11.1 SEA FOG OFF THE CALIFORNIA COAST:
HISTORICAL PERSPECTIVE AND CLIMATOLOGY

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1. INTRODUCTION

The extreme variability of fog off the California coast in both space and time has led to a series of hypotheses regarding sea fog formation in this area. We historically examine the research environment and work of several scientists who contributed to our understanding of this phenomenon (Table 1). Furthermore, we compare and contrast the hypotheses in light of known climatology (frequency distribution of sea fog).

Contributor/Year	**Mechanism for Sea Fog**
G. I. Taylor/1917	Eddy Diffusion over Cold Water
Horace Byers/1930	Summertime climate off California coast/NW winds in conjunction with cold SSTs
Joseph Anderson/1931	Stratus lowering
Sverre Petterssen/1937	unstable stratification (warm SSTs) gives rise to convection/turbulence in marine environment
Dale Leipper/1948	Hot spells/ warm air from continent moves over adjoining ocean off West Coast/inversion creation/radiative cooling

Table 1. Summary of contributions

2. CLIMATOLOGY OF SEA FOG OFF THE CALIFORNIA COAST

There are two climatological studies of West Coast fog that have admirably served the meteorological and oceanographic communities. The first is a wartime publication prepared by the *U. S. Army Air Forces* [1944]. The second study appeared as a technical report from SIO [*Filonczuk et al*. 1995]. This publication is notable for its use of an extensive database linked to the Comprehensive Ocean Atmospheric Data Set [COADS, *Woodruff et al.* 1987; *Bottomley et al*. 1990]. We have extracted information from Filonczuk et al. (1995) and have graphically presented it in Fig. 1. In each region the frequency distributions of fog are shown.

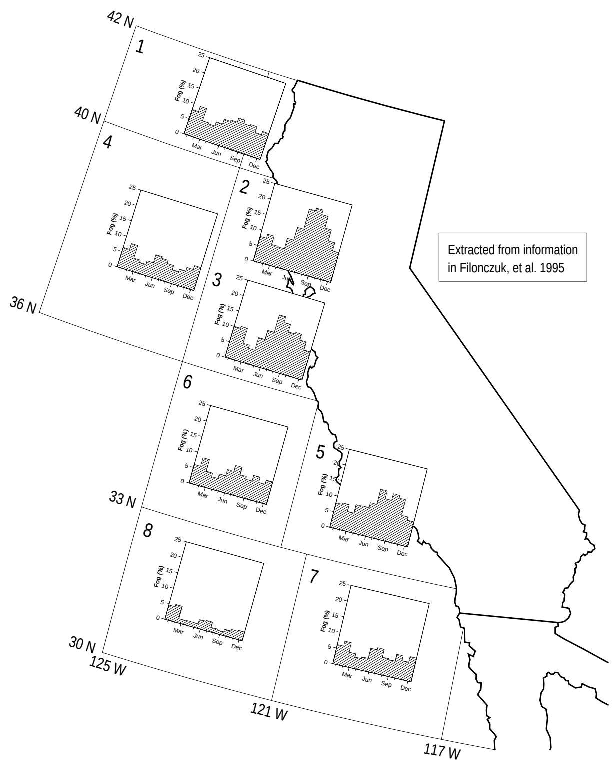

Figure 1. Monthly frequencies of sea fog off the California coast [Extracted from information in *Filonczuk et al.* 1995].

The ordinate of the frequency distributions denotes the percent of the time during a given month that fog was observed in that region. simply stated, the percentage is based on the number of observations with fog present divided by the total number of observations.

The annual frequencies of fog at various lighthouses along the California coastline are taken from information in *U. S. Army Air Forces* [1944] and displayed in Table 2.

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Station Name	Annual Number of Hours with Fog
Point Loma	273
Los Angeles	640
Point Conception	273
Point Arguello	901
San Luis Obispo	929
Point Sur	845
Farallon Islands	844
Point Reyes	1411
Point Arena	1111
Blunts Reef	1572
St. George Reef	949

Table 2. Fog records for lighthouse stations along the California coast (15 - 23 years of record). Extracted from *U. S. Army Air Forces* [1944].

