Salinas	4	9
	Stockton	4	8
6.	Beaumont	5	8
	Carlsbad	5	9
	Hayward	5	9
	Monterey	5	8
	Palm Springs	5	8
	San Francisco AP	5	11
	San Jose	5	9
	Santa Barbara	5	7
	Vandenberg AFB	5	12
7.	Oxnard	6	9
	Santa Ana	6	9
8.	LAX	7	10
	San Diego	7	10

* Less than 3 knots

Table 3-6

Rank Order of Wind Speeds

April (16 PST)
1979-80

Rank		Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots			Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Edwards AFB	0*	11		Lancaster	5	16
	Paso Robles	0	9		Monterey	5	9
2.	Victorville	1	8		Needles	5	9
3.	Blythe	2	7		Palm Springs	5	13
	Castle AFB	2	6		Santa Barbara	5	8
	Imperial	2	6		Stockton	5	9
	Inyokern	2	8		Travis AFB	5	9
	March AFB	2	5		Vandenberg AFB	5	10
	Norton AFB	2	7	7.	Alameda	6	12
4.	Daggett	3	9		Carlsbad	6	9
	Fresno	3	6		Gillespie Field	6	9
	Lemoore NAS	3	7		Oxnard	6	10
	Marysville	3	8	8.	El Monte	7	9
	Modesto	3	7		LAX	7	11
	Red Bluff	3	8		Pt. Mugu	7	7
	Sacramento	3	8		San Diego	7	10
	Thermal	3	8		San Jose	7	12
5.	Arcata	4	9		Santa Rosa	7	9
	Bakersfield	4	7	9.	Ontario	8	12
	San Nicolas Is.	4	12		Salinas	8	12
	Ukiah	4	8		Santa Ana	8	9
6.	Beaumont	5	7	10.	Hayward	9	14
	Burbank	5	8		San Francisco AP	9	15
	Concord	5	10				

*Less than 3 knots

Table 3-7

Rank Order of Wind Speeds

July (08 PST)
1979-80

Rank		Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Alameda	0*	4
	Arcata	0	3
	Bakersfield	0	4
	Beaumont	0	5
	Blythe	0	5
	Burbank	0	3
	Carlsbad	0	5
	Castle AFB	0	6
	Concord	0	7
	Edwards AFB	0	5
	El Monte	0	3
	Gillespie Field	0	0
	Hayward	0	5
	Imperial	0	6
	Inyokern	0	1
	Lancaster	0	6
	March AFB	0	0
	Marysville	0	6
	Monterey	0	2
	Needles	0	9
	Norton AFB	0	0
	Ontario	0	4
	Oxnard	0	4
	Palm Springs	0	5
	Paso Robles	0*	2
	Pt. Mugu	0	3
	Salinas	0	3
	San Jose	0	4
	Santa Barbara	0	5
	Santa Rosa	0	0
	Thermal	0	5
	Ukiah	0	0
	Vandenberg AFB	0	1
	Victorville	0	3
2.	Daggett	2	9
	LAX	2	5
	Lemoore NAS	2	5
	Modesto	2	6
	Sacramento	2	6
	San Nicolas Is.	2	9
	Santa Ana	2	5
	Stockton	2	5
3.	Fresno	3	5
	Red Bluff	3	7
	San Diego	3	6
	San Francisco AP	3	7
4.	Travis AFB	4	12

*Less than 3 knots

Table 3-8

Rank Order of Wind Speeds

July (12 PST)
1979-80

Rank		Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Blythe	0*	7
	Edwards AFB	0	6
	Imperial	0	6
	Needles	0	7
	Paso Robles	0	6
	Thermal	0	6
	Ukiah	0	5
	Victorville	0	5
2.	Inyokern	1	4
	Norton AFB	1	4
3.	Lemoore NAS	2	6
	March AFB	2	4
	Modesto	2	7
	Santa Rosa	2	6
4.	Bakersfield	3	6
	Burbank	3	7
	Castle AFB	3	6
	Fresno	3	5
	Red Bluff	3	7
	Sacramento	3	7
	Travis AFB	3	10
5.	Alameda	4	8
	Arcata	4	7
	Beaumont	4	7
	Daggett	4	7
	El Monte	4	6
	Gillespie Field	4	7
	Lancaster	4	12
	Marysville	4	7
	Monterey	4	7
	Palm Springs	4	7
	San Jose	4	8
	Santa Barbara	4	7
	Stockton	4	6
	Vandenberg AFB	4	9
6.	Concord	5	9
	Ontario	5	8
	Pt. Mugu	5	7
	San Nicolas Is.	5	10
7.	Carlsbad	6	9
	Hayward	6	9
	Oxnard	6	8
8.	LAX	7	9
	San Diego	7	9
	San Francisco AP	7	12
	Santa Ana	7	10
9.	Salinas	8	10

*Less than 3 knots

Table 3-9

Rank Order of Wind Speeds

July (16 PST)
1979-80

Rank		Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Blythe	3	7
	Castle AFB	3	7
	Inyokern	3	9
	Sacramento	3	8
2.	Arcata	4	7
	Beaumont	4	7
	Daggett	4	10
	Fresno	4	7
	Imperial	4	7
	March AFB	4	6
	Marysville	4	10
	Needles	4	9
	Thermal	4	6
	Victorville	4	10
3.	Bakersfield	5	8
	Gillespie Field	5	8
	Lemoore NAS	5	8
	Modesto	5	10
	Monterey	5	8
	Norton AFB	5	8
	Red Bluff	5	7
	San Diego	5	9
	San Nicolas Is.	5	12
	Santa Barbara	5	8
	Vandenberg AFB	5	9
4.	Alameda	6	11
	Burbank	6	9
	Carlsbad	6	8
	Oxnard	6	9
	Palm Springs	6	12
	Paso Robles	6	13
	Pt. Mugu	6	7
	Stockton	6	8
	Travis AFB	6	10
	Ukiah	6	9
5.	Edwards AFB	7	12
	El Monte	7	9
6.	Concord	8	11
	Hayward	8	11
	LAX	8	11
	San Jose	8	12
	Santa Ana	8	11
	Santa Rosa	8	11
7.	Salinas	9	12
	Ontario	9	12
8.	San Francisco AP	12	17
9.	Lancaster	14	19

Table 3-10

Rank Order of Wind Speeds

October (08 PST)
1979-80

Rank	Station	Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Alameda	0*	3
	Arcata	0	0
	Bakersfield	0	3
	Beaumont	0	4
	Blythe	0	0
	Burbank	0	0
	Carlsbad	0	4
	Castle AFB	0	4
	Concord	0	4
	Edwards AFB	0	1
	El Monte	0	-
	Fresno	0	4
	Gillespie Field	0	0
	Hayward	0	3
	Imperial	0	5
	Inyokern	0	0
	Lancaster	0	0
	LAX	0	3
	Lemoore NAS	0	2
	March AFB	0	0
	Marysville	0	5
	Modesto	0	4
	Monterey	0	3
	Needles	0	0
	Norton AFB	0	0
	Ontario	0*	3
	Oxnard	0	4
	Palm Springs	0	5
	Paso Robles	0	0
	Pt. Mugu	0	1
	Red Bluff	0	5
	Sacramento	0	4
	Salinas	0	5
	San Diego	0	4
	San Francisco AP	0	4
	San Jose	0	2
	San Nicolas Is.	0	5
	Santa Barbara	0	3
	Santa Rosa	0	0
	Stockton	0	2
	Thermal	0	4
	Travis AFB	0	3
	Ukiah	0	0
	Vandenberg AFB	0	2
	Victorville	0	2
2.	Daggett	4	9

*Less than 3 knots

Table 3-11

Rank Order of Wind Speeds

October (12 PST)
1979-80

Rank		Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Arcata	0*	5
	Bakersfield	0	4
	Blythe	0	4
	Burbank	0	5
	Daggett	0	7
	Edwards AFB	0	4
	Gillespie Field	0	6
	Hayward	0	6
	Imperial	0	5
	Inyokern	0	3
	Lemoore NAS	0	4
	March AFB	0	3
	Modesto	0	6
	Needles	0	6
	Norton AFB	0	3
	Paso Robles	0	5
	Red Bluff	0	6
	Salinas	0	8
	San Jose	0	5
	Santa Rosa	0	4
	Ukiah	0	0
	Victorville	0	4
2.	Castle AFB	1	4
	Ontario	1	6
	Thermal	1	5
3.	Alameda	2	5
	Concord	2	7
	Fresno	2	5
	Lancaster	2	9
	Pt. Mugu	2	5
	San Nicolas Is.	2	8
	Travis AFB	2	6
4.	Marysville	3	5
	Monterey	3	6
	Oxnard	3	8
	Sacramento	3	6
	Stockton	3	4
	Vandenberg AFB	3	6
5.	Palm Springs	4	7
	San Francisco AP	4	8
	Santa Barbara	4	7
6.	Beaumont	5	9
	Carlsbad	5	9
	San Diego	5	9
	Santa Ana	5	9
7.	LAX	6	8

* Less than 3 knots

Table 3-12

Rank Order of Wind Speeds

October (16 PST)
1979-80

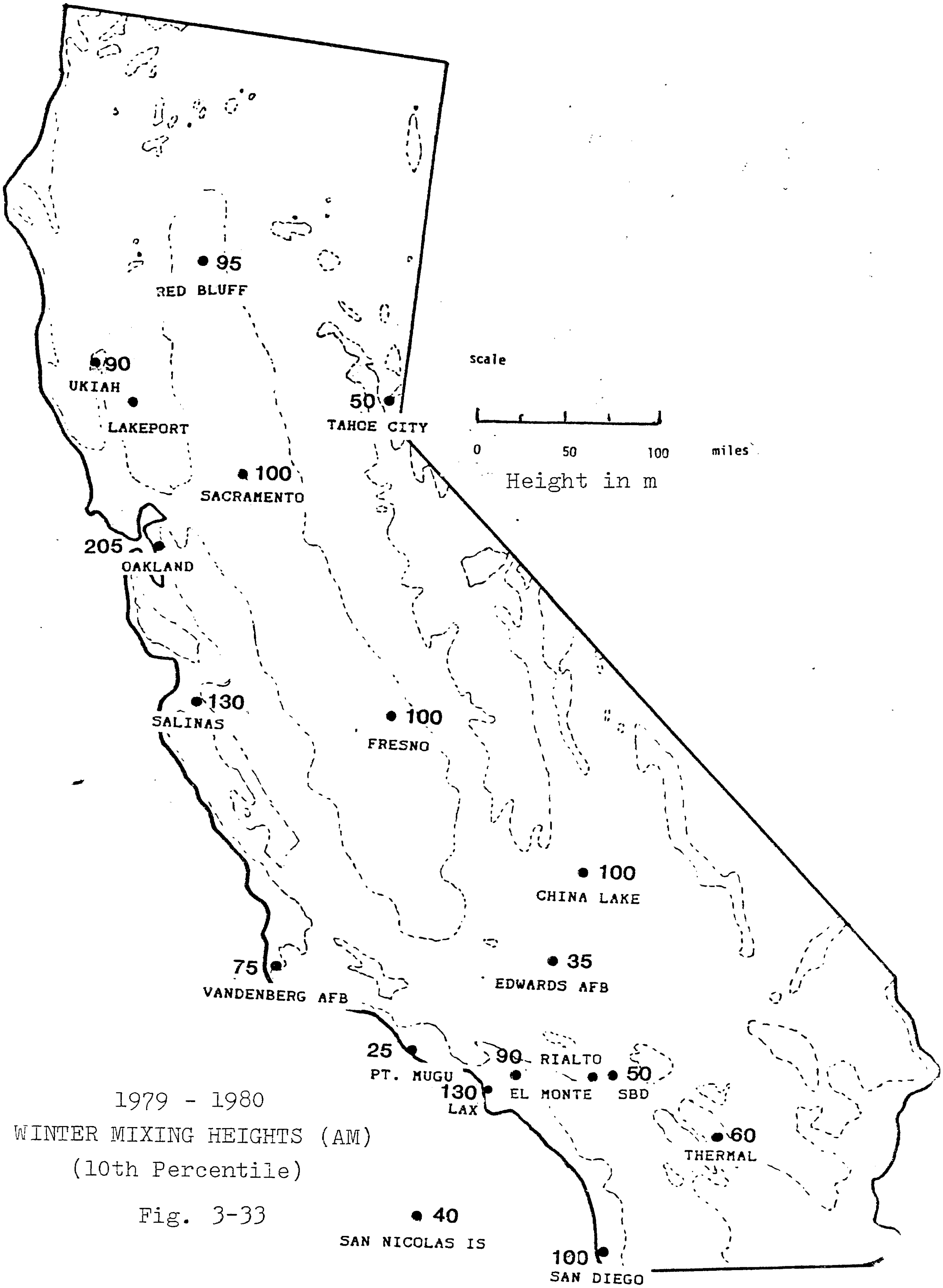
Rank		Percentile 10th Wind Speed Knots	Percentile 50th Wind Speed Knots
1.	Blythe	0*	6
	Castle AFB	0	6
	Edwards AFB	0	6
	Imperial	0	5
	Inyokern	0	5
	Lemoore NAS	0	5
	Marysville	0	6
	Modesto	0	6
	Needles	0	8
	Ukiah	0	6
	Victorville	0	5
2.	March AFB	1	4
3.	Arcata	2	5
	Lancaster	2	15
	Monterey	2	7
	Norton AFB	2	6
	Pt. Mugu	2	5
	Sacramento	2	6
	San Nicolas Is.	2	9
	Thermal	2	5
	Vandenberg AFB	2	7
4.	Bakersfield	3	6
	Concord	3	7
	Fresno	3	5
	Red Bluff	3	5
	Santa Barbara	3	7
	Stockton	3	5
	Travis AFB	3	6
5.	Alameda	4	9
	Beaumont	4	7
	Burbank	4	6
	Daggett	4	7
	Oxnard	4	8
	Palm Springs	4	8
	Paso Robles	4	9
6.	Carlsbad	5	8
	Gillespie Field	5	7
	Ontario	5	10
	San Diego	5	9
	Santa Ana	5	9
	Santa Rosa	5	9
7.	Hayward	6	9
	LAX	6	10
	San Francisco AP	6	13
	San Jose	6	10
8.	Salinas	8	11

* Less than 3 knots

summarizations are more variable than might be expected in reality.

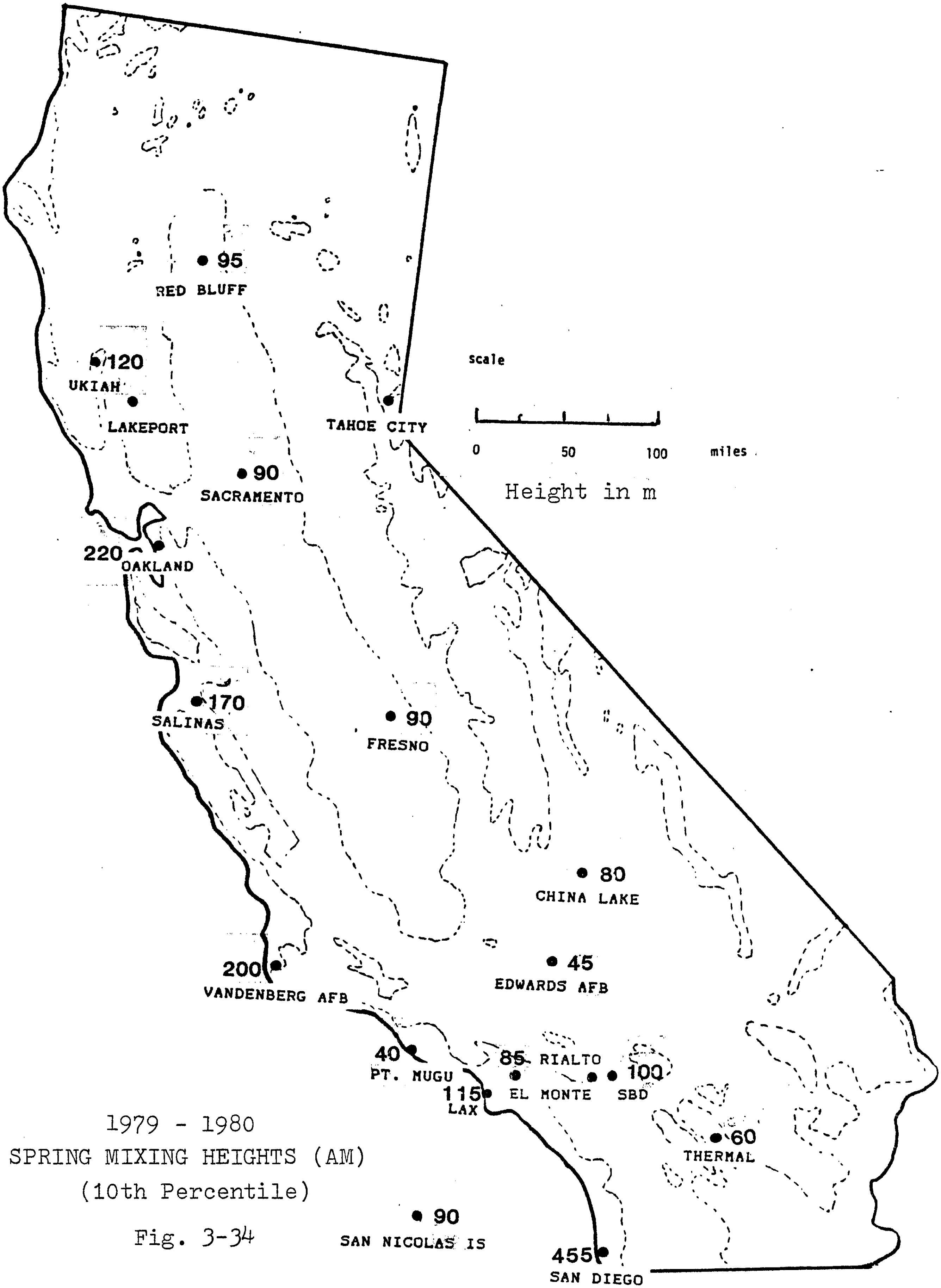
Low mixing heights are of primary interest in air pollution work. Data are plotted in map form in terms of the lowest 10th percentile for the morning and afternoon estimates. Since there were more morning soundings than afternoon, the afternoon estimates were based on the morning sounding and the afternoon maximum temperature. Due to the data gaps, data for December, January, February, etc. were summarized together to produce a seasonal estimate.

Tenth percentile data for morning and afternoon for the four seasons are presented in Figs. 3-33 through 3-40. 50th percentile data are given in Figs. 3-41 through 3-48 and in the Appendix. Tables 3-13 through 3-20 give the rank order of the 10th and 50th percentile mixing heights for the stations appearing in the figures.



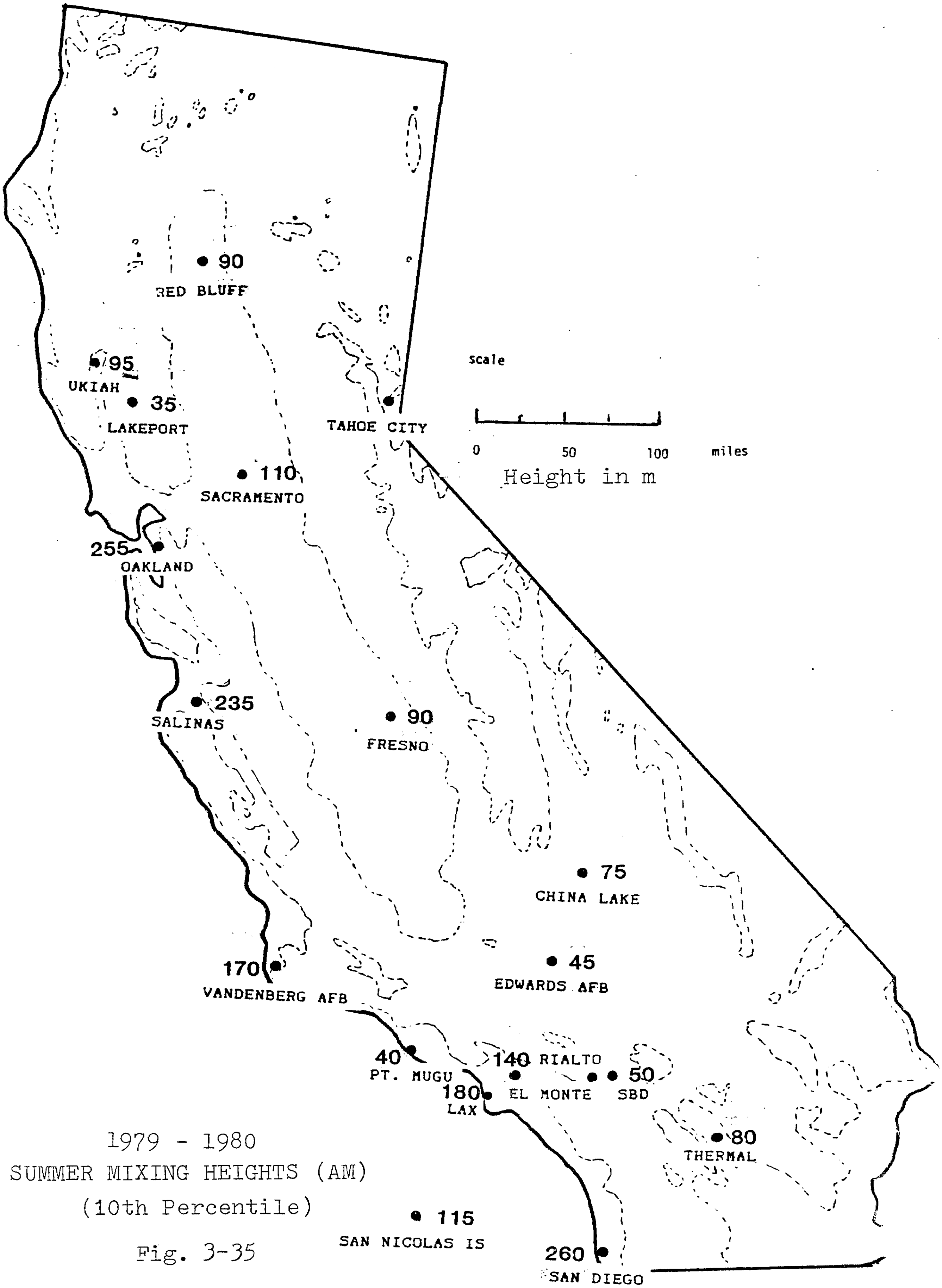
1979 - 1980
WINTER MIXING HEIGHTS (AM)
(10th Percentile)

Fig. 3-33



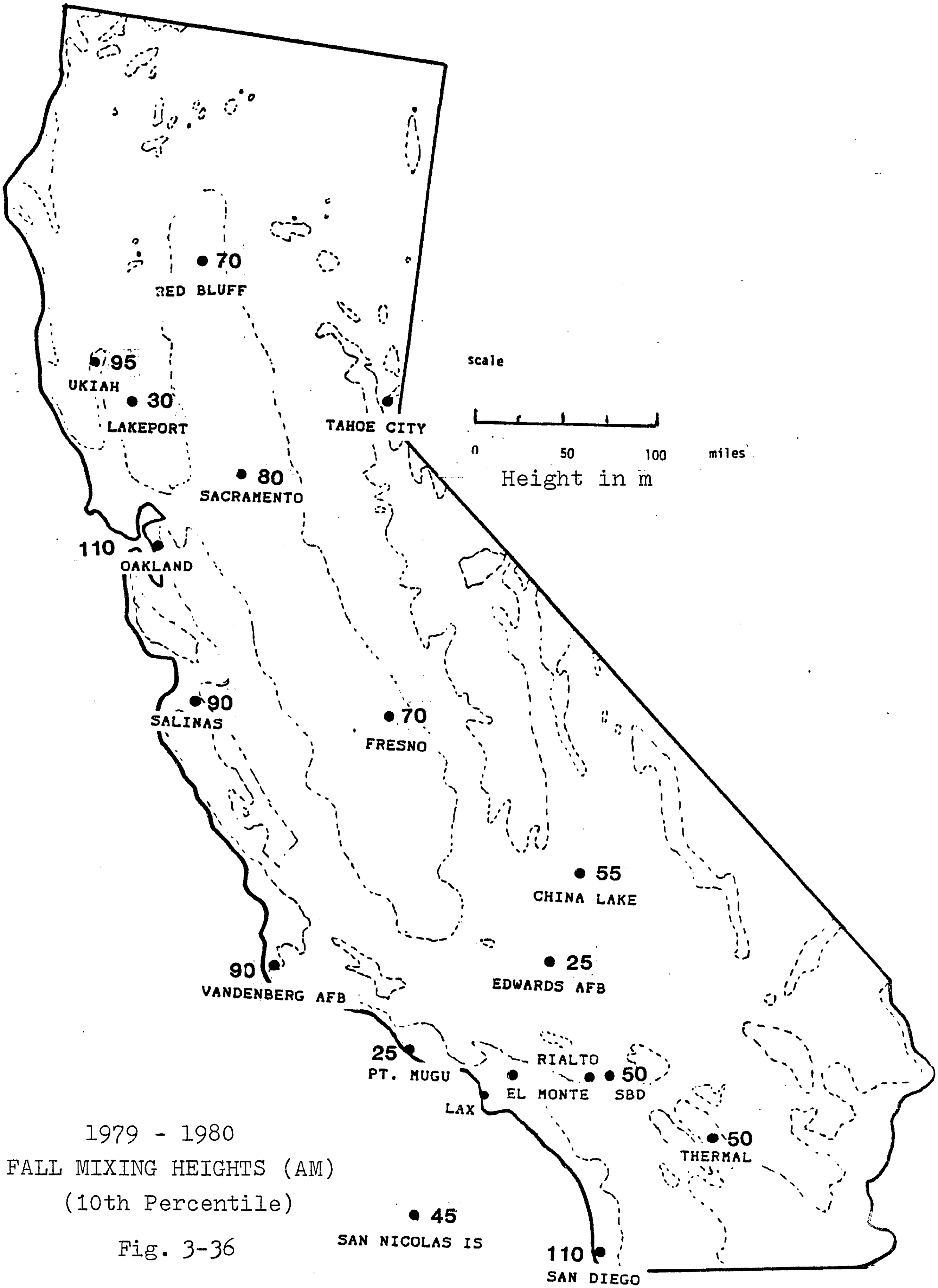
1979 - 1980
SPRING MIXING HEIGHTS (AM)
(10th Percentile)

Fig. 3-34



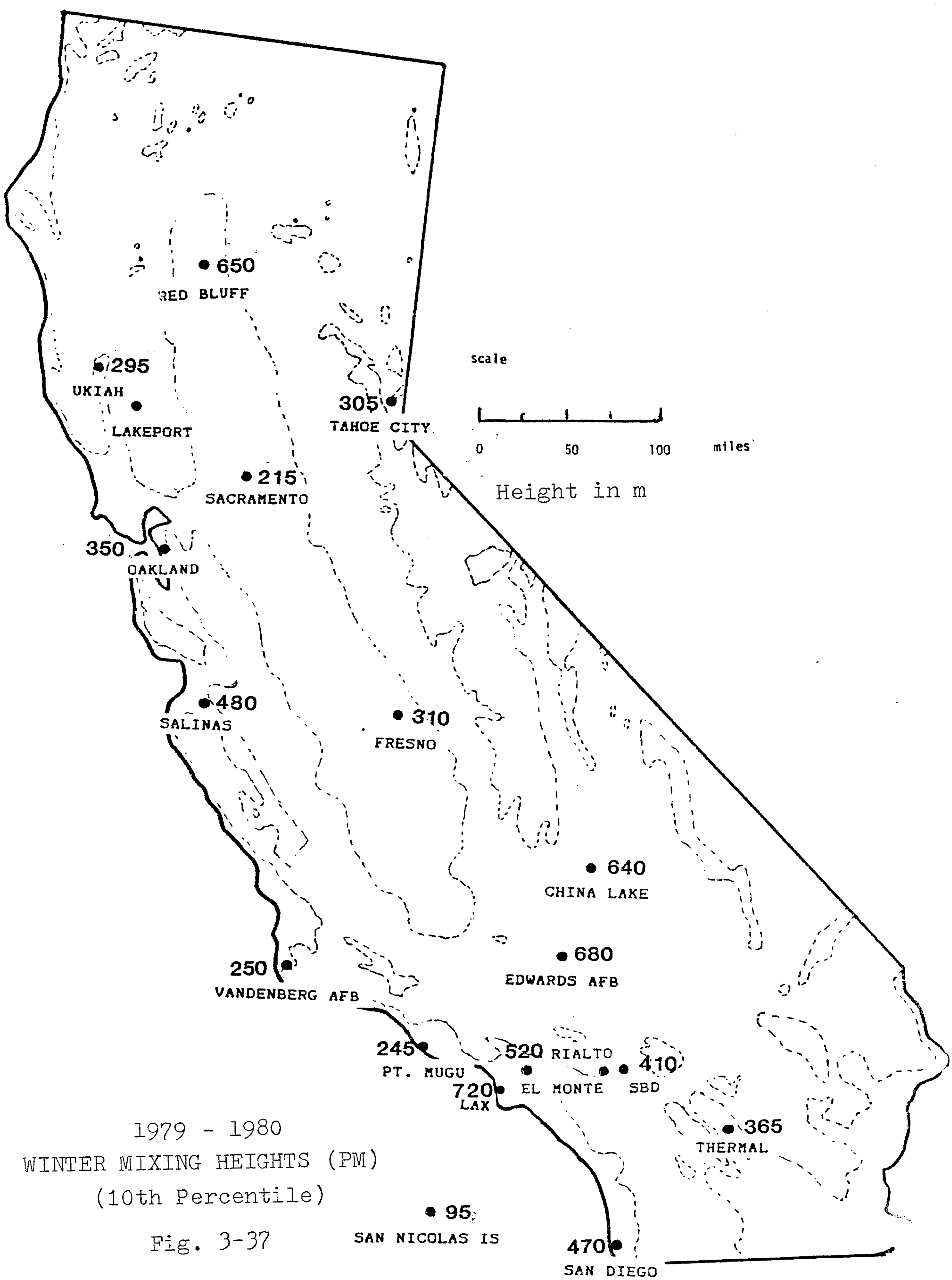
1979 - 1980
SUMMER MIXING HEIGHTS (AM)
(10th Percentile)

Fig. 3-35



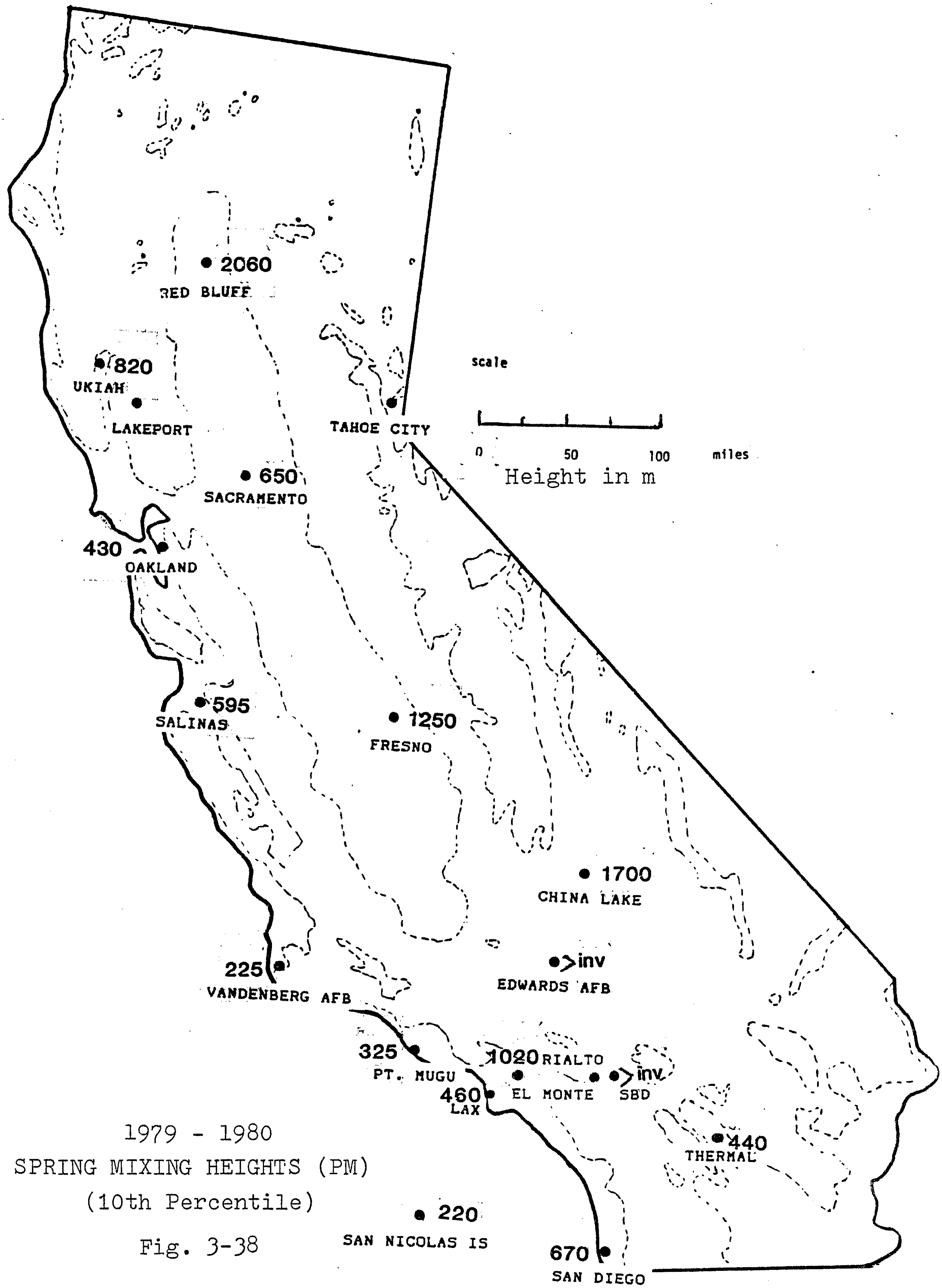
1979 - 1980
FALL MIXING HEIGHTS (AM)
(10th Percentile)

Fig. 3-36



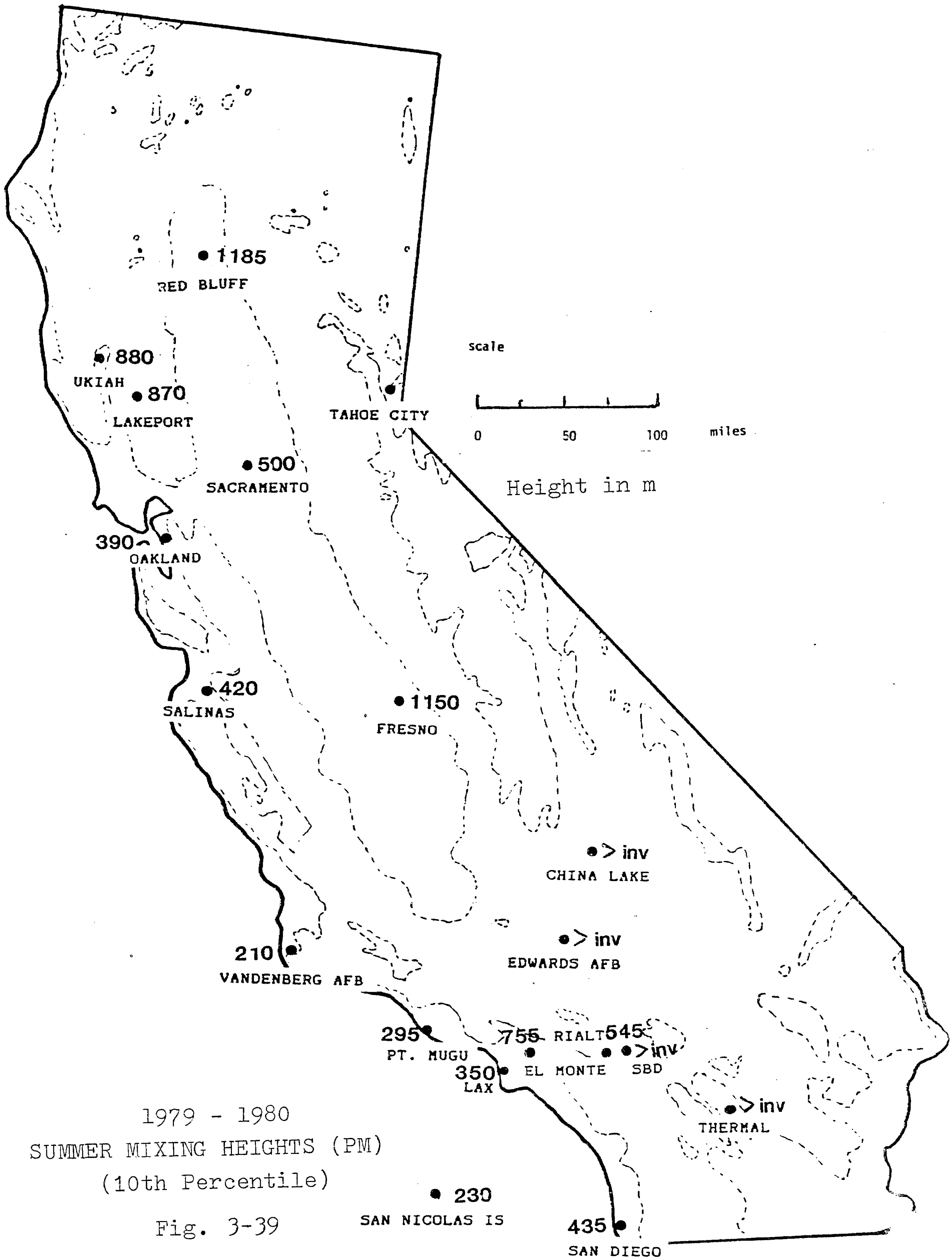
1979 - 1980
WINTER MIXING HEIGHTS (PM)
(10th Percentile)

Fig. 3-37



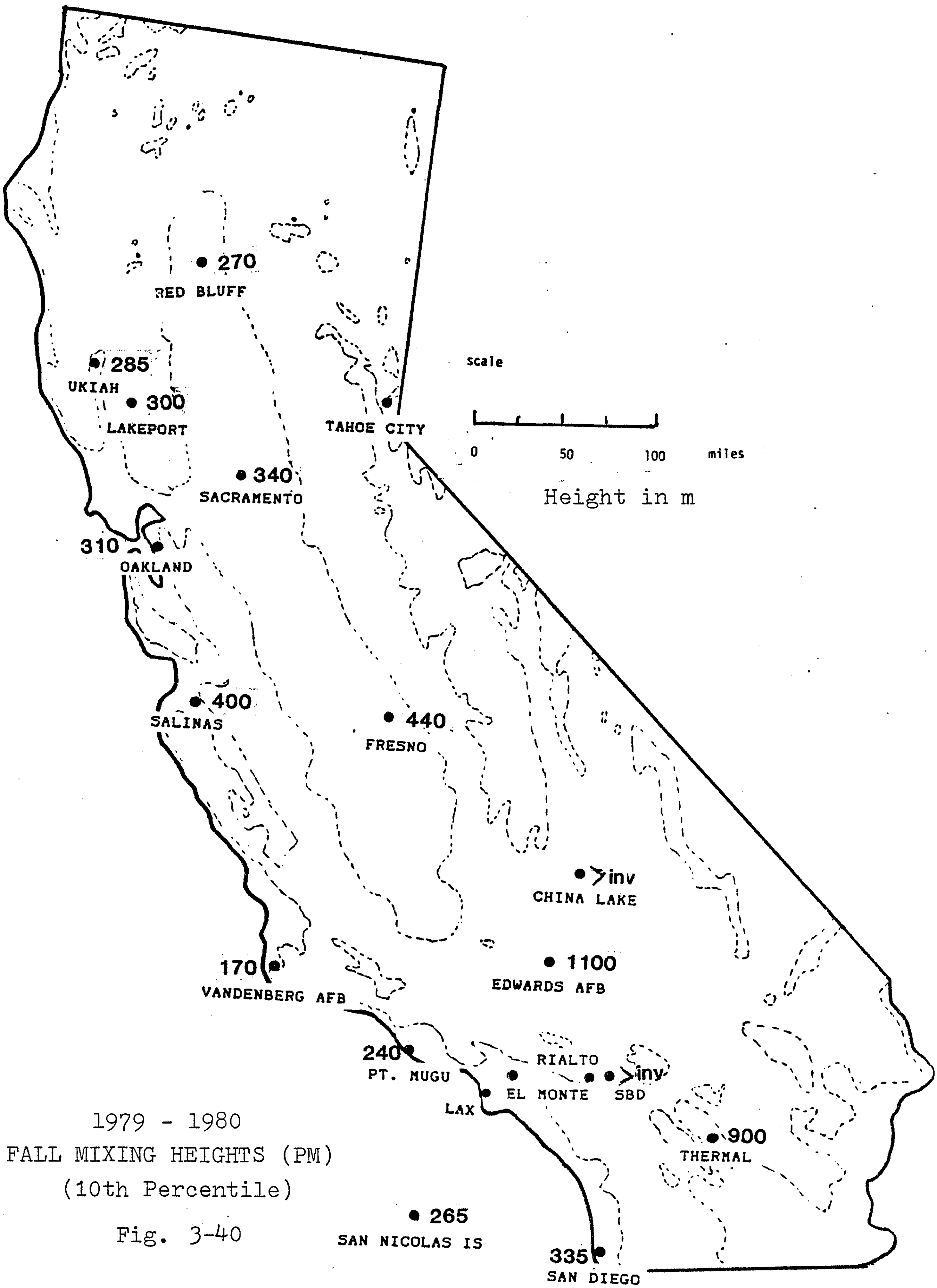
1979 - 1980
SPRING MIXING HEIGHTS (PM)
(10th Percentile)

Fig. 3-38



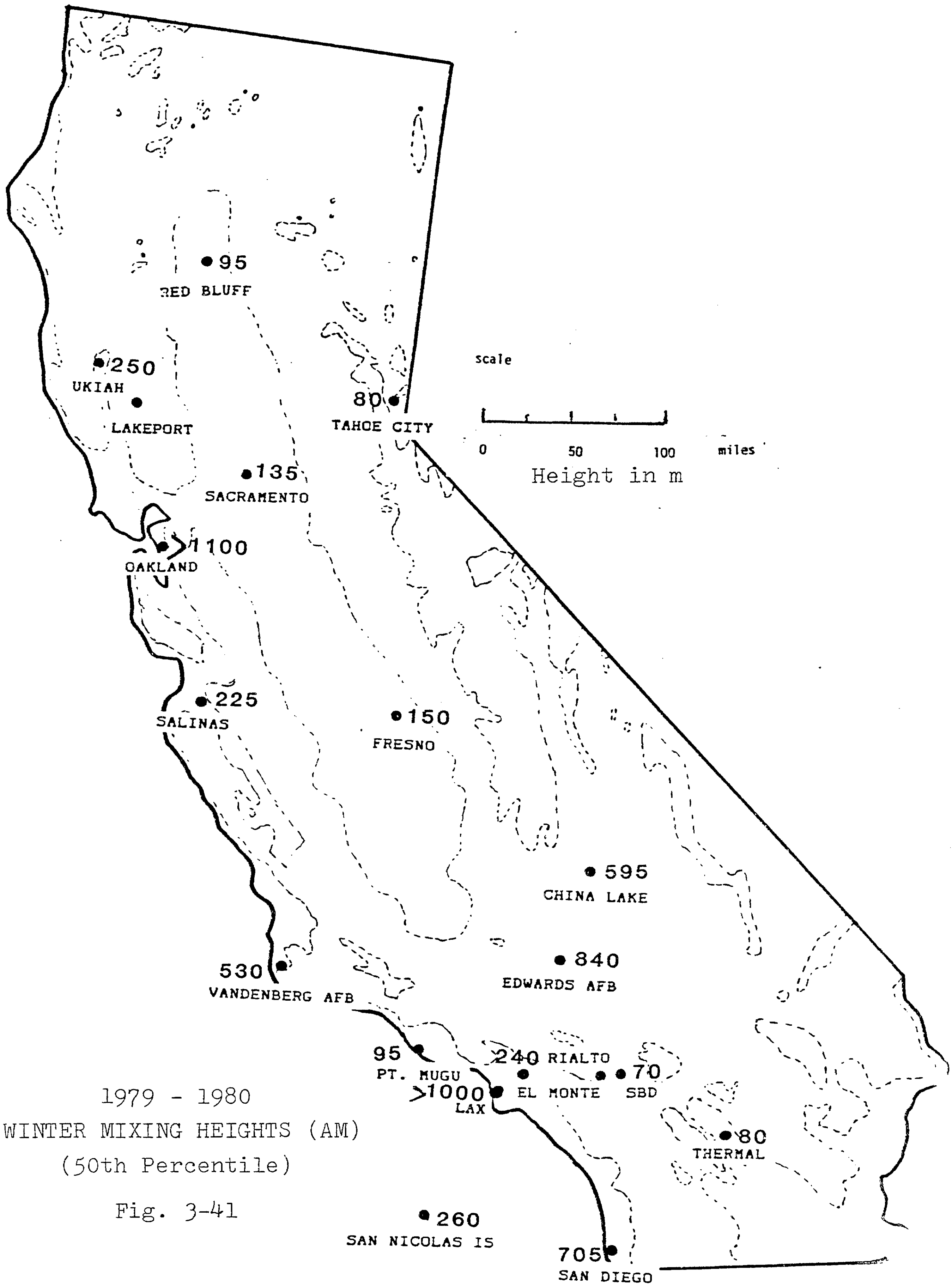
1979 - 1980
SUMMER MIXING HEIGHTS (PM)
(10th Percentile)

Fig. 3-39



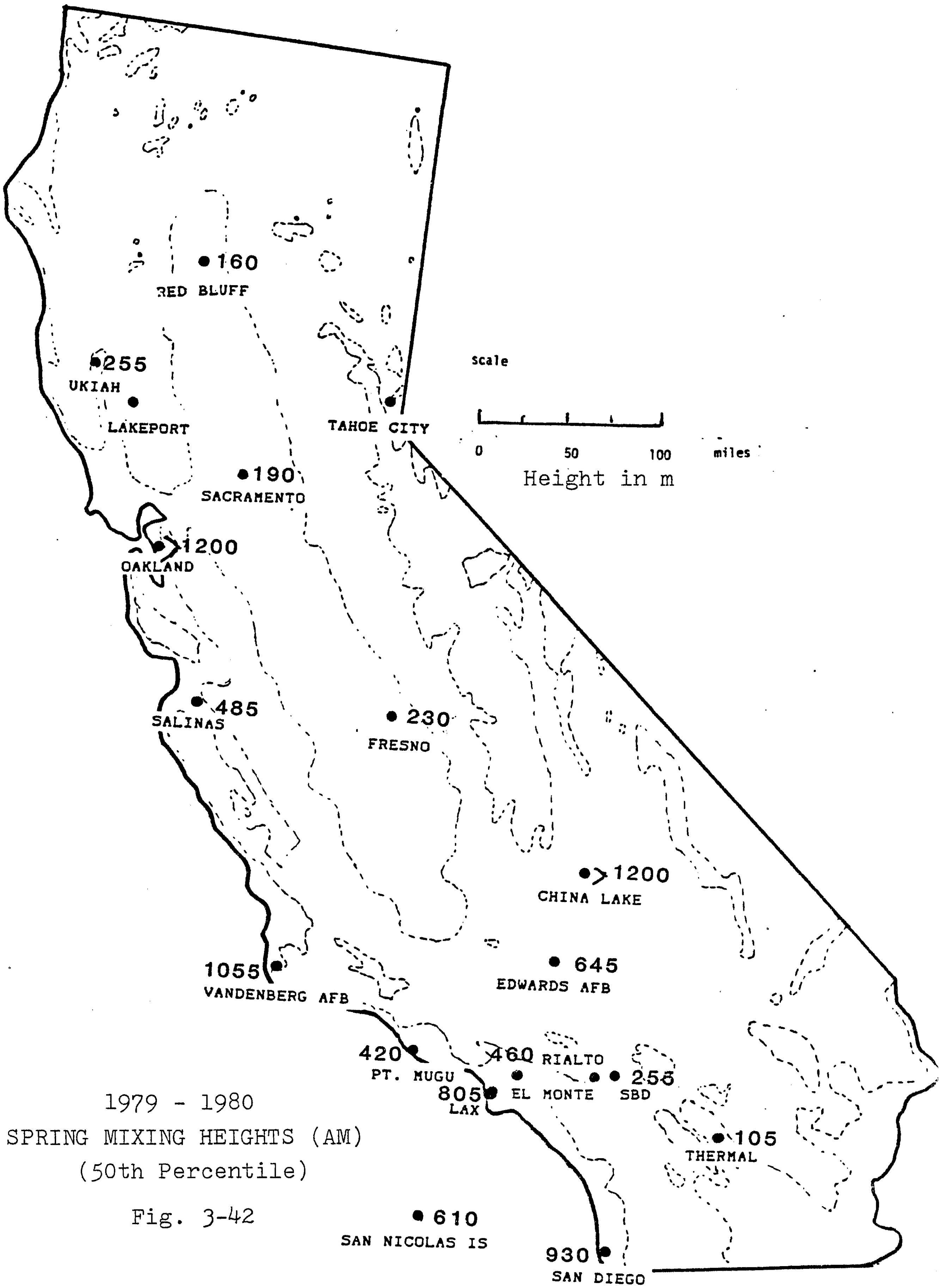
1979 - 1980
FALL MIXING HEIGHTS (PM)
(10th Percentile)