These lighthouses are ordered from south to north in the table and their locations are shown in Fig. 2.

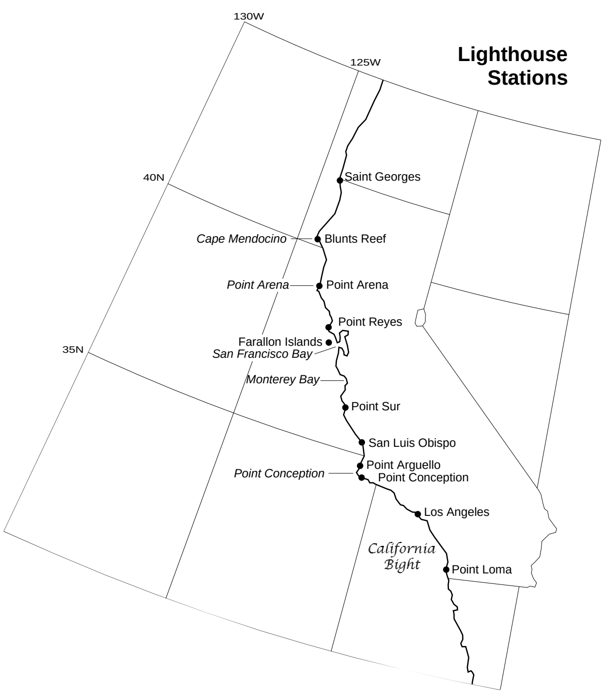

Figure 2. Locations of lighthouses referenced in Table 2.

The table shows that the minimum of fog production on the California coast occurs near San Diego. From Los Angeles to Point Conception a decline is noticeable, but close to the northward of this point, there is an abrupt rise. Point Arguello exhibits more than three times the number of foggy hours than shown at Point Conception, yet the two lighthouses are only 12 miles apart. Viewed macroscopically, the average number of hours of fog at these lighthouses generally increases from south to north. The stretch of coast between San Francisco and Cape Mendocino exhibits the greatest number of foggy hours while the coastal segment south of Point Conception has the least. If we take the ratio of the largest number of hours (1572 at Blunts Reef) to the smallest (273 at both Point Loma and Point Conception), we find that the average number of hours with fog varies by a factor of 6 over this network.

3. DISCUSSION

During the two-decade period, 1930 – 1949, several mechanisms for the formation of sea fog off the California coast were proposed: flow of humid air over cold SST anomalies, vertical mixing in an unstably stratified boundary layer, lowering of stratus cloud, and transport of hot/dry air from land to sea. Fog formation due to mixing of humid yet unsaturated air masses, typically the movement of nocturnally cooled land-based air to the ocean, was documented in the 1970s. The array of fog-producing mechanisms is indeed varied, as it should be in the case of a coastline that encompasses weather regimes of the mid-latitudes and subtropics.

The monthly frequencies of fog attest to the complicated nature of the phenomenon. Furthermore, the frequencies in regions 2, 3, 5, and 7 (Figure 1) are not strictly sea fogs, but a combination of fog observed at coastal stations and ships at sea. Thus, we must exercise caution in relating mechanisms of sea fogs to frequency distributions in these regions. Nevertheless, with some certainty we can link the summer maximum in fog frequency for regions 2 and 3 (between Cape Mendocino and San Francisco) with the cold SST anomalies off the coast in concert with the northwesterly flow in these regions.

It is not meaningful to ascribe a given fog-producing mechanism to a particular region; the fairest statement is that the various mechanisms have some likelihood in each area. Yet, we know that fog associated with unstable stratification is much less likely in the sea off the northern coast than it is off the southern coast at any time of the year. Similarly, the absence of sustained upwelling in the California Bight will reduce the chances of fog production via airflow over anomalously cold water.

REFERENCES

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