Fig. 3-40



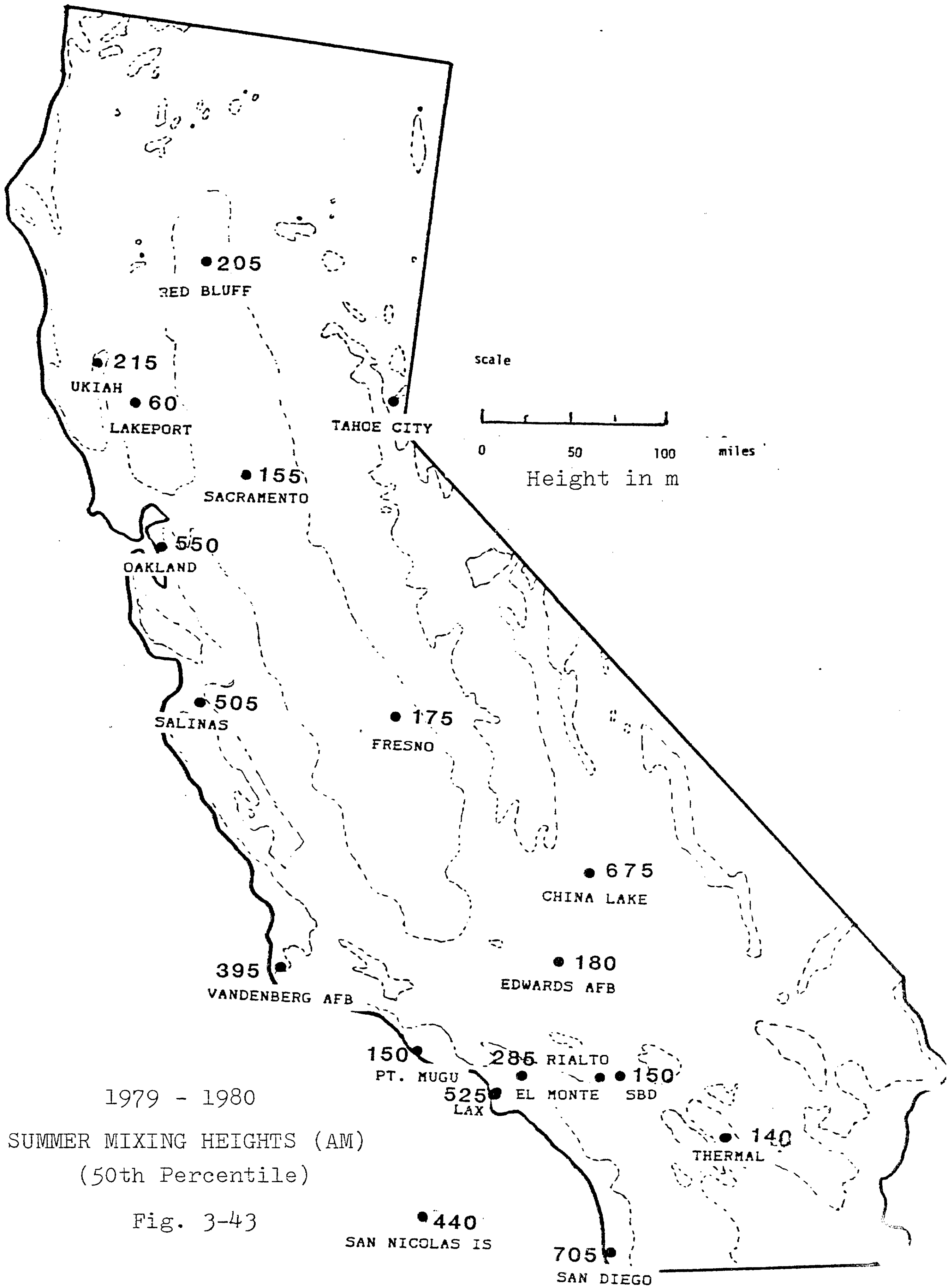
1979 - 1980
WINTER MIXING HEIGHTS (AM)
(50th Percentile)

Fig. 3-41



1979 - 1980
SPRING MIXING HEIGHTS (AM)
(50th Percentile)

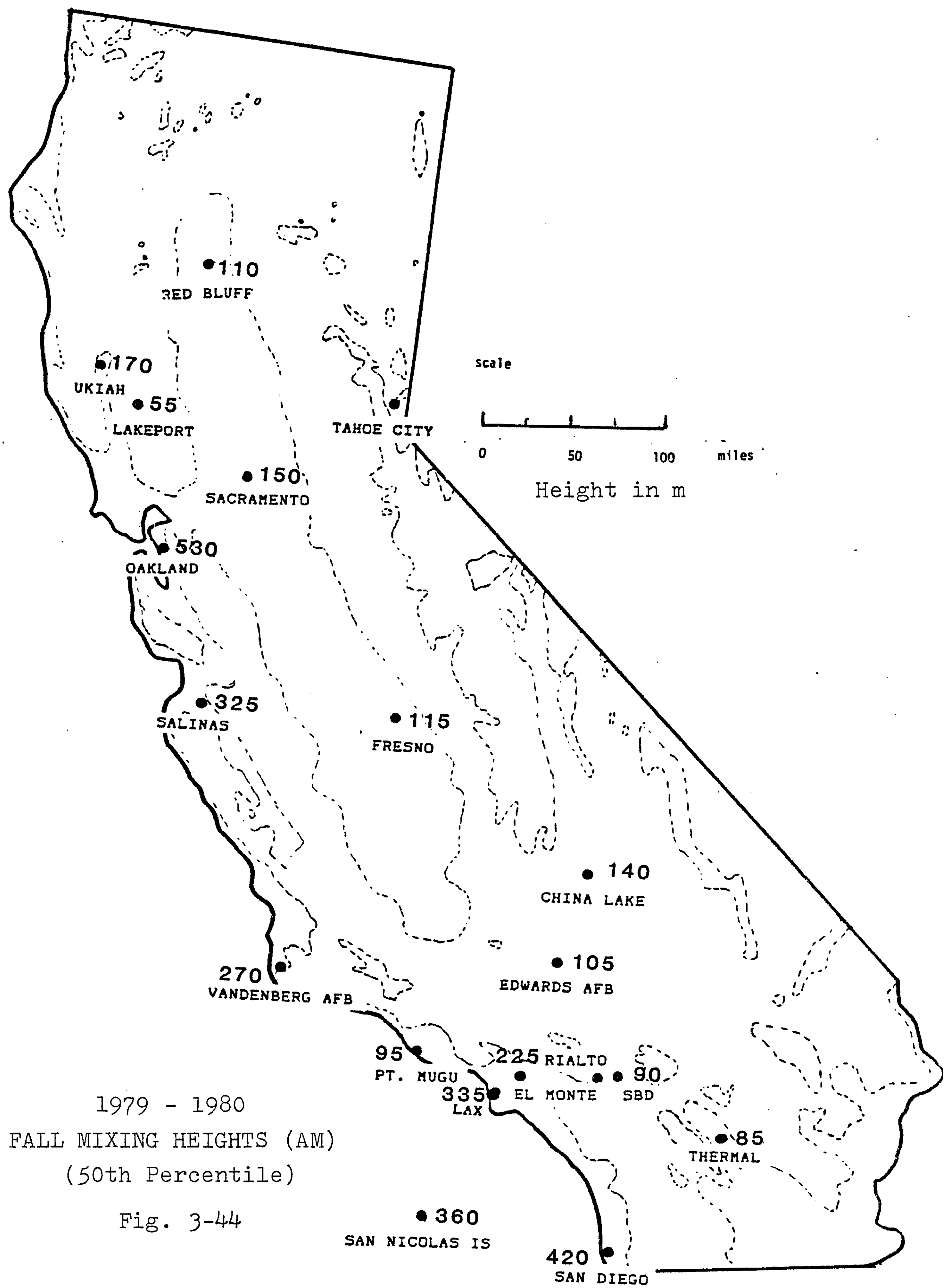
Fig. 3-42



1979 - 1980

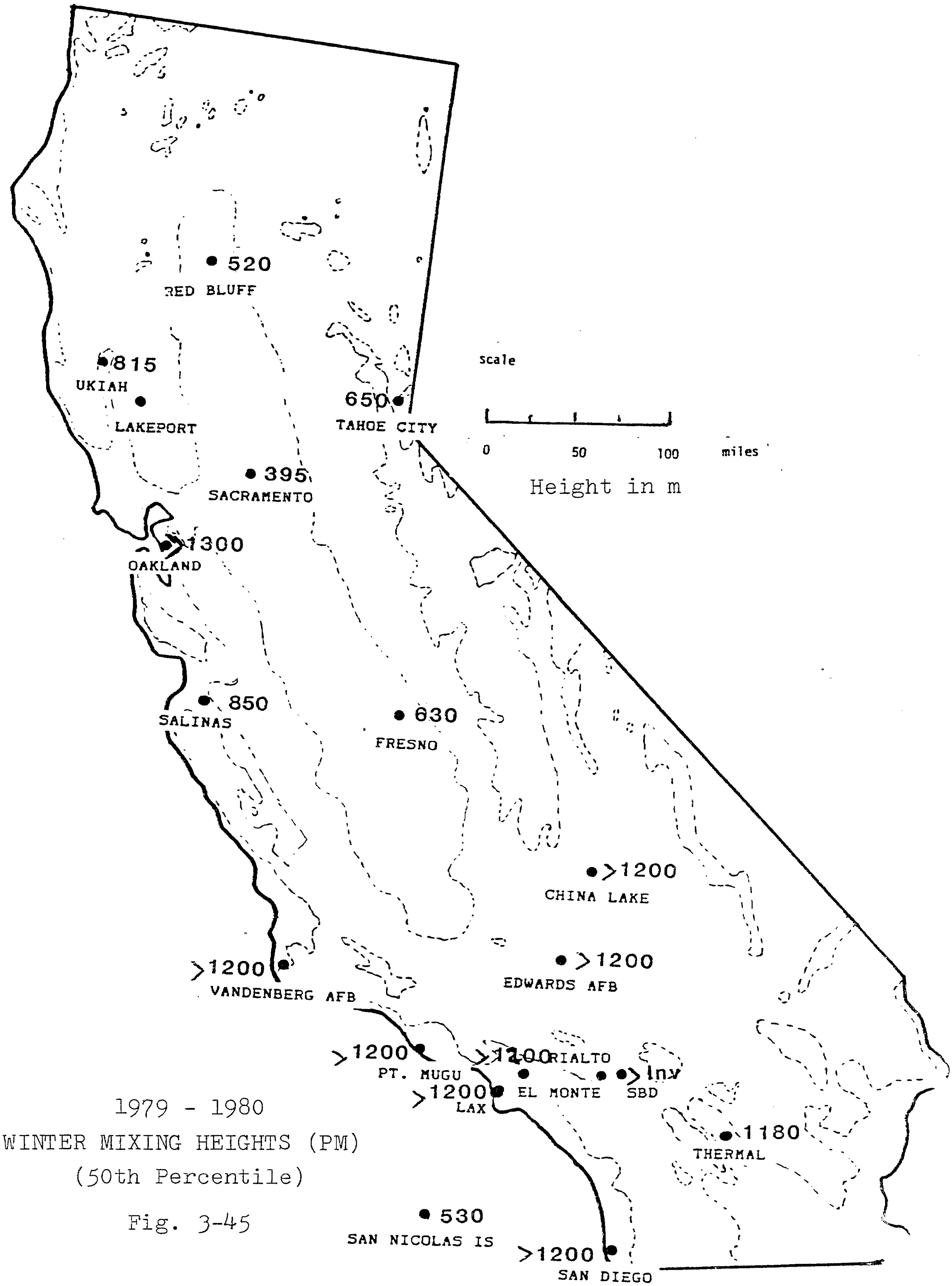
SUMMER MIXING HEIGHTS (AM)
(50th Percentile)

Fig. 3-43



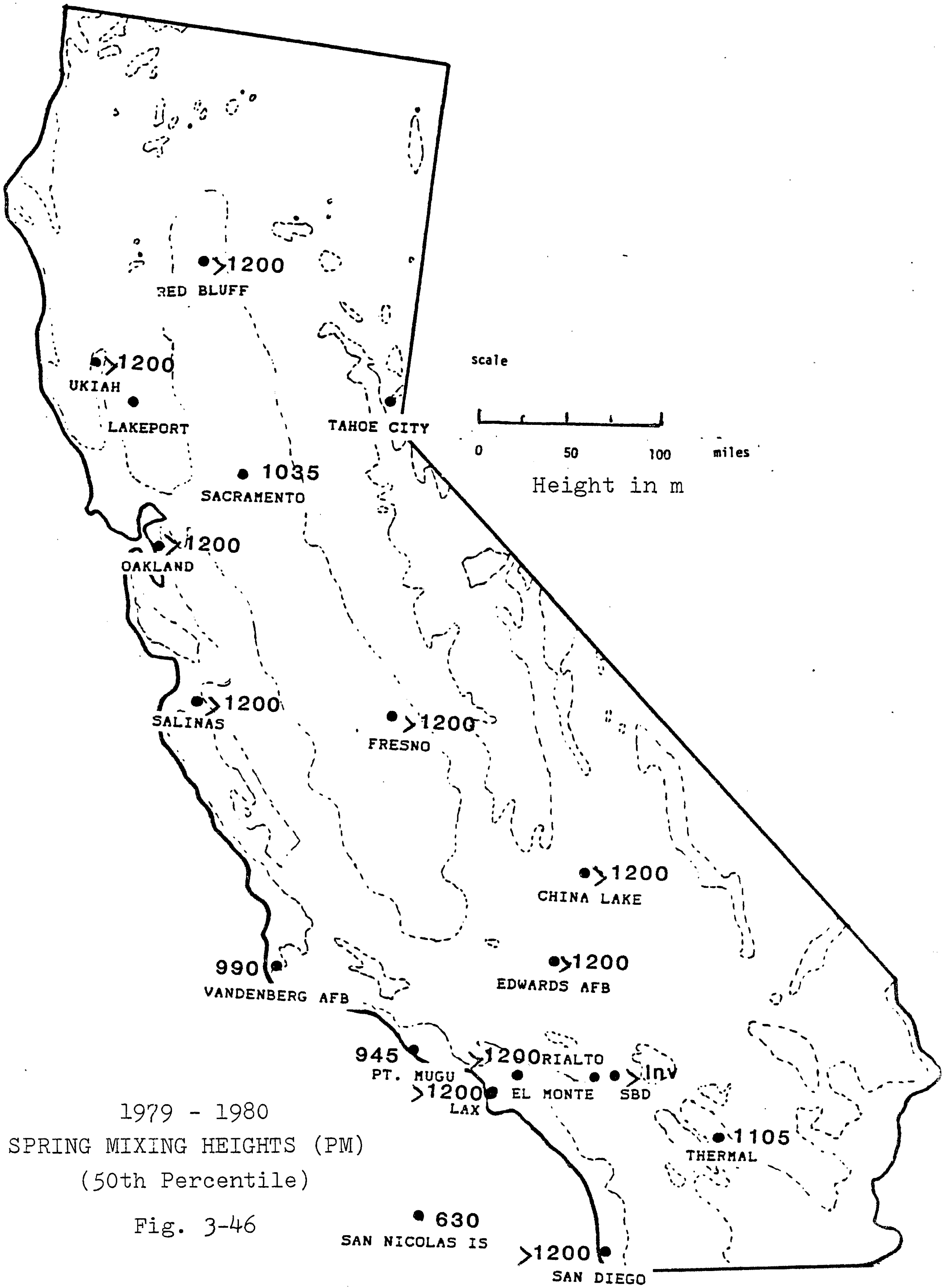
1979 - 1980
FALL MIXING HEIGHTS (AM)
(50th Percentile)

Fig. 3-44



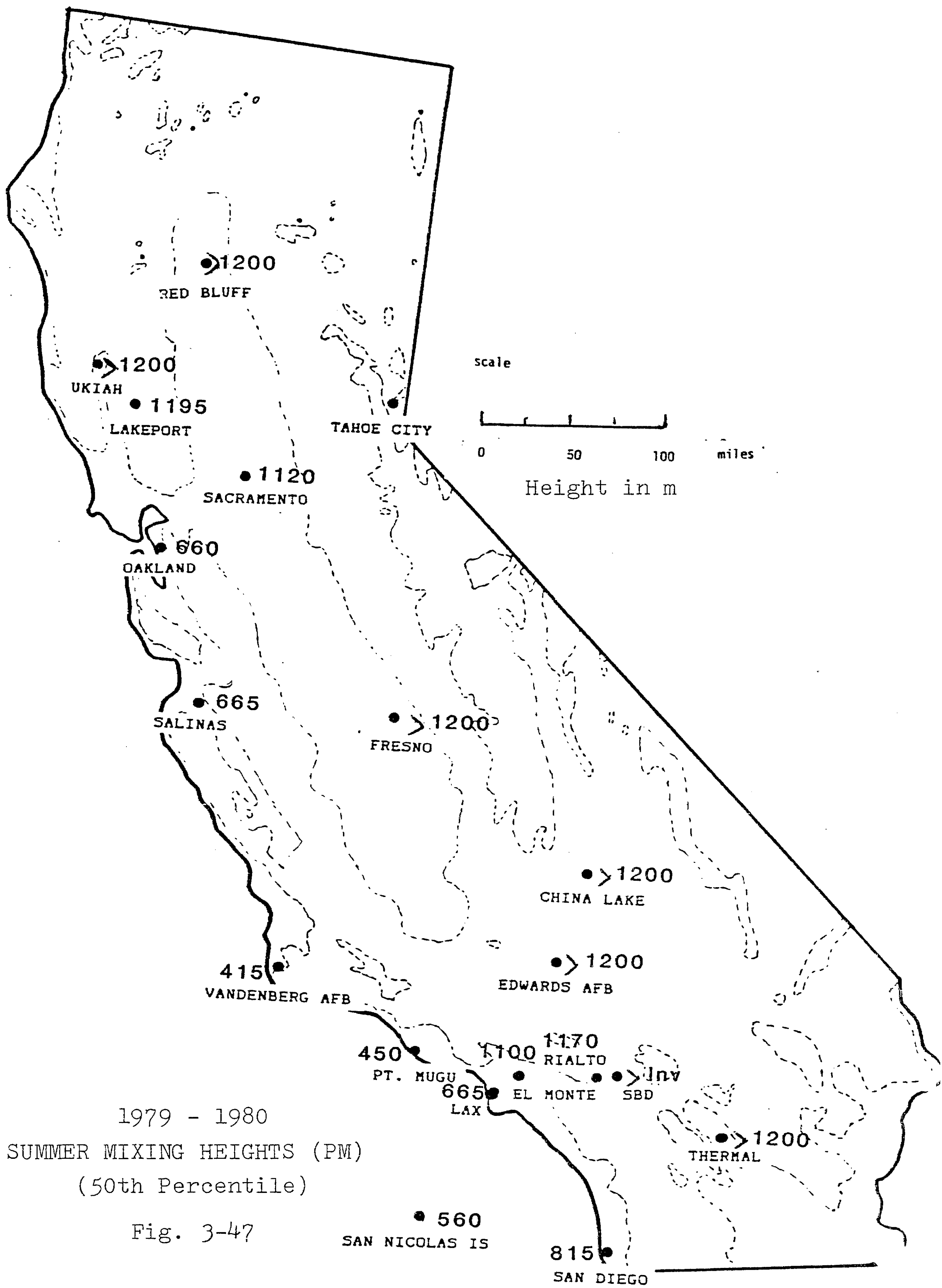
1979 - 1980
WINTER MIXING HEIGHTS (PM)
(50th Percentile)

Fig. 3-45



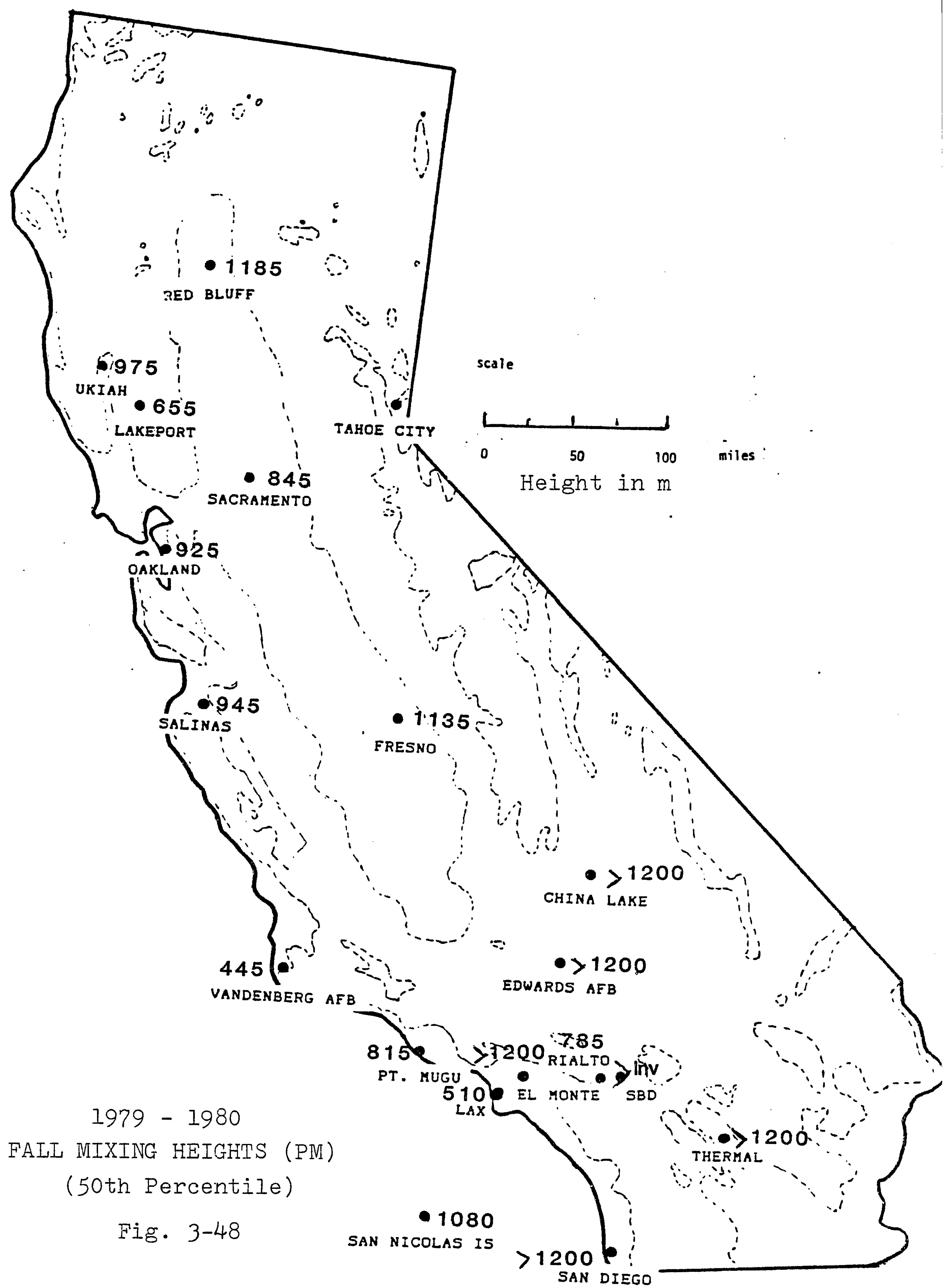
1979 - 1980
SPRING MIXING HEIGHTS (PM)
(50th Percentile)

Fig. 3-46



1979 - 1980
SUMMER MIXING HEIGHTS (PM)
(50th Percentile)

Fig. 3-47



1979 - 1980
FALL MIXING HEIGHTS (PM)
(50th Percentile)

Fig. 3-48

Table 3-13

Rank Order of Mixing Heights

Winter (AM)
1979-80

10th Percentile Rank		Height	50th Percentile Rank		Height
1.	Pt. Mugu	25 m	1.	San Bernardino	70 m
2.	Edwards AFB	35	2.	Tahoe City	80
3.	San Nicolas Is.	40		Thermal	80
4.	San Bernardino	50	3.	Pt. Mugu	95
	Tahoe City	50		Red Bluff	95
5.	Thermal	60	4.	Sacramento	135
6.	Vandenberg AFB	75	5.	Fresno	150
7.	El Monte	90	6.	Salinas	225
	Ukiah	90	7.	El Monte	240
8.	Red Bluff	95	8.	Ukiah	250
9.	China Lake	100	9.	San Nicolas Is.	260
	Fresno	100	10.	Vandenberg AFB	530
	Sacramento	100	11.	China Lake	595
	San Diego	100	12.	San Diego	705
10.	LAX	130	13.	Edwards AFB	840
	Salinas	130	14.	LAX	>1000
11.	Oakland	205	15.	Oakland	>1100

Table 3-14

Rank Order of Mixing Heights

Winter (AM)
1979-80

10th Percentile Rank		10th Percentile Height	50th Percentile Rank		50th Percentile Height
1.	Pt. Mugu	40 m	1.	Thermal	105 m
2.	Edwards AFB	45	2.	Red Bluff	160
3.	Thermal	60	3.	Sacramento	190
4.	China Lake	80	4.	Fresno	230
5.	El Monte	85	5.	San Bernardino	255
6.	Sacramento	90		Ukiah	255
	San Nicolas Is.	90	6.	Pt. Mugu	420
	Fresno	90	7.	El Monte	460
7.	Red Bluff	95	8.	Salinas	485
8.	San Bernardino	100	9.	San Nicolas Is.	610
9.	LAX	115	10.	Edwards AFB	645
10.	Ukiah	120	11.	LAX	805
11.	Salinas	170	12.	San Diego	930
12.	Vandenberg AFB	200	13.	Vandenberg AFB	1055
13.	Oakland	220	14.	China Lake	>1200
14.	San Diego	455		Oakland	>1200

Table 3-15

Rank Order of Mixing Heights

Summer (AM)
1979-80

10th Percentile			50th Percentile		
	Rank	Height		Rank	Height
1.	Lakeport	35 m	1.	Lakeport	60 m
2.	Pt. Mugu	40	2.	Thermal	140
3.	Edwards AFB	45	3.	Pt. Mugu	150
4.	San Bernardino	50		San Bernardino	150
5.	China Lake	75	4.	Sacramento	155
6.	Thermal	80	5.	Fresno	175
7.	Fresno	90	6.	Edwards AFB	180
	Red Bluff	90	7.	Ukiah	215
8.	Ukiah	95	8.	El Monte	285
9.	Sacramento	110	9.	Red Bluff	325
10.	San Nicolas Is.	115	10.	Vandenberg AFB	395
11.	El Monte	140	11.	San Nicolas Is.	440
12.	Vandenberg AFB	170	12.	Salinas	505
13.	LAX	180	13.	LAX	525
14.	Salinas	235	14.	Oakland	550
15.	Oakland	255	15.	China Lake	675
16.	San Diego	260	16.	San Diego	705

Table 3-16

Rank Order of Mixing Heights

Fall (AM)
1979-80

10th Percentile Rank		10th Percentile Height	50th Percentile Rank		50th Percentile Height
1.	Pt. Mugu	25 m	1.	Lakeport	55 m
	Edwards AFB	25	2.	Thermal	85
2.	Lakeport	30	3.	San Bernardino	90
3.	San Nicolas Is.	45	4.	Pt. Mugu	95
4.	San Bernardino	50	5.	Edwards AFB	105
	Thermal	50	6.	Red Bluff	110
5.	China Lake	55	7.	Fresno	115
6.	Fresno	70	8.	China Lake	140
	Red Bluff	70	9.	Sacramento	150
7.	Sacramento	80	10.	Ukiah	170
8.	Salinas	90	11.	El Monte	225
	Vandenberg AFB	90	12.	Vandenberg AFB	270
9.	Ukiah	95	13.	Salinas	325
10.	Oakland	110	14.	LAX	335
	San Diego	110	15.	San Nicolas Is.	360
			16.	San Diego	420
			17.	Oakland	530

Table 3-17

Rank Order of Mixing Heights

Winter (PM)
1979-80

10th Percentile			50th Percentile		
	Rank	Height		Rank	Height
1.	San Nicolas Is.	95 m	1.	Sacramento	395 m
2.	Sacramento	215	2.	Red Bluff	520
3.	Pt. Mugu	245	3.	San Nicolas Is.	530
4.	Vandenberg AFB	250	4.	Fresno	630
5.	Ukiah	295	5.	Tahoe City	650
6.	Tahoe City	305	6.	Ukiah	815
7.	Fresno	310	7.	Thermal	1180
8.	Oakland	350	8.	China Lake	>1200
9.	Thermal	365		Edwards AFB	>1200
10.	San Bernardino	410		El Monte	>1200
11.	San Diego	470		LAX	>1200
12.	Salinas	480		Oakland	>1200
13.	El Monte	520		Pt. Mugu	>1200
14.	China Lake	640		Salinas	>1200
15.	Red Bluff	650		San Bernardino	> inv
16.	Edwards AFB	680		San Diego	>1200
17.	LAX	720		Thermal	>1200

Table 3-18

Rank Order of Mixing Heights

Spring (PM)
1979-80

10th Percentile

	Rank	Height
1.	San Nicolas Is.	220 m
2.	Vandenberg AFB	225
3.	Pt. Mugu	325
4.	Oakland	430
5.	Thermal	440
6.	LAX	460
7.	Salinas	595
8.	Sacramento	650
9.	San Diego	670
10.	Ukiah	820
11.	El Monte	1020
12.	China Lake	>1200
	Edwards AFB	> inv
	Fresno	>1200
	Red Bluff	>1200
	San Bernardino	> inv

50th Percentile

	Rank	Height
1.	San Nicolas Is.	630 m
2.	Pt. Mugu	945
3.	Vandenberg AFB	990
4.	Sacramento	1035
5.	Thermal	1105
6.	China Lake	>1200
	Edwards AFB	>1200
	El Monte	>1200
	Fresno	>1200
	LAX	>1200
	Oakland	>1200
	Red Bluff	>1200
	Salinas	>1200
	San Bernardino	> inv
	San Diego	>1200
	Ukiah	>1200

Table 3-19

Rank Order of Mixing Heights

Summer (PM)
1979-80

10th Percentile

Rank		Height
1.	Vandenberg AFB	210 m
2.	San Nicolas Is.	230
3.	Pt. Mugu	295
4.	LAX	350
5.	Oakland	390
6.	Salinas	420
7.	San Diego	435
8.	Sacramento	500
9.	Rialto	545
10.	El Monte	755
11.	Lakeport	870
12.	Ukiah	880
13.	Fresno	1150
14.	Red Bluff	1185
15.	China Lake	> inv
	Edwards AFB	> inv
	San Bernardino	> inv
	Thermal	> inv

50th Percentile

Rank		Height
1.	Vandenberg AFB	415 m
2.	Pt. Mugu	450
3.	San Nicolas Is.	560
4.	Oakland	660
5.	LAX	665
	Salinas	665
6.	San Diego	815
7.	El Monte	1100
8.	Sacramento	1120
9.	Rialto	1170
10.	Lakeport	1195
11.	China Lake	>1200
	Edwards AFB	>1200
	Fresno	>1200
	Red Bluff	>1200
	San Bernardino	> inv
	Thermal	>1200
	Ukiah	>1200

Table 3-20

Rank Order of Mixing Heights

Fall (PM)
1979-80

10th Percentile

Rank		Height
1.	Vandenberg AFB	170 m
2.	Pt. Mugu	240
3.	San Nicolas Is.	265
4.	Red Bluff	270
5.	Ukiah	285
6.	Lakeport	300
7.	Oakland	310
8.	San Diego	335
9.	Sacramento	340
10.	Salinas	400
11.	Fresno	440
12.	Thermal	900
13.	Edwards AFB	1100
14.	China Lake	> inv
	San Bernardino	> inv

50th Percentile

Rank		Height
1.	Vandenberg AFB	445 m
2.	LAX	510
3.	Lakeport	655
4.	Rialto	785
5.	Pt. Mugu	815
6.	Sacramento	845
7.	Oakland	925
8.	Salinas	945
9.	Ukiah	975
10.	San Nicolas Is.	1080
11.	Fresno	1135
12.	Red Bluff	1185
13.	China Lake	>1200
	Edwards AFB	>1200
	El Monte	>1200
	San Bernardino	>1200
	San Diego	>1200
	Thermal	>1200

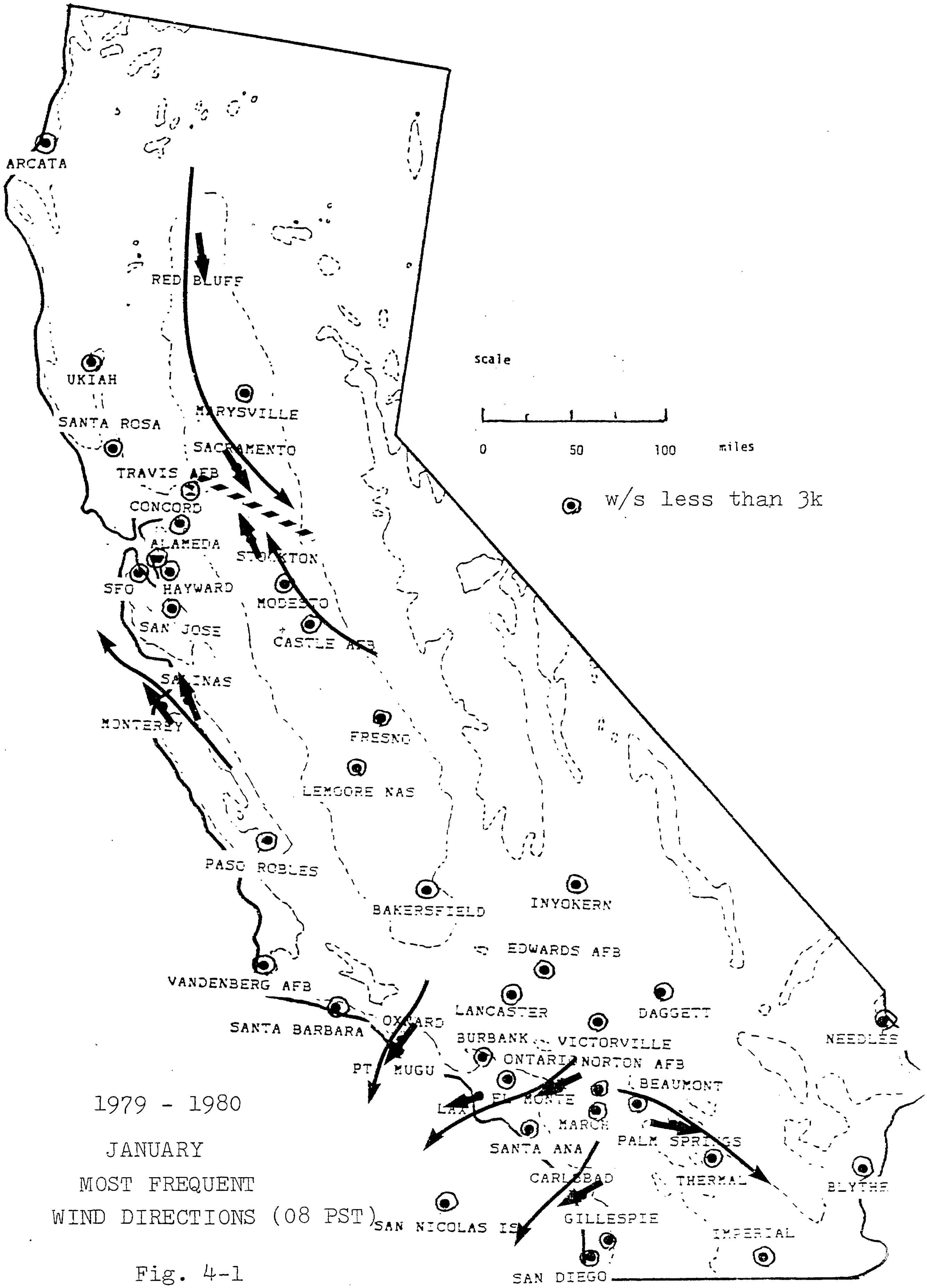
4.0 TRANSPORT PATTERNS

4.1 Most Frequent Streamlines

Most frequent wind directions (on a 36-point scale) have been obtained for the 47 surface stations in California at 08, 12 and 16 PST for the months of January, April, July and October. A two-year data set (1979-80) was used for the analysis. The results of the study are summarized in Figs. 4-1 through 4-12. Tabular data are given in the Appendix. In many instances the most frequent wind was a "calm" (less than 3 knots). These are indicated in the figures. The streamlines shown in the figures have been drawn only for those areas and times when the most frequent wind was not a calm.

A similar presentation of predominant wind flow patterns has recently been published by Hayes et al(1984) in a CARB climatology study. Hayes has constructed more detailed streamline maps than shown in Figs. 4-1 through 4-12 in terms of one dominant flow pattern for each season. The figures included here are less detailed but show the presence of calm conditions and also divide each season into three time periods. The two representations should supplement each other and should be used together to obtain a detailed description of flow patterns in California.

The strong influence of terrain on dominant wind flow patterns in California is emphasized in Figs. 4-1 through 4-12. There are only limited openings in the terrain along the coast through which surface air flow can reach the interiors. A major opening is the Carquinez Straits to the east of San Francisco. During most of the year there are low level trajectories through the Straits into the Central Valley. A portion of the flow is deflected northward into the Sacramento Valley while part of the flow passes south into the San Joaquin Valley. Minor intrusions of coastal air into interior valleys are shown to the southeast of Arcata and Salinas. The flow from the Bay Area into the Central Valley occurs through the Carquinez Straits and through Altamont Pass (east of Livermore). These routes represent by far the major transport corridors into the Central Valley in northern California.



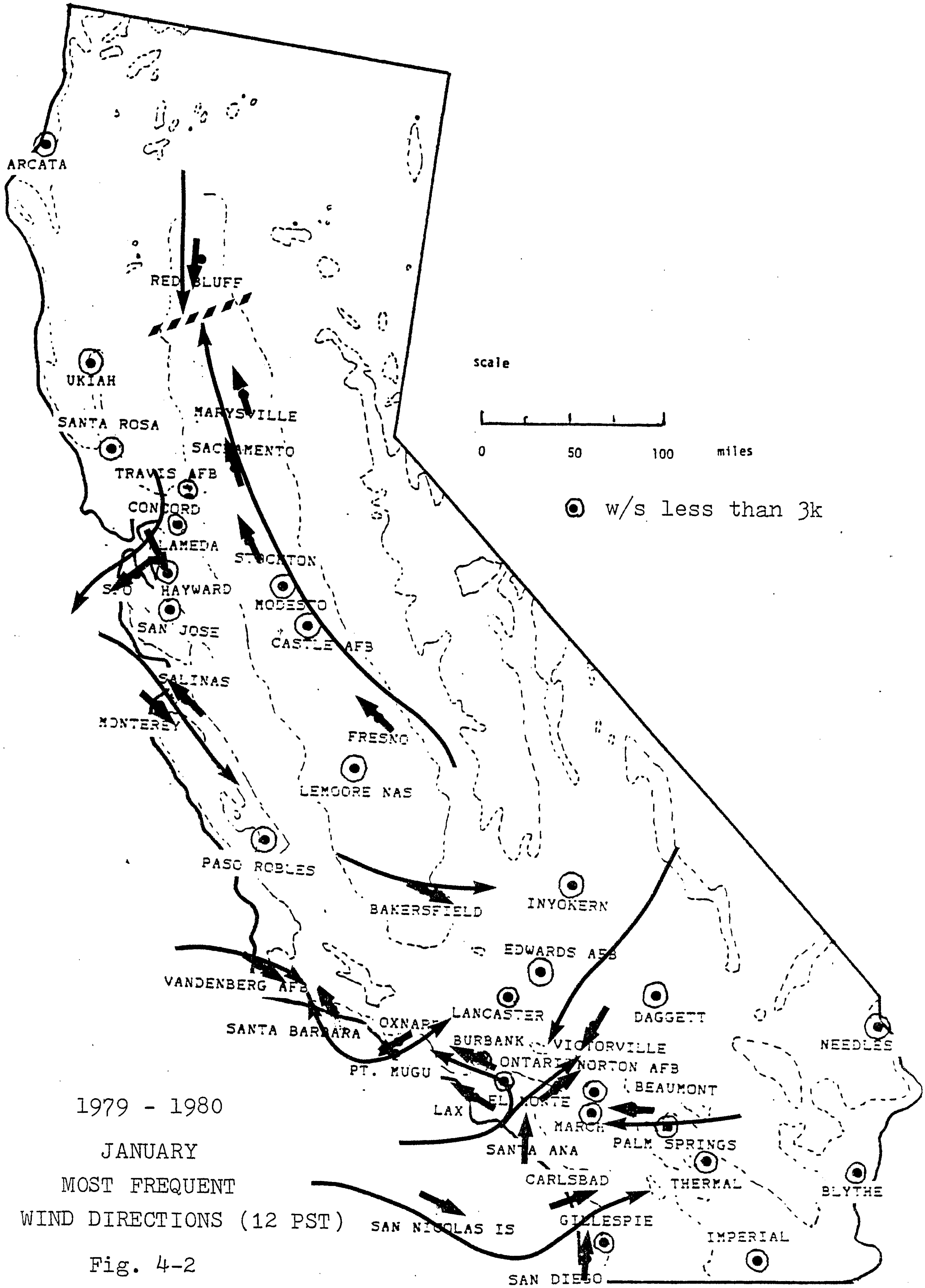
1979 - 1980

JANUARY

MOST FREQUENT

WIND DIRECTIONS (08 PST)

Fig. 4-1



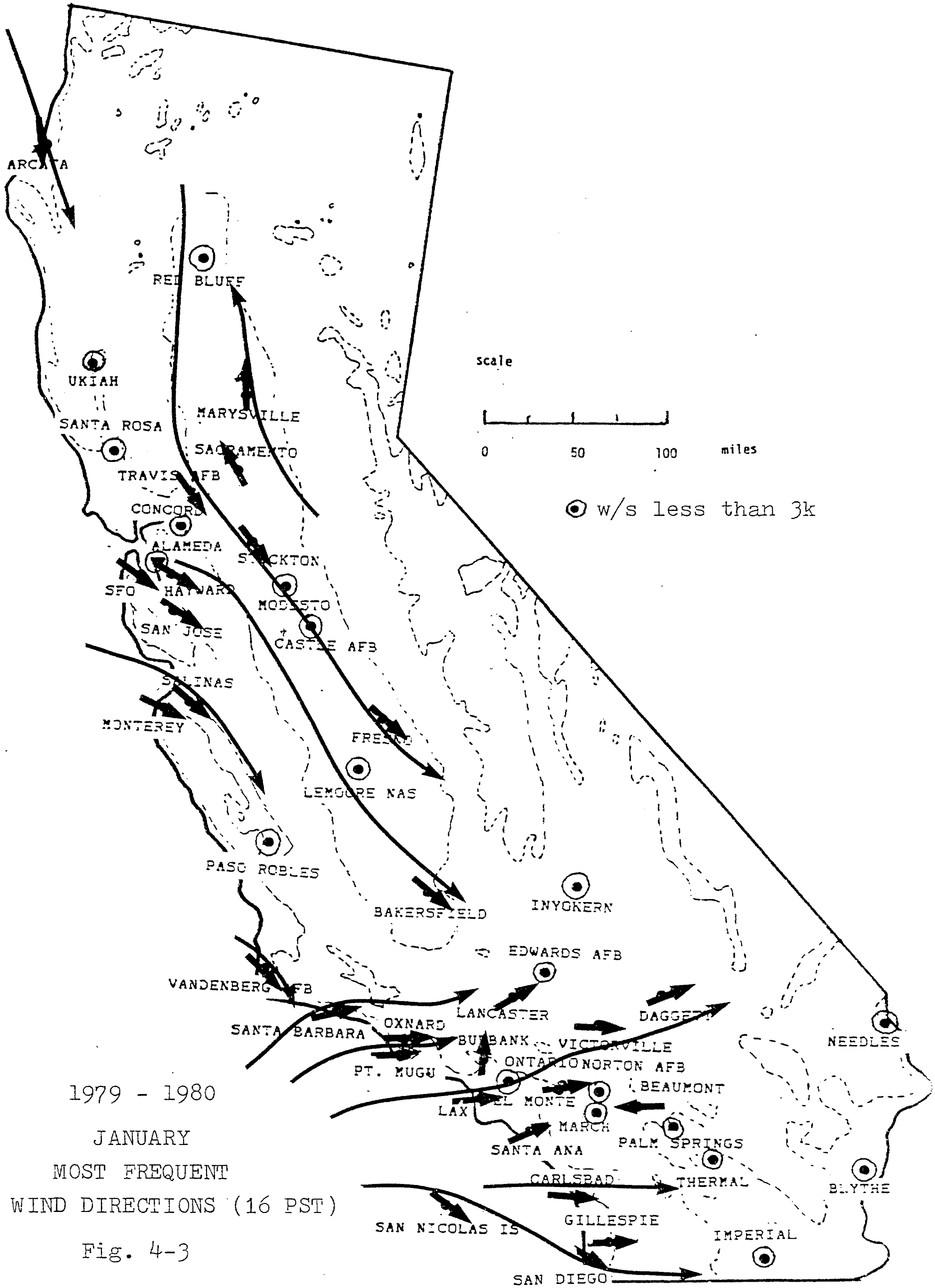
1979 - 1980

JANUARY

MOST FREQUENT

WIND DIRECTIONS (12 PST)

Fig. 4-2



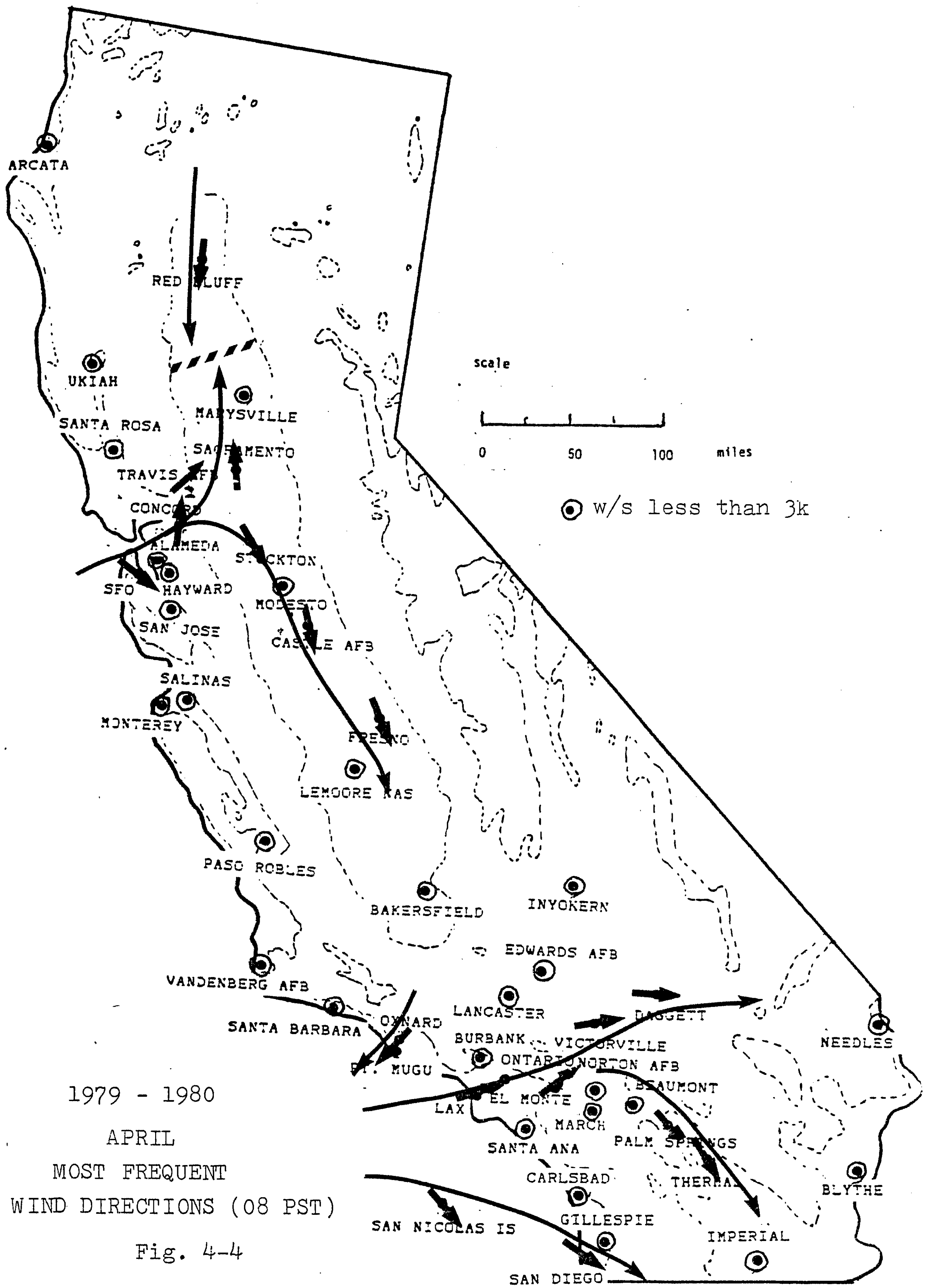
1979 - 1980

JANUARY

MOST FREQUENT

WIND DIRECTIONS (16 PST)

Fig. 4-3



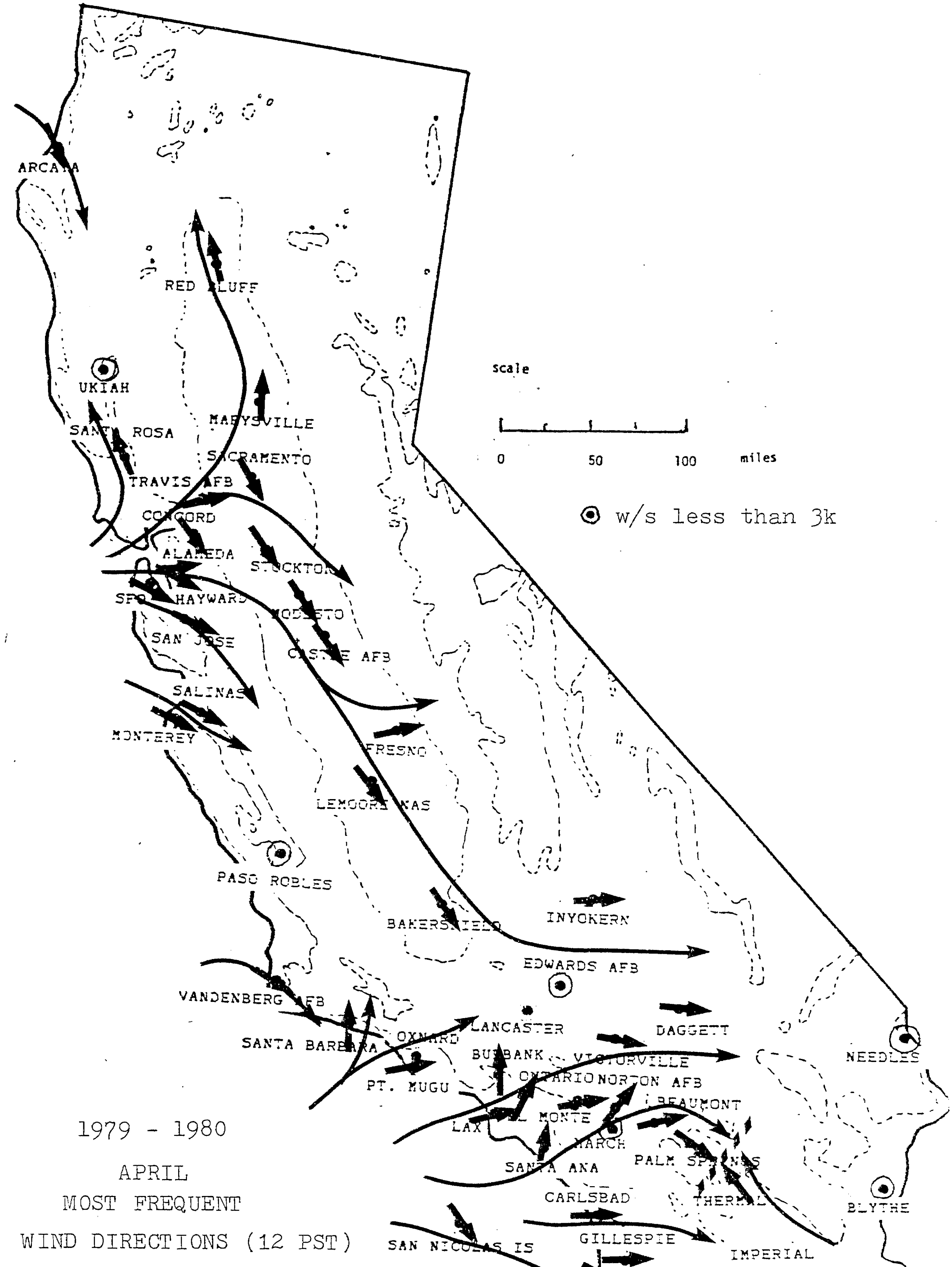
1979 - 1980

APRIL

MOST FREQUENT

WIND DIRECTIONS (08 PST)

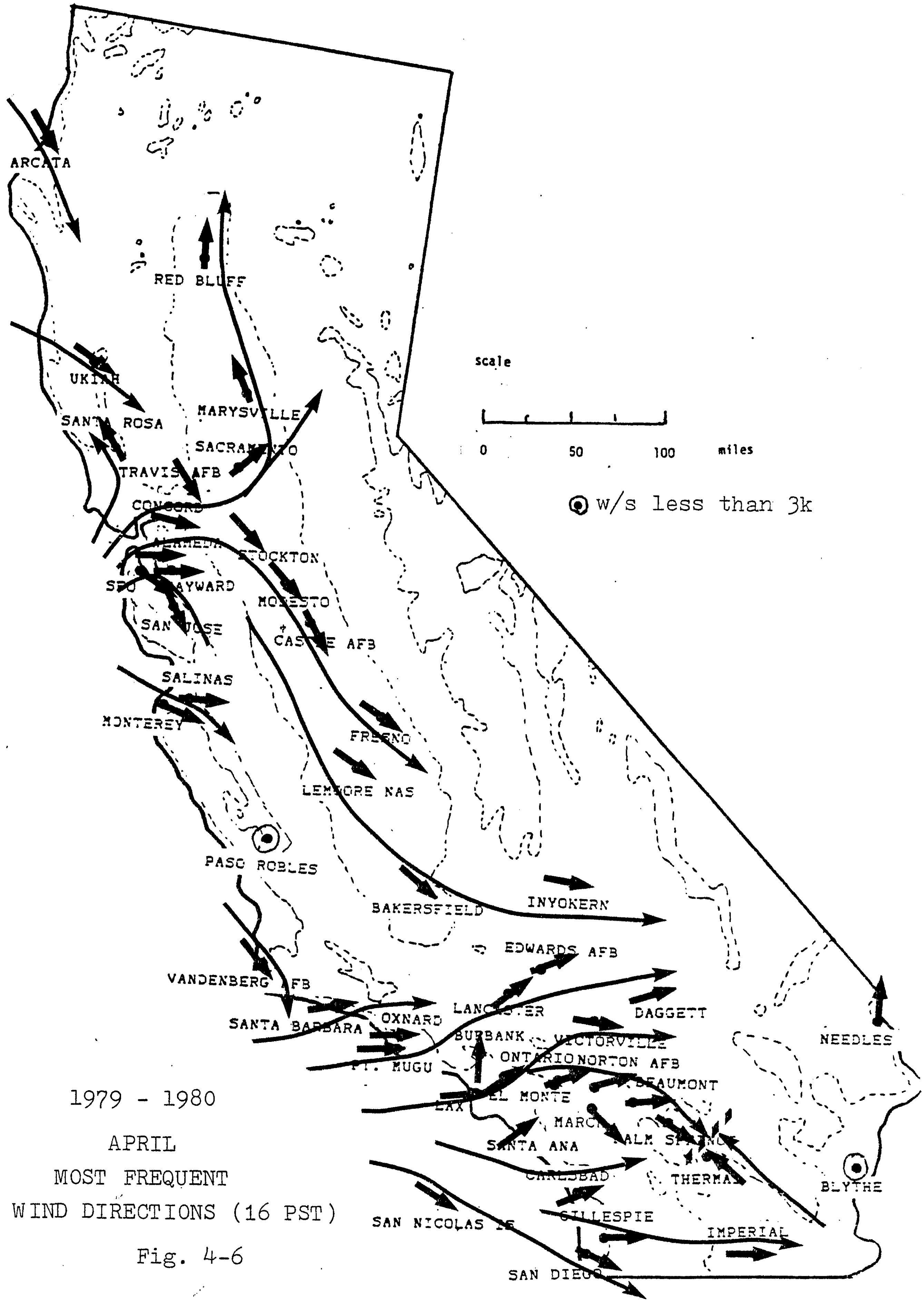
Fig. 4-4



1979 - 1980

APRIL
MOST FREQUENT
WIND DIRECTIONS (12 PST)

Fig. 4-5



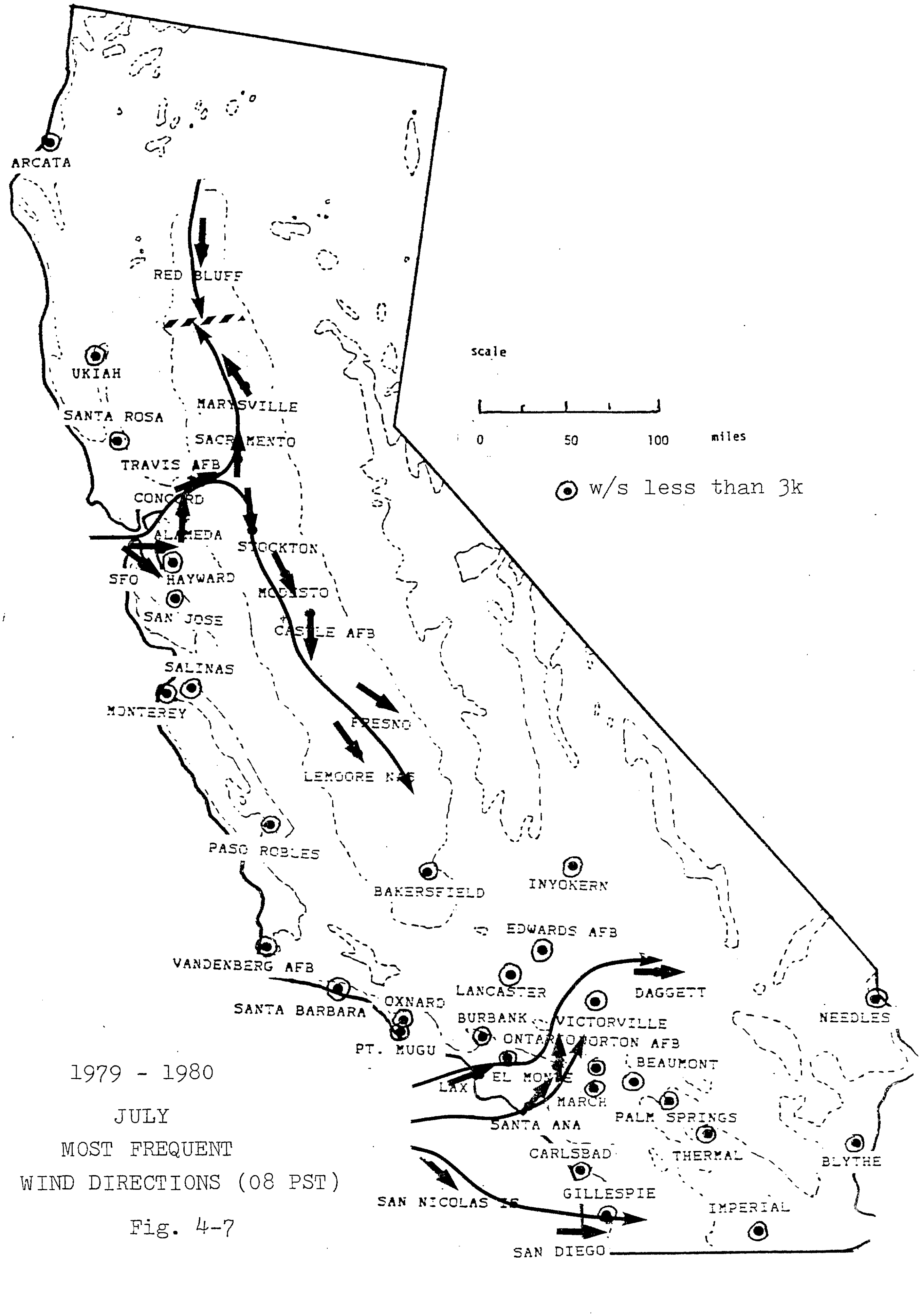
1979 - 1980

APRIL

MOST FREQUENT

WIND DIRECTIONS (16 PST)

Fig. 4-6



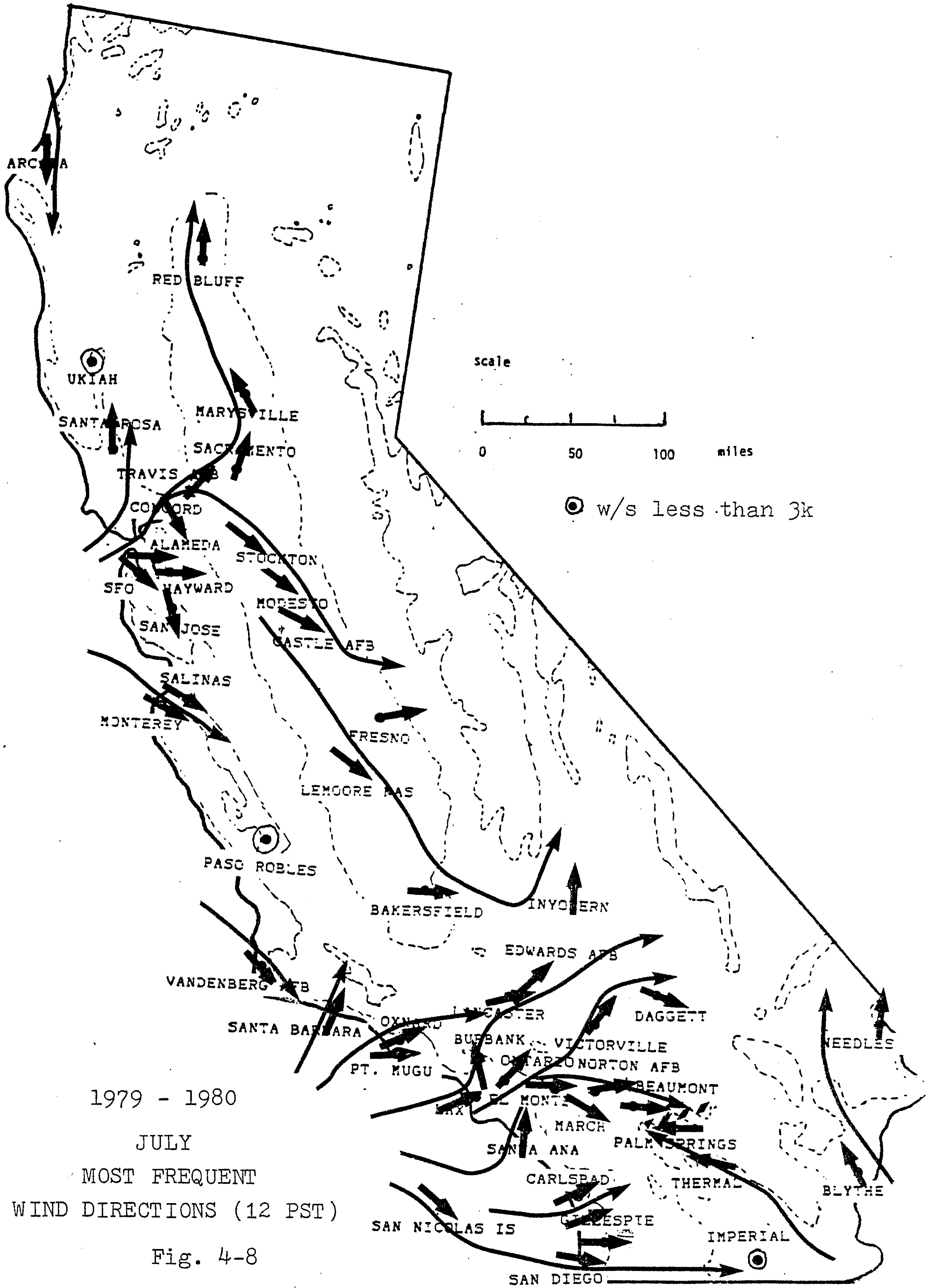
1979 - 1980

JULY

MOST FREQUENT

WIND DIRECTIONS (08 PST)

Fig. 4-7



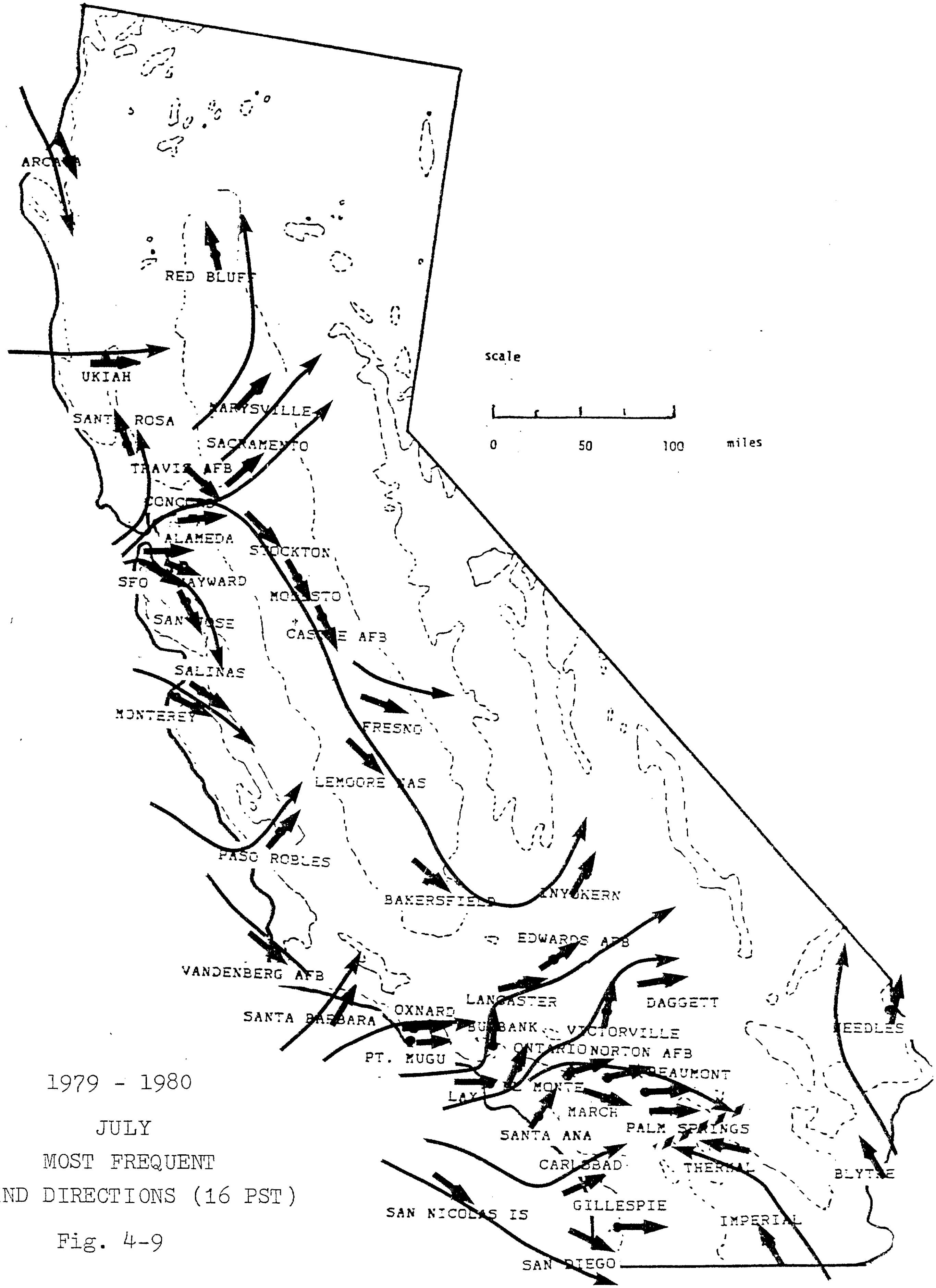
1979 - 1980

JULY

MOST FREQUENT

WIND DIRECTIONS (12 PST)

Fig. 4-8



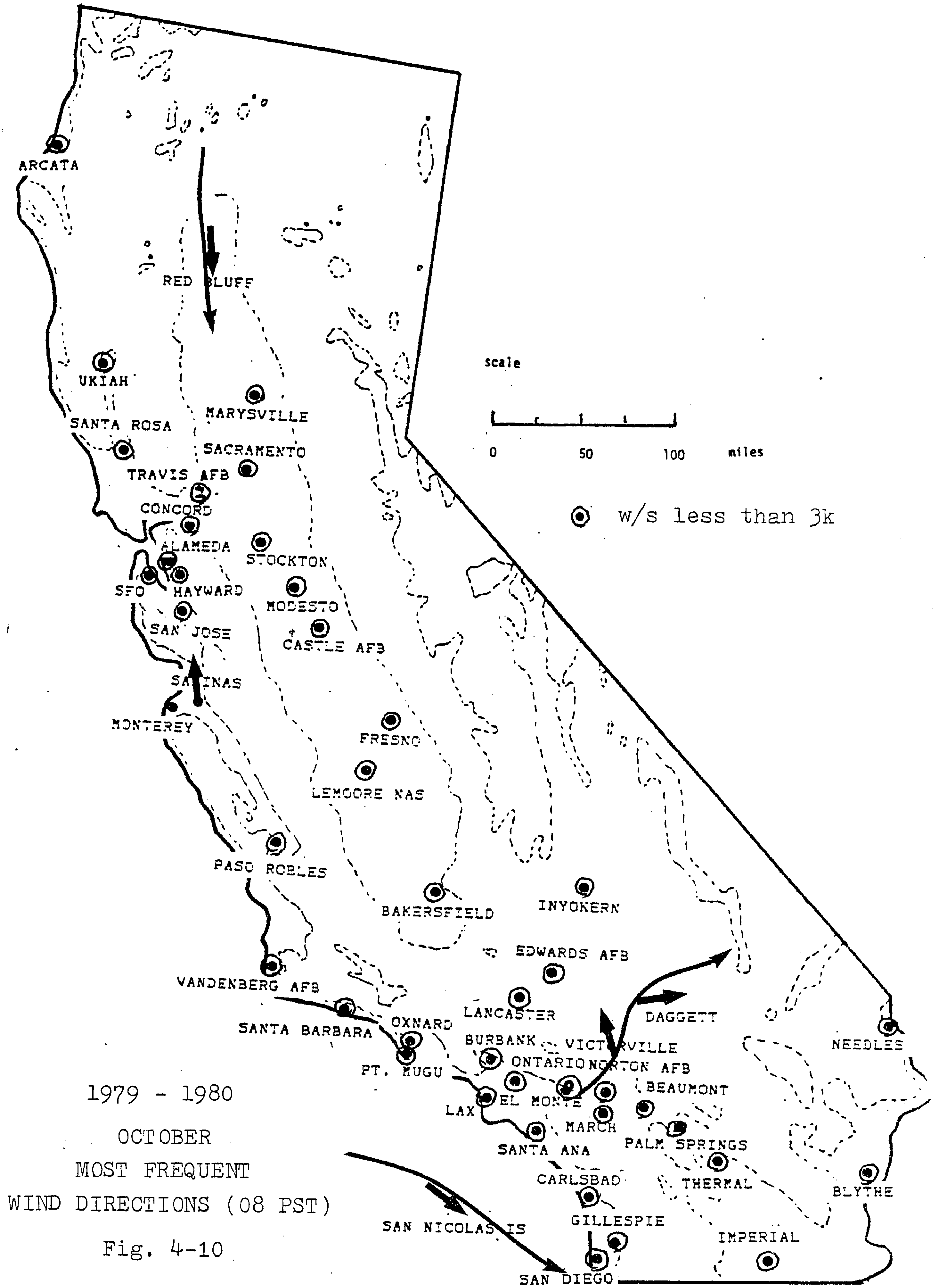
1979 - 1980

JULY

MOST FREQUENT

WIND DIRECTIONS (16 PST)

Fig. 4-9



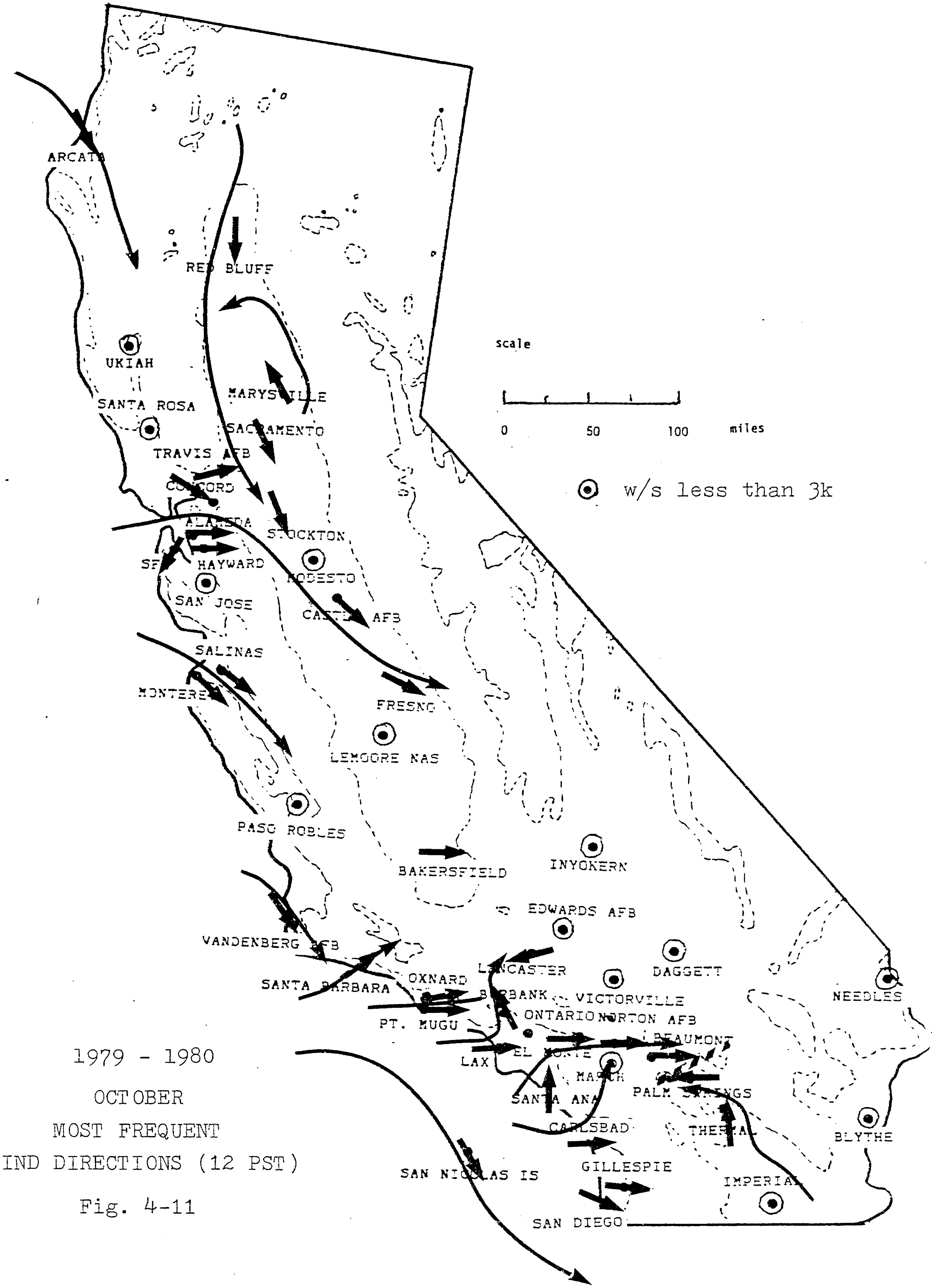
1979 - 1980

OCTOBER

MOST FREQUENT

WIND DIRECTIONS (08 PST)

Fig. 4-10



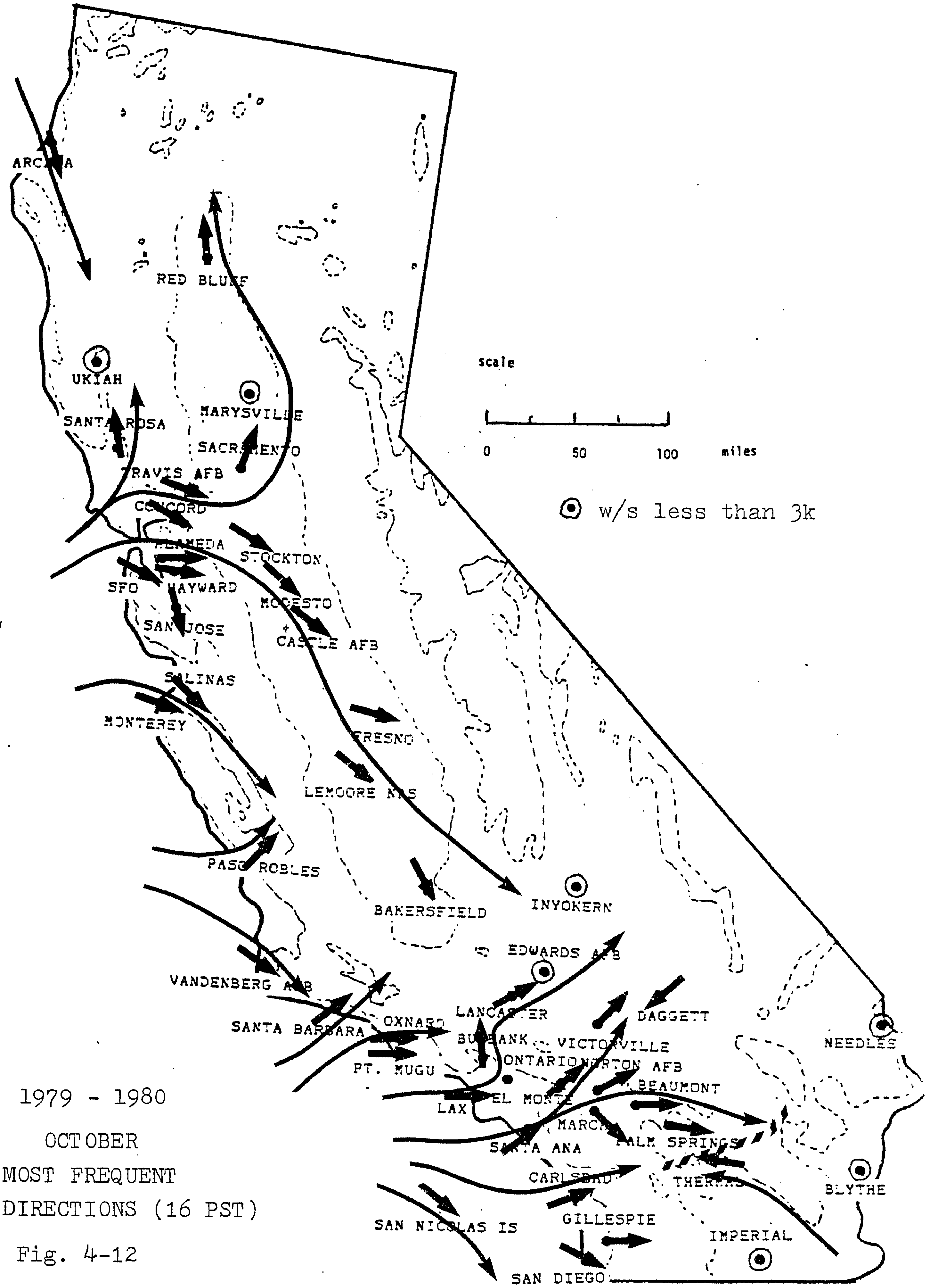
1979 - 1980

OCTOBER

MOST FREQUENT

WIND DIRECTIONS (12 PST)

Fig. 4-11



1979 - 1980

OCTOBER

MOST FREQUENT

WIND DIRECTIONS (16 PST)

Fig. 4-12

In the southern part of the state the major terrain feature is the extensive coastal plain which permits easy access of coastal air to an inland distance of 50-60 miles from Los Angeles to San Diego. There are several passes which permit coastal air to be transported into the desert from the coastal plain. These are Soledad Canyon, Cajon Pass and San Gorgonio Pass. In addition, there are several air flow routes from San Diego County into the Imperial Valley. The two most prominent routes from San Diego County are along the U.S. - Mexican border and the Anza - Borrego area.

The diurnal influence on dominant wind flow patterns is also apparent in Figs. 4-1 through 4-12. Inland heating during the daytime results in intensified pressure gradients during the afternoon from the coast - inland. These power a diurnal monsoon which influences most of the state (e.g. Fig. 4-9). The true sea breeze flow, representing air moving from offshore - inland, only penetrates some 50 miles or so inland from the coast (Fosberg and Schroeder, 1966) and does not account for all of the flow patterns shown in Fig. 4-9.

There are three other consistent flow patterns which are of some importance in pollutant transport. There is frequently a flow from the north in the northern part of the Sacramento Valley (e.g. Red Bluff) even when winds in the southern part of the valley are from the south to southeast. This northerly flow contributes to the formation of the "Schultz Eddy" in the southern part of the Sacramento Valley and tends to limit pollutant transport from the southern Sacramento Valley into the northern part.

During the summer months (Figs. 4-8 and 4-9) there is generally a southeasterly flow in the Imperial Valley and the southeastern Mojave Desert. This flow is part of the monsoon which transports moist, tropical air into the southwestern part of the U.S. Humidities are occasionally quite high in the Imperial/Coachella Valleys under these conditions (dew points in the 70's). These high humidities add to aerosol growth in the area and result in lower visibilities than might otherwise be expected. In addition, the prevalence of southeasterly winds in the Imperial/Coachella Valleys limits the impact of pollutants from the South Coast Air Basin generally to the Coachella Valley.

The third consistent flow pattern is through the Carquinez Straits and the western side of the San Joaquin Valley during the summer (the San Joaquin Valley and differences between the Sacramento and San Joaquin Valleys will be discussed later). Westerly winds through the Carquinez Straits and the northwesterly winds of moderate intensity through the western San Joaquin Valley occur frequently both day and night.

4.2 Interbasin Transport

During the past ten years CARB has carried out a number of research studies to investigate interbasin transport in the state. Figs. 4-13 through 4-18 summarize the trajectories for interbasin transport which have been documented by these and other studies. It is not implied that there are no other interbasin effects but it is believed that the most significant are included in the figures.

San Francisco Bay Area Air Basin

Fig. 4-13 shows pollutant trajectories from the San Francisco Bay Area into the Sacramento Valley and San Joaquin Valley Air Basins. During the afternoon impact can also occur in the Mountain States Air Basin from upslope flow on the western side of the Sierras.

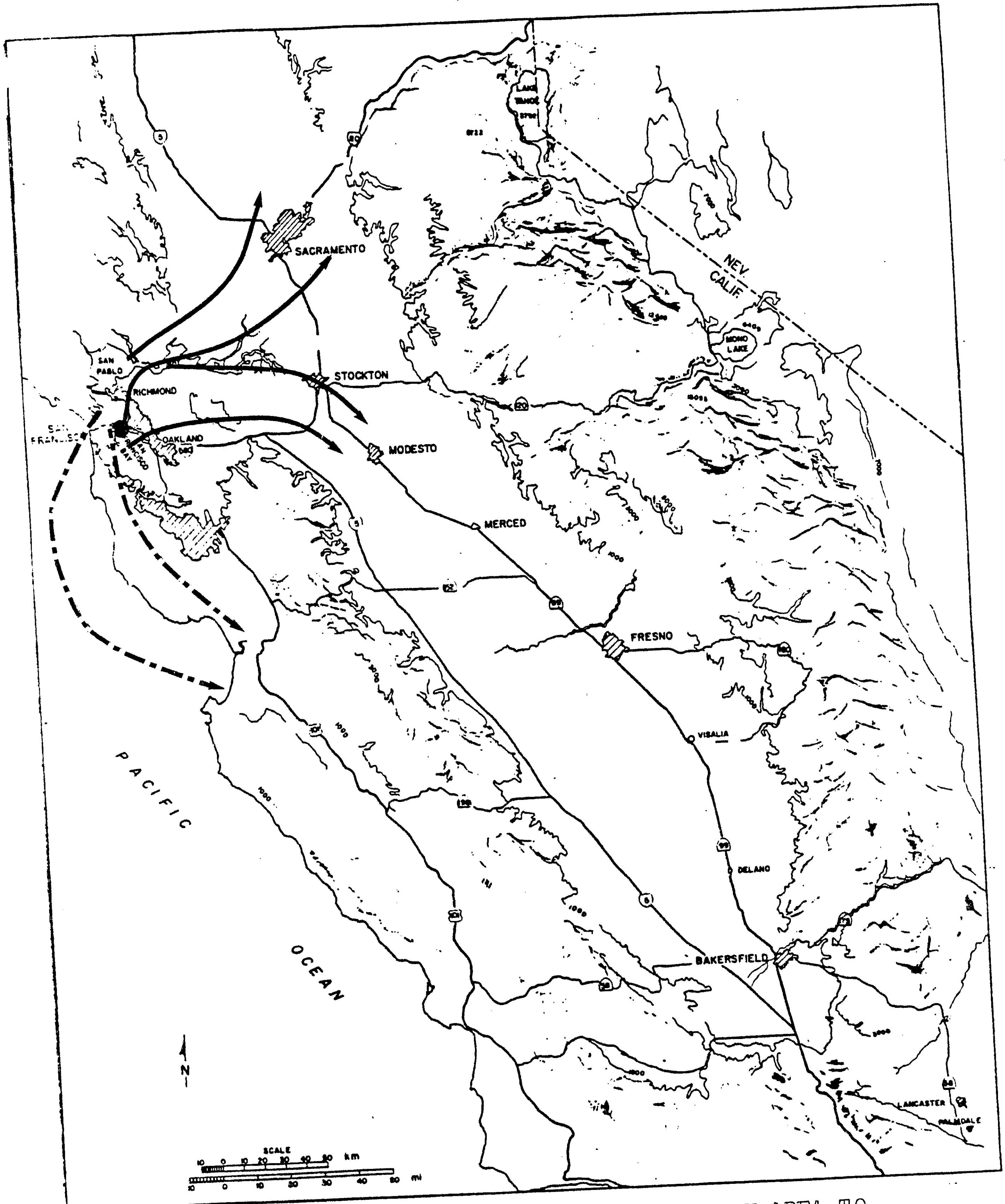
These trajectories were documented in two CARB studies (Smith et al, 1977 and Lehrman et al, 1981). Tracers were released from locations in the Carquinez Straits area (e.g. Vallejo and Pinole). Results from one tracer release from Vallejo indicated significant impact in the Sacramento area itself and transport into the Sacramento Valley, including Marysville and Williams. A more frequent transport route from the Bay area is through Lodi-Stockton into the San Joaquin Valley. An additional route through Livermore and the Altamont Pass into the San Joaquin Valley has been documented by a tracer release.

The trajectories shown in the figure can occur at any time during the year but are most frequent and most significant during the summer.

Another CARB study (Dabberdt et al, 1983) examined the transport from the San Francisco Bay Area Air Basin into the North Central Coast Air Basin. A trajectory for this flow is also shown in Fig. 4-13. The trajectory follows an offshore route from San Francisco southward into Monterey Bay. A second route was observed through the Santa Clara and San Benito Valleys between San Jose and Hollister.

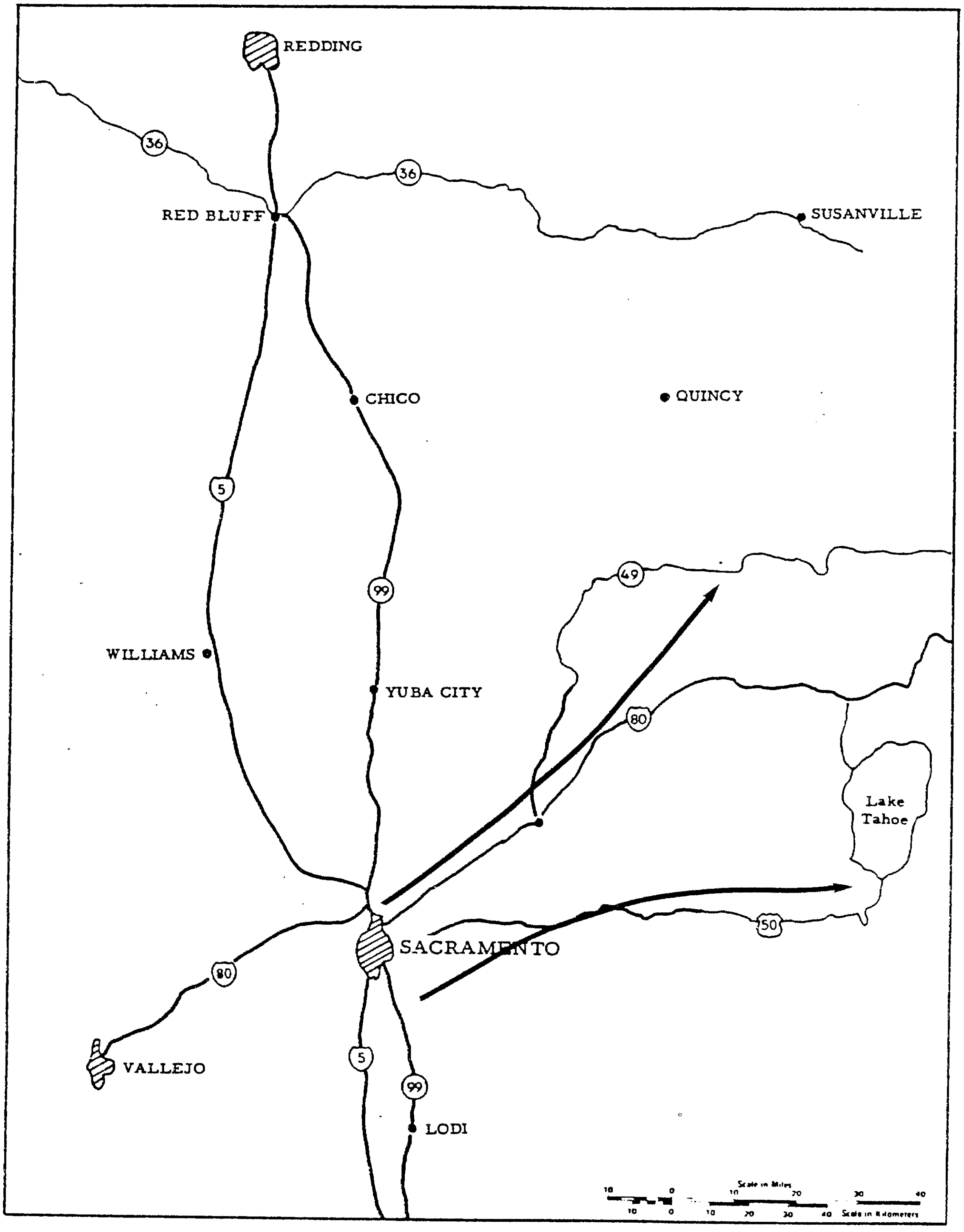
Sacramento Valley Air Basin

Pollutant trajectories from the Sacramento Valley Air Basin are shown in Fig. 4-14. These were obtained from CARB tracer studies reported by Lehrman et al (1981).



INTERBASIN TRANSPORT FROM SAN FRANCISCO BAY AREA TO SACRAMENTO VALLEY AND NORTH CENTRAL COAST

Fig. 4-13



INTERBASIN TRANSPORT FROM SACRAMENTO VALLEY
TO MOUNTAIN COUNTIES BASIN

Fig. 4-14

During the afternoon the principal trajectory in summer from the urban area of Sacramento is toward Auburn and the western slopes of the Sierras (Duckworth and Crowe, 1979). These areas are a part of the Mountain Counties Air Basin. Some transport into the Lake Tahoe Air Basin may take place under the same conditions (Unger, 1978) but on a much less significant scale.

These trajectories are most frequent and significant during summer afternoons but may occur at other times of the year.

In view of the close proximity of Sacramento to the northern boundary of the San Joaquin Valley Air Basin it is inevitable that pollutants can, on occasion, be transported into the San Joaquin Valley Air Basin. This transport, however, has not been documented in formal studies.

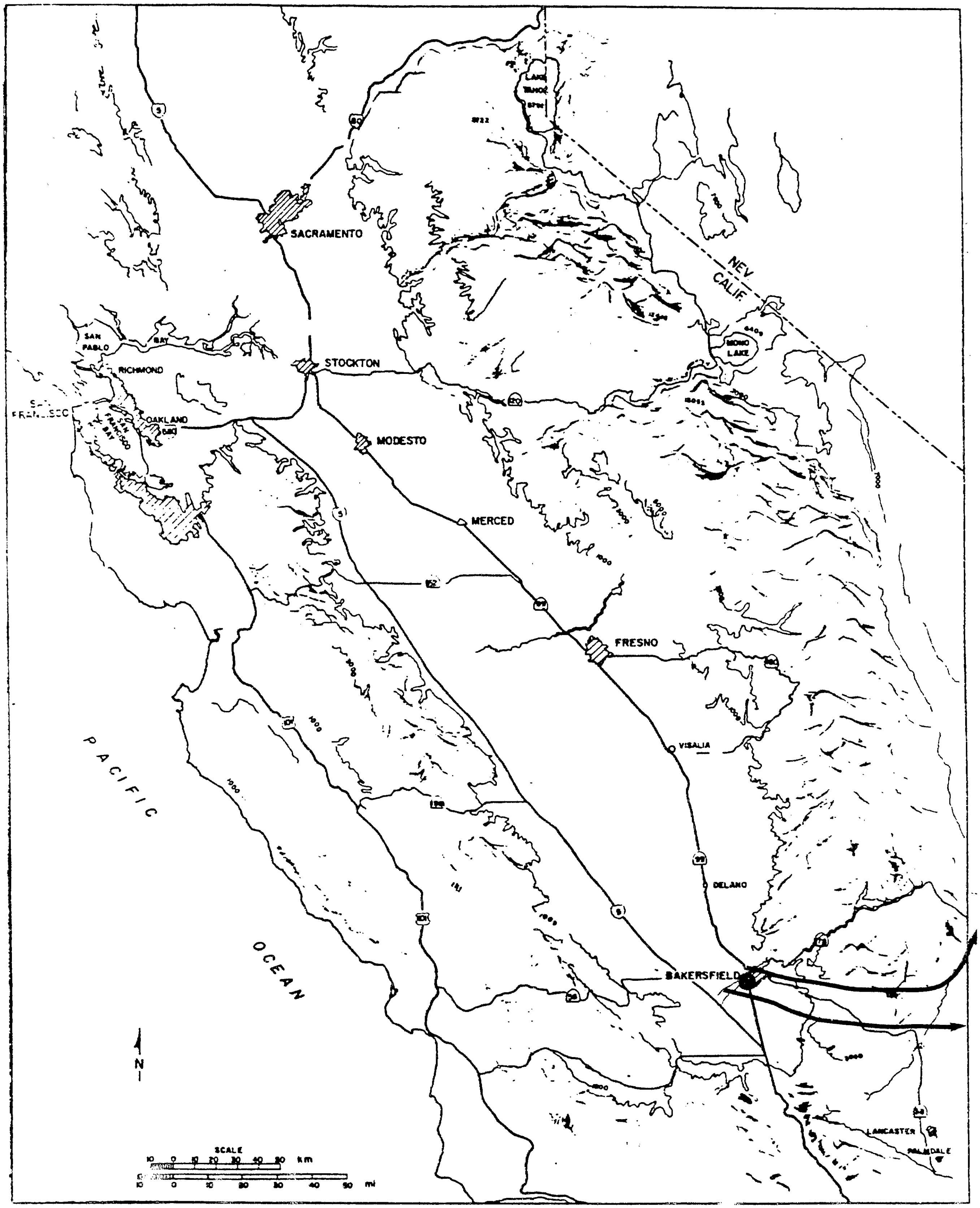
San Joaquin Valley Air Basin

The main exit route for pollutants from the San Joaquin Valley Air Basin is out the southeast end of the valley over the Tehachapi Ridge. This trajectory is shown in Fig. 4-15. A CARB study (Smith et al, 1981) provided information to document this pollutant transport, (Reible et al, 1982) analyzed the transport of tracer and aerosols from the Oildale area and demonstrated their impact on the Southeast Desert Air Basin from Inyokern to Mojave.

The trajectories are most significant and frequent during the summer months but may occur at other times of the year with less impact.

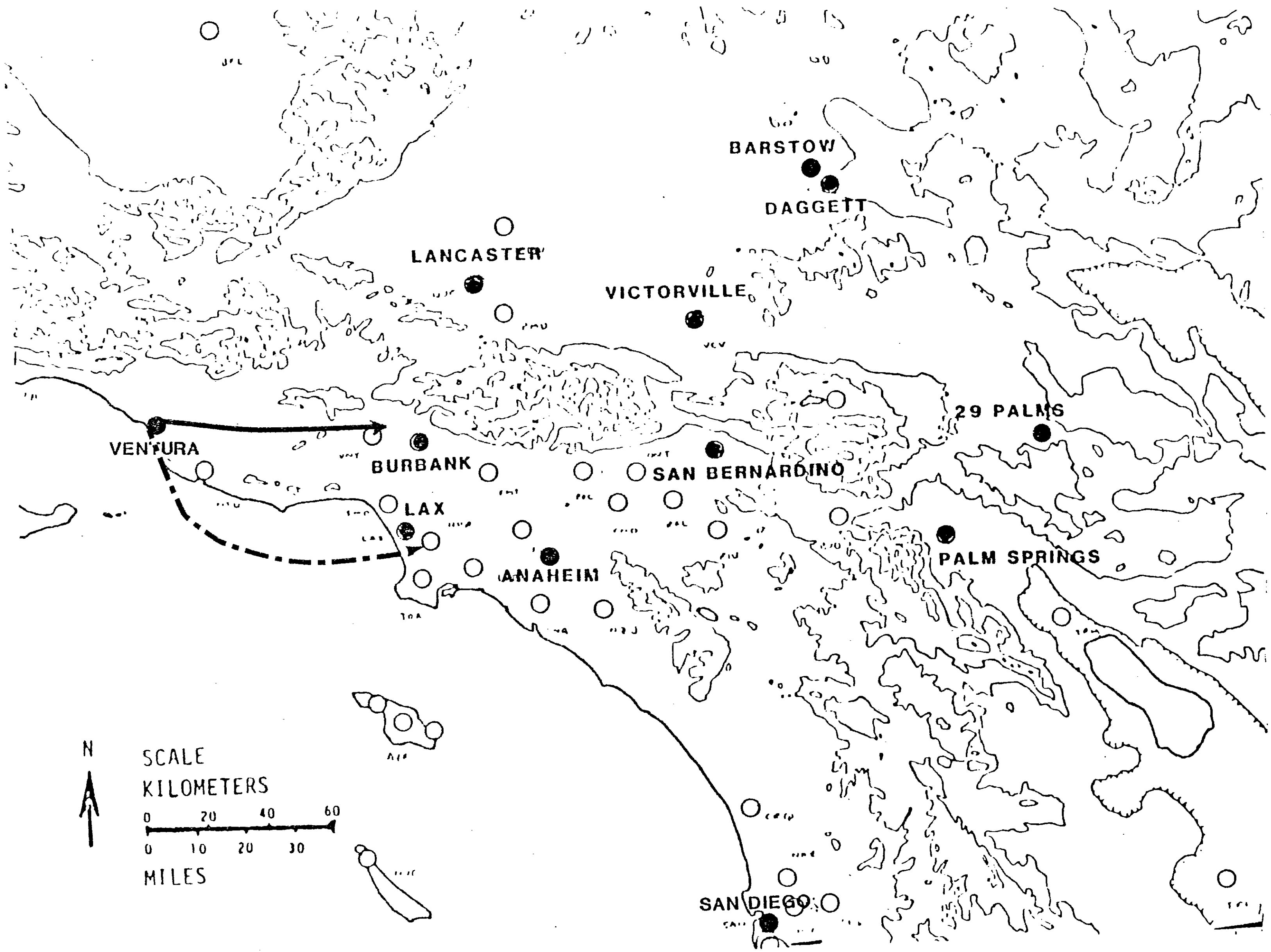
South Central Coast Air Basin

Fig. 4-16 shows trajectories from the South Central Coast Air Basin into the South Coast Air Basin. These trajectories were obtained from tracer releases by Lamb et al (1978). Releases were made from the Oxnard Plain near Ventura. Tracer samples were obtained as far east as Burbank and at Lennox along the coastal strip. These trajectories represent an afternoon path eastward through the San Fernando Valley and a (generally) offshore track along the coast and inland with the sea breeze. The latter path may also occur during the daytime hours in the presence of offshore pressure gradients.



INTERBASIN TRANSPORT FROM SAN JOAQUIN VALLEY TO SOUTHEAST DESERT

Fig. 4-15



INTERBASIN TRANSPORT FROM SOUTH CENTRAL COAST
TO SOUTH COAST AIR BASIN

Fig. 4-16

South Coast Air Basin

A major study was carried out by CARB in 1981 to investigate the transport of pollutants into the Southeast Desert Air Basin (Smith et al, 1983a). Trajectories shown in Fig. 4-17 were derived from this study.

Principal transport routes are through Soledad Canyon, Cajon Pass and San Gorgonio Pass. Impacts on the northern end of the Coachella Valley are both frequent and significant. The transport is a dominant feature of the summer months but also occurs at other times of the year.

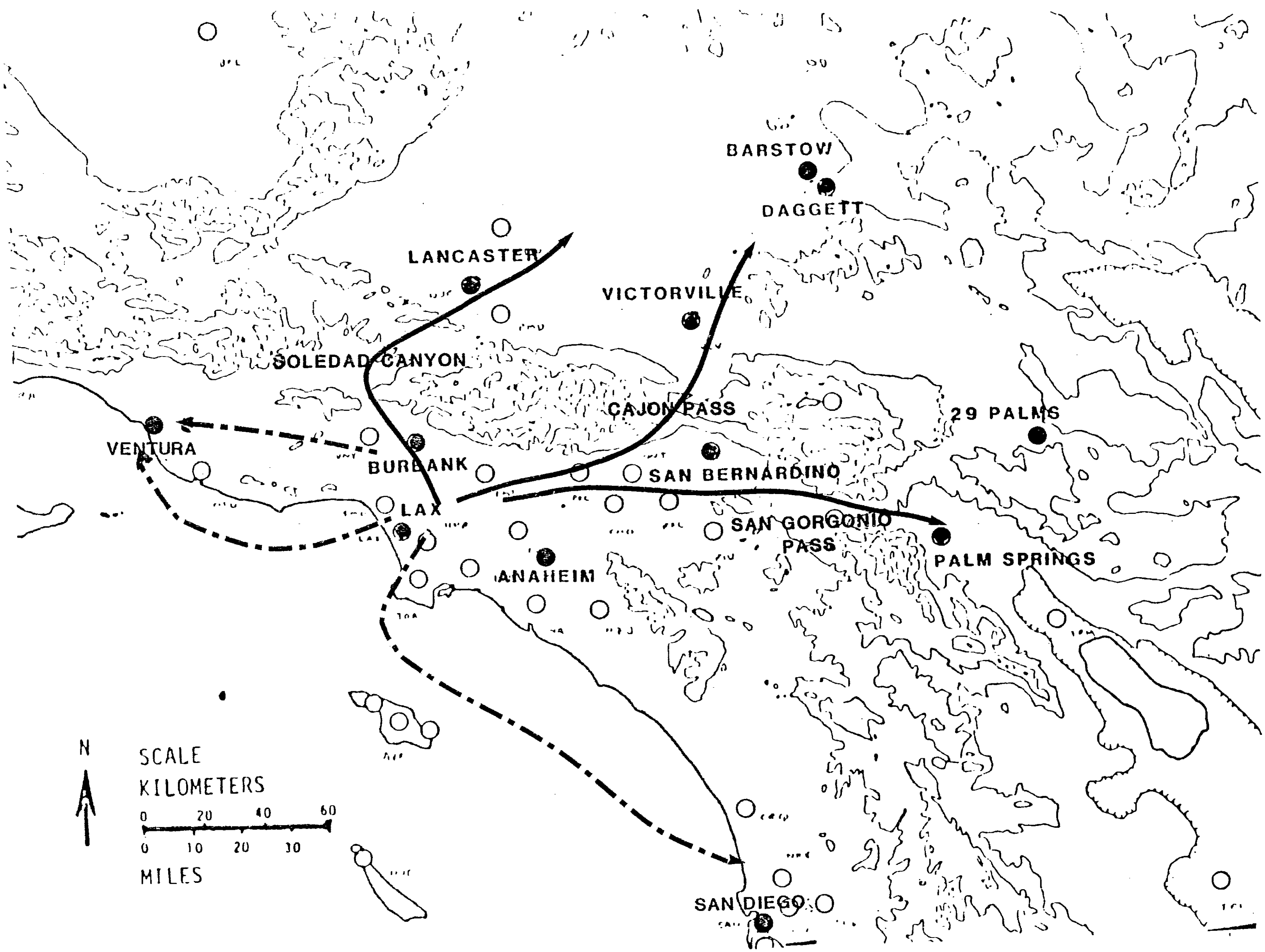
There has recently been considerable interest in the impact of South Coast Air Basin pollutants on the South Central Coast Air Basin. Two transport routes have been identified. One of these is offshore from the South Coast, northwestward and thence inland in the Ventura area with the sea breeze. This pattern has been discussed by Kauper and Niemann (1975), Shair et al (1982) and by Smith et al (1983b). A tracer study by Shair et al produced direct evidence of this transport.

The second transport route is westward from the San Fernando Valley into eastern Ventura County. Smith et al (1983) show evidence of this transport aloft. Recent studies indicate that the impact in the eastern part of Ventura County can be significant.

Kauper and Niemann (1977) carried out a study to document transport of ozone from the South Coast Air Basin into the San Diego Air Basin. The transport route as suggested in Fig. 4-17 is offshore from the South Coast Air Basin, southeastward and then inland on the sea breeze.

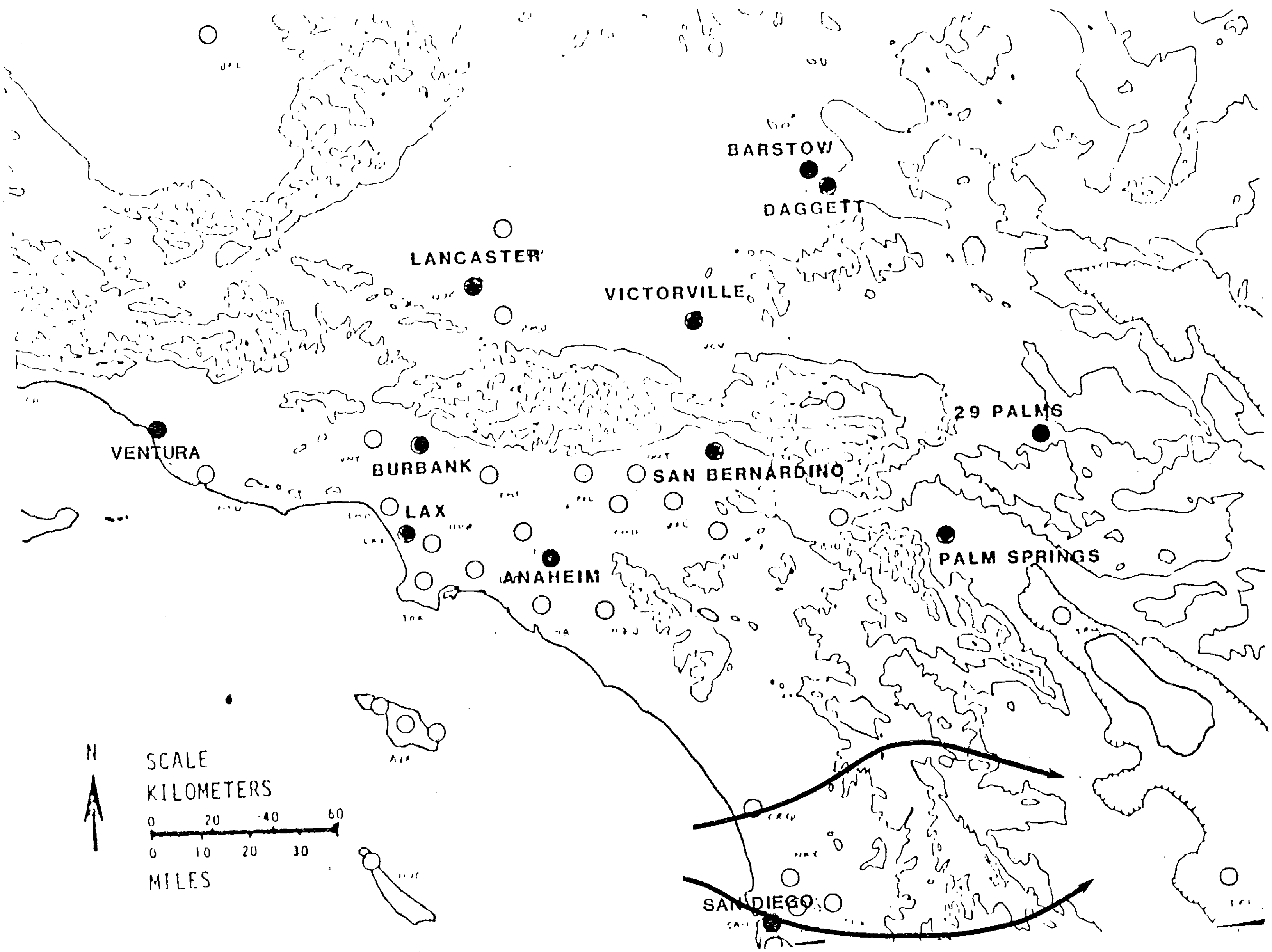
San Diego Air Basin

There are two principal air flow routes from the San Diego Air Basin into the Southeast Desert Air Basin. One of these is along the U.S - Mexican border through Mountain Springs Pass. The other empties into the Borrego/Anza through valleys which are oriented in a northwest-southeast direction. Probable air flow trajectories along these routes are shown in Fig. 4-18.



INTERBASIN TRANSPORT FROM SOUTH COAST TO SOUTH CENTRAL COAST, SOUTHEAST DESERT AND SAN DIEGO BASINS

Fig. 4-17



INTERBASIN TRANSPORT FROM SAN DIEGO TO SOUTHEAST DESERT BASIN

Fig. 4-18

Although tracer studies have not been carried out along these routes there is evidence of the flow through Mountain Springs Pass and at Borrego. In addition, westerly winds at Imperial occasionally appear in the afternoon, accompanied by characteristic changes in humidity as the marine air enters the desert.

5.0 CHARACTERISTICS OF AIR POLLUTION POTENTIAL

The preceding sections have dealt with the distributions of some of the individual parameters which influence air pollution potential in California. The present section discusses several techniques for utilizing some of these parameters to represent meteorological air pollution potential in the state.

5.1 850 mb Temperature

For a number of years the 850 mb (about 5000 ft. msl) temperature has been used as a simple guideline for expressing air pollution potential in California (e.g. Kinosian and Duckworth, 1973). Most of the supporting studies to justify this usage have expressed the relationship between the daily 850 mb temperature and the highest ozone value occurring in the basin of interest. Aron (1983) found a correlation of 0.8 for the 850 mb temperature vs. highest ozone in the Los Angeles basin. Dabberdt (1983) also found a correlation coefficient of 0.8 for a one-month period in the North Central Air Basin. Smith et al (1983) calculated a coefficient of 0.77 for a one-month period in the South Central Coast Air Basin.

The value of the 850 mb temperature as an indicator of air pollution potential is related to the information on stability which it provides. Low inversion heights and pronounced inversion strengths occur with warm temperatures aloft. Along the coast in the summer, the surface temperatures are strongly influenced by the ocean temperatures and remain fairly constant from one day to the next. The temperature aloft then provides a direct measure of the vertical stability, particularly near the coast. Aron (1983) found a slightly higher correlation of ozone in Los Angeles with the temperature at 900 mb. The 850 mb level, however, is a standard reporting level and that temperature is more readily accessible.

Table 5-1 (a) gives correlation coefficients between peak hourly ozone and daily 850 mb temperature (morning sounding) for several key locations in the state. For Sacramento the temperature at 5000 ft. from the aircraft sounding was used.

Table 5-1

Correlation of 850 mb Temperature and Peak Ozone
(July - August)

(a). 1979-80

Ozone Location	Year	Correlation	Temperature Location
Sacramento	1979	.55	Sacramento *
	1980	.52	
Fresno	1979	.76	Los Angeles
(Olive St.)	1980	.66	
Bakersfield	1979	.64	Los Angeles
(Chester St.)	1980	.52	
Fontana	1979	.71	Los Angeles
	1980	.61	
Piru	1979	.78	Los Angeles
	1980	.74	

* 5000-ft. temperature

(b). 1977-82

Ozone Location	Year	Correlation	Temperature Location
Fresno	1977	.45	Los Angeles
	1978	.67	
	1979	.76	
	1980	.66	
	1981	.45	
	1982	.47	
Bakersfield	1977	.39	Los Angeles
	1978	.66	
	1979	.64	
	1980	.52	
	1981	.52	
	1982	.47	
Fontana	1977	.40	Los Angeles
	1978	.61	
	1979	.71	
	1980	.61	
	1981	.29	
	1982	.69	

The correlations in Table 5-1 (a) range from 0.52 to 0.78 for the indicated locations. Highest correlations were found at Piru which is only a short distance from the coast. Sacramento and Bakersfield appear to have the lowest correlations.

Table 5-1 (b) explores the year-to-year variations at Fresno, Bakersfield and Fontana. It is to be noted that correlations in certain years (e.g. 1977 and 1981) are relatively low at all locations. On the other hand, in 1978-80 the correlations are consistently higher at all stations. The reason for this year to year variation appears to lie in the statistical character of the data sets. Table 5-2 gives the standard deviation of the 850 mb temperature at Los Angeles for July - August for each of the six years (1977-82), calculated from once per day values.

Table 5-2

Standard Deviation of 850 mb Temperature
(July - August)

Year	Standard Deviation
1977	3.07° C
1978	3.51
1979	4.26
1980	4.75
1981	2.17
1982	3.31

It should be noted that the standard deviations are lowest for 1977 and 1981 and highest for 1978-80, in agreement with the distribution of correlation coefficients. A small standard deviation in 850 mb temperature limits the effectiveness of the parameter as an indicator of ozone and allows randomness in the data to exert a greater influence on the correlation coefficient. It would therefore appear that the lower correlation coefficients in Table 5-1 (b) do not represent a deterioration in the 850 mb temperature relationship but rather a lack of opportunity to demonstrate the temperature influence over a wide range of temperature values.

It is concluded that the 850 mb temperature is a useful indicator of ozone potential, given a sufficient amount of variability. There is also an indication that correlations may be particularly high along the immediate coast where the difference between the ocean surface temperature and the 850 mb temperature is an effective indicator of stability. Conversely, there is less value in the use of 850 mb temperatures in the desert because of the strong surface heating associated with the warm temperatures aloft and the consequent increases in vertical mixing.

5.2 Holzworth Air Pollution Potential

5.2.1 Effect of Surface Sources

Holzworth (1972) developed an urban dispersion model to be used with climatological data to generate statistics on air pollution potential. The model was as follows:

$$X/Q = 3.994\ (S/u)^{0.115} \tag{1}$$

when no pollutants reach a uniform vertical distribution and

$$X/Q = 3.613\ H^{0.130} + \frac{S}{2Hu} \tag{2}$$

when some pollutants have reached a uniform vertical distribution.

X = pollutant concentration
Q = area emission rate
S = along-wind distance across city
H = mixing height
u = wind speed

There is no dependence on downwind distance in the model. The concentrations are appropriate to those over the city. Holzworth calculated pollution potentials for two city sizes (along-wind distance S) of 10 km and 100 km.

The meteorological variables included in the model are wind speed only for equation (1) and wind speed and mixing height for equation (2). In the latter equation the product (Hu) usually plays a more important role than the term which includes $H^{0.130}$. High concentrations are therefore primarily dependent on low wind speeds and low mixing heights.

The Holzworth computational scheme was used for all of the available sounding data for the 17 sounding locations in the state. Potentials for the morning and afternoon soundings were both calculated from the morning sounding with appropriate adjustments in the surface temperature as suggested by Holzworth. Data were grouped into winter (December - February), spring (March - May), summer (June - August) and fall (September - November). Computations were made for 10 and 100 km city sizes and the results are presented in the Appendix in terms of 50 and 90 percentile values.

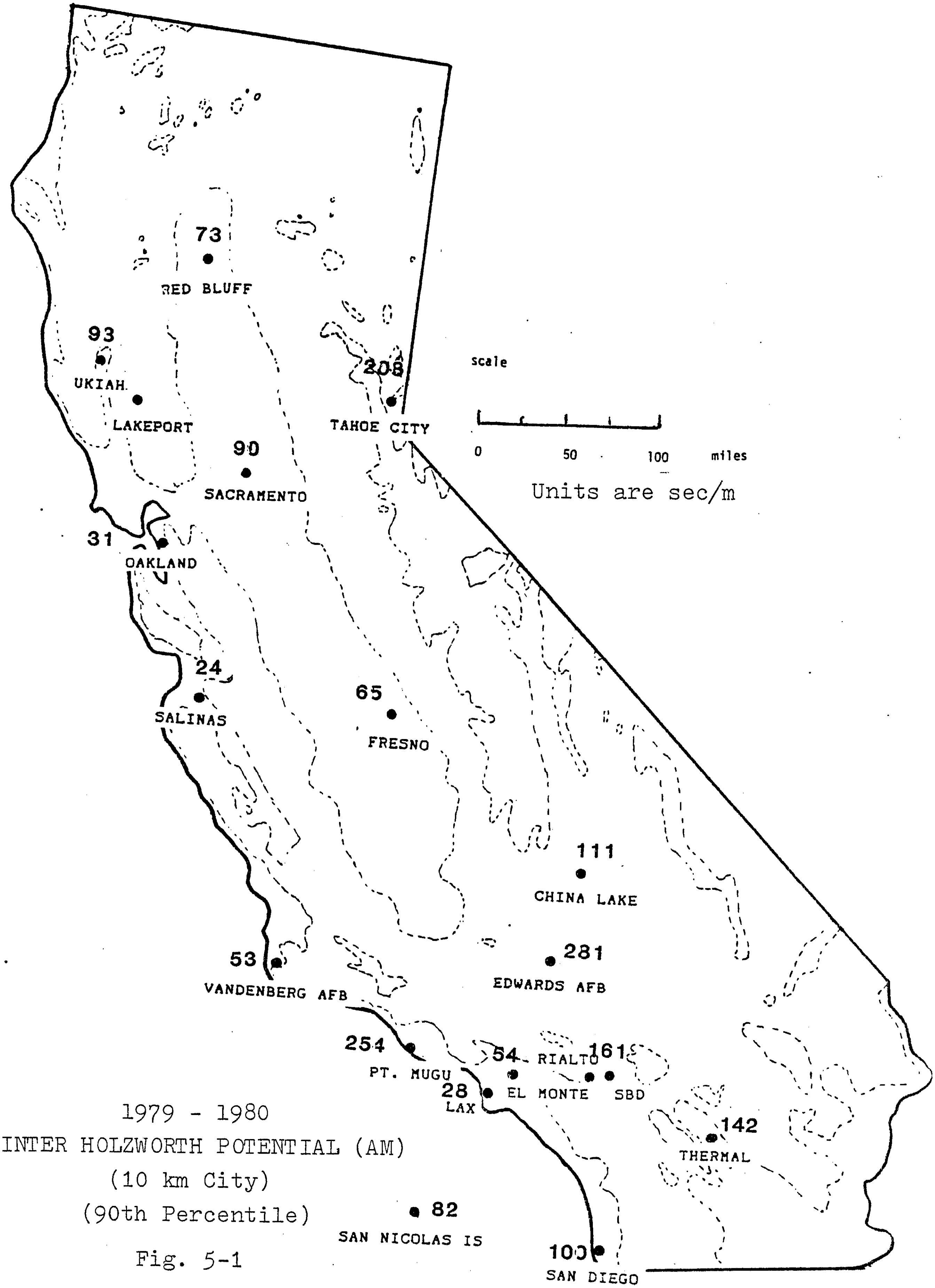
Comparison of the data in the Appendix with Holzworth's results was possible for Oakland and San Diego. The present results showed somewhat lower concentrations than Holzworth for Oakland but somewhat higher values for San Diego. The calculated values in the Appendix are generally similar to those given in the CARB Staff Report (1974) for comparable locations.

Figs. 5-1 through 5-4 show maps of the calculated air pollution potential at the 90 percentile upper level for the morning, for a 10 km city size and for the four seasons. The data indicate rather clearly the inland, low wind speed areas where morning potential would be expected to be high. These areas include San Bernardino, Edwards AFB, Thermal, Inyokern and Ukiah. Values in the Central Valley are relatively high in the winter and fall. The coastal areas tend to show low values of air pollution potential with the notable exception of Pt. Mugu and San Diego (winter and fall). The values at Pt. Mugu are primarily the result of low mixing heights.

The comparable afternoon representation of pollution potential is shown in Figs. 5-5 and 5-6 for winter and fall, respectively. Ninetieth percentile spring and summer values ranged from 11 to 15 throughout the state and do not show any area variations of particular interest. Variations in the potential for winter and fall are also not very large but suggest slightly higher values near Ukiah and in the Sacramento Valley.

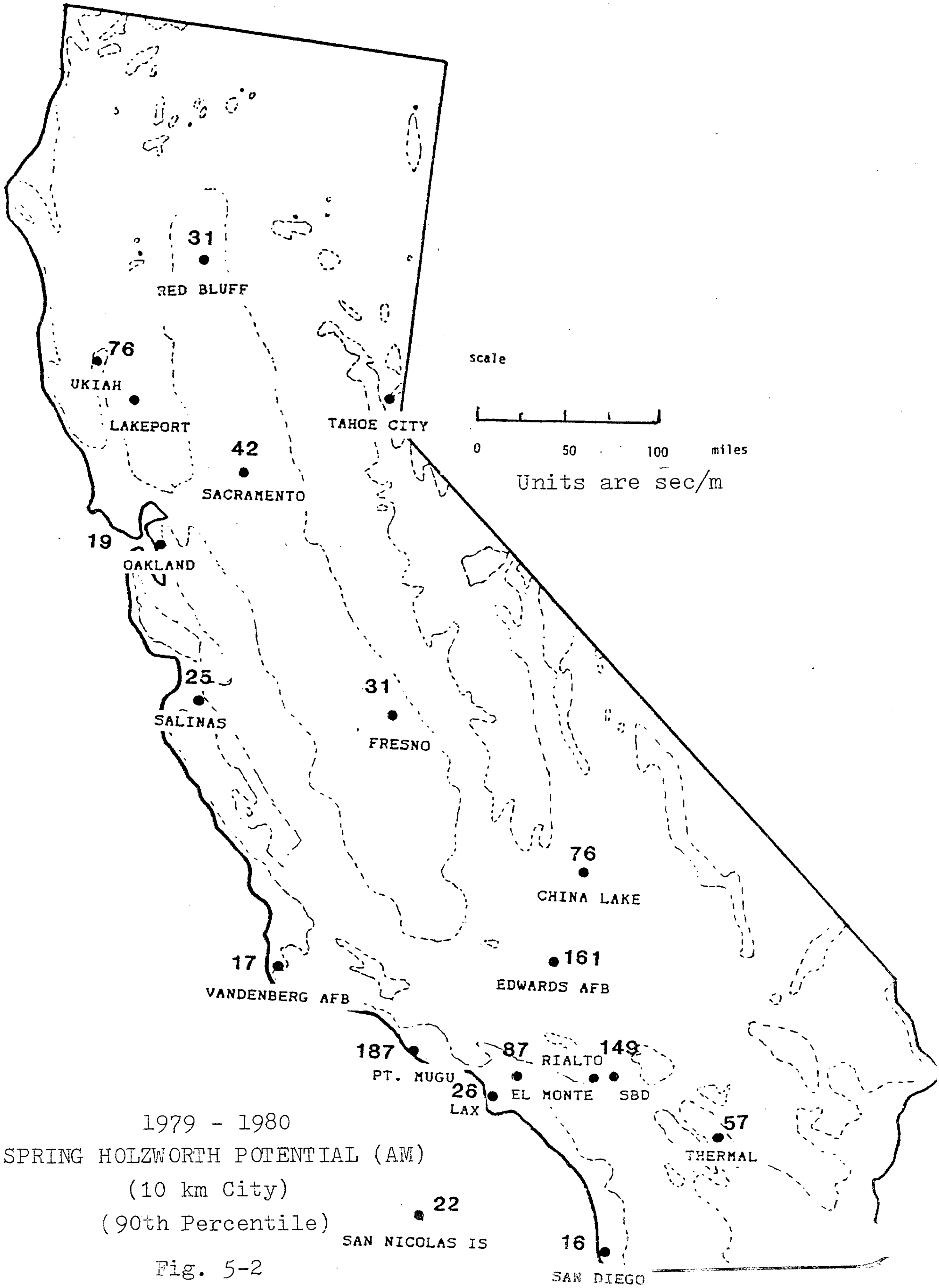
Figs. 5-5 and 5-6 illustrate the limitations of the Holzworth technique. For moderate mixing heights such as occur generally in the afternoon the calculated pollution potential is a function of wind speed only. Since the frequency distribution of wind speeds in the afternoon tends to be similar at most locations, the calculated afternoon potential does not vary much throughout the state and hence does not contain much information of value.

Table 5-3 shows the results of correlating morning or afternoon values of Holzworth potential (10 km city size) with the peak ozone concentration for the same day. Correlations for 1979 and 1980 were calculated separately. Locations where the peak ozone concentrations were observed are shown in parenthesis if different from the sounding location.



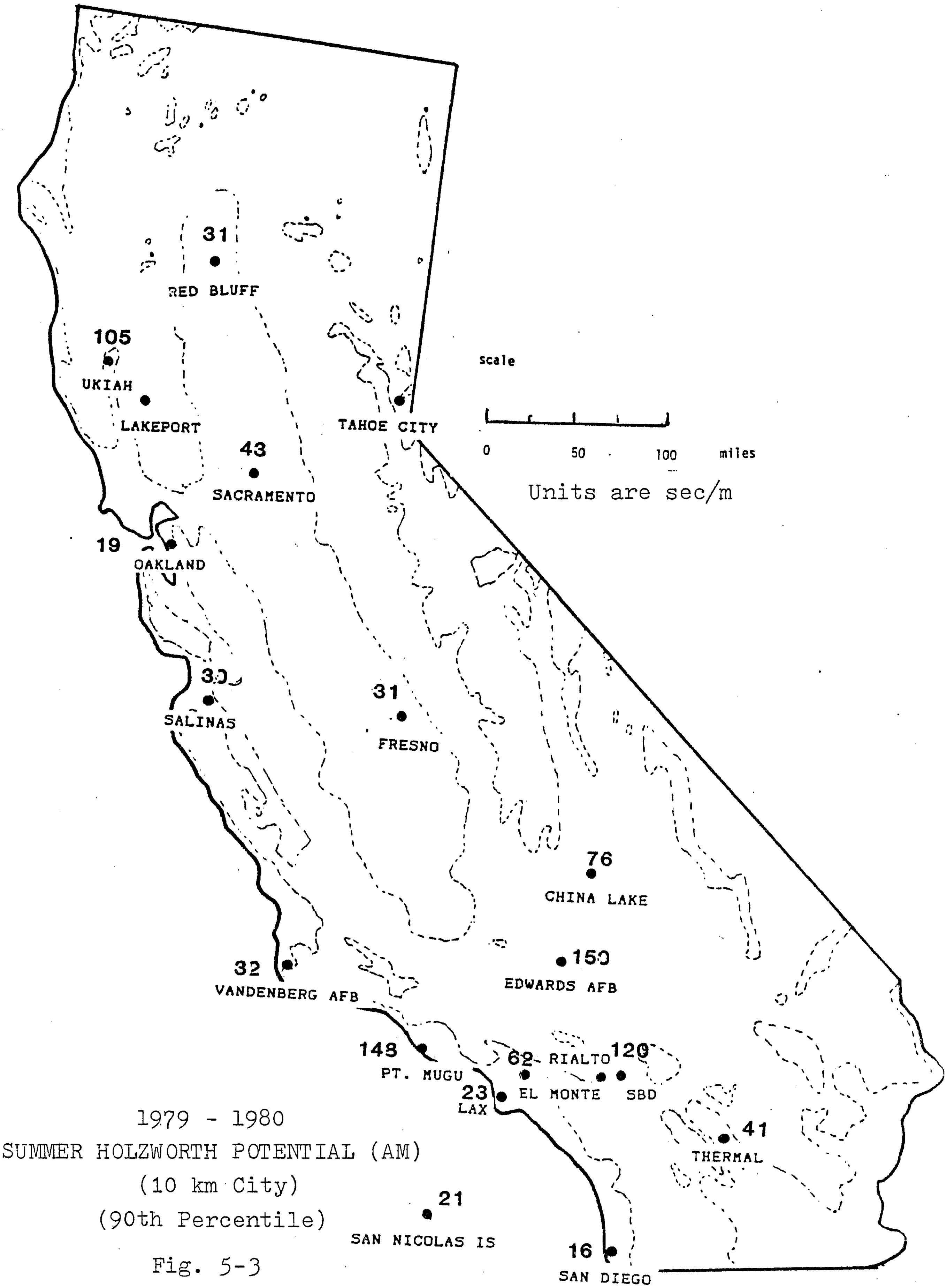
1979 - 1980
WINTER HOLZWORTH POTENTIAL (AM)
(10 km City)
(90th Percentile)

Fig. 5-1



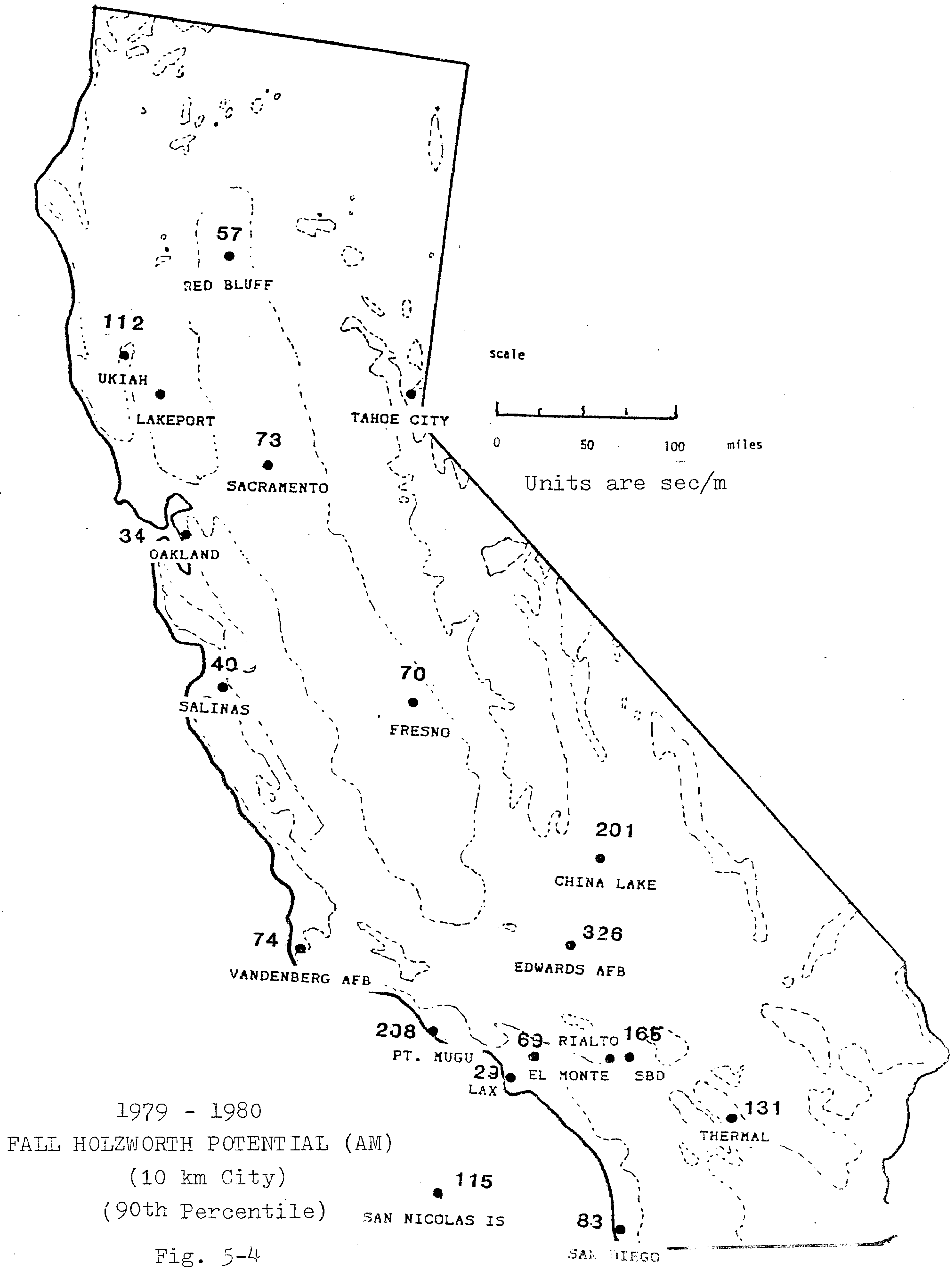
1979 - 1980
SPRING HOLZWORTH POTENTIAL (AM)
(10 km City)
(90th Percentile)

Fig. 5-2



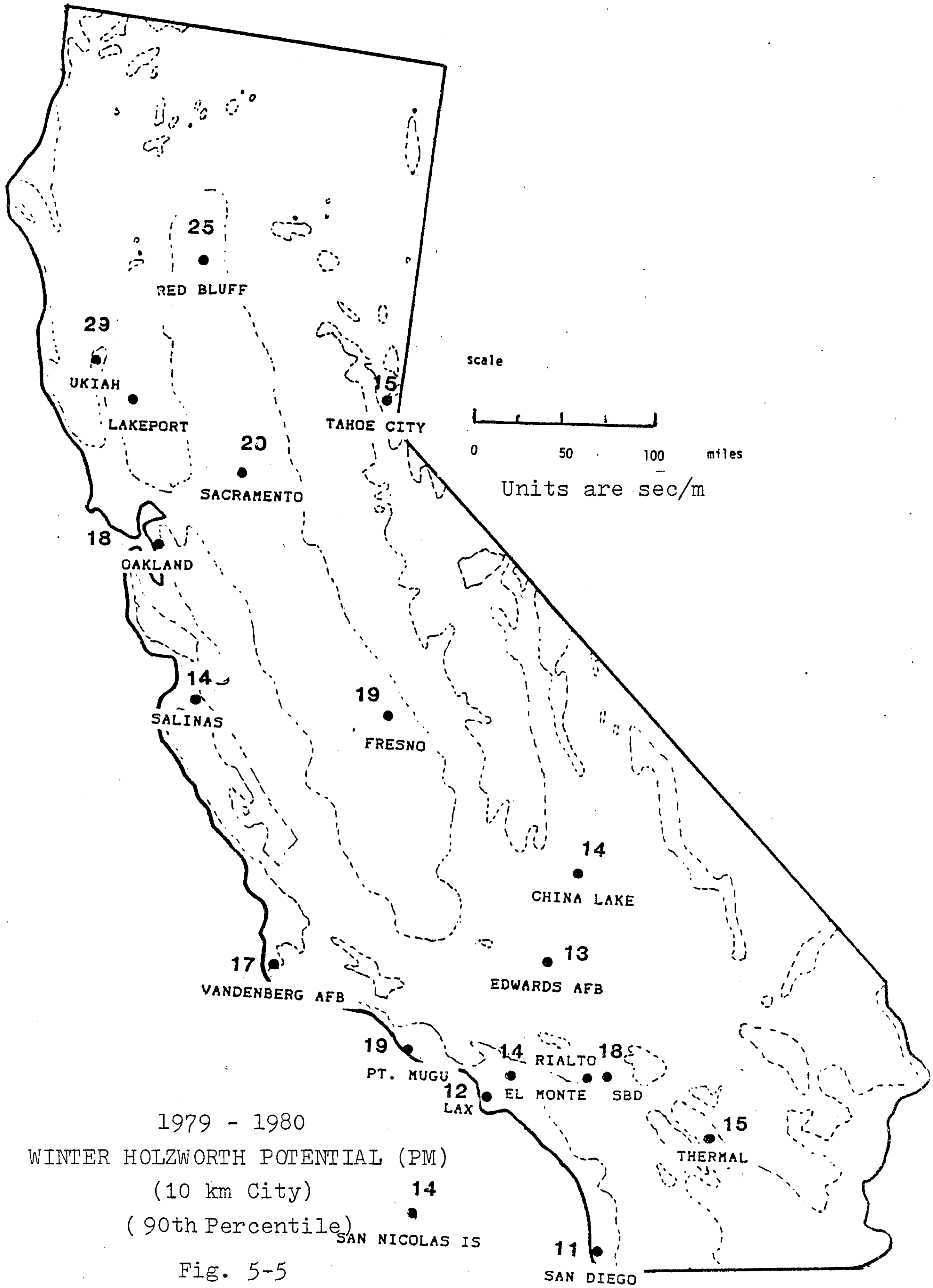
1979 - 1980
SUMMER HOLZWORTH POTENTIAL (AM)
(10 km City)
(90th Percentile)

Fig. 5-3



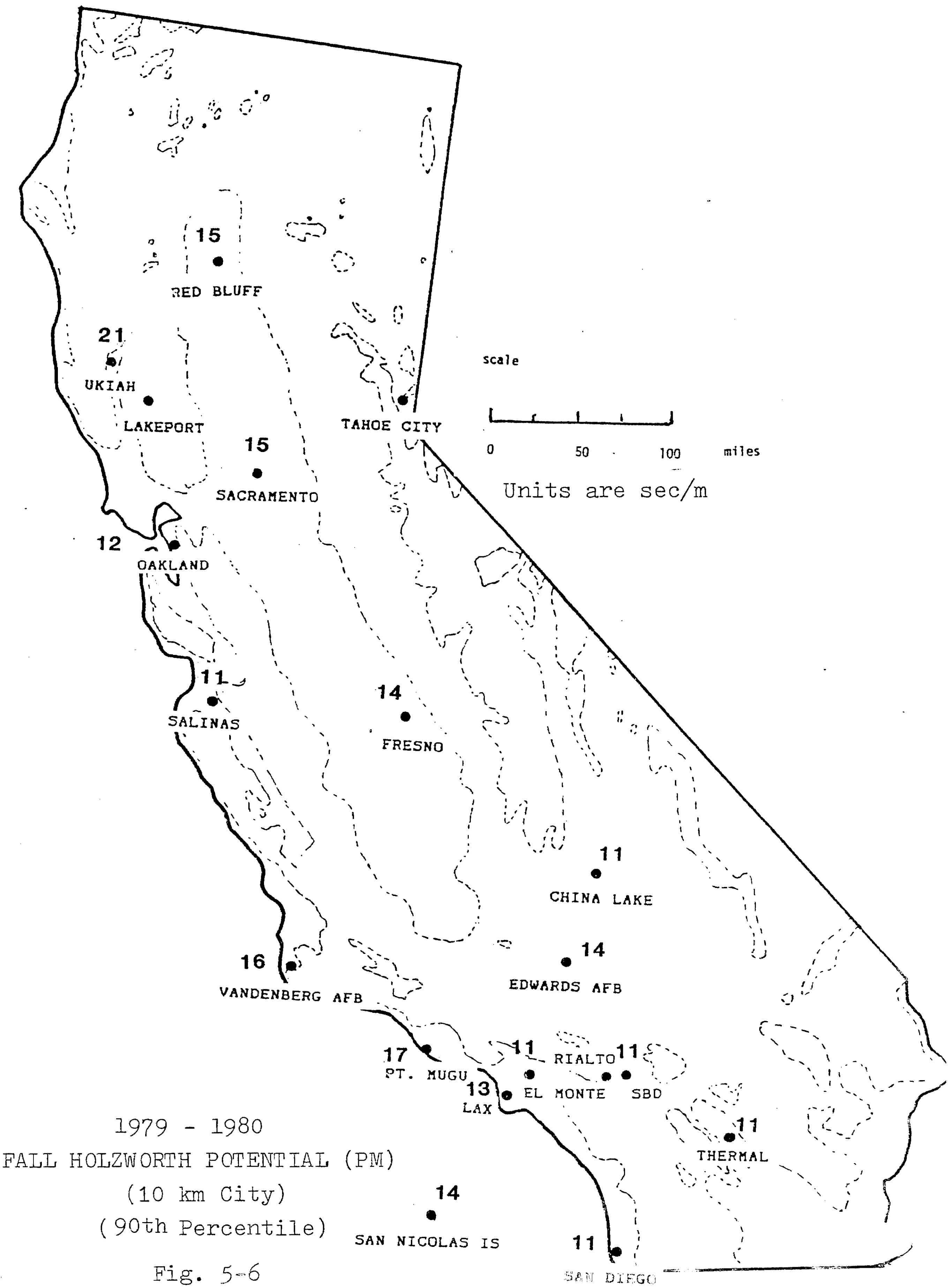
1979 - 1980
FALL HOLZWORTH POTENTIAL (AM)
(10 km City)
(90th Percentile)

Fig. 5-4



1979 - 1980
WINTER HOLZWORTH POTENTIAL (PM)
(10 km City)
(90th Percentile)

Fig. 5-5



1979 - 1980
FALL HOLZWORTH POTENTIAL (PM)
(10 km City)
(90th Percentile)

Fig. 5-6

Table 5-3

Correlations of Ozone Concentrations and Holzworth Potential (July - August) (10 km City Size)

Location	Year	Time	Correlation
Sacramento	1979	AM	.54
		PM	.41
	1980	AM	.30
		PM	-.08
Fresno	1979	AM	.70
		PM	.20
	1980	AM	-.01
		PM	-.06
Pt. Mugu (Piru)	1979	AM	.06
		PM	.05
	1980	AM	.17
		PM	.51
San Bernardino (Fontana)	1979	AM	.35
		PM	.00
	1980	AM	.09
		PM	.05
Los Angeles (UCLA) (Fontana)	1979	AM	.60
		PM	.31
El Monte (Fontana)	1979	AM	.38
		PM	-.05

The data in Table 5-3 show considerable variability. It is significant that the correlations are not very consistent from one year to the next. The principal features of the data appear to be:

1. With the exception of Pt. Mugu the peak ozone concentration usually correlates better with the morning potential than with the afternoon.

2. Correlations of morning potential at Pt. Mugu with the Piru ozone peak do not show any utility. This probably indicates that the morning potential calculations at Pt. Mugu are not very reliable.

3. Correlations using 1980 data were consistently poor at all stations. This is in contrast to the use of the 850 mb temperature where the correlations for both the 1979 and 1980 periods were relatively high.

The lack of consistency in the data shown in Table 5-3 is, in part, due to the imprecise observational data which goes into the potential calculations. Mixing height is not measured but estimated by approximate methods. At low wind speeds, the accuracy of the obsrved values is reduced by anemometer limitations. As a consequence, the statistical distributions of air pollution potential may be meaningful but considerable variability may exist from day to day.

Another important limitation in applying the Holzworth method for identification of high ozone potential is that directional transport of pollutants by wind is not considered. In California, the day to day variations in wind are relatively small and the location of areas of highest average ozone concentrations are strongly dependent on the climatology of directional transport.

5.2.2 Effect of Source Height

The effect of source height on the Holzworth surface air pollution potential was examined by stratifying mixing heights to 0-167m, 167-334m and above 334 m. Two indicators of surface potential were calculated:

1. The proportion of days when an elevated source in the layers (167-334 and above 334 m) would not impact the surface (i.e. the mixing height was below the source layer).

2. The 50th percentile pollution potential for each data set in which the mixing height was 0-167, 167-334 and greater than 334 m. These calculations are given in

Table 5-4 for the four seasons and for selected sounding locations in the state. As an example of the data for Sacramento, if the source heights were between 167 and 334 m the ground impact on winter mornings would be zero on 80% of the days (100% for source heights above 334 m). In part b of the table, the 50 percentile potential value for those cases of mixing heights less than 167 m was 35 sec/m and 11 sec/m if the mixing layer depth was 167-334 m.

Table 5-5 summarizes the geographical variations in the effect of source height on surface air pollution potential if the source height is assumed to be in the range of 167-334 m (agl). Releases at this level are above the mixing layer on 80% of the winter mornings at Sacramento but on only 15% of the days at Oakland. The inland locations show a much greater effect of elevated releases compared to coastal areas and the effect is more pronounced in the winter and fall at all locations.

In the afternoon releases at 167-334 m (agl) are above the mixing layer on only 0-5% of the afternoons at all locations with the exception of Fresno in winter (12%).

The following comments summarize the data in Table 5-4 and 5-5:

1. Morning elevated sources in the inland areas are associated with zero impact at the surface more frequently than coastal locations. This is a particularly strong influence during winter and fall.

2. This factor is not very significant in the afternoon. Occurrences of zero potential from any of the listed source heights are rare except in winter.

3. The greatest reduction in surface concentrations resulting from the release of pollutants from elevated sources appears to occur during the morning in the San Bernardino area where pollutants would frequently be released above a strong surface-based inversion.

4. The least reduction in surface concentrations due to the release of pollutants from an elevated source may occur at Oakland where the mixing heights are usually high in comparison with other locations and pollutants from an elevated source would frequently be released into (and not above) the mixing layer.

Table 5-4

Effect of Source Height on Holzworth Potential
(10 km City)

Sacramento

a. Frequency of Zero Potential at Surface

		Source Height 167-334 m	Source Height >334 m
Winter	AM	80 %	100 %
	PM	13	40
Spring	AM	59	79
	PM	1.7	1.7
Summer	AM	33	97
	PM	0	0.9
Fall	AM	62	93
	PM	0.7	3.7

b. Air Pollution Potential (50 percentile)

		Source Height <167 m	Source Height 167-334 m	Source Height >334 m
Winter	AM	35 sec/m	11 sec/m	-
	PM	5	13	13 sec/m
Spring	AM	20	14	9.8
	PM	5	-	9.6
Summer	AM	29	14	9.5
	PM	-	13	9.5
Fall	AM	29	16	11
	PM	5	13	10

Table 5-4 (cont.)

Oakland

a. Frequency of Zero Potential at Surface

		Source Height 167-334 m	Source Height >334 m
Winter	AM	15%	36 %
	PM	5	25
Spring	AM	3	18
	PM	-	1.5
Summer	AM	5	20
	PM	-	5
Fall	AM	18	34
	PM	-	4

b. Air Pollution Potential (50 percentile)

		Source Height <167 m	Source Height 167-334 m	Source Height >334 m
Winter	AM	36 sec/m	17 sec/m	10 sec/m
	PM	17	13	10
Spring	AM	23	18	10
	PM	-	9	9
Summer	AM	25	17	11
	PM	-	9	9
Fall	AM	30	19	11
	PM	-	10	10

Table 5-4 (cont.)

Fresno

a. Frequency of Zero Potential at Surface

		Source Height 167-334 m	Source Height >334 m
Winter	AM	64%	77 %
	PM	12	29
Spring	AM	40	69
	PM	-	0
Summer	AM	48	88
	PM	-	0.7
Fall	AM	76	95
	PM	-	0.9

b. Air Pollution Potential (50 percentile)

		Source Height <167 m	Source Height 167-334 m	Source Height >334 m
Winter	AM	34 sec/m	15 sec/m	11 sec/m
	PM	15	14	11
Spring	AM	26	15	10
	PM	-	-	9
Summer	AM	24	14	10
	PM	-	9	9
Fall	AM	31	17	13
	PM	-	9	10

Table 5-4 (cont.)

LAX

a. Frequency of Zero Potential at Surface

		Source Height 167-334 m	Source Height >334 m
Winter	AM	24%	44 %
	PM	0	7.3
Spring	AM	14	29
	PM	0	1.7
Summer	AM	10	33
	PM	0	7
Fall	AM	22	52
	PM	0	4

b. Air Pollution Potential (50 percentile)

		Source Height <167 m	Source Height 167-334 m	Source Height >334 m
Winter	AM	26 sec/m	18 sec/m	10 sec/m
	PM	-	13	10
Spring	AM	28	17	11
	PM	-	9	10
Summer	AM	32	17	13
	PM	-	11	10
Fall	AM	27	20	13
	PM	-	13	10

Table 5-4 (cont.)

San Bernardino

a. Frequency of Zero Potential at Surface

		Source Height 167-334 m	Source Height >334 m
Winter	AM	74 %	86 %
	PM	1.5	3
Spring	AM	40	65
	PM	1.1	1.1
Summer	AM	55	77
	PM	0	0
Fall	AM	74	87
	PM	0	0

b. Air Pollution Potential (50 percentile)

		Source Height <167 m	Source Height 167-334 m	Source Height >334 m
Winter	AM	74 sec/m	27 sec/m	18 sec/m
	PM	5	13	11
Spring	AM	106	36	14
	PM	5	-	10
Summer	AM	74	46	24
	PM	-	-	9
Fall	AM	115	32	23
	PM	-	-	9

Table 5-4 (cont.)

San Diego

a. Frequency of Zero Potential at Surface

		Source Height 167-334 m	Source Height >334 m
Winter	AM	30 %	47%
	PM	1.5	6
Spring	AM	3	11
	PM	1.3	2
Summer	AM	1.5	12
	PM	-	4
Fall	AM	23	37
	PM	0.8	7

b. Air Pollution Potential (50 percentile)

		Source Height <167 m	Source Height 167-334 m	Source Height >334 m
Winter	AM	68	19	10
	PM	23	13	10
Spring	AM	38	15	10
	PM	64	13	10
Summer	AM	32	16	11
	PM	-	9	9
Fall	AM	71	18	12
	PM	19	11	9

Table 5-5

Frequency of Zero Potential at Surface from Release at 167-334 m (agl)

Winter (AM)

Location	Frequency of Zero Potential
Sacramento	80%
San Bernardino	74
Fresno	64
San Diego	30
LAX	24
Oakland	15

Spring (AM)

Sacramento	59
San Bernardino	40
Fresno	40
LAX	14
San Diego	3
Oakland	3

Summer (AM)

San Bernardino	55
Fresno	48
Sacramento	33
LAX	10
Oakland	5
San Diego	1.5

Fall (AM)

Fresno	76
San Bernardino	74
Sacramento	62
San Diego	23
LAX	22
Oakland	18